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Importance of wetland ecosystems for disaster risk reduction: A review+

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Abstract
The importance of wetland ecosystems is considered in this paper. The Ramsar Convention on Wetlands in 1972 is an index from which the importance is reviewed. Reasons why wetlands are disappearing are discussed as well as the short and long-term effects of such disappearances. The disaster reduction potential of wetlands is explained to justify why wetlands should be preserved. The threats that degrade wetlands are mainly anthropogenic and can be addressed through integrated ecosystem management approach. The contents of a good wetland management policy are also proffered.

Introduction

The World Wetland Day (WWD) as celebrated on February 2nd of every year has its origin in the Ramsar Convention on Wetlands held in Iraq in 1972.The mission of the convention was to enhance "the conservation and wise use of all wetlands through local and national actions and international cooperation as a contribution towards achieving sustainable development throughout the world." From the mission so stated, we could define localaction as what we are doing now, that is, celebrating the WWD here in the University of Uyo in AkwaIbom State, Nigeria.This is an important activity because all stakeholders in the wetland project in AkwaIbom Sate are here represented, including students, teachers, non-governmental organizations, and government parastatals and ministries whose mandate covers wetland conservation, management and initialization. The national action is exemplified in Nigeria being signatory to the Ramsar Convention and establishing biodiversity units in the Federal Ministry of Environment and other related parastatal. The international cooperation is exemplified in activities that have transboundary impacts on wetlands, e.g., shared wetland systems such as the Lake Chad wetland which is transboundary between Nigeria and Chad Republic. In 1985, the Interstate Forecasting Centre (IFC), established within the framework of Hydroniger Project was for the benefit of countries located within the River Niger basin (under the auspices of Niger Basin Authority for nine member countries) with headquarters in Niamey (Niger Republic). The main aim was to assist riparian countries in protecting biodiversity and to minimize the catastrophic effect of drought and flood.

The Ramsar Convention is supported by three major strategies which may be regarded as pillars on the convention stands. In addition to international cooperation on transboundary wetlands, another important pillar is the recognition of wetlands of international importance as sites of conservation.

There are over 2,220 Ramsar Sites in 169 countries, covering over 215 million ha. These are associated with the next pillar that seeks to establish wise use of all wetlands, through the maintenance of their ecological character by implementing ecosystem approaches. The ecosystem approaches are implemented, having been made part of national plans, policies, legislation, management actions and public education.

The Ramsar Convention on wetlands has regularly been updated and modified through series of strategic plans. The most recent-the Vision of the 4thRamsar Strategic Plan 2016-2024- emphasized that "*wetlands be conserved, wisely used, restored and their benefits recognized and valued by all*". The Plan highlights the urgent need to restore degraded wetlands that are relevant to biodiversity conservation, disaster risk reduction, livelihoods, climate change mitigation and adaption. It is clearly from this strategic plan that the theme of the 2017 World Wetland Day Celebration has been derived.

The 4thRamsar Strategic plan has given broad reasons why wetlands are disappearing as:

(i)   Conversion of wetlands for intensive agriculture;
(ii) Conversion of wetlands for building, infrastructure and industrial use;
(iii) Impact of climate change;
(iv) Over-exploitation of water and other wetland resources.

When wetlands disappear, the result could be subtle but the long-term effects are often disastrous. The following results would be apparent:

(i)   Disruption of the hydrological cycles;
(ii) Increasing occurrence of floods and droughts;
(iii) Significant increase in carbon emission;
(iv) Increasing land degradation and loss of productivity.

What are wetlands?

Considering the importance attached to wetlands, it is necessary that we explore its operational definition. A

wetland is a transitional land between terrestrial and aquatic system where water table is usually high, being at the surface or near the surface. It is also a land that is periodically covered by shallow water and which in normal circumstances support or would support vegetation that is typically adapted to saturated spoils. According to Ramsar Convention, wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanently or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed six metres. Ramsar's definition of wetland is broad enough to include lakes, rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.

The definitions imply that wetlands are found all over the world, meaning that they are of global importance, not only in terms of their varying hydro-geomorphology, but because they sustain unique biodiversity and human livelihoods. Wetlands are very productive environments which support numerous plant and animal species and other ecosystem services including food, flood control, groundwater recharge and climate change mitigation. However, the quality of wetlands has continued to decline which means that the ecosystem services which wetlands provide to enhance livelihoods are being compromised.

Wetland ecosystems and disaster recovery

Based on the general definition of ecosystem, wetland ecosystems are dynamic complexes of plants, animals and living communities (including man) and their non-living environment interacting as functional components. They are the basis of all life and livelihoods in the wetland. They provide systems upon which major industries related to the wetlands area based e.g., agriculture, fisheries, timber and other extractive industries. This means that the wetland ecosystem provides goods and other benefits that enable people and communities to withstand and recover from disasters. Therefore, the wetland ecosystem can be healthy or sustainable when it is intact and discharging its functions in terms of yielding resources to meet current demands, with excess for future generations. In this regard we may say that the wetland ecosystem has integrity which means it possesses resilience to support risk reduction. For the wetland ecosystem to support risk reduction it should have the capacity to provide the following functions:

(i)   Provision of food – if the wetland can be cultivated to yield food then its integrity has not been compromised. Seasonally flooded wetlands are important food sources in many countries of the world. These wetlands permit all year cultivation since flood water is located in depressions after the flood might have receded, thus making soil moisture available for replanting after the first harvest.

(ii)   Grazing function – if the wetland can provide fodder for livestock and game, then its integrity is high. Wetlands often provide all year fodder stock which livestock rely on even in times of drought.

(iii) Fiber and fuel – if the wetland yields wood for cooking, fiber for artisanal craft and thatch for housing, then its integrity has been sustained.

(iv)   Medicinal plants – wetlands are habitats for several plants that have medicinal uses. Often, these plants do not occur elsewhere outside that wetland ecosystem since they are specialized plants. For example, the medicinal uses of mangroves are specific to the brackish/saline swamps where they occur in the tropics and sub-tropics.

(v)   Trade and tourism – commonly, may wetland ecosystems attract tourists because of their unique habitat. In Southeast Asia, ecotourism in mangrove areas attract numerous visitors. Associated with tourism in the craft, development in local souvenir industries and livelihoods.

(vi)   Provision of Timber – several wetlands yield timber for construction and furniture making when properly managed. Many wetlands that have lost their timber products have been due to unsustainable utilization.

(vii) Fishing – if the wetland ecosystem provides spawning grounds for fish and also fishing grounds for protein supply, then its integrity has been sustained.

(viii) Transportation – wetland routes have been known to enhance transportation between or among communities. This is because road infrastructure could be difficult to build due to the nature of the terrain and high water table. Wetland ecosystem integrity in this aspect should not be compromised through pollution of waterways and siltation of creeks.

(ix)   Provision of water – if the wetland supplies water for domestic and industrial use, then its integrity is satisfactory.

(x)   Climate regulation – wetlands should act as sink for greenhouse gases and also influence local and regional temperatures or generate peculiar micro climates that encourage human habitation.

(xi)   Regulates natural hazard – regulation of natural hazard is an important function of any wetland

e.g., it supports flood control, acts as buffer for drought and as breaks for wild fires.

(xii) Biodiversity bank – wetlands are habitats for wildlife including rare species. They are sanctuary for migratory birds, wetland birds and rare plants including medicinal plants. Wetlands are replete with pollinators that help to perpetual and preserve germplasm.

(xiii) Spiritual functions - wetland ecosystems can enhance the spiritual base of communities in terms of worship and faith. Many communities locate their spiritual activities in wetlands which also help to preserve their biodiversity since they are regarded as sacred.

(xiv) Educational – wetlands have educational functions, particularly reserves and sites of importance in terms of research and for training. Pristine vegetation is often studied in permanent plots. Also experiments on carbon sink in many instances utilize undisturbed wetlands.

Threats that degrade wetland ecosystems

There are several threats that are indication that incipient degradation has occurred in a wetland and that the wetland is losing its integrity. These include:

(i) Invasive alien species – when species that is not native to a particular wetland is introduced, it may change or modify the ecology of the wetland to suit it. Sometimes the modification could be extreme such that native species are displaced away from the wetland and could become extinct or endangered. This is the case in the estuaries of southeastern Nigeria where the introduction of nipa palm (*Nypa fruticans*) has caused the native mangroves to be degraded.

(ii) Overgrazing – overgrazing results when the carrying capacity of a wetland is exceeded through the introduction of too many grazing animals like cattle, sheep, goat etc. Since wetlands usually hold the last reserves of moisture in a dry environment, they provide all-year fodder for animals. Even if the fodder is starvation diet, large number of animals' crowd into the wetlands leading to complete loss of vegetation cover and the attendant effects on the soil moisture regime.

(iii) Uncontrolled fire – under normal conditions, wetlands should act as natural fire breaks, but when the climate becomes dry wetlands could burn just like any other vegetated ecosystem. This arises when the water table declines due to removal of vegetation, over harvesting of ground water, construction of drainage channels or reclamation. Then environmental costs of human activities could cause the wetland surface to be dry and combustible.

(iv) Soil erosion – the removal of the surface soil by wind, running water (or moving ice in temperate areas) has posed serious threat to wetlands. Soil erosion is initiated by human activities e.g. agricultural activities and other resources exploitation which lead to low water table, fire outbreaks and loss of vegetation. These would change the ecological characteristics of the wetland leading to loss of vegetation. As the soils are exposed, erosion intensifies and the wetland degrades.

(v) Sedimentation – sedimentation results when large quantities of particles are delivered into the wetlands from outside the framework of the wetlands. Loss of vegetal cover, sheet wash and precipitation could increase the quantity of suspended particles and organic materials that are delivered into the wetlands. Sedimentation could cause the water table to diminish, sometimes beyond the reach of shallow- rooted aquatic plants. The water may no longer be available to birds and animals.

(vi) Pollution – pollution of wetlands results when there is convergence in-flow of run off from diverse sources. Urban runoff and overland flow from farms often contain pollutants that adversely affect wetlands e.g. lead and other heavy metals are constituents of urban runoff while nitrates from farms could enrich the wetlands such that they are choked off by luxuriant weeds.

(vii) Climate variability – climate variability results from change in climate or short term fluctuation in climate. The existence of wetland is strongly tide to climate resilience i.e., the ability of the climate to always provide favourable conditions for the wetlands to the perpetuated. Once the equilibrium conditions between wetlands and climatic factors are lost e.g. increase incidents of drought which affects the hydrological cycle or regime, the wetland becomes threatened.

(viii) Change in water regime – change in water regime occur due to natural causes or man-made causes. For instance, drought condition could alter the hydrological cycle through lowering of the water table. Man-made structures e.g. roads, canals and reservoirs could alter the hydraulic characteristics and hydrology of wetlands.

(ix) Conversion of wetland to other uses – land use change and associated dynamics could alter the vegetation cover and structure of wetlands e.g. through agricultural activities and urban expansion. Conversation to urban areas creates

impermeable surfaces that affect recharge while irrigation could affect the water regime.

(x)   Lack of human management capacity – in many countries, the capacity to manage wetlands is low. Wetland resources are still regarded as open access. Consequently, these resources are exploited in an unsustainable manner.

(xi) Lack of material resources and institutions – many countries have not yet created institutions or given responsibilities to existing institutions for the proper management of wetland ecosystems. Responsibilities are often shared among numerous government departments, NGOs, research institutes and universities each with peculiar interest which could be conflicting. Resources e.g. budgets for wetland activities are often regarded as peripheral. Consequently, material support is linking.

(xii) Lack of awareness of wetland benefits – many wetlands are regarded as having low economic value.

The mangroves, for instance are regarded as wastelands of little or no value by government and communities (which is why large areas of wetlands are often converted to other uses). The ecological benefits and functions of wetlands are very rarely considered. The low premium put on wetlands has been one of the main threats to wetlands today.

Disaster Risk Reduction (DRR) and wetlands

Clearly, a healthy wetland is in a dynamic equilibrium with the environment and even if the equilibrium is lost through man-made or natural interference, it possesses the resilience for self- restoration when conditions improve. A healthy wetland presents a risk reduction model in a natural setting since it is an ecosystem whose functions are driven by nature. On the other hand, disaster is a sudden accidental or natural catastrophe that causes great damage or loss to life; could disrupt the functioning of communities, resulting in human, material, economic and environmental losses. Disaster put ecosystems and human economies at risk through ecological distortions and failure of resources–related economic activities.

Disaster risk reduction is therefore a concept and practice of reducing risks through systematic effects to analyze and reduce the causal factors of disasters. The concept builds on understanding wetland ecosystem functioning, the components and energy pathways and their interrelationships and the difference ecosystem components. The practice seeks to reduce exposure to hazards, lessen vulnerability of people and property, introduce wise management of land and the environment and improve on the preparedness and

early warning for adverse events. Therefore, ecosystems such as wetlands and coastal forests not only support livelihoods through regular ecosystem services, but also reduce disaster risks. This is why the theme of the 2017 World Wetland Day celebration is "Wetlands for Disaster Risk Reduction". What implies here is that for wetlands to help in disaster risk reduction, the road-map should be through the ecosystem approach.

Management of wetlands for Disaster Risk Reduction: The Ecosystem Approach

Ecosystem – based approach to wetland management is a strategy for the integrated management of land, water and living resources that promote conservation and sustainable use of wetland in an equitable way, and which aspires to maintain the natural structure and functioning of the ecosystem. Actually, it is an environmental management approach that recognizes the full array of interactions within that wetland ecosystem, including humans, rather than considering single issues, species or ecosystem services in isolation. The rationales for adopting the ecosystem approach are based on the following observations:

(i)   70% of total global wetland ecosystem have been lost since 1900;

(ii) Wetland ecosystem loss is a root cause of increasing disaster risk;

(iii) 90% of all extreme events are water-related or wetland ecosystem related;

(iv) Where coastal wetlands ecosystems were destroyed, effects of storm surges have been catastrophic.

(v)   Restoring wetland ecosystems rather than constructing preventing structures is a guarantee for protection against drought and flood.

Within the ecosystem approach, wetlands actually hold solutions to reducing disaster risks. The approach does not emphasize engineering solutions as realistic options to reducing disaster risks; thus wetland ecosystem management emphasizes the following:

(a)   Maintaining and regenerating natural wetland ecosystems as the most effective method of reducing risk. Ecosystem maintenance involves activities that would sustain existing functions without distorting the ecology of the system. Mass removal of biomass for example, inhibits biological productivity through photosynthesis. Therefore, deforestation of wetlands should be discouraged where planting programmes have not been put in places. Regeneration of natural wetland ecosystems involve creating conditions (approximating the natural state) that would allow, over time, for the ecosystem to self-restore. These activities would enhance the

wetland ecosystem services thus reducing livelihood risks.

(b) Reforestation could provide the best protection against disasters. The is because the physical presence of vegetation are the best buffers against such elements as coastal storm surges, strong winds, erosion and gulling, and drought. Systematic reforestation of wetlands is perhaps the best method to sustain the hydrological system by reducing siltation through soil wash and sedimentation while at the same time maintaining the numerous ecosystem services associated with stable floral component.

(c) Planting climate-tolerant seed varieties has been recognized as an approach to cope with decreasing water table and changing climate. Terracing could reduce the amount of soil washed into wetland depressions as well as stabilize the sides from slumping and landslides. Generally planting of climate tolerant plants can build wetland resilience against floods, droughts and destructive winds.

(d) Recognizing the fact that vulnerability to risk can rarely be due to a single cause, is a major step towards extracting activity for implementation within the ecosystem approach. For instance, one of the major causes for the disappearance of a wetland may be found several tens of kilometers away where a recharge area has been made impermeable or where the water has been channeled away for other uses. The aquifer on which the wetland depends world then experience low recharge and lower water table. Over-harvesting of ground water within the recharge basin could also degrade wetlands. An understanding of the linkages between the physical factors and anthropological could combine to define the vulnerability. Thus a holistic consideration is desirable and a matter of best practice.

(e) Paying greater attention to ensure that we are more resilience to whatever surprise may arise from a changing climate system is perhaps an overriding factor in wetland ecosystem management. The emphasis here is that the impacts of changing climate are still being evaluated. There are many issues that science is still investigating of which we cannot claim complete knowledge. For example, some climate events, which could be extreme, may be one–shot events that have no antecedents in human history. How these events affect wetland ecosystems demand greater attention and ability for rapid adjustment if rises are to be reduced.

Some policy issues in Disaster Risk Reduction

The weight of any ecological policy lies in its ability to recognize the importance of the ecological entity and value of the functions derived from it. Ecological policies over the years have suffered from unrealistic valuations of the goods and services and wetlands have been the most affected. Not being usually inhabited by man, they are often the first port of call when land regarded as "useless" is required for convection to other uses. Thus the potential which wetland ecosystems have in disaster risk reduction is often not recognized. However, any emerging policy from nations such as Nigeria that is signatory to the Ramsar Convention should be based on the fact that:

(i) Healthy wetland ecosystems make crucial contribution to the residence of communities and nations. They provide a range of benefits which help to reduce, buffer and assist societies in adapting to increasing disaster risk. They are the basis of community resilience by providing water and other important products to the local people.

(ii) Wetland ecosystem degradation destroys nature's ability to regulate hazards and to provide services such as food and water. Therefore, wetland ecosystem degradation must be considered as one of the root causes of disaster risk.

(iii) Investing to address underlying risk factors is more cost-effective than disaster response and recovery and contributes to saving lives and protecting assets. Therefore, wetland restoration must be at the center of solutions to reduce disaster risk.

(iv) It is important to understand how wetlands are spatially connected within a wider landscape and how interventions in a wetland could have positive or negative implications for the wider area. This means that risk reduction measures must be planned at multiple spatial scales, form local inland wetlands, lakes to river basins, deltas and wetlands of transboundary nature.

(v) The design and implementation of wetland ecosystem–inclusive risk reduction measures require collaboration with multiple sectors e.g. land use planners, development organizations and local communities. Stakeholders must be properly identified and their concerns about the proposed activities addressed so that the risk reduction measures will be supported and sustained.

The content of any policy should be robust such that activities can be systematically extracted to build up implementation content. The policy should have among others, the following implementation content:

(a) Programmes that maintain wetlands and restore their ecological character to cope with drought;

(b) Programmes which seek to mainstream wetlands across relevant government sectors to help prevent wetland loss;

(c) Programme that seek to increase awareness and the need for action are build capacity in wetland management;

(d) Programmes that develop and apply wetland management tools to warn of onset of disasters e.g. drought;

(e) Programmes that update national wetland inventories and extent of wetlands;

(f) Programmes that manage and restore wetlands as part of contingency planning to mitigate the impact of natural phenomena e.g. floods and to provide resilience against drought;

(g) Programmes that provide incentives to sustainable agricultural practices which maintain and restore the ecosystem services provided by wetlands.

Conclusion

Wetlands hold massive potential for disaster risk reduction and should be preserved in its natural state. Their functions cannot be enhanced by the introduction of external structures without offsetting the natural equilibrium upon which the resilience of these fragile ecosystems is built. Thus the ecosystem approach appears to offer satisfactory solutions to maintaining the integrity of our wetlands for disaster risk reduction

Acknowledgements

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Utilization of family planning techniques among female farmers in Oruk Anam Local Government Area of Akwa Ibom State, Nigeria

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Key words:	Abstract
Utilization, family planning, knowledge, information, challenges	Attempts at improving women's health in rural communities of Akwa Ibom State through family planning services are hampered by dearth of information on extent of use and constraints to use of these services. To close this gap, the study examined use and constraints to use of family planning techniques among female farmers in Oruk Anam Local Government Area of Akwa Ibom State, Nigeria. A total of 120 respondents were selected for the study using multi-stage sampling technique. Structured questionnaires were used for data collection. The data were analyzed using descriptive and inferential statistical tools. Results showed that mean age of the respondents was 38.56 years, while 65.84 % were married. Natural methods, abstinence during unsafe period and injectable were the most available family planning techniques in the area with ranks of 1st, 2nd and 3rd respectively. Major sources of information on family planning were peers/colleagues, spouse and friends/relatives with means of 1.31, 1.25 and 1.17 respectively. Majority of the respondents (98.33 %) had high knowledge of the rudiments of family planning. Barrier methods, hormonal contraceptive and withdrawal method were the most used family planning techniques in the area as they ranked 1st, 2nd and 3rd respectively. Major constraints to use of the family planning techniques were perceived side effects of using contraceptives, inadequate information on use of some contraceptives and perceived low efficacy of preferred contraceptive method with ranks of 1st, 2nd and 3rd respectively. Significant relationship ($r^2 = 0.54$, $p < 0.05$) existed between number of family planning techniques available to the respondents and extent of use of family planning techniques in the area. It is recommended that organizations as well as development agencies should organize enlightenment programmes to debunk perceived side effect of contraceptive use. Such programmes should also ensure that relevant information on use and effectiveness of contraceptives is available to rural farmers.

Introduction

Family planning refers to activities aimed at assisting people in birth control in order to limit their family sizes. It involves the use of both natural and modern contraceptive techniques to reduce the number and control the timing of conception. According to Starbird *et al*., (2016), family planning helps to prevent unwanted pregnancy, reduce maternal and child mortality and enhance the health of the mother and child. Moreover, some family planning techniques help to prevent the transmission of sexually transmitted infections, thereby improving reproductive health of the users. Federal Government of Nigeria (FGN, 2014) observed that family planning is one of the most cost-effective ways to prevent maternal, infant and child mortality.

Agricultural production also has its share of the advantages of family planning. This is in consideration of the fact that the health of the farmer and that of other members of the household have direct bearing on extent of agricultural production. The farmer must first be healthy to muster enough energy and strength required for farm work (Ghatak and Madheswaran, 2014). Moreover, manhours meant for agricultural production are lost if any member of the farming household is sick. The sickness of a member of the household has negative multiplier effects on availability of labour and financial resources for agricultural production. Also, caregivers' time, energy and financial resources could be diverted to the treatment of the ailment of the sick member of the household. Therefore, in order to step-up agricultural production, the health of the farmer must be given the required attention; and one way of doing this is by encouraging family planning.

The role of women in agricultural production in Nigeria is well acknowledged (Barau and Oladeji, 2017). However, women are faced with the stress of child bearing and rearing, performance of domestic chores and sometimes double-up as bread winners for their various households. These affect their contributions to agricultural production in terms of labour supply and supply of other production resources. In order to reduce the stress from maternal activities, use of family planning techniques to space and reduce the number of pregnancies, deliveries and child rearing becomes essential. According to Kavanaugh and Anderson (2013), family planning helps to improve the welfare of the entire family unit. World Health Organization (WHO, 2017) observed

that there are different types of family planning techniques available. These include hormonal contraceptives, Intrauterine Device (IUD), barrier methods and vasectomy. However, the under-utilization of these family planning techniques in some areas may be attributed to many factors including insufficient information on the family planning services. Consequently, improper spacing of pregnancies and childbirths and their attendant problems persist among the women. It is observed that some women become pregnant again without recovering from the stress of the former. This has a negative implication on their health and potentials for agricultural production.

As in every developing nation, rural women in Nigeria carry great burden of poor health related to closely spaced pregnancies and childbirth. In order to improve the health of the women through the use of family planning services, information on the extent of use and challenges to use of the services is essential. But there is a dearth of information on this important aspect of the women's life. To fill the gap, the study assessed the extent of use and challenges to use of family planning techniques among farmers in Oruk Anam LGA, Akwa Ibom State. Specifically, the study identified the types of family planning techniques available, examined the sources of information on family planning, assessed the knowledge of the farmers on family planning, examined the extent of use and ascertained the challenges to use of family planning techniques among farmers in the study area.

Hypothesis of the study

HO_1: There is no significant relationship between the number of family planning techniques available to the respondents and their use of the family planning techniques.

Methodology

The study was carried out in Oruk Anam LGA, Akwa Ibom State, Nigeria. The LGA is located in the southwestern part of the State and shares boarders with Ikot Abasi and Mkpat Enin LGAs in the southern and eastern parts and Ukanafun LGA in the west. Its projected population as at 2016 was 241,400 people (City Population, 2016). Its inhabitants are mostly farmers, craftsmen and civil servants. All adult female farmers (18 years and above) in the area made up the population of the study. The study adopted a multi-stage sampling technique in which 120 respondents were selected. In the first stage, simple random sampling technique was used to select four communities out of the 166 communities that make up the LGA. In the second stage, households were identified in the selected communities through

household listing and systematic sampling procedure was used to select 120 households. In the third stage, simple random sampling method was used to select an adult female from each sampled household in households with more than one adult female.

Structured questionnaires were used to collect primary data, and frequency, percentage, mean, rank and Pearson Product Moment Correlation (PPMC) were used to analyze the data. To assess farmers' knowledge on family planning, the respondents were required to respond to statements on family planning from a list that was presented on a 4-point Likert-type scale of Strongly Disagreed = 1, Disagreed = 2, Agreed = 3 and Strongly Agreed = 4, for positively worded statements and the reverse for negatively worded statements. To examine the extent of use of family planning techniques, the respondents were asked to indicate from a list of techniques that were presented on a 3-point scale of Not utilized = 0, Rarely utilized = 1 and Often utilized = 2. Moreover, to ascertain the challenges to use of the family planning techniques, the respondents were asked to indicate from a list of possible challenges to the use of family planning techniques on a 3-point scale of Not a challenge = 0, Minor challenge = 1 and Major challenge = 2. Indexes and means were computed and used to classify and rank the various phenomena.

Results and Discussion

Results in Table 1 showed that mean age of the respondents was 38.56. This is almost similar to the observation by Asa and Daniel (2015) who noted that the mean age of farmers in rural areas of Akwa Ibom State is 40. It indicates that many respondents were in their reproductive age and this has implications on the utilization of family planning services as the women still need to space their children or decide on the number of children to bear. It also showed that 65.84 % of the respondents were married, while the rest were made up of singles, divorced and widowed. This result conforms to the findings of Asa and Solomon (2010) who observed that majority of women farmers in the rural areas of Akwa Ibom State were married. The married may likely have the need to plan their families to boost their health as mothers and enhance the overall wellbeing of the entire family.

Educational status of the respondents showed that 86.67 % of the respondents had formal education, with only 13.33 % with informal education. The high number of educated individuals suggests that use of family planning techniques may be high as Anguko (2014) noted that highly educated women are more likely to desire fewer children who they can adequately provide for as compared to the less educated ones. Religious characteristic showed that

99.17 % of the respondents were Christians, while 0.83 % were traditional worshipers. Religious belief could affect contraceptive use in the area. However, a study in Mozambique found that despite Catholic Church's opposition to contraceptive use, there was high contraceptive use among Catholics in the area (Agadjanian, 2013).

Number of children owned by the respondents as shown in Table 1 indicated that many respondents (44.16 %) had between 3-5 children, with 5 as the mean. In some communities like Igbo, where male children are preferred (Nnadi, 2013), women keep bearing children till the desired number of male children are given birth to, and use of contraceptive may be adversely affected. However, an experience of unintended pregnancy may likely increase contraceptive use (Fotso, 2014). The mean monthly income of the farmers was ₦28,150.00. The monthly income of the farmers may affect the type and extent of use of family planning techniques because, according to Etim (2006), income has direct effect on the choice of family planning technique. The result also revealed that 40.83 % and 29.17 % of the respondents had farming and trading as their primary livelihood activities respectively though many may diversify to other livelihood activities to make ends meet. According to Abimbola (2013), people diversify to many livelihood activities to cater for their families. However, level of involvement in a livelihood activity affects individual's income which may likely affect the choice and use of contraceptive.

Types of family planning techniques available in the area
Majority of the respondents (90.00 %) indicated natural method (safe period) as the most available family planning technique in the area as shown in Table 2. The natural method is available to almost all women as many have learnt to identify these periods which may include specific days after menstruation and during lactation (Rakhi and Sumathi, 2011). This was followed by abstinence during safe and/or unsafe period (87.50 %), injectable (86.67 %) and withdrawal method (81.67 %). In some cases, the sign for abstinence is the use of beads. Many husbands respect the beads when sighted on the woman's waist and will not force their wives to sex, knowing she is in her menstrual or unsafe period. However, it is obvious that this method could only be effective if the husband will not force his wife to sex (Albert, 2014). Other methods include IUD (29.17 %) and sterilization (20.83 %).

Sources of information on family planning
Table 3 showed that peers/colleagues were major sources of information on family planning in the area with a mean of 1.31. The result suggests that training

and involvement of peers and colleagues in disseminating information on family planning can boost access to the information in the area. Spouse and friends/relatives were ranked 2nd and 3rd respectively as major sources of the information. These could be suitable sources or channels of the information if their potentials are harnessed into disseminating the information. Msovela et al., (2016) in a related study noted that close to a half of the respondents reported to have obtained family planning information from their spouses. Minor sources were radio, television and magazine with means of 0.69, 0.65 and 0.60 respectively.

Knowledge of rudiments of family planning
According to Table 4, majority of the respondents (78.33 %) agreed that condoms prevent pregnancy and Sexually Transmitted Infections (STIs) when used correctly and consistently, while 66.67 % strongly agreed that contraceptive pills taken appropriately can only prevent unwanted pregnancy and not STIs. It further indicated that 80.84 % strongly agreed that sterilization method is difficult or impossible to reverse. The high knowledge of contraceptive was also observed in a similar study in Tanzania by Sweya et al., (2016). The high knowledge of rudiments of family planning could boost the use of family planning activities in the area. Generally, the respondents were most knowledgeable of the fact that natural method requires a clear knowledge of one's safe period to be effective, with a rank of 1. Moreover, the respondents know that male or female condoms should be worn correctly before penetration, with a rank of 2.

Index of respondents' knowledge of rudiments of family planning
Table 5 showed that 98.33 % of the respondents had high knowledge of rudiments of contraceptives, while 1.67 % had low knowledge. The result suggests that statements on rudiments of contraceptives presented to the farmers were too elementary. This finding is in accordance with an earlier observation by Alege et al., (2016) who reported that knowledge of family planning was nearly universal. However, the high knowledge may not translate to high utilization of the contraceptives because of challenges to the use of the contraceptives.

Extent of use of family planning techniques
Results in Table 6 showed that barrier methods including condoms and diaphragms were often used by 80.83 % of the respondents and was ranked as the most utilized family planning technique in the area.

The result may be attributed to the relatively low cost and dual functions of barrier methods in preventing unwanted pregnancy and STDs. This is corroborated by the observation of Olugbenga-Bello *et al*., (2011) who noted that condoms are the most utilized means of family planning. Hormonal contraceptives and withdrawal methods were ranked 2nd and 3rd most utilized family planning techniques. The result may be linked to the high accessibility to contraceptive pills. Moreover, withdrawal method has no financial obligation attached to it, and may be used at will. However, implants and sterilization methods were the least used family planning techniques in the area with means of 0.11 and 0.00 respectively.

Table 7 showed that 59.17 % of the respondents were rated low in the use of the family planning techniques, while only 40.83 % were adjudged high on the use of the contraceptives. This suggests that there are incidences of unintended pregnancies and abortions in the area. Moreover, the population of the area could rise uncontrollably with some sexually transmitted diseases. According to WHO (2017), male and female condoms protect against unintended pregnancies as well as STIs, including HIV/AIDS.

Table 1: Socio-economic characteristics of the respondents

Socio-economic characteristic	Frequency	Percentage (%)	Mean
Age (years)			
≤ 20	2	1.67	
21-40	82	68.33	38.56
≥ 41	36	30.00	
Marital status			
Married	79	65.84	
Single	22	18.33	
Divorced	4	3.33	
Widowed	15	12.50	
Educational status			
Informal education	16	13.33	
Primary	57	47.50	
Secondary	41	34.17	
Tertiary	6	5.00	
Religion			
Christianity	119	99.17	
Islam	0	0.00	
Traditional	1	0.83	
Number of Children			
0-2	23	19.17	
3-5	53	44.16	5
6-8	41	34.12	
≥ 9	3	2.50	
Monthly income (₦)			
$\leq 20,000$	86	71.67	
21,000 – 40,000	24	20.00	28,150.00
$\geq 41,000$	10	8.33	
Primary livelihood activity			
Farming	49	40.83	
Trading	35	29.17	
Civil service	6	5.00	
Others	30	25.00	

Table 2: Family planning techniques available in the area

Family Planning Technique	Not Available (%)	Available (%)	Rank
Natural method (safe period)	10.00	90.00	1st
Traditional method (waist beads, herbs)	20.83	79.17	5th
Implants	75.00	25.00	9th
Injectable	13.33	86.67	3rd
Abstinence during safe and/or unsafe period	12.50	87.50	2nd
Intrauterine Device (IUD)	70.83	29.17	8th
Barrier method (condoms and diaphragms)	45.00	55.00	6th
Withdrawal method	18.33	81.67	4th
Hormonal contraceptives (pills)	65.00	35.00	7th
Sterilization	79.17	20.83	10th

Table 3: Sources of information on family planning in the area

Sources	Not at all	Rarely	Often	Mean	Rank
Radio	58.33	16.67	25.00	0.69	8th
Friends/relatives	6.67	71.67	21.66	1.17	3rd
Television	59.17	18.33	22.50	0.65	9th
Traditional birth attendants	56.67	7.50	35.83	0.81	5th
Peers/colleagues	5.83	59.17	35.00	1.31	1st
Doctors and nurses	55.83	10.00	34.17	0.80	6th
Spouse	10.00	57.50	32.50	1.25	2nd
Pharmacy/Patent Medicine Store operators	5.00	75.83	19.17	1.16	4th
Family planning clinics	57.50	10.00	32.50	0.77	7th
Magazines	62.50	17.50	20.00	0.60	10th

Table 4: Respondents' knowledge of rudiments of family planning

Statements	SD	D	A	SA	Mean	Rank
Condoms prevent pregnancy/STIs when used correctly and consistently	0.83	6.67	78.33	14.17	3.06	7th
Contraceptive pills taken appropriately can only prevent unwanted pregnancy and not STIs	1.67	0.83	30.83	66.67	3.63	4th
Male or female condoms should be worn correctly before penetration	0.83	0.83	13.34	85.00	3.83	2nd
Sterilization method is difficult or impossible to reverse.	0.83	3.33	15.00	80.84	3.76	3rd
To be effective, natural methods require a clear knowledge of one's safe period	0.00	0.83	15.00	84.17	3.84	1st
Not all contraceptives are 100 % effective	0.00	1.67	62.50	35.83	3.35	5th
Condom may burst during intercourse if not worn properly	0.00	1.67	70.83	27.50	3.26	6th
Daily, contraceptives are to be taken consistently for effectiveness	1.67	5.83	73.33	19.17	3.10	8th

SD = Strongly Disagreed; D = Disagreed; A = Agreed; SA = Strongly Agreed

Table 5: Index of respondents' knowledge of rudiments of family planning

Knowledge Score	Frequency	Percentage (%)	Remarks
< 20	2	1.67	Low
≥ 20	118	98.33	High

Table 6: Respondents' extent of use of family planning techniques

Family Planning Techniques	Never (%)	Rarely (%)	Often (%)	Mean	Rank
Natural method (safe period)	5.83	73.33	20.83	1.15	4th
Traditional method (waist beads, herbs)	11.67	77.50	10.83	0.67	7th
Implants	65.83	21.67	12.50	0.11	9th
Injectable	12.50	65.83	21.67	0.83	6th
Abstinence during safe and/or unsafe period	10.00	69.17	20.83	0.91	5th
Intrauterine Device (IUD)	57.50	15.00	27.50	0.20	8th
Barrier method (condoms and diaphragm)	6.67	12.50	80.83	1.55	1st
Withdrawal method	4.17	70.00	25.83	1.22	3rd
Hormonal contraceptives (pills)	10.83	17.50	71.67	1.51	2nd
Sterilization	100.00	0.00	0.00	0.00	10th

Table 7: Index of use of family planning techniques

Mean Utilization Index	Frequency	Percentage (%)	Remarks
< 1.0	71	59.17	Low
≥ 1.0	49	40.83	High

Challenges to use of family planning techniques

Results of challenges to use of family planning techniques as presented in Table 8 revealed major challenges to include perceived side effects of using contraceptives (ranked 1st), inadequate information on use of some contraceptive (ranked 2nd) and perceived low efficacy of preferred method of family planning technique (ranked 3rd). Asekun-Olartnmoye *et al.*, (2013) in a related study observed that the most common reasons for not using contraceptives by many in Nigeria were fear of side effects of use of contraceptives and ignorance of the contraceptive method. However, if the severity of these challenges is reduced, the extent of use of the contraceptives could be enhanced. Lack of power by women to make decision on contraceptive use was ranked 8th as one of the factors affecting contraceptive use. Okoro and Odebode (2014) in their study on hindrances to use of HIV/AIDS information in rural areas of the State identified gender inequality as one of the factors affecting women's decisions on sexual issues. Least among the barriers to contraceptive use in the area were scarcity of contraceptive (ranked 12th) and high cost of contraceptive (ranked 11th). These constraints being least could be attributed to the readily availability and the low cost of some contraceptives in the area.

Index of challenges to use of family planning techniques as presented in Table 9 showed that most respondents (65.00 %) were severely hindered in the use of family planning techniques. The hindrances are likely to bring about low utilization of family planning techniques and its attendant problems. It is therefore pertinent to reduce the effects of these hindrances to the barest minimum because according to Darroch (2013), inaccessibility to family planning services results in many unwanted pregnancies and maternal deaths.

Result of Tested Hypothesis

H_O: There is no significant relationship between the number of family planning techniques available to the respondents and use of the family planning techniques. Table 10 showed that a significant and positive relationship ($r^2 = 0.54$, $p < 0.05$) exists between the number of family planning techniques available to the respondents and extent of use of family planning techniques by the respondents. This indicates that, the more the family planning techniques available to the respondents, the greater their extent of use of these techniques. It therefore requires that the women be exposed to many family planning techniques which they can choose from. This result agrees with the observation of Omo-Aghoja *et al.*, (2006) who noted that availability and awareness of contraceptives enhance their utilization.

Table 8: Challenges to use of family planning techniques

Factors	Not a challenge (%)	Minor challenge (%)	Major challenge (%)	Mean	Rank
High cost of contraceptives.	65.00	13.33	21.67	0.57	11th
Scarcity of contraceptives	70.00	7.50	22.50	0.53	12th
Inadequate skill in contraceptives use.	65.00	5.83	29.17	0.65	9th
Lack of power by women to make decision on contraceptive use.	6.67	64.17	29.17	1.08	8th
Discomfort for using contraceptives.	8.33	61.67	30.00	1.22	4th
Lack of dialog between partners with regards to contraceptive use.	4.17	64.17	31.66	1.18	6th
Religious constraints that prohibit the use of contraceptives.	66.67	6.67	26.67	0.60	10th
Having no child/not having the required number of children.	7.50	61.67	30.83	1.12	7th
Perceived side effects of using contraceptive.	5.00	63.33	31.67	1.27	1st
Poor attitude of some family planning service providers towards women seeking family planning services.	6.67	67.50	25.83	1.20	5th
Inadequate information on use of some contraceptives.	4.17	67.50	28.33	1.24	2nd
Perceived low efficacy of preferred method of family planning.	5.00	67.50	27.50	1.23	3rd

Table 9: Index of challenge to use of family planning techniques

Mean challenge	Frequency	Percentage (%)	Remarks
< 1.0	42	35.00	Low
≥ 1.0	78	65.00	High

Table 10: Relationship between number of family planning techniques available and use of family planning techniques

Variable	r^2	p	Remark
Family planning techniques available	0.54	0.03	Significant

Correlation is significant at the 0.05 level

Conclusion and Recommendations

The women farmers were mostly literate, married and Christians. Major sources of information on contraceptives were peers/colleagues, spouse and friends/relatives. Use of contraceptives in the area was low. Main constraints to use of the information were perceived side effects of using the contraceptives and inadequate information on use of some contraceptive. It is recommended that peers/colleagues and friends/relatives be train to disseminate information on family planning in the area. Also, to ease the constraints to use of the contraceptives, organizations as well as development agencies should organize enlightenment programmes to inform the farmers on available contraceptive and to debunk perceived side effects of contraceptive use. Such programmes should also ensure that relevant information on effectiveness of contraceptives is made available to rural farmers in the state. The farmers should also be informed of suitable contraceptive to the various individuals to reduce discomfort experience in use of the contraceptives. Moreover, family planning service providers should show favourable attitude towards those seeking family planning services.

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Reproduction and dynamics of exploited population of *Pellonula leonensis* (Boulenger, 1916) (Clupeidae) in Cross River Estuary, Nigeria.

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Key words:

Abstract

The exploited population of *Pellonula leonensis* in the Cross River estuary, southeastern Nigeria was studied. A total of 1,771 specimens of *Pellonula leonensis* were examined out of which 720 were considered for reproduction studies. Females were more abundant in the population than males (1.3:1.0), (female-male ratio). Temporal variation in gonadosomatic index showed that the species spawn year-round with major peak in November (dry season) and minor peak in June (wet season). The seasonalized Von Bertalanffy growth equation was fitted to the monthly length frequency data and the following parameters were obtained: $L\infty$ = 13.5 cm total length, K = 1.1 yr^{-1}, C = 0.65, WP = 0.3. The seasonalized length converted catch curve gave Z (the instantaneous total mortality coefficient) = 6.17 yr^{-1}. M (the instantaneous natural mortality coefficient) was estimated as 2.39 yr^{-1} while F (the instantaneous fishing mortality coefficient) was 3.7 yr^{-1}. The computed current exploitation rate E (= $^{F}/z$) which was 0.61 is greater than the maximum value E_{max} of 0.42 predicted from the Beverton and Holt relative yield per recruit model. This implies that the fishery is over exploited.

Introduction

Clupeids are known to be of marine origin, though some have radiated to colonize other aquatic ecosystems like lakes, lagoons, rivers, estuaries and reservoirs throughout the world except the Antarctic. About 300 clupeid species have been reported and are said to contribute about 30% of the total world fish landings (Sirimongkonthaworn and Fernando, 1994; NDDC, 2004). In the tropics especially West Africa, clupeids are abundant, affordable and highly valued particularly by the lower income folks. However, in developed countries of the world, much of the marine catches are processed into fish meal and also used as fish bait.

Pellonula leonensis is a schooling (shoaling) pelagic clupeid which is distributed in the West African. Atlantic coastal waters. It occurs both in fresh water and brackish water of moderate salinity (Wolfgang, 1990). They are of high commercial importance in different parts of Africa e.g. in Lake Kainji, Nigeria (Otobo, 1979) in Lake Kivu, Rwanda (Spliethoff, *et al*., 1983) and Lake Kariba, Zimbabwe (Kunzel and Lowenberg, 1990).

Inspite of the vital role of the fishery in the economic advancement of Nigeria and particularly the study area, information on the biology of the species is scanty. There is thus serious need for more research on the breeding cycle, spawning grounds, growth, mortality, gear selectivity, recruitment in Nigeria in-shore waters in order to formulate rational exploitation and management policies for these valuable species. This study will not only contribute to the knowledge of the general biology and ecology of the population of *Pellonula leonensis* in the study area but will also provide a dependable tool for effective management of the fishery.

Materials and methods

This study was carried out from January to December 2015. Sampling was conducted fortnightly in a month throughout the duration of study. The samples were bought from fishers who landed at the beach (Fig. 1) which lies between latitude 4^0 30^{1}N and 4^0 40^{1}N and longitude 8^{0}10^{1}E and 8^{0}20^{1}E in various gears were used which included handline gillnets, cast net, longlines, handlines and beach seines. Samples were identified according to Teugels *et al*., (1992).

A total of 720 specimens were subjected to close examinations in the Department of Animal & Aquatic Environmental Biology Laboratory, University of Uyo, Uyo. Morphological measurements including total length (TL) and standard length (SL) were measured to the nearest 0.1 cm using to measuring board and total weight (TW) of the fish was taken to the nearest 0.1 g using a top loading electronic balance (Mettle balance). The specimen was later elicited, sexed (by examination of the goals). The gonads were removed, blotted dry and weighted (GW) to the nearest 0.001 g. Somatic weight (SW) of each specimen was calculated thus:

$$SW = TW - GW \qquad \text{Equation (1)}$$

Where

TW = Total weight of fish (g); GW = gonad weight (g).

The Gonadosomatic index (GS1) was using the formula:

$$GSI = \frac{GW.100}{SW} \qquad \text{Equation (2)}$$

Where

GW = Gonad weight (g); SW = Somatic weight (g)

The condition index (C1) was determined by the formula (Silva and De Silva, 1981).

$$CI = \frac{SW.100}{TL^3}$$ Equation (3)

Where

SW = Somatic weight (g); TL = Total length (cm)
The values of GSI and CI were used to evaluate trends in reproduction investments.
FiSAT software (Gayanilo *et al.,* 1996) was used for the analysis of length frequency data set. Growth was parameterized by the Von Bertalanffy growth function (VBGF):

$$L_t = L_\infty (1 - e^{-k(t-t_0)})$$ Equation (4)

Where

L_t = Length at age t, L_∞ = the asymptotic length (cm), K=Von Bertalanffy growth coefficient (yr^{-1}), t_o = age of the fish at zero length (yr).
Equation (4) does not incorporate the effect of changing season on growth Somer (1988) seasonalized VBGF was thus used:

$$L_t = L_\infty (1 - e^{-k(t-t_0)-(ck/2) \sin 2(t-t_s)+(ck/2)C \, in \, 2 (t_0-t_s)})$$

                    Equation (5)

Where

C = amplitude of growth oscillation (ranging from 0 to 1); t_s = time (yr) between birth and the beginning of the first growth oscillation. By means of ELEFAN in FiSAT, a sequentially arranged and restructured length frequency data set was obtained to objectively define peaks, which were assumed to be cohorts. The preliminary value of L_∞ was then seeded into ELEFAN 1 to optimized values of the VBG coefficients. The seasonalized length-converted catch curve (Pauly *et al.,* 1995) was used to obtain the instantaneous mortality coefficient Z of the single negative exponential mortality model.

The empirical model of Pauly (1980) was used to estimate the instantaneous natural mortality coefficient, M. The probability of capture (P) of each length class was analyzed using the ascending left of the length-converted catch curve (Pauly, 1987 and 1990). This entails dividing the number actually sampled by the expected numbers (obtained by backward extrapolation of the straight. Portion of the catch curve) in each length class of the ascending part of the catch curve. By plotting the cumulative probability of capture against mid-length, a resultant curve was obtained from which the length of first capture L_c was taken as corresponding to the cumulative probability of 50%. The seasonal recruitment of patterns of species were reconstructed using the entire length frequency data set of the sample. The relative yield per recruit (Y^1/R^1) and relative biomass per recruit (B^1/R^1) were predicted using the Beverton and Holt (1966) method as modified by Pauly and Soriano (1986).

Fig. 1: Map of the Cross River estuary, Nigeria showing the sample collection stations

Results

A total of 720 specimens of *Pellonula leonensis* were examined. Out of these, 42.5% (306 individuals) were males and 57.5% (414 individuals) were females. Thus, there was significantly more females than males in the population (1 male to 1.3 females, $X^2 = 16.2$, 11 df, $P < 0.001$). On the seasonal basis, the dry season sample (n = 360) consisted 41.7% (150) males and 58.3% (210) females (1 male to 1.4 females, $X^2 = 45.07$, df = 1, P <0.05). The rainy season sample (n=360) consisted of 42.8% (154 individuals) males and 57.2% (206 individuals) females (1 male to 1.4 females, ($X^2 = 46.66$, 1 df, P >0.05). Thus, the numerical strength of females exceeded those of males in both seasons (Table 1).

The monthly trends in gonadosomatic index (GSI) for both sexes were shown in Figs. 2a and b. There were major peaks in November in both sexes and minor peaks in January, June and August. In all, the species bred year-round.

The monthly length frequency data for the 12 months' period was shown in Table 2. Using LEFAN I, the following optimized and seasonalized VBG parameters were obtained: $L\infty = 13.50$ cm, $K= 1.15$ yr^{-1}, $C = 0.65$, $WP = 0.3$.

In Fig. 3, the VBG curves with these seasonalized parameters have been superimposed on both the normal and restructured length frequency histograms. The growth performance index $Ø^1$ was 2.32. The seasonalized catch curve, (Fig. 4) gave the estimated Z as 6.17 yr^{-1}. Our estimated F (the instantaneous fishing mortality coefficient) was 3.17 yr^{-1} (Note: $F = Z – M$).

The computed exploitation rate E (= F/z) was 0.61. From the analysis of probability of capture of each length class L_c was 4.25 cm (Fig. 5).

The Selection Ogive procedure was used to compute the relative yield-per-recruit. This method assumes that the probability of capturing a fish is a direct function of its length (Fig. 6). The following results were obtained: $E_{max} = 0.42$, $E_{10} = 0.36$ and $E_{50} = 0.28$.

Table 1: Sex Ratio of P.*leonensis* in Cross River Estuary, Nigeria

Month	N	Male (M)	Female (F)	M:F Ratio	Cal. 7^2–Test
January	60	29	31	1:1.1	1.07ns
February	60	26	34	1:1.3	1.06 ns
March	60	26	34	1:1.3	1.06 ns
April	60	22	38	1:1.7	4.27*
May	60	22	38	1:1.7	4.27*
June	60	31	29	1:1.1	0.07 ns
July	60	32	28	1:1.1	0.09 ns
August	60	19	41	1:1.1	0.27*
September	60	28	32	1:1.1	0.27ns
October	60	20	40	1:2.0	0.67*
November	60	24	36	1:1.5	0.60*
December	60	27	33	1:1.2	0.07ns
Total	**720**	**306**	**414**	**1:1.30**	**16.20***

*P < 0.01; ns = not significant

Fig. 2a: Monthly variation in Gonadosomatic Index (GSI) and Condition Index (CI) for male species of *P. leonensis*
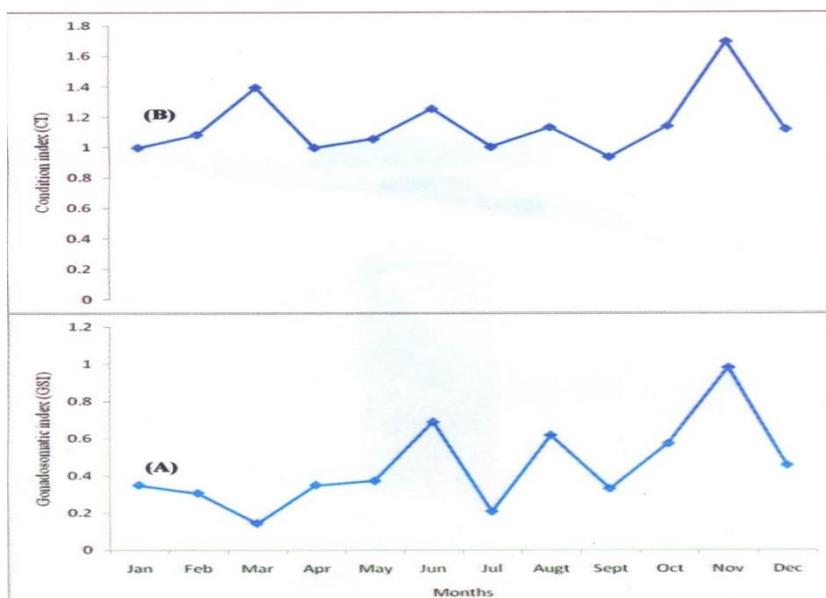
Fig. 2b: Monthly variation in Gonadosomatic Index (GSI) and Condition Index (CI) for female species *P. leonensis*

Table 2: Length (cm) frequency data of *Pellonula leonensis* take from the Cross River estuary (Nigeria) from January to December, 2010 ML-mid length of class interval (cm), N = 1,774

ML/Date	01/10	02/10	03/10	04/10	05/10	06/10	07/10	08/10	09/10	10/10	11/10	12/10
2.0												
2.5												
3.0		3	1						6		2	
3.5	1	11	0						54	14	18	19
4.0	29	33	2	1				1	66	36	39	59
4.5	79	65	5	20	4	13	12	21	20	20	20	18
5.0	22	17	7	42	42	16	19	38	7	25	26	30
5.5	7	10	41	20	24	19	26	30	3	13	14	6
6.0	8	8	44	20	24	19	26	30	3	13	14	12
6.5	4	4	23	30	28	33	25	14	0	7	6	7
7.0	3	2	13	11	21	23	19	12	0	6	5	0
7.5		1	8	4	11	21	4	2	0	1	1	1
8.0			2	6	2	7	2	4	3		1	
8.5			0	0	2	3	2	2	1		1	
9.0			0	0				0				
9.5			0	0				0				
10.0			0	0				0				
10.5			2	0				1				
11.0				1								
Total	153	154	148	155	151	140	130	12	160	142	147	152
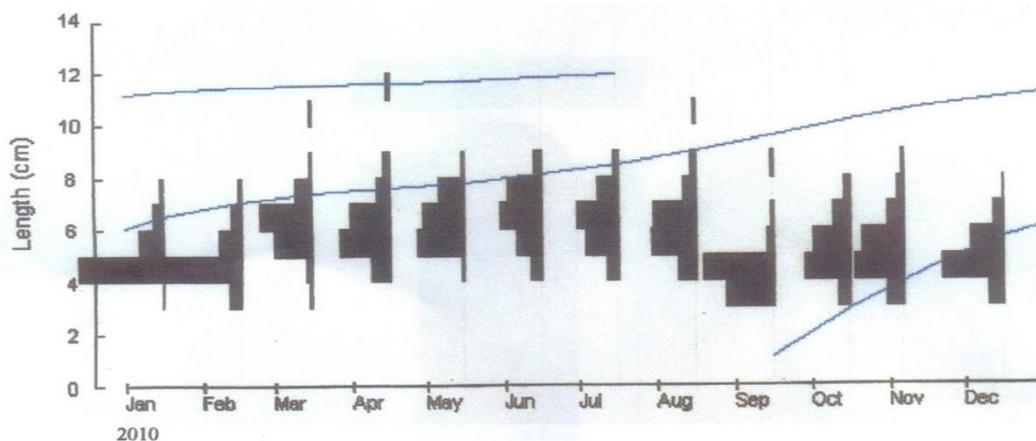
Fig. 3: Seasonalized Von Bertalanffy's growth curves for *P. leonensis* (L_∞ = 13.5 cm, K = 1.15 yr^{-1}, C = 0.65, WP = 0.3) superimposed on the restructured length frequency histograms
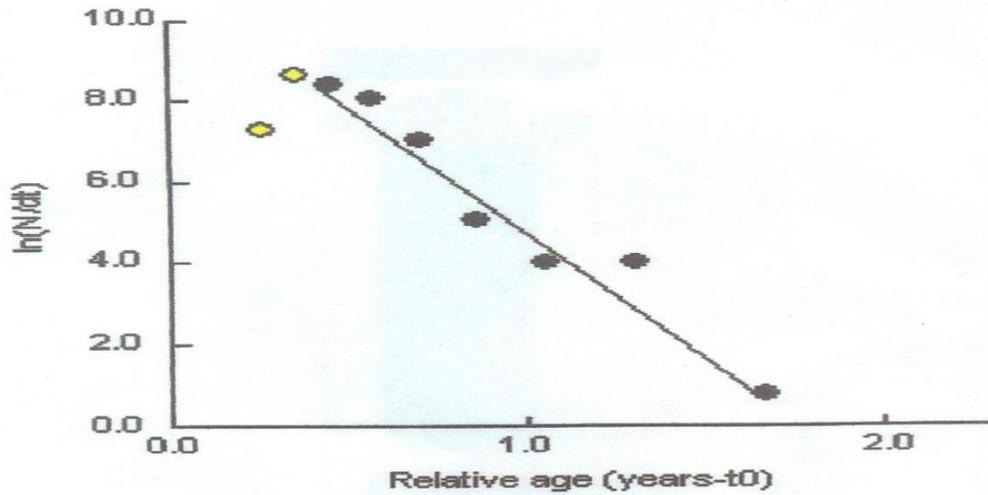
Fig. 4: Seasonalized length – converted catch curve for *P. leonensis* from where the slope of the descending right arm (black dots) of the line with sign changed gives an estimate of the seasonalized Z
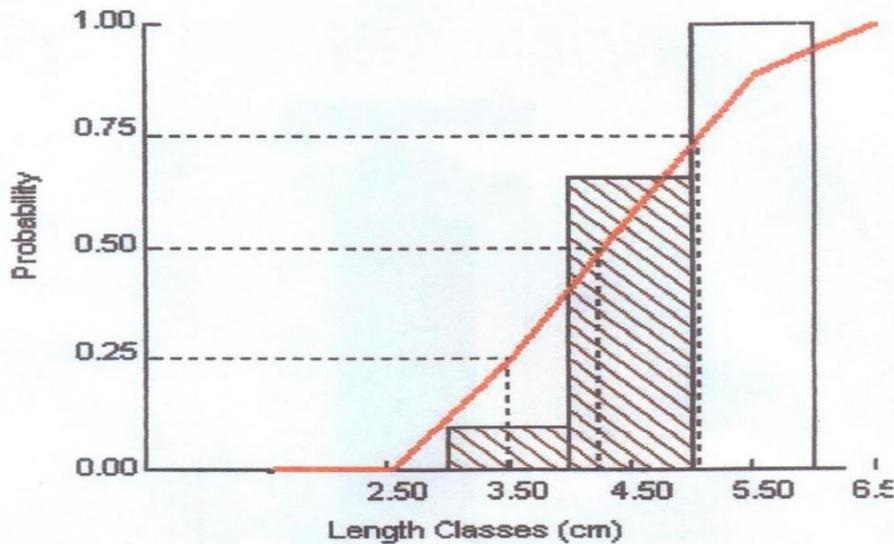
Fig. 5: Probability of capture of each size class of *P. leonensis*. The estimated length at first capture L_{50} or L_c = 4.25 cm, L_{25} = 3.49 cm and L_{75} = 5.05 cm
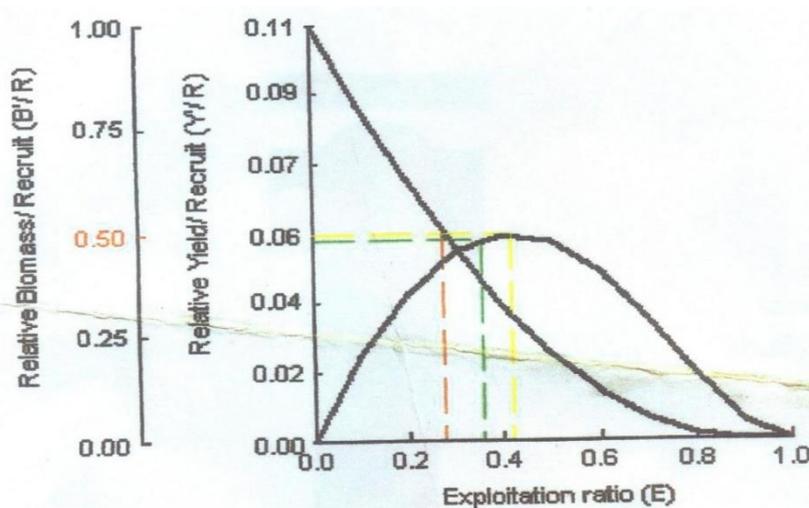
Fig. 6: Relative yield-per-recruit and relative biomass per-recruit using selective O_{give} procedure. Summary statistics: E_{max} = 0.42, E_{10} = 0.36, and E_{50} = 0.20

Discussion

Studies on related species of *P. leonensis* including *Ilisha africana* and *Ethmalosa fimbriata* are very comparatives. The numerical preponderance of females over males in this study is similar to the findings of Stokholm and Isebor, (1993) who recorded 1 male to 2 females' ratio in the area of Benin Republic and off Lagos State, Nigeria. Although it is different from the observations of Marcus and Kusemiju (1984), in the coastal waters of Lagos where the sex ratio was 1:1 in populations of *Ilisha africana*. A 1:1 sex ratio may be due to the absence of sex-related differences in longevity or mortality in a population. This may imply that in Cross River estuary females *P. leonensis* live longer than males.

Species exhibited major peaks in November in both mean GSI and CI. Thus, the species undergoes one major breeding episode during the dry season. There were also subsidiary peaks in GSI in June and August and in CI, March, May and August respectively. In all, the species breeds all-year-round. In Kainji Lake and Warri River, they also breed throughout the year. The peak dry season breeding ensures that the majority of the newly hatched juveniles profit maximally from the abundant shrimp (which is a principal diet of *P. leonensis* during this period (Akpan *et al*., 2005; Okon, 2015). Other marine clupeids e.g. *Ethmalosa fimbriata* and *Ilisha africana* in the Nigerian coastal waters also breed year-round with a dry season peak (Okon, 2000; King *et al*., 1988; Marcus, 1982a, b). During the dry season, the wave climate is more clement being devoid of turbulence and storms which usually adversely affect egg and larval survival. It therefore makes ecological sense for this species to peak-breed during this relatively calm period. GSI is useful in elucidating the seasonal timing of the fish's breeding activity and an index indicating the amount of material resources invested in the gonad. It represents the primary reproductive effort of the fish.

In this population of *P. leonensis* under study, the fecundity (F) was related to the length (L) through the regression equation: $F = 0.443TL^{2.9}$ with r = 0.736. The Von Bertalanffy growth function (VBGF) is the most widely used growth model in quantifying fish growth. It does not account for the effect of changing season on growth. Seasonalization of growth model serves to incorporate seasonal oscillation in order to produce bias-free parameters. Fish growth parameters could be obtained using annuli on hard parts like otoliths, marked-recaptured experiment or length-frequency data. Analysis of length frequency was employed in this study because annuli on otoliths of *P. leonensis* were indistinct. A number of studies (Marshall, 1987; Showers, 1996; Chukwu *et al*., 2011a and b) have used length-frequency analysis and the results are comparable to those from annuli studies.

The results of the VBG parameters obtained using ELEFAN were comparable with those of Balogun (1987) (L_∞ = 12.2 cm in Epe Lagoon, Nigeria; Ita (1983) L_∞ = 15.0 cm in Cross River).

In this study, the amplitude of growth oscillation, C = 0.65 and the winter point was 0.3 i.e. between March and May. Seasonal oscillation in growth is a well-documented phenomenon in aquatic organisms especially in temperate areas where low winter temperature could lead to growth retardation or even complete growth stoppage, and higher summer temperature could lead to accelerated growth. The Nigerian coastal waters experience an elevated water temperature year-round. In Cross River estuary, the difference between the mean maximum surface water temperature (29 °C) and the mean minimum (25 °C) could be less 4 °C. Thus, in this environment temperature fluctuation might not be a major factor in growth retardation. Probably, growth retardation could be attributed to spawning stress.

The estimated F (the instantaneous fishing mortality coefficient was 3.7 yr^{-1}) and Z = 6.17 yr^{-1}. The computed current exploitation rate, E (= F/Z) was 0.61. From the analysis of probability of capture of each length class, L_C was 4.25 cm. L_C is one of the important inputs used in computing the relative yield-per-recruit. The more realistic Selection Ogive procedure gave the following results: E_{max} = 0.42, E_{10} = 0.36, E_{50} =0.28. The estimated current exploitation rate, E = 0.61 is far in excess of the predicted maximum E_{max} of 0.42. The implication is that the fishery is being overexploited. The high Z/K value (5.37) lends additional support to this assertion. As a general rule, when $Z/K > 1$, then the stock is mortality dominated; if < 1, then it is growth dominated and when it is equal to one, then mortality balances growth (Barry and Terger, 1989). In a mortality dominated population, a value of Z/K = 2 indicates a light level of exploitation. In this study, the estimated Z/K value was 5.37. This implied that the level of exploitation was very heavy. Considering the open-access fisheries of the study area, the fisheries stand the risk of being over-capitalized if not managed properly. Then there is a need for management intervention in this fisheries. Such could include, but not limited to increasing mesh size and decreasing effort. The management strategy in terms of reducing effort might entail limiting the number of entry into the fishery, setting quotas or instituting off-season period. One or a combination of these strategies are necessary to avoid the collapse of the fishery. But it is worth noting that forestalling stock depletion must not be pursued in isolation. Some social goals such as attaining the net benefit of the fishery to the society, improving the economic status of the community and maximizing job opportunity in the fishery are some salient policy objectives that must be considered in adopting any management strategy.

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Hepatotoxicity in *Clarias gariepinus* exposed to a sublethal dose of Ethanolic extract of a plant-based pesticide

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Key words:

hepatotoxicity, *Clarias gariepinus*, ethanolic extract, *Dinnettia tripetala*

Abstract

Dinnettia tripetala (pepper fruit) is a popular Nigerian spicy food and medicine whose piscicidal potential has been established. This research was conducted to assess the effects of *D. tripetala* fruit extract on the histopathology of the liver of *C. gariepinus* (African catfish) using static bioassay. Fingerlings of *C. gariepinus* (size and body weight ranged from 3.9–7.6 cm and 0.08–3.75 g respectively) were exposed to a median lethal concentration of 0.7 g/l (96 hours LC_{50}) of the extract to assess its effects on the histology of the fish liver. The pathological lesions observed on the exposed liver tissue included congestion of the space of disse and a mild area of inflammation compared to the control where the liver maintained its normal cellular pattern. The deformation of the liver of exposed fish was indicative of the deleterious potential of this plant-based product. The consequences of these structural alterations were reduced physiological efficiency and ultimately, death. Hence, the ichthyotoxic and hepatotoxic property of *Dinnettia tripetala* had been confirmed and its toxicity could be applied in aquaculture to eliminate undesirable fish species prior to stocking**.**

Introduction

Fish farming is a fast-growing business in many parts of the world including Nigeria (Ada *et al.*, 2012). In fish farming operations, it is a common management practice to get rid of unwanted fish prior to stocking with desirable fish fingerlings (Ojutiku *et al*., 2012). Due to their environmentally-friendly nature, plant-derived pesticides are being increasingly used in place of their synthetic counterparts for this operation. Unlike synthetic pesticides, plant-derived pesticides are easily biodegradable, leave no residues in the environment and are easily reversed in fish subjected to chronic concentrations. However, several studies have shown that these plant toxins at low concentrations are very toxic to all groups of aquatic fauna including fish (Olufayo, 2009). Extracts from plants such as *Derris elliptica, Moringa oleifera, Parkia biglobosa, Balanites aegyptica, Prosopsis africana, Euphorbia, Tephrosa vogelii, Acacia pennata, Tetrapleura tetraptera* and *Nerium indicum* are known to be ichthyotoxic. The deliberate introduction of these plant extracts in the aquatic ecosystems can cause changes in tissues and organs of organisms leading to alterations in physiological functions (Adeogun *et al.,* 2012) and ultimately reduction in aquatic productivity. An earlier report by Isangedighi and Ambrose (2016) had established the ichthyotoxicity of *Dinnettia tripetala* fruit following the induction of lesions on the kidney of exposed fingerlings of *Clarias gariepinus*. There is however, no information on the effects of any part of this plant on the liver of any fish species. The present study sets

out to close this void by evaluating the toxicity of *D. tripetala* on the histology of the liver of *C. gariepinus.* Histological researches on fish organs, particularly liver is remarkably sensitive tool to reveal detrimental effects in fish induced by toxic agents (Cengiz and Unlu, 2006). The fish liver constitutes a vital organ with a wide range of functions, including glycogen storage (fuel for the body), helping to process fats and proteins from digested food; making of proteins that are essential for blood clotting and detoxification (Dorcas and Solomon, 2014)

D. tripetala (pepper fruit tree) belongs to the family Annonaceae. It is a popular Nigerian spicy food and medicinal plant cultivated in southern states of Nigeria where the leaves and fruits are used in combination with other herbs for treatment of cough, infantile convulsion, and worm infestation (Ejechi and Akpomedaye, 2005). The peppery fruits of *D. tripetala* are added to the diet of postpartum women to aid uterine contraction (Okwu and Morah, 2005). The fruit is also used for relieving gas discomfort in the digestive tract and as antiseptic. The root functions as spice in the preparation of dog meat dishes in southeast Nigeria (Adedayo *et al.,* 2010). *Dinnettia* oil had been reported by Udoessien and Ifon (1984) to have the ability to protect cowpea against storage insect pest. The efficiency of pulverized and extracts of *D. tripetala* as a deterrents of fish beetle (*Dermestes maculates*) on stored dried smoke fish has also been reported (Olayinka-Olagunji, 2014). Nwaogu *et al.,* (2007) investigated phytochemical content of *Dinnettia tripetala* and detected the presence of

saponins, flavonoids, tannins and cyanogenic glycosides.

Materials and methods
Collection and acclimatization of *Clarias gariepinus*
Clarias gariepinus was chosen based on its ability to withstand stress and its popularity among fish consumers in Nigeria. Fingerlings of *C. gariepinus* used were obtained from Safe Food Farms in Uyo, Akwa Ibom State. Their weights and total lengths ranged from 0.08 to 3.75 g and 3.9 to 7.6 cm respectively. They were transported to the Laboratory in a polythene bag containing aerated water. The experimental fish were kept in the Laboratory for acclimatization in transparent plastic tanks of length 22.6 cm and width of 18.5 cm. They were adapted to Laboratory conditions for two weeks before being used in the experiment. The fish were fed twice a day during the period of acclimatization at 5 % of the body weight with branded commercial feed and the water was changed twice a day and at the same time for the two weeks' period of acclimatization, in order to remove faecal materials and unconsumed feeds. The tanks were covered with netting material to guard against fish jumping out of the plastic container and protection from predators. Feeding was discontinued during the experiment.

Preparation of ethanolic extract of *Dinnetia tripetala*
D. tripetala fruits were air-dried until a constant weight was achieved and pulverized. The homogenized sample was extracted with ethanol. The extract was evaporated to dryness in rotary evaporator at 60 °C and preserved in a refrigerator until needed.

Static bioassays
Ten randomly selected fish were distributed in three plastic tanks, two containing a predetermined median lethal dose (96 hour LC_{50}) of 0.7 g/L (Isangedighi and Ambrose, 2016) for 96 hours and a control tank containing extract-free water only. Within the duration of the experiment, water in the tank was replaced every 48 hours with fresh extract solution. Temperature and pH were determined at the beginning of the experiment and maintained at optimal levels.

Preservation of fish organs for histopathological analysis
Following the period of exposure, the fishes to be taken for histopathology examination were randomly selected from the experimental and control tanks. They were dissected to remove the liver. The liver tissues were fixed in Bouin's fluid embedded in paraffin and sectioned (7 microns' thickness) for staining with haematoxylin/eosin stain. Histopathological changes due to treatment with the extract were noted and photographed

Results
Behavioral changes observed in fish treated with *D. tripetala* extract included restlessness, erratic swimming, gulping of air at the water surface and several attempts at jumping out of the tank. Fish in the control group exhibited none of the aforementioned behaviour. Fig. 1a showed liver tissue without treatment (control) revealing normal cellular pattern with area portal triad, space of disse, hepatocytes and sinusoidal lining all within normal limits. Liver tissue treated with 0.7 g/l of the extract (Fig. 1b) showed congestion of the space of disse and area of mild inflammation.

Discussion
Fish behavioral changes such as restlessness, erratic swimming, gulping of air at the water surface and attempting to jump out of the tank attest to the ichthyotoxic property of *D. tripetala*. These abnormalities are indicative of stress as a result of exposure to the toxicant. The alterations observed in the histology of liver are additional evidence of the deleterious effect of the introduced plant-based product. Similar structural changes in the liver have been reported for *C. gariepinus* exposed to a sublethal dose of *Piper guineense* (Isangedighi *et al.*, 2014). Cengiz *et al.*, (2001) attributed these changes to the fact that the liver is a detoxification centre with consequent affinity to the offending toxicant. Lesions in the liver tissue of fish have been reported to be responsible for the inability of the liver tissue to supply the products of metabolism for optimal growth as well as the elimination of waste products generated by metabolic activities. The liver is considered the most important target organ from a toxicological point of view because of its role in detoxification, biotransformation and excretion of xenobiotics (Adeogun *et al.*, 2012). It has the ability to degrade toxic compounds but its regulatory mechanism can be overwhelmed by elevated concentration of these compounds which could subsequently result in structural damage. Prolonged impairment in the ability of the liver to carry out its physiological functions ultimately ends in death as a weakened physiological condition can make the fish more vulnerable to predation, parasitism or disease. The toxicity of *Dinnettia tripetala* is probably a result of synergism among its various active components.
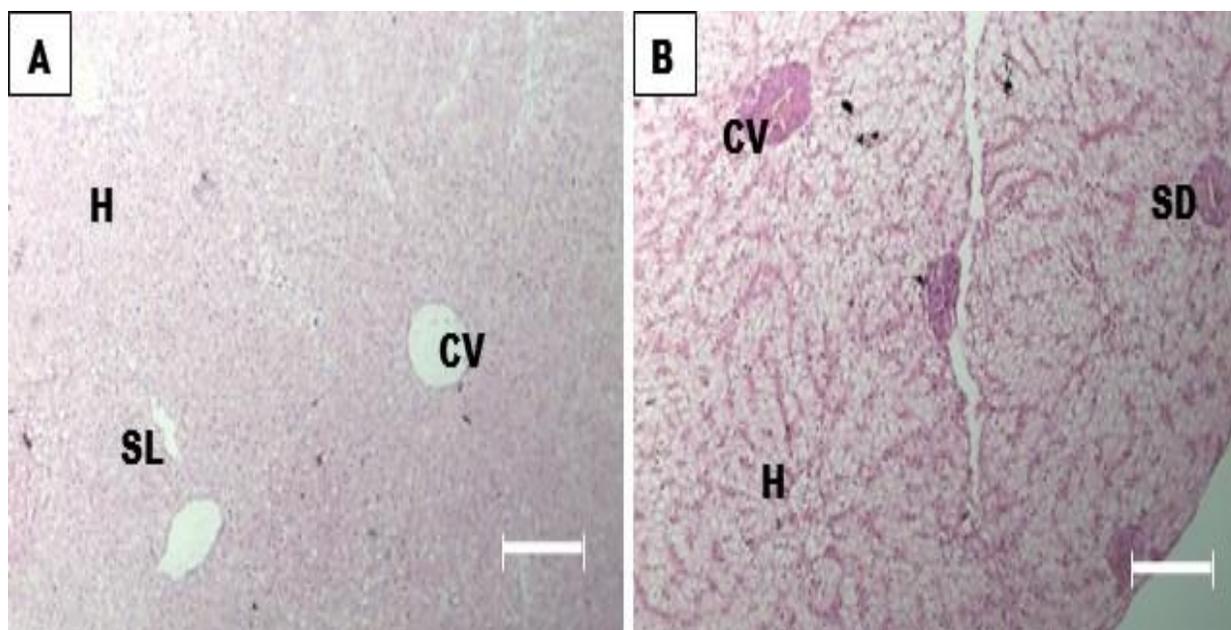
Fig. 1: Histologic sections through the control liver without treatment (a) and liver treated with 0.7 g/l of *Dinnettia tripetala* (b) stained with H and E technique (CV- Central vein, H-Hepatocyte, SD – Space of disse, SL -Sinusoidal layer) (Scale Bar = 50 microns)

Conclusion

This report confirms both the ichthyotoxic and hepatotoxic property of *Dinnettia tripetala*. The plant extract deforms the histologic morphology of the liver thereby hindering its physiological functions which eventually leads to death. The possibility of intrusion of this plant-based product into the aquatic ecosystems in sufficiently high concentrations is presently remote and may not give course for concern. However, its toxicity could be applied in aquaculture to eliminate undesirable fish species prior to stocking.

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Morphometric basis of cannibalism in African catfish *Heterobranchus longifilis x Clarias gariepinus* hybrid fingerlings/juveniles

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Type I cannibalism, type II cannibalism, body length, body weight, hybrid fingerlings

Abstract

Hybrid fingerlings and juveniles of the African catfish were produced from the cross between *Heterobranchus longifilis* female and *Clarias gariepinus* male. Regression equations were developed on the basis of morphometric measurements of 471 fingerlings/juveniles to predict the incidence of cannibalism in the stock of the African catfish hybrid fingerlings/juveniles. The hypothetical equations: Maximum prey weight, PyWt = 0.99LogWt-1.004 and maximum prey total length, PyTL = 0.5 Pd TL – 4.09 were obtained. These models under estimated cannibalism that occurred hence, were revised after 94 paired trials involving 15 predators (Pd) to obtain the following actual models: PyWt = 0.828LogPdWt – 0.44, r^2 = 0.814, and PyTL = 0.481PdTL + 13.44, r^2 = 0.854. These models however, predicted type II cannibalism but could still indirectly predict incomplete cannibalism, which occurred beyond its limit. It was recommended that to prevent both types of cannibalism, sorting should be done regularly until the maximum size difference between the larger and the smaller fish is reduced to or below 2.76 times in weight and 1.40 times in length.

Introduction

The generic hybrids of the African clariid catfishes *Heterobranchus* species and *Clarias gariepinus,* and their parents are very significant in the aquaculture economy of the Sub-Saharan Africa due to their superior aquaculture potentials and the peoples' preference (Baras, 1999; Khaleg, 2000; Baras *et al.*, 2014; Obirikorang *et al.*, 2014). The economic production of these species however suffers a critical constrain due to their cannibalistic behaviour. Incidence of cannibalism in these fishes is very remarkable especially in the early ontogeny (Kaiser *et al.*, 1995; Baras, 1999; Solomon and Udoji, 2011; Obirikorang *et al.*, 2014; Abubakar *et al.*, 2015). Cannibalism is the act of killing and consuming the whole or major parts of a conspecific individual irrespective of its stage of life history (Smith and Reay, 1991, Baras and Jobling, 2002; Qin *et al.*, 2004). This behaviour is considered ubiquitously phenomenal across the animal kingdom (Fox, 1975; Polis, 1981). It has been reported in about 104 families of teleost fishes across 390 species (Pereira *et al.,* 2017) as against earlier reported cases in 36 families involving 106 species (Smith and Reay 1991). Cannibalism appears to be most significant among the larvae and juveniles of piscivorous fishes (Baras and Jobling, 2002; Krol *et al.*, 2014; 2019). Sibling cannibalism is viewed as a specialized predation strategy evolved as a mechanism to enhance survival of 'fit individuals' (Mollah *et al.*, 1999). The cost of this strategy is high when considering the report of Abubakar *et al.,* (2015) that a total cannibalism of 67 % was observed among the fingerlings of *Clarias gariepinus*. Sibling cannibalism could occur as type 1 marked by the prey being incompletely swallowed from the tail without size limitation and is peculiar to the early stages of fish ontogeny. It could also be type 2 occasioned by a cannibal ingesting its prey from the head in a size dependent manner and is typical of larger fish (Hecht and Appelbaum, 1988; Baras and d'Almeida, 2001; Baras and Jobling, 2002; Kestemont *et al.*, 2003).

Cannibalism in fishes is influenced by myriads of internal and external factors which have been largely reviewed with some mitigating measures by many authors including Naumowicz *et al.,* (2017) and Pereira *et al.,* (2017). The respective effects of these factors are seen to be grossly indistinguishable (Patrick *et al.*, 2003). According to Folkvord and Ottera (1997), when there is equality of all factors the rate of cannibalism would be dependent on somatic growth rate. Baras *et al.,* (2000) asserted that the impact of cannibalism is often more pronounced among larval and juvenile fish with high energetic requirements which exhibit significant growth depensation compared to adults. It is thus believed that when cannibalism is consequent on size dispersal (Rudolf, 2006), cannibals exhibit growth superiority over non-cannibals (Berge *et al.*, 2010; Huss *et al.,* 2010b; Pereira *et al.*, 2017), thus perpetuating social dominance and cannibalism. This obviously underscores the assertion that cannibalism is the cause and consequence of size heterogeneity given that the larger fish consume the smaller ones hence, cannibalism affects size heterogeneity as it is affected by size heterogeneity (Hecht and Appelbaum, 1988; Baras,1999; Patrick *et al*, 2003). Melard *et al.*, (1996) submitted that the severity of cannibalism would climax in the early weeks or months of the life history when the divergent growth of individuals would peak. It therefore implies that the initial size heterogeneity and superior

growth capabilities promote cannibalism (Baras and de'Almeida, 2001; Hseu, 2004). The largest fish in the cohort first becomes a cannibal (Giles *et al.*, 1986). These cannibals bear morphological similarities but are larger phenotypes compared to normal phenotypes (Mollah *et al.*, 1999).

Cannibals may not cannibalize all sizes of perceived preys, considering the fact that cannibalism has its benefits and costs (Baras *et al.*, 2000; Hseu *et al.*, 2004). The predator in its choice of prey is limited by factors such as mouth gape, pharyngeal gape, oral jaw, teeth, gill rakers, head width, body depth, length and the ratio of size between the cannibal and the potential prey, predator foraging strategy, defensive behaviour amongst others (Baras, 1999; Baras *et al*, 2005; Baras and Jobling, 2002; Baras *et al.,* 2000; Patrick *et al.*, 2003; Hseu *et al.*, 2007; Pereira *et al.*, 2017). Pereira *et al.*, (2017) reported that mouth gape of predator in relation to prey size is the most important. Accordingly, mouth gape limitation is species specific and ontogenetic dependent. Similarly, Hseu (2002), Baras and Jobling (2002), Hecht and Pienaar (2007) asserted also that the size ratio between predator and the prey for which cannibalism occurs also varies with species.

Heterobranchus longifilis and *Clarias gariepinus* are not only cannibalistic, they both also display size variation in their crucial ontogenetic stages (Kaiser *et al.*, 1995; Baras, 1999; Baras and de'Almeida, 2001; Baras *et al.,* 2010, 2014; Atse *et al.*, 2008; Solomon and Udoji, 2011; Obirikorang *et al.*, 2014). The production of juveniles of the African catfishes is constrained principally by cannibalism amongst other factors (Kaiser *et al.*, 1995; Abubakar *et al.*, 2015) and this constitute a major problem to the small scale hatchery operators (Pantastico *et al.*, 1998). Considering genetic basis of cannibalism (Dionne, 1985; Hecht and Pienaar, 2007; Baras *et al.*, 2011; Liu *et al.*, 2017), with both *H. longifilis* and *C. gariepinus* being cannibals in their own respects, their hybrid has proved to be cannibalistic (Maradun *et al.*, 2019). The ratio of cannibal size to prey size has been established for *H. longifilis and C. gariepinus* (Baras, 1999; Baras and de'Almeida, 2001) but none for their hybrid as yet. It is instructive to investigate this in the light of the report of genetic moderation of the rate of cannibalism in the hybrids of *Silurus meridionalis* and *S. asotus* (Yang *et al.*, 2015). This work sought to evaluate the ratio of predator size to prey size in the African catfish hybrid *H. longifilis* × *C. gariepinus* based on revised morphometric models with a view to suggesting the possible size of fish for grading in order to minimize cannibalism and enhance better survival during culture.

Materials and methods
Experimental fish
Hybrid fingerlings/juveniles of *Heterobranchus longifilis* and *Clarias gariepinus* were produced from 2.0 kg *H. longifilis* female induced with ovaprim (syndel, Canada) to ovulate, and 1.50 kg male *C. gariepinus.* Fertilized eggs collected were incubated in a 2.0 m x 2.5 m concrete breeding tank to hatch. Post yolk fry obtained were reared in the same tank with flow through system till seven weeks of age, they were fed to satiation six times daily with artemia shell free, in the first two weeks then cat fish starter feed (coppens) 0.2 – 0.3 mm for 2 weeks; mixtures of 0.5 – 0.8 mm and 0.8 – 1.2 mm; 0.8 – 1.2 mm and 1.5 mm; and 1.5 and 2 mm particle sizes subsequently for one week each. Over this period, the large sized fingerlings/juveniles were progressively sorted out and reared in a separate tank to avoid cannibalism. At the end of seven weeks, a total of 471 fingerlings was picked out cutting across all size categories and used for the experiments as described below.

Construction of theoretical or hypothetical models
The fingerlings/juveniles used ranged from 30 to 133 mm in total length and 0.2 to 13.8 g in weight. From the fingerlings/juveniles selected, morphometric indices were measured with a digital vernier calliper (Absolute Digimatic Mituioyo Sakato, Japan). These indices were total length measured from the tip of the snout to the end of the caudal fin, head width between the insertion of the pectoral spine on both sides of the body, and the mouth width between the bases of the largest barbels/maxillary barbels both ends of the mouth. The width of each fingerling was also taken. To reduced handling stress on the fish 0.5 g of benzocaine was dissolved in 1 ml of 70% alcohol (Ethanol) and used to anaesthetized the fish in 5 litres cool fresh water at 100 ppm. African cat fish of the sizes are known to exercised type II cannibalism (Baras, 1999) which involves the predatory fish swallowing the prey fish whole from the head. The head of hybrid African cat fish such as the parent *H. longifilis* and *C. gariepinus* is highly ossified and are dorsa-ventrally flattened (Teugels, 1986, Holden and Reeds*,* 1972; Adriaens and Verraes, 1998; Adriaens *et al.,* 2001; Herrel *et al.,* 2002), and appears to give the body widest across section near the end of the head at the insertion of the pectoral fin. This presupposes that for a predatory African cat fish hybrid to swallow its kind as prey, its mouth width must be larger than or at par with the head width of the prey. Consequently, two linear models were developed (1) in terms of weight by regressing log head width (Hw) against log total weight (Wt) and log mouth width (Mw) against log total weight; (2) in terms of length by regressing head (Hw) and Mw) versus total length TL. A theoretical or hypothetical models to estimate the maximum prey size. Equation for a given predator size and hypothetical equation was derived from combining the two separate equations of each set in order to colligate the prey weight (PyWt) and predator weight

(PdWt), and prey total length (PyTL) and predator total length (PdTL) respectively.

The above relationships were presented as follows:

Bodyweight/mouth width: $LogPdMw = b_1 LogPd Wt + a_1 = 1$

Body weight /head width: $LogPyHw = b_2 LogPyWt + a_2 = 2$

(Combining 1 and 2) Body width prey: $LogPyWt = (b_1 b_2^{-1}) LogWtPd + (a_1 - a_2) b_2^{-1} = 3$

Body length/Mouth width: $PdMw = b_4 PdTL + a_4 = 4$

Body length/Head width: $HwPy = b_5 PyTL + a_5 = 5$

(Combining 4 and 5) Body length prey: $(PyTL) = (b4 b_5^{-1}) PdTL + (a_4 - a_5) b_5^{-1} = 6$

Where

a_1, a_2, a_4, and a_5 were intercepts of equations 1, 2, 4, and 5 respectively and b_1, b_2, b_4, b_5 were regression coefficients of equations 1, 2, 4, and 5 respectively, and Pd, Py were predator and prey African catfish hybrid fingerlings respectively.

Paired fish trials to test the regression models

In order to assert the validity of the hypothetical models, 15 larger fingerlings/juveniles (Total length, TL: 79.0–1330 mm, and weight, Wt: 3.2–13.8 g) were selected as predators and 94 smaller fingerlings (Total length, TL: 30–98 mm; weight, Wt: 0.2–5.2 g) as prey. Feed was withdrawn from the fish for 24 hours prior to the commencement of the experiment. A total of 94 paired trials were conducted in 15 transparent white plastic vats (24 cm x 24 cm x 20 cm), each containing 10 L of fresh water under ambient conditions of temperature (28-30 ℃) and lighting (12.05D, 11.53L) from November 4-12, 2019. Each vat was fitted with a netting cover, water flow through and air supply systems. A predator of known weight (Wt) and total length (TL) to cover the selected range was placed in each vat. Each predator was paired with a prey of known Wt and TL. Whenever a particular prey was swallowed, killed and mutilated or devoured, another prey of slightly higher Wt and TL was introduced while any mutilated parts left were removed. This was systematically executed for each predator till a prey size which cohabited the vat with the predator for 48 hours was attained. The sizes of the largest prey ingested and, killed and mutilated by each predator were respectively recorded as the maximum or limit for that particular predator. The size of the surviving prey beyond the limit of cannibalism was respectively noted for each predator (cannibal). Prey-predator ratios were determined for all recorded weights and total lengths. The experiment lasted for 8 days.

Statistical Analysis

Regression analyses were performed using XLStat 2015 (Addinsoft, Oslo, Norway) statistical package ran on IBM compatible computer.

Results
Prey - predator models

The linear regression models of both the mouth width (Mw) and head width (Hw) exhibited strong relationships with the body weight (Wt) and total length (TL) in the African cat fish hybrid. These relationships in the *Heterobranchus longifilis* × *Clarias gariepinus* hybrid Mw and Hw on body weight and total length were as shown in Table 1 and Figs. 1 and 2.

The maximum weight and total length of a prey within predation limit of the predator could be estimated following the arrows in fig. I and II respectively. A certain predator weight and total length relates strongly to the predator's mouth width (Mw) which is assumed to be the equivalence of the preys' head width (Hw) corresponding to the weight and total length of the prey. The two respective equations in Table 1 were combined to produce the hypothetical equations (5 and 6) which could be used to estimate the largest ingested prey weight or maximum total length respectively for any predator:

Maximum prey Wt: $LogPy Wt = 0.99 LogPdWt - 1.004 = 5$

Maximum prey total length: $PyTL = 0.5 PdTL - 4.09 = 6$

Paired fish testing of models:

The paired fish trials revealed that from a total of 94 prey involved, 64 fish (68.09 %) were completely swallowed, 15 (13.33 %) killed and mutilated of which 2 (2.13 %) of the total prey or 15.96 % of total killed and mutilated prey) were extracted from the mouth of 2 dead cannibals, while 15 (15.33 %) prey survived.

Some of the killed and mutilated preys were variously devoured in bits and later, swallowed up in no particular order (head or tail first) depending on the piece. Sometimes, only heads were discarded or head with vertebral column.

On comparing the hypothetical models (equations 5 and 6) with the observed data, it was evident that the models underestimated the maximum prey weight and total length relative to the predator weight and total length respectively (Figs. 3 and 4 and Tables 2 and 3).

All the predicted prey sizes were smaller than the actual maximum prey sizes swallowed relative to the predator sizes (Tables 2 and 3; Figs. 3 and 4). According to the predictive or regression equation, the maximum predicted (swallowed) prey weights for 3.5 and 10.2 g predators were 0.34 and 0.99 g respectively but 1.3 and 2.3 g were observed. Similarly, the predicted maximum total length of prey for 80.7 and 118.2 mm predators were respectively 36.26 and 55.01 mm, but 55.3 and 70.1 mm were respectively observed. It became imperative for the predictive equations to be revised as follows:

Maximum prey weight: $PyWt = 0.829 logPdWt - 0.44$, $r^2 = 0.814$;

Maximum prey total length: PyTL = 0.481 PdTL +13.44, r^2 = 0.854.

The Wt and TL of the killed and mutilated prey were higher than those of swallowed prey but lower than those of surviving prey for a particular predator.

Table 1: Models summarizing the relationship between some morphometric parameters in *Heterobranchus longifilis* × *Clarias gariepinus* fingerlings/juveniles (471 fish, 30 to 133   mm; 3.2 to 13.8 g)

Relationship	Equation	r^2	N
Body Length/mouth width	PdMw = 0.0854 Pd TL + 0.7922	0.9387	471
Body Length/head width	PyHw = 0.1726 Py TL + 1.4981	0.9437	471
Body weight/mouth width	Log PdMW = 0.297Log PdWt + 0.722	0.9168	471
Body weight/head width	Log PyHw = 0.3001LogPyWt + 1.023	0.9227	471
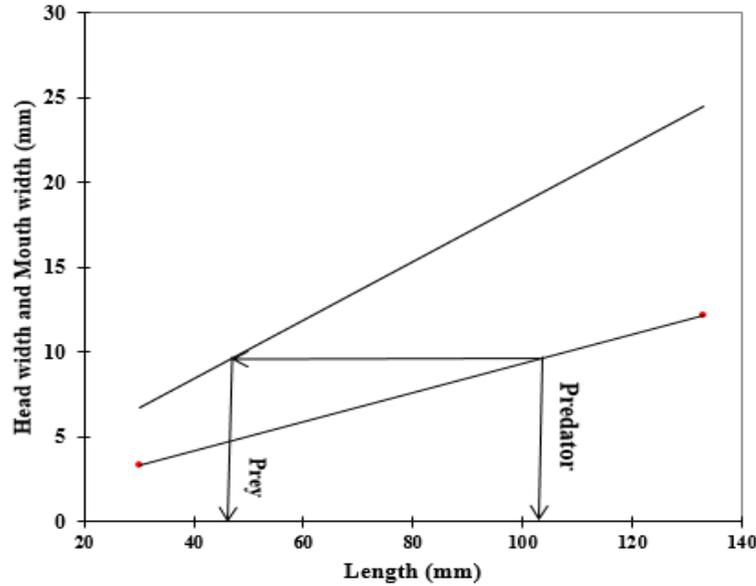
Fig. 1: Relationship of mouth width and head width to body weight in *Heterobranchus longifilis* × *Clarias gariepinus* fingerlings/ juveniles
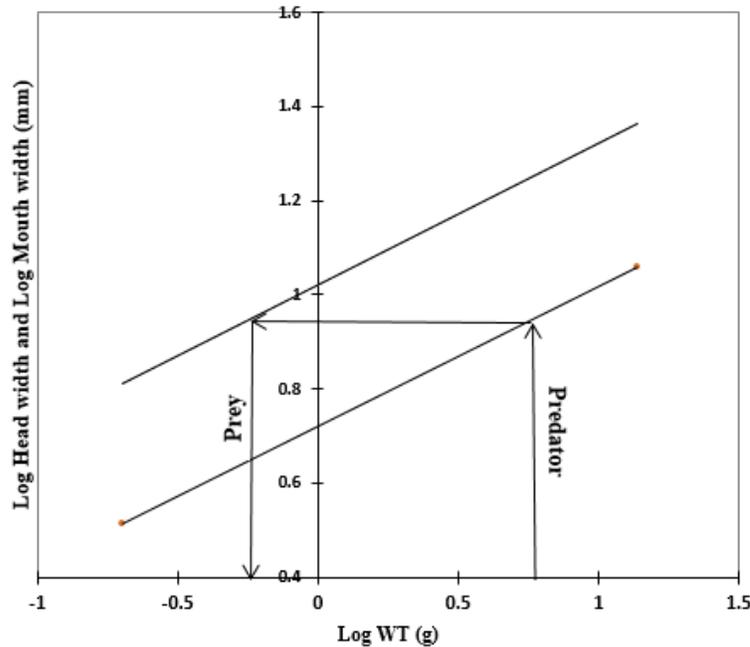
Fig. 2: Relationship of mouth width and head width to body weight in *Heterobranchus longifilis* × *Clarias gariepinus* fingerlings/juveniles
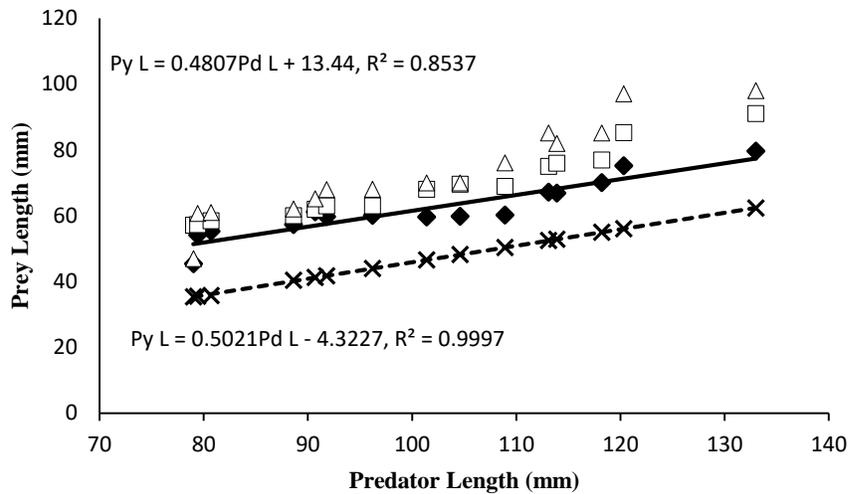
Fig. 3: Relationship between predator and prey lengths in *Heterobranchus longifilis* x *Clarias gariepinus* hybrid

Keys

□	Killed and Mutilated total length (TL)
◆	Swallowed Prey TL
△	Survived Prey TL
X	Predicted Prey TL
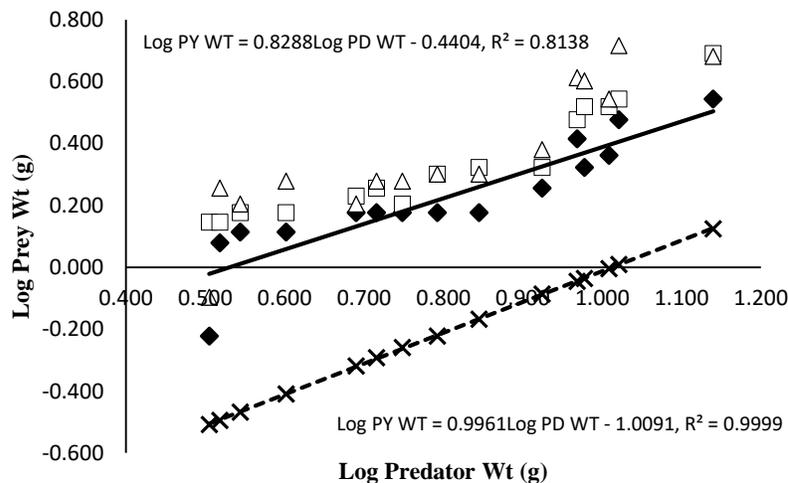
Fig. 4: Relationship between predator and prey weights in *Heterobranchus longifilis* x *Clarias gariepinus* hybrid

Keys

□	Killed and Mutilated Prey Wt
◆	Swallowed Prey Wt
△	Survived Prey Wt
X	Predicted Prey Wt

Exceptions to these particular observations were found in predators of TL = 79.0 mm and Wt = 3.2 g with killed prey greater than survived, and PdTL, 104.6; Wt, 6.2 which killed and survived Wt were equal. The size of the preys generally appeared to increase with increasing predator size. However, the size ratios of the observed swallowed prey appeared to decrease as the predator weight increased except in a few cases.

It was observed that allometry growth pattern of the head width and mouth width with the length varied among certain individuals and also, some juveniles were observed to be much longer compared to their relative weights. For example, a 35.4 mm fish had a head width of 9.0 mm, mouth width of 4.5 mm and weighed 0.7 g while a 60.1 mm fish had a head width of 8.0 mm, mouth width of 4.0 mm and weighed 0.4 g.

Table 2: Predator and prey (observed, predicted, killed/mutilated and survived preys) lengths in *Heterobranchus longifilis* × *Clarias gariepinus* fingerlings/juveniles

Predator Length (mm) PD TL	Swallowed prey length (mm) Observed					Swallowed prey length (mm) Predicted					Killed/Mutilated prey length (mm)					Survived prey length (mm)				
	PY TL	Ratio (PY L/PD TL)	%	Ratio (PD / PY TL)	%	PY TL	Ratio (PY/PD TL)	%	Ratio (PD/PY TL)	%	PY TL	Ratio (PY/PD TL)	%	Ratio (PD/PY TL)	%	PY TL	Ratio (PY/PD TL)	%	Ratio (PD/PY TL)	%
79.0	45.4	0.57	57.47	1.74	174.01	35.41	0.45	44.82	2.23	223.10	57.1	0.72	72.28	1.38	138.35	47.0	0.59	59.49	1.68	168.09
79.4	54.1	0.68	68.14	1.47	146.77	35.61	0.45	44.85	2.23	222.97	57.3	0.72	72.17	1.39	138.57	60.7	0.76	76.45	1.31	130.81
80.7	55.3	0.69	68.53	1.46	145.93	36.26	0.45	44.93	2.23	222.56	58.5	0.72	72.49	1.38	137.95	61.0	0.76	75.59	1.32	132.30
88.6	57.3	0.65	64.67	1.55	154.62	40.21	0.45	45.38	2.20	220.34	60.0	0.68	67.72	1.48	147.67	62.1	0.70	70.09	1.43	142.67
90.7	61.2	0.67	67.48	1.48	148.20	41.26	0.45	45.49	2.20	219.83	62.0	0.68	68.36	1.46	146.29	65.2	0.72	71.89	1.39	139.11
91.8	59.8	0.65	65.14	1.54	153.51	41.81	0.46	45.54	2.20	219.56	63.0	0.69	68.63	1.46	145.71	68.0	0.74	74.07	1.35	135.00
96.2	60.1	0.62	62.47	1.60	160.07	44.01	0.46	45.75	2.19	218.59	63.0	0.65	65.49	1.53	152.70	68.1	0.71	70.79	1.41	141.26
101.4	59.7	0.59	58.88	1.70	169.85	46.61	0.46	45.97	2.18	217.55	68.1	0.67	67.16	1.49	148.90	70.0	0.69	69.03	1.45	144.86
104.6	59.9	0.57	57.27	1.75	174.62	48.21	0.46	46.09	2.17	216.97	69.6	0.67	66.54	1.50	150.29	70.0	0.67	66.92	1.49	149.43
108.9	60.2	0.55	55.28	1.81	180.90	50.36	0.46	46.24	2.16	216.24	68.9	0.63	63.27	1.58	158.06	76.1	0.70	69.88	1.43	143.10
113.1	67.2	0.59	59.42	1.68	168.30	52.46	0.46	46.38	2.16	215.59	75.0	0.66	66.31	1.51	150.80	85.2	0.75	75.33	1.33	132.75
113.9	67.8	0.60	59.53	1.68	167.99	52.86	0.46	46.41	2.15	215.47	76.0	0.67	66.73	1.50	149.87	82.0	0.72	71.99	1.39	138.90
118.2	70.1	0.59	59.31	1.69	168.62	55.01	0.47	46.54	2.15	214.87	77.0	0.65	65.14	1.54	153.51	85.2	0.72	72.08	1.39	138.73
120.3	75.2	0.63	62.51	1.60	159.97	56.06	0.47	46.60	2.15	214.59	85.3	0.71	70.91	1.41	141.03	97.1	0.81	80.71	1.24	123.89
133.0	80.0	0.60	60.15	1.66	166.25	62.41	0.47	46.92	2.13	213.11	91.1	0.68	68.50	1.46	145.99	98.0	0.74	73.68	1.36	135.71
Mean ±SE		0.62± 0.011		1.63± 0.028			0.46± 0.002		2.18± 0.093			0.68± 0.007		1.47± 0.016			0.72± 0.012		1.40± 0.026	

Table 3: Predator and prey (observed, predicted, killed/mutilated and survived preys) weights in *Heterobranchus longifilis* × *Clarias gariepinus* fingerlings/juveniles

Predator Weight (g)		Swallowed prey weight (g)									Killed prey weight (g)					Survived prey weight (g)				
		Observed (g)				Predicted (g)														
PD WT	PY WT	Ratio (PY/PD wt)	%	Ratio (PD/PY Wt)	%	PY Wt	Ratio (PY/PD wt)	%	Ratio (PD/PY Wt)	%	PY WT	Ratio (PY/PD wt)	%	Ratio (PD/PY Wt)	%	PY WT	Ratio (PY/PD wt)	%	Ratio (PD/PY Wt)	%
3.2	0.6	0.19	18.75	5.33	533.33	0.31	0.097	9.69	10.32	1032.26	1.4	0.44	43.75	2.29	228.57	0.8	0.25	25.00	4.00	400.00
3.3	1.2	0.36	36.36	2.75	275.00	0.32	0.097	9.70	10.31	1031.25	1.4	0.42	42.42	2.36	235.71	1.8	0.55	54.55	1.83	183.33
3.5	1.3	0.37	37.14	2.69	269.23	0.34	0.097	9.71	10.29	1029.41	1.5	0.43	42.86	2.33	233.33	1.6	0.46	45.71	2.19	218.75
4.0	1.3	0.33	32.50	3.08	307.69	0.39	0.098	9.75	10.26	1025.64	1.5	0.38	37.50	2.67	266.67	1.9	0.48	47.50	2.11	210.53
4.9	1.5	0.31	30.61	3.27	326.67	0.48	0.098	9.80	10.21	1020.83	1.7	0.35	34.69	2.88	288.24	1.6	0.33	32.65	3.06	306.25
5.2	1.5	0.29	28.85	3.47	346.67	0.51	0.098	9.81	10.20	1019.61	1.8	0.35	34.62	2.89	288.89	1.9	0.37	36.54	2.74	273.68
5.6	1.5	0.27	26.79	3.73	373.33	0.55	0.098	9.82	10.18	1018.18	1.6	0.29	28.57	3.50	350.00	1.9	0.34	33.93	2.95	294.74
6.2	1.5	0.24	24.19	4.13	413.33	0.60	0.097	9.68	10.33	1033.33	2.0	0.32	32.26	3.10	310.00	2.0	0.32	32.26	3.10	310.00
7.0	1.5	0.21	21.43	4.67	466.67	0.68	0.097	9.71	10.29	1029.41	2.1	0.30	30.00	3.33	333.33	2.0	0.29	28.57	3.50	350.00
8.4	1.8	0.21	21.43	4.67	466.67	0.82	0.098	9.76	10.24	1024.39	2.1	0.25	25.00	4.00	400.00	2.4	0.29	28.57	3.50	350.00
9.3	2.6	0.28	27.96	3.58	357.69	0.90	0.097	9.68	10.33	1033.33	3.0	0.32	32.26	3.10	310.00	4.1	0.44	44.09	2.27	226.83
9.5	2.1	0.22	22.11	4.52	452.38	0.92	0.097	9.68	10.33	1032.61	3.3	0.35	34.74	2.88	287.88	4.0	0.42	42.11	2.38	237.50
10.2	2.3	0.23	22.55	4.43	443.48	0.99	0.097	9.71	10.30	1030.30	3.3	0.32	32.35	3.09	309.09	3.5	0.34	34.31	2.91	291.43
10.5	3.0	0.29	28.57	3.50	350.00	1.02	0.097	9.71	10.29	1029.41	3.5	0.33	33.33	3.00	300.00	5.2	0.50	49.52	2.02	201.92
13.8	3.5	0.25	25.36	3.94	394.29	1.33	0.096	9.64	10.38	1037.59	4.9	0.36	35.51	2.82	281.63	4.8	0.35	34.78	2.88	287.50
Mean ±SE		0.27± 0.014		3.85± 0.200			0.10± 0.000		10.28± 0.014			0.35± 0.014		2.95± 0.117			0.38± 0.023		2.76± 0.161	

Discussion

The African catfish, *Heterobranchus longifilis* × *Clarias gariepinus* hybrid fingerlings/juveniles exhibited both complete and incomplete cannibalisms during the study. The complete cannibalism involved the predator or cannibal swallowing the prey whole from the head, type II cannibalism. This accounted for about 64 % of the cannibalized prey. Baras (1999) had similar results with a population of 30 days old juvenile vundu (*Heterobranchus longifilis)* with initial ratio of 4 % of cannibal in which type II cannibalism of 75.5–79.9 % was recorded over 15-day period. Many authors (Babiak *et al*., 2004*;* Szkudlarek and Zakes, 2007*;* Krol and Zielinskil, 2015; Krol and Zakes, 2016; Krol *et al.,* 2019) have attributed higher cannibalistic losses to type II cannibalism. This remarkable level of loss can be very consequential to both wild and cultured populations as well as to the fish culturists. This type of cannibalism is believed to be governed by certain logistics which include the size ratio between the cannibal and the prey and morphometries such as mouth gape, body depth or head width (Qin and Fast, 1996; Baras,1999; Baras and Jobling, 2002; Xi *et al*, 2016). These morphometries have been shown to relate greatly to the weight and length. Hence, the size of both the predator and the prey could be determined from their relationships (Qin and Fast, 1996; Hseu *et al.,* 2004; Fassehaye *et al.,* 2006). The underlying principle here which affects type II cannibalism is that the mouth width of the cannibal should be at par or greater than the body depth or head width of the prey (Qin and Fast, 1996; Baras, 1999; Fassehaye *et al.,* 2006). In the present study however, the head widths of the swallowed prey were larger than the mouth widths of the predators. Thus, the maximum size of prey fully engorged by the predators was greater than the maximum size (weight and total length) predicted by the equations (hypothetical or predictive models) based on the morphometric parameters. The predictive models therefore, underestimated the maximum prey size realities in *H. longifilis* × *C. gariepinus* hybrid fingerlings or juveniles by 16 % in terms of total length and 17 % in terms of weight. The models predicted that a predator of TL 96.2 mm or Wt 5.6 g should ingest a maximum prey of 45.75 % of its total length or 10 % of its weight. The actual observation revealed that this predator could swallow prey of 62.5 % of its total length or 27 % of its weight. Similar results that underestimated the maximum prey size relative to the predator's mouth width had previously been obtained by Qin and Fast (1996) in *Channa striatu;* Hseu *et al.,* (2004) in *Epinephelus lanceolatus* and Baras *et al*., (2014) in *Heterobranchus longifilis*. They associated it with a possible elasticity of the mouth parts. This could be the likely explanation in the present study. The possible elasticity or expansion of the mouth parts in this African catfish hybrid could be linked to Van

Wassenbergh *et al.,* (2004) that ventral rotation of the hyoid is largely responsible for the expansion of buccal cavity in *Clarias gariepinus.* It thus appears that the pharyngeal gape of the African catfish hybrid might not attain the same scale of expansion or elasticity as the mouth part, or is slightly larger than the mouth gape. This is viewed from the observation that some preys larger than the mouth width that were engorged through the mouth gape also passed through pharyngeal gape but others that equally passed through the mouth gape were restrained at the pharyngeal gape and were spitted out. The pharyngeal slit is one restraining factor in prey size selection (Sibling, 1991). However, where the prey shaped could be compressed or deformed this limitation would be less significant (Kisaliogly and Gibson, 1976) but a serious constraint if the reverse is the case (Wainwright and Richard, 1995) as in the African catfish hybrid with a hard and non-deformable skull.

Incomplete cannibalism was evident in preys killed and mutilated. Two (2.15 % of total cannibalized fish or 13.35 % of the total kill and mutilated prey) of these fish were able to pass through both the mouth and pharyngeal gap but get stuck in the oesophagus of the predator resulting to the death of both the predator and the prey due to obstruction and suffocation. The death of both predator and prey is of great consequence as it represents double losses in addition to the possible cannibalistic losses perpetuated by both of these juveniles in the course of their ontogenetic development. In the other killed preys, the cannibals killed their preys through repeated bites that mutilated the fins and the body. The carcasses were devoured through further mutilations sometimes leaving only the heads or heads and vertebral column or no parts at all by swallowing up the mutilated trunks randomly, depending on the size. This was a rather mixed cannibalistic approach rather than a sole type I cannibalism as seen in Hecht and Appelbaum (1988) and Baras (1999).

This incomplete cannibalistic behaviour might partly be the consequence of the development of the cranial skeletal and muscular elements of the African catfish to optimize biting and grasping in addition to suction feeding (Adriaens and Verrases, 1998; Adriaens *et al.,* 2001; Herrel *et al.,* 2005; Van Wassenbergh *et al.*, 2004; 2005). According to Baras *et al.,* (2000), the cannibals have preference for smaller prey but might resort to type I (tail first cannibalism) in their absence. Predator may also be at the risk of predation, and where prey selection involves predation risk, it becomes necessary for predators to select prey with minimal risk (Gilliam,1990; Nilsson and Bronmark, 1999). It appears that the absence of the smaller prey could account for the incomplete cannibalism observed in this work. About 15 % of incomplete cannibalism in the African catfish hybrid reported here is in consonance

with 19.2 % recorded by Onwuteka and Prince (2015) on *Clarias gariepinus.* The significance of this type of cannibalism is that mouth gape might not be a significant barrier to the exercise of the phenomenon. This could explain group cannibalism or communal consumption whereby some smaller fish (potential prey) could cannibalize on a bigger one (supposedly predator) that appeared weak or stressed up (Obirikorang *et al.,* 2014; Umanah and Nlewadim, 2019).

Size ratio between the prey and cannibal or vice-versa has been considered as a very important logistic of type II cannibalism to identify the threshold of cannibalism or feasibility criterion (Baras and Jobling, 2002; Xi *et al.,* 2016) essentially as this cannibalism type thrives on the existence of size heterogeneity. Baras and Jobling (2002) stated that this ratio varies from species to species. Baras (1999) reviewed Hecht and Appelbaum (1988) and gave the lowest ratios of size and weight of cannibal to the prey size and weight as 2.1 and 10.4 for *Clarias gariepinus*. He provided the logistics for *Heterobranchus longifilis* to be 1.75 and 6.00 respectively. In the present study, the observed ratio for the swallowed prey mean maximum total length and weight to the cannibal mean minimum total length and weight were 0.62 ± 0.011 and 0.27 ± 0.014 respectively. Conversely, the ratios of mean minimum predator to maximum prey total length was 1.63 ± 0.028 and mean minimum predator to prey weight was 3.85 ± 0.200 and were all similar to Baras (1999). The ratio of prey size to predator size were observed in this work to decrease to some extent with increasing predator size as reported by Qin and Fast (1996). Incidentally, at a mean ratio of 0.35 ± 0.014 (35 %) predator weight and 0.68 ± 0.007 (68 %) predator total length (i.e. 8 % Wt and 6 % TL above the limit of type II cannibalism) resulted to a swift in cannibalism pattern of the African catfish hybrid from type II to incomplete cannibalism. As it would be expected at higher mean ratios (0.38 ± 0.32 or 38 % predator weight and 0.72 ± 0.012 or 72 % predator total length) cannibalism was not observed resulting to the surviving preys (15 %). However, a certain prey of 25 % PdWt and 59.5 % PdTL was able to survive a predator which had killed a prey 72 % its TL and 44 % its Wt.

The logistic of cannibalism (size ratio) is most times either in terms of weight (Fassenhage *et al.,* 2006) or length (Hseu *et al.,* 2004). This to some extent could create problems even in a unit population where there may exist certain genetic and environmental variables (Houston and De Angelis, 1987) at individual levels. There may not be constant uniformity in growth allometry among members giving rise to slight variability in the condition factor among different individuals. Certain members might not be as robust or heavy as they appear long or as light as they appear short. This could lead to erroneous estimate when the

premise of decision is on only one index. The death of both the predator and the prey in this work resulted from longer fish whose head widths might have had weaker allometry to their length. When swallowed, a great part of the body was still outside and thus, got stuck into the predator and suffocated it to death. Baras *et al.,* (2011) also attributed this occurrence to limited stomach capacity. Slight variability in head widths among individuals relative to their total length were noticed in a few more juveniles. This possibly could be a genetic effect being hybrids from *Heterobranchus longifilis* and *Clarias gariepinus* with relatively slight different head sizes. It might also be as a result of the vast majority of the fingerlings/juveniles being below 127 mm standard length. This length marks the commencement of post-metamorphic growth in *Clarias gariepinus* which period no substantial shape changes of the cranium system are expected (Adriaens and Verraes 1998; Herrel *et al.,* 2005), it is therefore implied that reasonable head changes could occur during the pre-metamorphic growth phase (Cook, 1996).

The prey-predator models obtained in this study covered only the swallowed prey representing type II cannibalism but not the killed and mutilated preys which represented incomplete cannibalism. The revised or practical models could still be relevant in predicting incomplete cannibalism which threshold is 8 % and 6 % in terms of prey weight and total length respectively beyond the limit of type II cannibalism. The manner of occurrence of cannibalism might not unnecessarily be over-emphasized since cannibalism represents losses whenever it occurs. However, the minute details could provide vital insight into the stock management approaches targeting its mitigation. In fish culture involving species marked by growth depensation and size heterogeneity, sorting or size grading has been recommended among other measures in order to reduce losses owing to cannibalism (Mollah *et al.*, 1999; Szczepkowski, *et al.*, 2011; Biu et al, 2015). An attempt to control cannibalism by sorting or grading *Heterobranchus longifilis* x *Clarias gariepinus* hybrid fingerlings or juveniles would require holistic sorting approaches. Mollah *et al.,* (1999) proved that cannibal phenotypes are easily discernible. According to Giles *et al.,* (1986), the largest fish in the stock first turns into a cannibal. The models obtained in this work have shown that individuals 1.47 ± 0.016 times longer and those weighing 2.95 ± 0.117 times more than others should be identified as cannibals or predators and therefore be removed from the stock. This should be conducted at regular intervals to avoid re-attainment of the cannibalism logistics.

Conclusion

The hybrid catfish (*Heterobranchus longifilis* × *Clarias gariepinus*) fingerlings/juveniles exhibited

both type II (complete) and incomplete cannibalism. The regression models based on morphometric parameters of the predator and the prey underestimated the cannibalistic reach of the African catfish hybrid. The incidence of incomplete cannibalism in addition to the capacity of the fish to cannibalize on prey larger than its mouth width could be responsible for group cannibalism in these fish. From this work, individuals great than 2.95 times in weight and 1.47 times in length are cannibals and must be separated from the stock to enhance good survival. This should regularly be practiced until the size difference between the larger and smaller fish is reduced below these thresholds in order to suppress cannibalism.

Acknowledgement

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Physicochemical parameters of Anthropogenic and Non-Anthropogenic locations in Eniong River, Akwa Ibom State, Nigeria

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Key words

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Abstract

This research was conducted to compare selected physicochemical water quality parameters of identified locations subjected to predominant anthropogenic activities as against locations of comparatively less or non-anthropogenic activities of Eniong River. Water samples for selected physicochemical parameters were collected with plastic containers, while samples for dissolved oxygen were collected using amber bottles. Temperature, pH, electrical conductivity, salinity, total dissolved solids, turbidity and dissolved oxygen were measured *in situ*. The heavy metals content of the water in sampled locations were analyzed using Atomic Absorption Spectrophotometer. The results obtained showed that pH ranged from 5.05 – 5.66 with the mean of 5.338±0.18; 5.08 – 6.1 averaging 5.49±0.3 for Anthropogenic Zone and Non-Anthropogenic Zones respectively. Statistically, the result shows that the mean value for Anthropogenic Zone is 9.95 with a standard deviation of 15.24 and that of the Non-Anthropogenic Zone value was 8.69 with a standard deviation of 13.06. The calculated t-value was 0.28 with 36 degrees of freedom (*df*) and the p-value of 0.78. However, since p>0.05, it therefore implies that there was no significant difference in the statistical values of the physicochemical characteristics of Eniong River samples between Anthropogenic and Non-Anthropogenic zones. The study concluded that despite the clearly contrasting scenarios of anthropogenic activities between the locations sampled, the resultant insignificant differences of the physicochemical parameters measured is attributable to the sustained dilution effects of the water in areas prone to anthropogenic activities, due to continual flow of the river from upstream to the down-stream areas. Recommendations included further research on the subject, mounting of monitoring/control and sensitization measures that are geared towards the reduction of pollutants into the river.

Introduction

Simpi *et al*., (2011) reported that water is one of the most vital compounds of the ecosystem, but due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity, there is heavy and varied pollution in aquatic environment; leading to degraded water quality and depletion of aquatic biota. It is therefore mainly as a result of anthropogenic activities that water resources; surface, underground and even atmospheric moisture within our planets gets adversely impacted; losing its fitness for natural use or purpose either entirely or in components.

Obio Usiere Community and its environs, the very upper reaches where Eniong River flows from, before traversing various other communities, prior to mixing (formation of a confluence) with water from Cross River, in a location; Obom-Itiat-Itu Community, is always saturated with atmospheric moisture and the peak of the rainy season coincides with periods of low evaporation, high rainfall intensity and frequency as well as high ground water recharge rates. Udosen *et al.,* (2016) reported that the above conditions are known to alter both the water quality status and the hydrologic regimes of river in the humid tropics. The report further highlighted very wide variations in the

physicochemical parameters during the wet season in sharp contrast to narrow range of coefficient of variations in dry seasons. Dan *et al.,* (2014) found that the seasonal variations, distribution pattern, enrichments and contamination of heavy metals in Qua Iboe river estuary showed elevated concentrations during the wet season months and they attributed this trend to adsorption/dissolution and distribution of the physicochemical parameters viz; temperature, salinity, pH, TDS, DO, TSS and electrical conductivity. These parameters were also found to be highly variable during wet season in Eniong River.

Eniong River is black in colour, hence classified as a blackwater river. Blackwaters are found throughout the world in inland rivers, creeks, floodplains, swamps and wetlands, especially after flooding (Fork, 2012; Hiriart-Baer *et al.,* 2013); where they normally play important part in maintaining a healthy ecosystem (Fellman *et al*., 2009). They result from high concentrations of fulvic acids and tannins, and organic carbon compounds through decay of organic materials such as leaf litter and woody debris carried by flood waters from terrestrial vegetations, resulting in dark amber-colored or tea-coloured water (Fork, 2012; Hiriart-Baer *et al.,* 2013). This is one of the main fuels for the aquatic food web, providing food for microbes and aquatic insects that, in turn, feed fish, frogs, birds

and other wetland animals (Bertilsson and Jones, 2003). Blackwaters tend to have low hydraulic gradients that generate lower average flow velocity and more variable flow than spring runs, irrespective of their geography (Fork, 2012). The slow flow of blackwater makes them hydrologically suitable for phytoplankton communities, but its low light transmission through the water-column limits production of phytoplankton. Eniong River is a blackwater river that has been influenced by anthropogenic activities. Some of these activities include historic logging practices where logs were floated down the river causing bank erosion and sedimentation (GSA, 2009). Also cassava mills sited along the bank of the river has most of the organic wastes of cassava peels and effluents arising from cassava fermentation and processing discharged into the river. Non-point sources of pollution are much harder to determine in a watershed, as they can be the product of a number of land-uses as well as anthropogenic activities. Non-point sources can include: agricultural run-off, septic tank contamination and developmental activities such as road building or shoreline stabilization (Cogger, 2009). Consequently, this study focused on determining the differences in physico-chemical parameters of some identified anthropogenic and non-anthropogenic activities in sections of the river. This is with a view to better understanding of the water pollution dynamics and proposing its management.

Materials and methods
Description of study area
Eniong creek (Fig. 1) is 24.2 m long and lies between latitudes 5º04' and 5º13'N, and between longitudes 7º47' and 7º58E. The river is stratified into three sections: lower, middle and upper. The lower section traverses two villages: Obio Usiere and Asang; the middle section traverses three villages: Obu, Obot-Apabio and Akani-Obio and the upper section had three villages: Ikpanya, Opoto and Nkana. The choice of the sampling stations was based on the contrasting geomorphometry of the sub-catchments and possible anthropogenic inputs from activities of transportation, farming practice, domestic and cottage industrial discharges into the river, which finally empties into main Cross River as a confluence.

Anthropogenic activities
Various anthropogenic perturbations were on-going in the bank and shore of the Eniong River (Fig. 2 a-d). Prominent among these were: (a) Cassava processing plant where raw and soaked peeled-cassava tubers were grounded into garri and foo-foo respectively in the processing plant; (b) Paddled canoe where in situ measurements of physico-chemical features of the river were taken from; (c) Transportation of fermented cassava in bags using dugout canoes and (d) Itu

Market Site where foodstuffs such as fresh and smoke-dried fish and crayfish, and farm produce including bunches of plantain and banana, groundnut seeds, cocoyam, three leaf yam, pepper, pumpkin, yam, cassava, waterleaf, etc. were sold. The water of Eniong River was being used in the processing and the generated organic wastes from these activities were directly introduced into the water without any pre-treatment. Thus, constituting major sources of human anthropogenic perturbations of this river that is a very important source aquatic resources, such as fishes of economic importance that supports the artisanal fisheries sector of the area.

Collection of Samples
Samples were collected from eight (8) locations spanning Okopedi River to Eniong River within the month of June, 2018. Prior to collecting the water samples, each container was first rinsed with the water from the River. Samples for physicochemical parameters were collected into one-liter plastic containers. Temperature, pH, electrical conductivity (EC), salinity and total dissolved solids (TDS) were measured *in situ* using Jenway Hand Held Meter Model 430. Turbidity was measured using Horiba Water Quality Meter Model W-2000S/W-23XD while dissolved oxygen (DO) was measured *in-situ* using Jenway Model 970 MK II. The heavy metals were analyzed by using Atomic Absorption Spectrophotometer (AAS) UNICAM 393 following the guidelines of standard methods for the examination of water and wastewater (APHA, 1998 and 2005). All *in situ* meters were calibrated prior to measurements. The samples for heavy metals were fixed with 70 % concentrated nitric acid to sustain the integrity of the samples before taking them to the Laboratory for analysis. Glass bottles were used to collect water sample for total hydrocarbon (THC) because glass does not contain any derivative of petroleum and was fixed with sulphuric acid. Discrete water samples were kept in an ice-packed container in the dark while in the field and refrigerated at 4 ºC until analysis in the Laboratory. A field laboratory samples handling chain of custody was maintained for all samples.

Data analysis
Data obtained from Laboratory analysis were subjected to independent t-test to determine if there were any significant differences between the anthropogenic and non-anthropogenic areas sampled.

Results
The following parameters were either higher or lower than the allowable limits of WHO: pH, electrical conductivity, turbidity, salinity, total dissolved solids, total suspended solids, dissolved oxygen, biochemical oxygen demand, nitrate, sulphate, iron, manganese, calcium, magnesium, copper and sodium (Table 1).

The results of the analyzed water parameters for both the anthropogenic and non-anthropogenic zones. pH at the Anthropogenic Zone ranged from 5.05 – 5.66 with the mean of 5.39±0.18 while the Non-Anthropogenic Zone ranged from 5.08 – 6.10 with the average of 5.49±0.32. Both zones had pH lower than the WHO limits, thus, implying that the water is acidic. Electrical conductivity at the Anthropogenic Zone ranged from 25.10 – 54.10 µS/cm with the mean of 36.24±10.27 µS/cm while the Non-Anthropogenic Zone ranged from 22.60 – 45.20 µS/cm with the average of 31.27±7.67 µS/cm. Turbidity at the

Anthropogenic Zone ranged from 39.40 – 76.80 NTU with the mean of 54.50±14.06 NTU while the Non-Anthropogenic Zone ranged from 40.10 – 65.60 NTU with the average of 46.40±8.86 NTU.

Salinity at the Anthropogenic Zone ranged from 0.02 – 0.04 ppt with the mean of 0.03±0.01 ppt while the Non-Anthropogenic Zone ranged from 0.02 – 0.03 ppt with the average of 0.02±0.01 ppt. The total dissolved solids at the Anthropogenic Zone ranged from 17.60 – 37.90 mg/l with the mean of 25.38±7.18 mg/l, while the Non-Anthropogenic Zone ranged from 15.80 – 31.60 mg/l with the average of 21.90±5.35 mg/l.

The Study Area showing Sampling Points
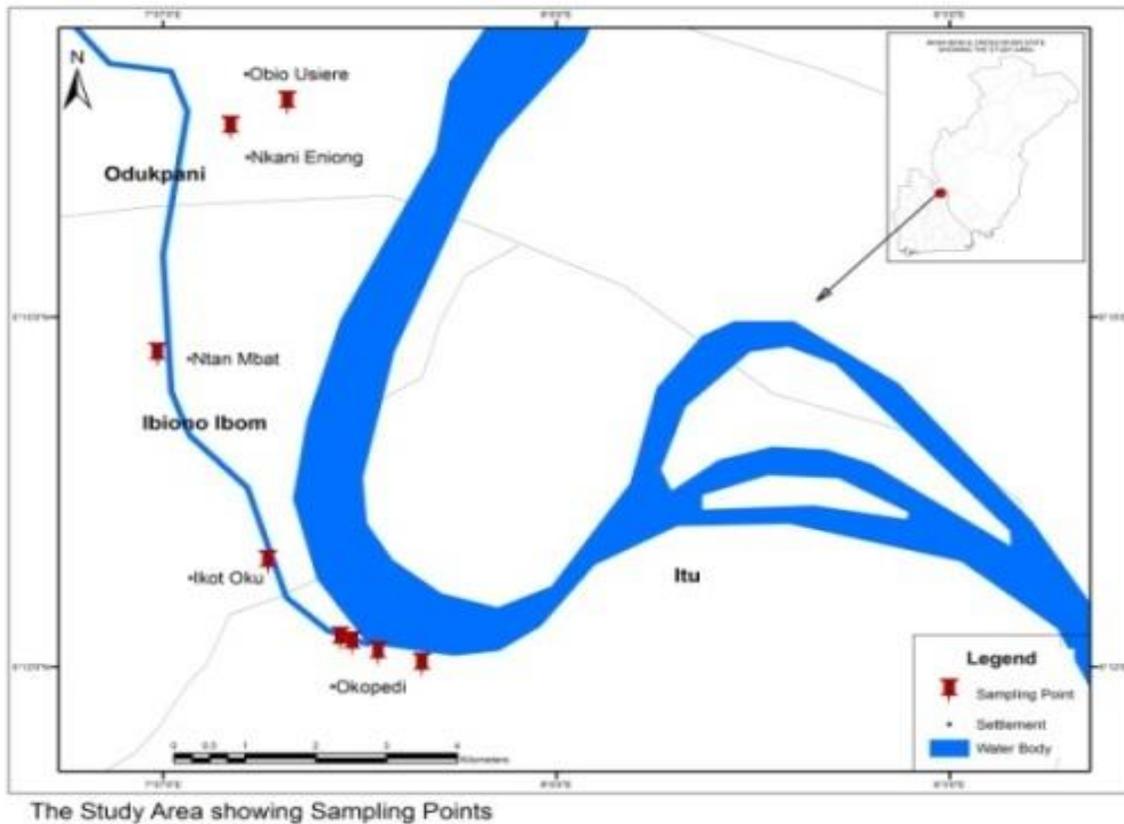
Fig. 1: Map of the lower Cross River showing the sampling locations in Eniong River in Akwa Ibom State, Nigeria. (Insert: Maps of Akwa Ibom and Cross River States showing Eniong River)

The total suspended solids at the Anthropogenic Zone ranged from 16.40 – 32.00 mg/l with the mean of 22.71±5.86 mg/l while the Non-Anthropogenic Zone ranged from 16.70 – 27.30 mg/l with the average of 19.34±3.69 mg/l. The total organic matter at the Anthropogenic Zone ranged from 1.86 – 3.23 % with the mean of 2.59±0.45 %, while the Non-Anthropogenic Zone ranged from 1.07 – 4.28 % with the average of 2.48±1.24 %. Dissolved oxygen at the Anthropogenic Zone ranged from 5.20 – 7.20 mg/l with the mean of 6.13±0.63 mg/l while the Non-Anthropogenic Zone ranged from 5.80 – 6.60 mg/l with the average of 6.20±0.29 mg/l. The biological oxygen demand at the Anthropogenic Zone ranged

from 0.10 – 0.80 mg/l with the mean of 0.43±0.23 mg/l while the Non-Anthropogenic Zone ranged from 0.10 – 0.50 mg/l with the average of 0.27±0.14 mg/l. The chemical oxygen demand at the Anthropogenic Zone ranged from 1.13 – 2.57 mg/l with the mean of 2.05±0.51 mg/l while the Non-Anthropogenic Zone ranged from 0.78 – 2.26 mg/l with the average of 1.72±0.53 mg/l. Nitrate at the Anthropogenic Zone ranged from 1.06 – 1.92 mg/l with the mean of 1.45±0.29 mg/l while the Non-Anthropogenic Zone ranged from 0.87 – 1.67 mg/l with the average of 1.21±0.24 mg/l. Phosphate at the Anthropogenic Zone ranged from 0.08 – 0.29 mg/l with the mean of 0.18±0.07 mg/l while the Non-Anthropogenic Zone

ranged from 0.07 – 0.52 mg/l with the average of 0.24±0.12 mg/l. Sulphate at the Anthropogenic Zone ranged from 0.36 – 3.79 mg/l with the mean of 2.76±1.42 mg/l while the Non-Anthropogenic Zone ranged from 0.26 – 3.28 mg/l with the average of 1.97±1.29 mg/l. Manganese at the Anthropogenic Zone ranged from 0.18 – 0.74 mg/l with the mean of 0.54±0.19 mg/l while the Non-Anthropogenic Zone ranged from 0.07 – 0.48 mg/l with the average of 0.35±0.14 mg/l. Calcium at the Anthropogenic Zone ranged from 0.14 – 26.80 mg/l with the mean of 22.68±4.83 mg/l while the Non-Anthropogenic Zone ranged from 10.50 – 26.60 mg/l with the average of 20.44±6.20 mg/l. Magnesium at the Anthropogenic Zone ranged from 2.20 – 2.49 mg/l with the mean of

2.36±0.1 mg/l while the Non-Anthropogenic Zone ranged from 2.05 – 2.37 mg/l with the average of 2.20±0.12 mg/l. Iron at the Anthropogenic Zone ranged from 3.05 – 3.67 mg/l with the mean of 3.27±0.21 mg/l while the Non-Anthropogenic Zone ranged from 2.67 – 3.37 mg/l with the average of 3.07±0.26 mg/l. Copper at the Anthropogenic Zone ranged from 0.05 – 0.18 mg/l with the mean of 0.13±0.04 mg/l while the Non-Anthropogenic Zone ranged from 0.02 – 0.18 mg/l with the average of 0.12±0.05 mg/l. Sodium at the Anthropogenic Zone ranged from 0.1 – 0.37 mg/l with the mean of 0.31±0.05 mg/l while the Non-Anthropogenic Zone ranged from 0.19 – 0.38 mg/l with the average of 0.26±0.07 mg/l.

Fig. 2: Showing different sampling points/anthropogenic activities observed during the study along Eniong River - a: Cassava Processing Plant; b: *In-situ* measurements; c: Cassava Fermentation; d: Market site.

Copper at the Anthropogenic Zone ranged from 0.05 – 0.18 mg/l with the mean of 0.13±0.04 mg/l while the Non-Anthropogenic Zone ranged from 0.02 – 0.18 mg/l with the average of 0.12±0.05 mg/l. Sodium at the Anthropogenic Zone ranged from 0.1 – 0.37 mg/l with the mean of 0.31±0.05 mg/l while the Non-Anthropogenic Zone ranged from 0.19 – 0.38 mg/l with the average of 0.26±0.07 mg/l. Statistically, the result showed that the mean value for Anthropogenic Zone was 9.95 with a standard deviation of 15.24 while that of the Non-Anthropogenic Zone value was 8.69 with a standard deviation of 13.06. The calculated

t-value was 0.28 with 36 degree of freedom (*df*) and a p-value of 0.78. However, since P>0.05, it therefore implied that there were no significant differences in the statistical values of the physicochemical characteristics of Eniong River samples between Anthropogenic and Non-Anthropogenic Zones. Furthermore, it was noted that although the mean value of 9.95 for Anthropogenic Zone showed that the statistical values for Anthropogenic Zone was a little higher than the Non-Anthropogenic Zone of 8.69 (with a mean difference of 1.27). The analysis

revealed that the mean differences between the two zones were not statistically significant.

These parameters were within the allowable WHO limits:

Table 1: Physicochemical characteristics of Eniong River, Nigeria

Parameter	Anthropogenic Zone		Non-anthropogenic		WHO accepted level
	Range	Mean ± SD	Range	Mean ± SD	
pH	5.05 – 5.66	5.39±0.18	5.08 – 6.10	5.49±0.32	6.5-8.5
EC (µS/cm)	25.10 – 54.10	36.24±10.27	22.60 - 45.2	31.27±7.67	500
Turbidity (NTU)	39.40 – 76.80	54.50±14.06	40.10 – 65.6	46.40±8.86	5
Salinity (ppt)	0.02 – 0.04	0.03±0.01	0.02 – 0.03	0.02±0.01	4
TDS (mg/l)	17.60 – 37.90	25.38±7.18	15.80 – 31.6	21.90±5.35	500
TSS (mg/l)	16.40 – 32.00	22.71±5.86	16.70 – 27.3	19.34±3.69	500
DO (mg/l)	5.20 – 7.20	6.13±0.63	5.80 – 6.60	6.20±0.29	5
BOD_5 (mg/l)	0.10 – 0.80	0.43±0.23	0.10 – 0.50	0.27±0.14	5
COD (mg/l)	1.13 – 2.57	2.05±0.51	0.78 – 2.26	1.72±0.53	N/A
Nitrate (mg/l)	1.06 – 1.92	1.45±0.29	0.87 – 1.67	1.21±0.24	50
Phosphate (mg/l)	0.08 – 0.29	0.18±0.07	0.07 – 0.52	0.24±0.12	N/A
Sulphate (mg/l)	0.36 – 3.79	2.76±1.42	0.26 – 3.28	1.97±1.29	250
Total Org. Matter (%)	1.86 – 3.23	2.59±0.45	1.07 – 4.48	2.48±1.24	N/A
Iron (mg/l)	3.05 – 3.67	3.27±0.21	2.67 – 3.37	3.07±0.26	1.00
Manganese (mg/l)	0.18 – 0.74	0.54±0.19	0.07 – 0.48	0.35±0.14	0.50
Calcium (mg/l)	0.14 – 26.8	22.68±4.83	10.5 – 26.6	20.45±6.20	75
Magnesium (mg/l)	2.20 – 2.49	2.36±0.10	2.05 – 2.37	2.20±0.12	30
Copper (mg/l)	0.05 – 0.18	0.13±0.04	0.02 – 0.18	0.12±0.05	2.00
Sodium (mg/l)	0.10 – 0.37	0.39±0.05	0.19 – 0.38	0.27±0.07	200

N/B: SD – Standard deviation of mean; N/A – Not applicable

Discussion

'Blackwater' occurs naturally in rivers and wetlands when decaying organic matter increases the level of dissolved tannin in the water, resulting in tea-coloured water. Hiriart-Baer *et al.,* (2013) described blackwater as when flood water moves across the floodplain, organic materials such as leaf litter and woody debris are broken down, which results in a higher concentration of dissolved organic carbon in the water. This is one of the main fuels for the aquatic food web, providing food for microbes and aquatic insects that, in turn, feed fish, frogs, birds and other wetland animals (Bertilsson and Jones, 2003). Blackwater in inland rivers and creeks is common, especially after flooding, and normally plays an important part in maintaining a healthy ecosystem (Fellman *et al*., 2009).

The pH of the study area was generally low. pH at anthropogenic point source was slightly lower than the pH at non-anthropogenic points. Therefore, there was no significant difference in pH between anthropogenic and non-anthropogenic zones. The mean pH of sampled areas of Eniong River tends towards acidity and this is typical of blackwater rivers due to high dissolution of organic matters in water resulting in release of fulvic acid as reported by Fork, (2012). The differences in the mean values of EC between the anthropogenic and non-anthropogenic zones in favour of the former can be justified by the relatively high

amount of dissolved substances in the water that aid electrical conductivity. EC is a measure of the total concentration of ions present in a water sample, which mostly is influenced by inorganic dissolved salts. Jonah and Avoaja (2019) supported this assertion by reporting that the positive increase of EC values of water bodies in wet season may be ascribed to the positive effect of rainfall which leads to subsequent runoff of nutrients and salt-rich substances from the inundated lands into the water body. This result is also in tandem with the report of Ekpo *et al*., (2012) for Ikpa River, Nigeria.

Clearly, the turbidity mean value for the anthropogenic zone was higher than that of the non-anthropogenic zone, due to the turbulence enhanced suspension of colloidal and particulate matter resulting from the discharges into the river from anthropogenic activities in such locations. WHO (2017) report which states that turbidity is caused by suspended chemical and biological properties in water, is a justification of higher turbidity levels of the anthropogenic zone as against the non-anthropogenic zone.

Similar to the turbidity were salinity, TDS, TSS and TOM mean readings for the anthropogenic zone which were generally higher than those of the non-anthropogenic zone as recorded from the sampled areas. The explanation for this trend is justified by the same principle of turbulence enhanced inundation of the anthropogenic zone by pollutants from the

anthropogenic activities that discharge solid wastes and effluents into the water at these locations. This is in agreement with Farm (2002).

Expectedly, the differences in DO, BOD_5 and COD mean values as recorded for both the anthropogenic and non-anthropogenic zones of Eniong River are in conformity with the known processes of dissolved oxygen behaviour in water as described by Zimmerman (1993). Dissolved oxygen is consumed either through chemical oxidation of these substances or through the respiratory processes of biological decomposition. The author further reported that decomposition of materials is a normal process in all aquatic ecosystems and is a function of decomposers such as bacteria and fungi. These organisms metabolize the organic matter as an energy and nutrient source and utilize dissolved oxygen in the process. However, serious consequences can result if these natural mechanisms are overloaded by large influxes of organic matter. Severe oxygen depletion can result in the loss of desirable aquatic life and may produce an odorous anaerobic system. The Blackwater River has a unique water chemistry that is generally, inherently, low in nutrient and dissolved oxygen levels which makes it particularly susceptible to undergoing changes when contaminated with nutrients or chemicals (Blackwater River State Forest, 2009).

Dissolved oxygen levels in inland rivers are typically around 6-9 mg/l, which maintains healthy habitat and a diverse mix of aquatic organisms. Low dissolved oxygen levels in inland rivers and creeks can lead to stress and death in native fish and other aquatic animals. Prolonged periods at or below 4 mg/l typically result in physiological stress to fish and crustaceans. Fish may be seen 'gasping' for air near the surface or floating on their sides and crayfish may leave the water. At 3mg/l and below, the risk of fish mortality, or fish kill, increases. Fish kills can be quite localized around areas where oxygen levels have been reduced (Ekpo *et al*., 2012).

The preceding variation levels of the nutrients/elements (phosphate, sulphate, magnesium, calcium, manganese, iron, copper and sodium) as recorded in Eniong River between the anthropogenic and non-anthropogenic zones as recorded for Eniong River, can be said to be typical of most flowing blackwaters. This sort of variation from one anthropogenically contrasting location to another, irrespective of the sources of introduction, is due to the inherent changes these elements undergo in water. The inherently low nutrient and dissolved oxygen levels of black water make it particularly susceptible to undergoing changes when contaminated with nutrients or chemicals. The result is a rapid movement of nutrients from their source to nearby ground or river waters. Nutrients entering the river can drive a proliferation of algal growth increasing the biological oxygen demand, resulting in a decrease of the already

low dissolved oxygen levels (Blackwater River State Forest, 2009). The sandy materials comprising much of the geology and soils in the area do not retain organic materials well and nutrient pollutants move through them easily. The result is a rapid movement of nutrients from their source to nearby ground or river waters. Nutrients entering the river can drive a proliferation of algal growth increasing the biological oxygen demand, resulting in a decrease of the already low dissolved oxygen levels (Blackwater River State Forest, 2009).

This unstable nature of these elements in blackwaters is affirmed in House and Denison, (2002). In that study these authors carried out in rivers from Thames catchment and reported that the Wey, Blackwater and Great Ouse, sewage inflows had no detectable effect on the sediment concentrations of total calcium, iron and organic matter whereas for the Blackwater and Great Ouse, the total phosphorus contents of the sediment were higher downstream of the effluent input in comparison with a less impacted upstream location. Relationships between the total phosphorus content of the sediments and contents of iron, calcium and organic matter indicated marked differences between the rivers. Although the organic matter content of the sediments was found to be a significant predictor for the total phosphorus concentration for the Blackwater and Great Ouse, the total iron content was also useful for the Blackwater and total calcium for the Great Ouse. It is postulated that this difference is a result of the sediment processes that are known to occur in these two systems, i.e. co-precipitation of phosphate with calcite in the Great Ouse and the formation of vivianite in anoxic sediments of the Blackwater. Other studies are in consonant with the observed trends (Farm, 2002; Eash *et al*., 2007; Augustyn *et al*., 2016). Hence, the Ho is therefore accepted and can be concluded that there is no statistical difference in the physico-chemical characteristics of Eniong River water between Anthropogenic Zone and Non-Anthropogenic Zone.

Conclusion

Despite the clearly contrasting scenarios of anthropogenic activities between the locations sampled, the resultant insignificant differences of the physicochemical parameters measured is attributable to the sustained dilution effects of the water in areas prone to anthropogenic activities, due to continual flow of the river from upstream to the down-stream areas and other associated chemical processes that tend to equalize concentration levels of pollutants in such flow of blackwaters. A research conducted by Dan *et al.,* (2014), corroborated this assertion of dilution effects bringing about a near homogenization of physico-chemical parameter levels in flowing rivers, irrespective of the location pollutant status; it was found that the seasonal variations, distribution

pattern, enrichments and contamination of heavy metals in Qua Iboe River estuary in Nigeria showed elevated concentrations during the wet season months. The authors attributed this trend to adsorption/dissolution and distribution of the physicochemical parameters viz; temperature, salinity, pH, TDS, DO, TSS and electrical conductivity.

Recommendations

Based on the findings of this study, the following recommendations were made:

- There should be concerted effort of the regulatory authorities to adequately monitor all forms of solid waste and effluent discharges into Eniong River particularly at the identified major anthropogenic areas, in order to reduce its pollution impacts on the river.
- Further researches such as microbial profile comparison between the anthropogenic and non-anthropogenic areas of the rivers should be carried out to as a means of further understanding the impacts of pollutants on the flora and fauna of the river.
- Sensitization and awareness campaign programmes should be mounted to enlighten all stake holders, particularly the local populace involved in the various waste and effluent generating anthropogenic activities on the need to curtail/eliminate practices, due to its negative impacts on the water quality of the river.

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Incidences and relative rank positioning pattern of mass media usage for climate change extension service delivery in Akwa Ibom State, Nigeria

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Mass media, incidences index, utilization, extension, service delivery, climate change

Abstract

Mass media have contributed greatly the communication on uncertainties surrounding climate change and have become very central to the enhancing of knowledge among the educated population in the environment with limited access to information resource material. Despite its strategic importance in the development process, the study sought to establish the pattern of mass media usage for climate change extension service delivery in Akwa Ibom State. Specifically, pattern of incidence index and relative rank positioning analysis of climate change information seeking behavior of field extension agents were analyzed, the usage incidences index and relative rank positioning analysis of mass media as information sources for climate change extension service were assessed and lastly, pattern of incidence index of usage of climate change information sources among field extension agents were ascertained. The study was conducted in Akwa Ibom State and the entire field extension agents who were present to participate in the survey served as the population and sample of the study. Primary data were used for the study and descriptive statistics were used to provide answers to the objectives. Based on the findings, the demographic characteristics revealed there was relative gender balance composition among the field extension officers and were educationally adequate indicating a minimum qualification of National Diploma Certificate constituting 23 % of the population. Age distribution indicated that more than 90 % of the populations were less than 50 years. The information seeking behavior of the field extension revealed various magnitude of incidences index and four major patterns were identified with the highest index pattern portraying information seeking on climatic issues as worthwhile and beneficial to understand. Utilization of old media sources were highly ranked and field agent were effectively proficient. Therefore, mass media sources were quite veritable source of information for the field extension agent.

Introduction

The mass media communications through web, television, radio and the papers offer the pathways that huge number people can get information and amusement. The media is one of the genuine instruments required for the conveyance of key messages on atmosphere issues (Adams *et al.*, 1999), particularly in the districts and areas that are as of low socioeconomic wellbeing status. It has moderately taken long for the world to confront the way that the earth is getting hotter and individuals are for the most part to be fault (IPCC, 2007a). Not all the world's occupants are prepared to acknowledge that everybody can make a move to alleviate the harm (Marty and Northey, 2002 and Ekpoh and Ekpoh, 2011), environmental change is currently a worldwide phenomenon and the effects in various locales is getting progressively huge (Spore Extraordinary Issue, 2008).

With increasing climatic change, much pressure is experiences by the population, which will be prone to more climate variability in the future, should seasons become shorter when temperature rises. Rice yield, for instance begin declining at once again 34 ℃. Much all the more stressing are changes in the stormy season and precipitation force, since these components have direct effect on yields and fisheries areas (IPCC, 2007b). Falling yields in zones that depend solely on farming have been noted to have

experience disruptive impact of climate change (Spore Extraordinary Issue, 2008, FAO/UN, 2007 and IPCC 2007a). In most developing regions, the early stage of climate variability was ascribed to sociocultural beliefs, as of late, a look into reports have revealed that the atmospheric and ecological changes have impacted on the vulnerabilities of vulnerabilities of people and over the planting seasons overtime, which has prompted an uncommon grouping of poor food productivity and nutritional inadequacies (FAO, 2008; Inyang and Okoro, 2008 and Inyang *et al.*, 2013). Nothing can stop the changing state of environment and climate and also the available options are to explore alternative to mitigate its impacts, thus, specialized help is required for formation of climate smart technologies to adapt to the effects of environmental change on vocations from fishery and agribusiness especially in the dry tropical locales in the sub-Saharan Africa (FAO/UN, 2007 and FAO, 2008).

It is fundamental that the field development communication specialists be progressively proactive in gaining and disseminating environmental change information data through the broad communications procedure to the regions that their level of knowledge is low. The messages that should be imparted unmistakably are: environmental change is genuine and the impact is long term; it is conceivable to adjust to the effects environmental change will bring and mitigate the causes and, there are dangers to the do-

nothing choice. This could be addressed essentially through raising the degree of attention drawn to the chances and dangers due to environmental change and to acknowledge their duties to adjust to and relieve against its effects. Individuals who are seriously affected by environmental change will be better ready to adjust on the off chance that they are very much educated about the issue. Farmers will change the assortments of seeds they plant, the harvests they develop, the occasions they plant and procure and versatile methods to advance aquaculture and oversaw distinctive fisheries. Water and different assets will be husbanded unmistakably more cautiously. Floods and dry spell will be envisioned and made arrangements for vocations and organizations will change and adjust, FAO/UN (Nourishment and Agribusiness Association, 2007).

Among a set of satisfactory and sustainable action to deal with limited human capacity on ecological, environmental and climatic change versatility is through training and learning augmentation. This could take several forms even including the mass and web-based approaches (Umejei, 2008; Onokerhoye, 2011; FAO (2008); IPCC, 2007b; Inyang *et al.*, 2004). Along these lines, data and information sourcing infrastructures forms the centre necessary for the capacity building process if advancement of productive field extension agents in rural improvement program and other sustainable development communication programme is emphatically wanted (Inyang *et al.*, 2004). As indicated by Udoh (2001); Solomon *et al.*, (2006); Inyang *et al.*, (2012), the field specialists are basically mandated for behavioural change information communication in crops, fisheries, ranging service, and domesticated animals. Their significant target is to encourage improved profitability and upgrade in national food security and mitigate poverty. They are to offer specialized advisory services to advance actualization of efficiency of intervention programmes. They are the educators to the farmers and non-farmers, Udoh (2001). Many researchers have observed vulnerability as changes in climatic conditions unfolds (Inyang *et al.*, 2013; IPCC, 2007a, b; FAO, 2008 and FAO/UN, 2007.

In spite of the fact that positive and negative situations are being estimated, numerous worries are paid towards more hazard to the farmers, farming households in Akwa Ibom State may not comprehend the drivers of environmental change (Inyang *et al.*, 2013). Yet, it is sure that the uncertainties of environmental and climatic change will adjust the agronomic time frame and cause numerous adaptive techniques in zones so as to alleviate and adjust to the unfolding condition (Fischer *et al.*, 2002). Certainly, incomes and other socio-economic livelihood activities that define socio-economic status of farmers would be in danger as lion's share are as of now living beneath the World Bank Poverty line of two (2) dollars per day (Adams *et al.*, 1999).

Akwa Ibom State in particular, could experience worst climate variability if a large portion of its agricultural and rural development communication officers are ignorant of the fundamental issues and the grave difficulties the critical issues have on the drivers of environmental and climate change (Umejei, 2008). Akwa Ibom State have experienced related stressors, which are impacting on the traditional agricultural procedure and yields, causing poor yield of crops and fisheries (Inyang and Okoro, 2008 and Inyang *et al.*, 2013). Having understood that perhaps the best ways to deal with a capacity building on ecological and climatic change developing effective curriculum on smart agricultural education, it got practical to survey the human asset resource of the Akwa Ibom Rural Development Program on the ecological and climatic change friendliness and how the field extension agent source information on topic.

Methodology

The study was carried out in Akwa Ibom State across the six (6) agricultural development project zones covering the thirty-one (31) local government areas being located at latitude $4^0 33^1$ and $5^0 33^1$ North and longitude $7^0 25^1$ and $8^0 25^1$ East. The State occupies a total land area of 7,246 km^2, with an estimated population of about 3.9 million (NPC, 2006). The study area is dominated by crop farmers, fisher folks and substantial fish farmers. In addition, some micro-livestock are usually raised at background of most homesteads.

The study population is made up of all field personnel or agricultural development communicators of Akwa Ibom State Agricultural Development Programme (AKADEP). The population served as the sample size, out of the 206 respondents earmarked to administer the questionnaire, a total of 178 respondents on the extension agents willingly participated in the exercise. Descriptive statistics such as frequency count and simple percentages were used to analyse data collected on socio-demographic characteristics, information seeking behaviour and mass media usage for information for climate change extension service by AKADEP agents. Incidence Index analytic procedure was used to derive the proportional or probabilistic estimate of the measurable attributes of the information seeking behaviour status on climate change and mass media usage for information for climate change extension service by AKADEP agents.

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Results and Discussion
Demographic characteristics of the field extension agents

Table 1 item 1. Showed that majority (61.2 %) of the respondents were male whereas 38.8 % were female. Item 2 revealed that 23.0 % of the respondents have National Diploma (ND), 42.1 % have Higher National Diploma (HND), 33.7 % have Bachelor's Degree while 1.1 % have other higher educational qualifications. This result revealed that all the respondents had acquired some form of formal education and should be capable of seeking

information with minimum supervision. As majority of the respondents are graduates, it implies that they should be better informed and able to communicate to others about topical issue like climate change. Item 4 showed that 66.3 % of the respondents were between the age ranges of 30- 39 years. Other distributions (27.0 % were in the range of 40-49 years, 6.7 % in the range of 50-59 years) the above deposition revealed that percentage decreases with an increase in age. Therefore, shows that AKADEP agents are relatively young agents supposed to be active, curious and willing to improve in their knowledge.

Incidence index and relative rank positioning analysis of climate-change information seeking behaviour of field extension agents
Table 2, item 1 revealed that 75.3 % of the respondents disagreed that they find it hard to go about searching for climate change literature in libraries while a few of 24.7 % agreed. This suggested that there is that curiosity and willingness to seek for climate change information in libraries and other sources among field agents. This corroborate with assertion by Awolumate (2008) that the agents do willingly seek climate change information in libraries and other sources. Item 2 about 14.6 % of the respondents agreed that they don't always like to waste their energy to search for climate change information while 85.4 % of the respondents disagreed on that. This implies that climate change is gaining more interest among the field agents of AKADEP this is owing to the quest of ensuring effective climate smart services. Item 3 about 19.1 % of the respondents agreed that they feel discouraged to source for climate change information considering the time needed for the search of such information while 80.9 % of the respondents disagreed with that. Item 4 about 63.5 % of the respondents agreed that they feel discouraged to source for climate change information because library services are poorly organized.

Pattern of incidence index of climate change information seeking behaviour of extension agents
Agricultural production in the face of changing climate requires an aggressive extension services and this goes with the effort to ensure effective climate smart service delivery. This ultimate objective is possibly achieved through the interactive knowledge exchange between field extension agents and research institutions that specialized in the climate smart agriculture. In addition to the above platform, the field agents alternatively seek for more climate change information from mass and social media to augment for the shortage that always result from institutional dysfunction. In their effort towards seeking alternative solutions, field agents' exhibits diverse behaviours to climate change information sourcing.
The result of the Table 3 revealed that majority (50 %) of the respondents considered climate change information sourcing a worthwhile and beneficial to understand with climate change information seeking

behaviour above 80 %. 20 % of the respondents with (CCISB less than 80 %) asserted that climate change information seeking is most interested to acquire extra information. In the same vein, 20 % of the respondents with (CCISB less than 70 %) perceived climate change information seeking as an obligatory task. A few representing 10 % of the respondents with (CCISB less than 60 %) were highly motivated in the week of climate change information in unorganized ways. Based on the distribution of the extension service delivery agents' climate change information seeking behaviours, there is an essentially an increased value system on the tropical issues among the extension service dysfunctional library services and facilities which ultimately affect the utilization of such facilities and services. This corroborate with the early assertion by Awolumate (2008) that Information sourcing infrastructure and environment do influence the pattern of information resource utilization especially on a subject matter that is quite technical and evolving. Based on the distribution of the respondents across the items, extension personnel were actively involved in climate change information seeking. This is inconsistent with the early claims by Idiake-Ochei *et al*., (2016); Awolumate (2008); Inyang *et al*., (2004).

Usage incidences index and relative rank positioning analysis of mass media as information sources for climate change extension service
Assessing the extension service delivery agents' extent of climate change information sources utilization is an attempt to assess the magnitude and the directions of use of climate change information sources among field extension agents. Accordingly, from the Table 4 below, it was revealed that the old media sources were the most preferred source of information among the respondents than the modern and electronic media. This was evident relatively from relative rank positions in Table 4 that showed that Journals (62.4 %), Radio/television (58.4 %), Newsletters (57.9 %), Newspaper/magazines (52.2 %) and Conference proceedings (51.1 %) as the most preferred information sources among the respondents. This result affirmed the previous claims by Awolumate (2008) and Idiake-Ochei *et al*., (2016) that asserted print source as preferred sources of information by extension service delivery agents.

Pattern of incidence index of usage of climate change information sources among field extension agents
Information sourcing forms the core requirement for capacity building process for field extension agents in Agricultural Development Programme and other development communication agencies. Hence, assessing the pattern of incidence index and implication of the usage of climate change information sources shades light to the effectiveness of the field extension agents to the climate change information sources as this will determine to a great extent quality and the number of climate smart

information at their disposal to ensure effective climate smart service delivery. Relatively from the Table 5, it was revealed that majority (36.4 %) of the respondents was better with climate change information sources status (CCISS) less than 60 %, equal rate 18.2 % of the respondents was good (CCISS less than 50 %) and worst (CCISS less than

20.0 %) respectively in terms of information gaining rate, equal rate 9.1 % of them were sufficient (CCISS 66.9 %), bad (CCISS less than 40 %) and worse (CCISS less than 30 %) respectively. This implies that the extension service delivery agents are considerably good.

Table 1: Distribution of field extension agents based on demographic characteristics

Item	Variable	Frequency	Percentage
1	**Sex**		
	Male	109	61.20
	Female	69	38.80
2	**Level of Education**		
	OND	41	23.00
	HND	75	42.10
	BSC	60	33.70
	PG certificates	2	1.10
3	**Age**		
	30-39	118	66.30
	40-49	48	27.00
	50-59	12	6.70

Table 2: Distribution of extension agents based on climate change information seeking behaviour

S/N	Information seeking behaviour	Strongly Disagree	Disagree	Agree	Incidence index	Relative Ranking
1	I find it hard to go about searching climate-change literatures or information in libraries	11.2	64.1	24.7	0.753 [b]	7th
2	I don't always like to waste my energy to search for climate change information.	20.4	65.0	14.6	0.854 [a]	1st
3	When I consider the time, I will use to search, I normally feel discouraged	25.2	55.7	19.1	0.809 [a]	4th
4	I do feel discouraged because library services are poorly organized.	19.5	17.0	63.5	0.365 [d]	10th
5	It is discouraging to search because my expectations are hardly available.	14.6	50.8	32.6	0.654 [c]	9th
6	I don't to find information when I don't have something as reward.	20.1	64.7	15.1	0.848 [a]	2nd
7	I cannot regard search for information as part of my hobby.	4.8	64.3	30.9	0.691 [c]	8th
8	I like to avoid situation that will require me searching for information.	7.1	76.6	16.3	0.837 [a]	3rd
9	I don't interest to search for information about climate change.	23.6	52.2	24.2	0.758 [b]	6th
10	I don't usually border myself to personally look for information since I will get from my friend.	6.6	73.8	19.6	0.804 [a]	5th

Table 3: Showing pattern of incidence index analysis and implication of climate change information seeking behaviour

CCISB Incidence index Pattern	CCISB Incidence Index range	CCISB Item Frequency	Percentages Composition	CCISB Index interval interpretation
A	0.8 - 1.00	5	50	Considered it a worthwhile and beneficial to understand
B	0.7 - 0.799	2	20	Most interested to acquire extra information
C	0.6 - 0.699	2	20	Perceiving as obligatory task
D	Less than 0.599	1	10	Highly motivated to seek for information in unorganized environment

Table 4: Distribution of field extension agents based on extent of utilization of climate change information sources

Item	Information sources	Extent of Usage			II and RRP
		Most	Rarely	Never	
A	**Old Media**				
1	Textbooks	30.90	58.40	10.70	[d]0.309[8th]
2	Catalogues	21.90	56.70	21.30	[e]0.219[9th]
3	Conference proceedings	51.10	38.80	10.10	[b]0.511[5th]
4	Dissertations and thesis	15.20	68.00	16.30	[f]0.152[11th]
5	Journals	62.40	28.70	9.00	[a]0.624[1st]
6	Monograph	42.10	38.80	19.10	[c]0.421[7th]
7	Newsletters	57.90	35.40	6.70	[b]0.579[3rd]
8	Newspaper/magazines	52.20	41.00	6.70	[b]0.522[4th]
B	**Modern and Electronic Media**				
9	CD. Rom literature search	16.90	61.20	21.90	[f]0.169[11th]
10	Radio/television	58.40	38.80	2.80	[b]0.584[2nd]
11	Internet/electronic mails	43.30	37.66	19.10	[c]0.433[6th]

Table 5: Showing pattern of incidence index analysis and implication of the usage of climate change information sources (CCISU)

CCISU Incidence index Pattern	CCISU Incidence Index range	CCISU Item Frequency	Percentages Composition	CCISU Index interval interpretation
A	0.6 - 0.699	1	9.09	Sufficient
B	0.5 - 0.599	4	36.36	Better
C	0.4 - 0.499	2	18.18	Good
D	0.3 – 0.399	1	9.09	Bad
E	0.2 – 0.299	1	9.09	Worse
F	0.1 – 0.199	2	18.18	Worst

Conclusion

This research focused on the estimate of the measurable attributes of the information seeking behaviour status on climate change and mass media usage for information for climate change extension service by AKADEP agents. The result of the study revealed that extension personnel were actively involved in climate change information seeking despite the poor library services experience by the respondents. The result of the study also revealed an increased value system on the topical issues among the extension service delivery agents. This was evident by the majority (50 %) of the respondents that considered climate change information sourcing a worthwhile and beneficial to understand with climate change information seeking behaviour above 80 %. The study as well revealed old media sources as the most preferred source of information among the respondents than the modern and electronic media. The result further revealed that the extension service delivery agents are considerably good in terms of effectiveness in seeking of climate change information as this will ensures effective climate smart extension service delivery. Based on the findings, Government should continue the recruit of young graduates for extension work as younger extension personnel tends to seek information more than the older extension personnel. There should be a proper linkage of extension institution and the agricultural research centers such as universities and research institutes.

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Attributes of the trophic biology of the long-legged aquatic Frog, *Ptychadena Bibroni* (Amphibia: Ranidae) in a rain-forest ecosystem wetland of Southeastern Nigeria

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Abstract

As a micro-livestock, *Ptychadena bibroni,* is one of the least studied frog species in the family Ranidae. Thus, literature of its biology in Nigeria is limited. Consequently, attributes of the trophic biology of the long-legged aquatic frog, *P. bibroni* were studied over a 12–month period, based on 499 specimens (total length range: 10.0 – 19.0 cm TL; snout vent length: 2.5 – 8.5 cm SVL), from perennial wetlands of Ikot Nkpene village, Nsit Atai Local Government Area, Akwa Ibom State, Nigeria. Feeding intensity was higher in females than males; it was also higher in dry season (November – April) than during the rains (May – October). Dominant food objects were the orthopterans (grasshoppers and crickets) while Annelida (earthworm), Arachnida (spider), hymenopteran ants, un-identified adult insects, insect remains, mud and abiogenic sand exception of tiny immature frogs (un-consciously eaten food object), were minor food objects. Variations in food composition with sex, months and season are presented. Food richness was higher males *vis-à-vis* the females and in dry than wet seasons. Diet breadth was higher in the dry than wet seasons, but no marked sex-link variation was discerned. Primarily, the study will fill the gap which still exists in the knowledge of some of these wetland resources. Secondly, these information gaps have to be filled to guarantee effective conservation planning and future action.

Introduction

Nigerian rainforest belt supports considerable stocks of aquatic anuran frogs. The genus *Ptychadena* constitutes a significant proportion of the frog fishing in different geographic terrain where they occur. In the wetlands of southeastern Nigeria, the genus *Ptychadena* (Family: Gobiidae) (Guibe and Lamotte, 1957) is usually the most abundant group; where it forms the dominant catch and/or landing of the subsistence fishery especially in the southern part of Nigeria.

The *P. bibroni*, in spite of it as a source of protein-rich to rural/urban communities of the rainforest of Nigeria, very little attention has been given to its biology and ecology. Save for Udo and Thomas (2008), no report was encountered for *P. bibroni*. Why this has been the case in Nigeria is probably mainly because basic literature has been lacking or inaccessible. Sexes are of anurans are generally the same in colour; but Udo and Thomas, (2008) reported sexual dimorphism in some morphometric parameters between sexes of *P. bibroni*. A large number of edible frogs belongs to the Pipidae/Xenopodidae and the Ranidae families in Nigeria; and the frogs are valued as food by humans and also have many cultural roles in literature, symbolism and religion (Udo, 2018).

There appears to be little information on taxonomic investigation of the amphibians of Nigeria. Confusion on a clear census of the anuran assemblages exists also; the available records merely showed that, there are at least 28 species of frogs (Stubbs and Groombridge, 1986; World Conservation Monitoring Centre, WCMC, 1988) but hitherto, Schiotz (1963) documented that, there were over sixty-seven species of frogs from Nigeria. In spite of this mix-up, reports by workers abound in Nigeria on the crowned bullfrog, *Hoplobatrachus occipitalis* (Udo *et al*., 2007; Ogoanah and Uchedike, 2011; Ajibola *et al*., 2016). Other investigations in areas of parasitology, ecotoxicology including biodiversity of the anurans have been reported (Reid *et al*., 1990; Aisien *et al*., 2009; Ezemonye and Tongo, 2010; Oldham, 2000; Akanni *et al*., 2003).

Generally, literature on food of anuran appears to reflect on unspecialized and opportunistic predators (Smith, 1951, Lee, 1967 or cf. Houston, 1973). The present study involving, assessment of diet and feeding intensity of the long-legged aquatic frog, *P. bibroni*, in

relation to sex, month and season, is a contribution to this dearth of literature on Nigerian frogs.

Materials and methods

The present study was conducted in perennial rainforest wetlands of Ikot Nkpene village, Nsit Atai Local Government Area (LGA) (4° 35' – 5° 12' and 7° 48' - 7° 42'), (Fig. 1). Akwa Ibom State, Nigeria. The perennial swamp is a fresh water body. Soil of the surrounding riparian vegetation is brown to black in colour and there is high percentage of humidification. Between September, 2009 and August, 2010, samples of *Ptychadena bibroni* were collected from the study area. The monthly samples were obtained using funnel and basket-valved traps (Udolisa *et al*., 1994). The specimens collected were preserved in 4-5% formalin and taken to Department of Fisheries & Aquatic Environment Management Laboratory, University of Uyo, for further analysis.

In the Laboratory, total length (TL: distance between tip of snout and end of longest toe on the stretched hind limb) (Udo and Thomas, 2008) and snout-vent length (SVL: distance between tip of snout and end of cloaca) of specimens were measured to the nearest 0.1 cm. Body weight of the frogs (BW) were taken on a top-loading (Mettler PS 160) electronic balance to the nearest 0.001 g.

Specimens were later dissected and the stomach removed and slit open. The degree of fullness of each stomach was estimated by an arbitrary 0 – 20 points scale; therefore, 0, 5, 10, 15 and 20 points were allotted to empty, ¼ full, ½ full, ¾ full and fully distended stomachs respectively. The percentage of non-empty stomachs (NES), full stomachs (FS), partially-filled stomachs (PFS i.e. ¼ to ¾ full stomachs) and mean stomach fullness (MSF) were used to evaluate patterns in feeding.

To examine diet composition of *P. bibroni,* the stomach contents of each specimen were placed in a petri-dish and aggregates were dispersed in distilled water. The contents were examined using dissecting microscope and assessed by the frequency of occurrence (cf. King *et al*., 1991); the integrated importance of each item was then expressed by an index; modified food object number ((*MFON*) by Udo (2002).

Food richness was defined as the number of major items in the diet; the *MFON* data were used to compute diet

breath based on Shannon's function, H. The generated data involving assessment of diet and feeding intensity of the frog species in relation to sex, month and season, were analyzed by t-test and d-statistics (Bailey, 1959, Ogbeibu, 2005).

Results

The number of specimens examined per month and their size ranges are presented in Table 1. Of the 499 specimens of *P. bibroni* examined for food, 9 (1.8%) had full stomachs, 497 (99.5%) non-empty and 488 (97.7%) partially-filled stomachs.

Change in feeding intensity with sex
A total of 499 specimens, comprising 349 males (size range 10.0 – 17.0 cm TL; 2.5 – 7.0 cm SVL; 4.132 – 25.383 g BW) and 150 females (11.0 – 19.0 cm TL; 4.1 – 8.5 cm SVL; 7.779 – 53. 526 g BW), were examined for sex-dependent variation in feeding intensity. The stomach repletion of both sexes showed that FS (d = 3.907 < 0.001) and MSF (t = 10.952, 496df, P < 0.001) were a significantly higher in females than males. Nevertheless, there was a significant increase in PFS (d = 12.297, P<0.001) in males over females, thus

suggesting that feeding intensity was higher in the female frogs *vis-à-vis* the males.

Change in feeding intensity with months
Despite variations in the monthly stomach repletion, peak value of NES (September, October, December, January, March – August), FS (October and December), PFS (January, March – June and August) and MSF (October and March) supposedly occurred in October, December and March. These results indicated high feeding intensity in October, December, March – June while low feeding intensity occurred in November and February.
A total of 255 specimens (size range 10.0 – 17.0 cm TL; 2.5 – 7.0 cm SVL; 4.518 – 25.383 g BW) were examined in the dry season and 344 (10.0 – 19.0 cm TL; 3.5 – 8.5 cm SVL; 4.132 – 53.526 g BW) in the rainy season. There was no significant seasonality in NES, FS, and PFS of the frogs (d-test: P > 0.05 in each case). However, there was a significant dry season increase in MSF (t = 2.9507, 496 df, P < 0.01), thus suggesting that feeding intensity was higher in the dry season than during the rains.
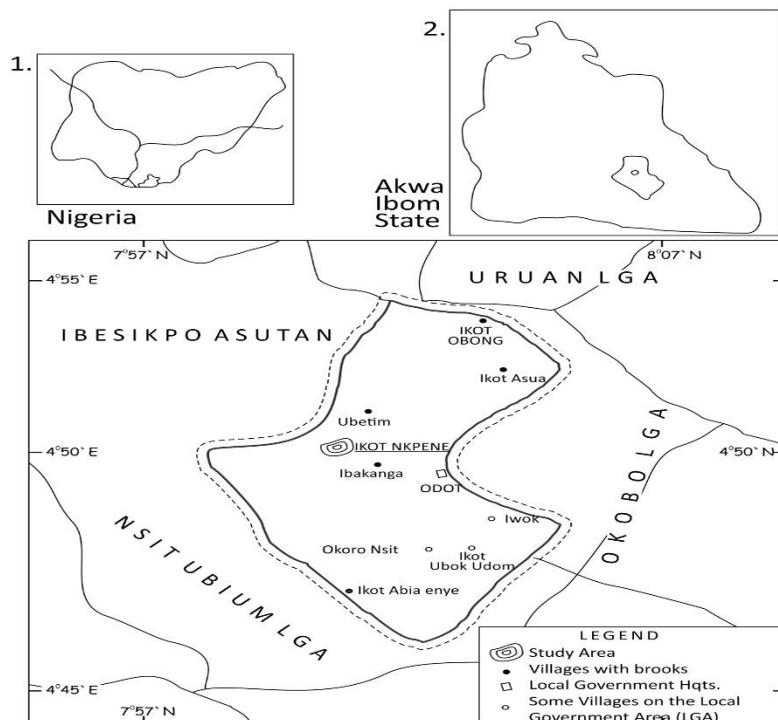

Fig. 1: Map of Nsit Atai Local Government Area showing the study area. **Insert 1:** Map of Nigeria showing location of Akwa Ibom State **Insert 2:** Map of Akwa Ibom State showing location of Nsit Atai Local Government Area.

Table 1. Monthly numbers and sizes of *P. bibroni* examined for food

Month	Number examined	Total length, TL (cm)	Snout-vent length, SVL (cm)
September	52	11.1 – 17.0	3.9 – 7.0
October	38	10.1 – 16.0	4.0 – 6.4
November	50	11.0 – 16.0	4.0 – 6.1
December	35	10.0 – 19.0	3.8 – 5.1
January	61	11.0 – 16.0	4.0 – 6.5
February	45	11.0 – 16.0	3.3 – 6.5
March	31	13. 0 – 16.5	4.0 – 6.0
April	38	13.0 – 16.0	3.5 – 6.0
May	39	13.0 – 15.0	4.2 – 5.3
June	39	11.0 – 17.0	3.0 – 6.0
July	38	10.0 – 15.0	2.5 –5.5
August	33	11.0 – 15.0	3.0 – 5.5

Diet composition
The overall stomach contents of *P. bibroni* (Table 2) revealed that 9 food objects were eaten; out of which 2

were of primary importance, 6 minor and one of incidental importance. The frogs fed prominently on Orthoptera (grasshopper 40.3% *MFON* and cricket

19.7% *MFON*) while earthworm, spider, ant, unidentified adult insect remains and sand grains (<10.0% *MFON*) were of minor importance, and only juvenile of frogs forming less than 1.0% *MFON* of the objects.

Annelida consumed were mainly earthworm, Arachnida were composed of spiders, Anuran comprised immature frogs, insects consisted of grasshopper, crickets, ants and unidentified adult insects, mud and sand grains. The occurrence of some immature frogs in the stomachs of some specimens studied was indicative of cannibalism and/or starvation. However, most of the stomach contents of *P. bibroni* from the study were revealing of active foraging on live animals. However, the inclusion of small amount of mud and sand grains is a clue that they also feed close to the substratum.

Change in diet with sex

Sex-dependent change in the food composition of *P. bibroni* is summarized in Table 3. Food richness was higher in males than females. Juvenile frogs and Hymenoptera (ant) were not ingested by females while the complete array of objects shown in Table 3 was consumed by the males. Although both sexes exhibited

similar patterns in the rank-order of the *MFON* of the food objects (r = 0.7302; P < 0.05), the proportions of some of them were different.

Males had significantly higher *MFON* of earthworm, unidentified insects, insect remains while females had higher *MFON* of spider, cricket, mud and sand grains. There was no variation with sex of the *MFON* of grasshopper. Diet breadth was 6.4% higher in males *vis-à-vis* the females.

Monthly dynamics in food richness ranged from 8 in August and September to 10 (January, July and October). High values (9 - 10) were recorded in January - July, October - December while low values (less than 9) were obtained in other months. Annelida, Arachnida, Orthopteora (grasshopper) Hymenoptera (ant), unidentified adult insects and sand grains predominated in all months.

Annelida peaked in February, August and November, Arachnida peaked in March and December, Grasshopper (Orthoptera: peaked in January, June and October), Ant (Orthopera: peaked in May), Un-identified adult insects peaked in September and October, and with peaks of sand grain occurring in May and September.

Table 2: Overall trophic spectrum of *P. bibroni*

Food object	Modified food object number (MFON %)
Annelida	
Earthworm	9.8
Arachnida	
Spider	4.3
Anura	
Immature frogs	0.8
Insecta	
Orthoptera	
+ Grasshopper	40.3
+ Cricket	19.7
Hymenoptera	
+ Ants	3.8
Un-identified adult insects	9.9
Insect remains	4.6
Mud	2.9
Sand grains	4.1

Table 3. Intersexual regimes in trophic spectrum of *P. bibroni*

Food object	Modified food object number MFON %		
	Males	**Females**	**d – statistics**
Annelida			
Earthworm	12.1	3.1	7.571**
Arachnida			
Spider	3.6	7.3	13.630**
Anura			
Immature frogs	1.1	-	-
Insecta			
Orthoptera			
+ Grasshopper	41.3	43.1	0.955ns
+ Cricket	18.2	28.8	21.250**
Hymenoptera			
+ Ants	4.9	-	-
Un-identified adult insects	11.1	7.1	3.208*
Insect remains	5.9	0.5	6.722**
Mud	1.3	8.0	10.485**
Sand grains	0.5	2.1	4.493**
Food richness	*10*	*8*	
Diet breadth	*0.762*	*0.713*	

* P= significant level: **< 0.001; *< 0.02; Not significant

Table 4. Seasonal variation in the trophic spectrum of *P. bibroni*

Food object	Modified food object number [MFON %]		
	Dry	**Wet**	**d - statistics**
Annelida			
Earthworm	12.3	4.2	**-**
Arachnida			
Spider	4.6	3.0	2.292*
Anura			
Immature frogs	0.5	-	-
Insecta			
Orthoptera			
+ Grasshopper	37.4	49.9	7.309**
+ Cricket	23.6	13.5	7.481**
Hymenoptera			
+ Ants	3.8	3.9	0.154ns
Un-identified adult insects	6.9	14.7	7.879**
Insect remains	4.5	3.6	1.343ns
Mud	2.6	2.5	1.163ns
Sand grains	3.7	2.7	1.212ns
Food richness	**10**	**9**	
Diet breadth	**0.797**	**0.693**	

* P= significant level: **< 0.001; *< 0.05; ns = Not significant

Orthopteran grasshopper was of primary importance in all the months; orthopteran cricket occurred as primary importance in January – June, November – December while of minor importance in the rest of the months except in August when it was not ingested. Unidentified insects and Arachnida were consumed as primary objects in July – October and February, August and November respectively, while of minor importance in the rest of the months. Exception of juvenile anuran (January) and months when a food object did not occur, all object were of minor importance. The monthly rhythms in diet breadth showed slight (12.3%) variability with value ranging from 0.866 in September to 0.987 in July. Similarly, food richness revealed low variability (20%) with values varying between 8 (August and September) and 10 (January, July and October).

The composition diet data for the two main seasons showed that the dry season food richness was slightly higher than the wet season value. The qualitative integrated importance of each item of the food compositions portrayed high similarity in both seasons apart from the exclusion of anuran juvenile during the rains. Similar seasonal trends occurred in the rank-order of the *MFON* of the food objects ($r_s = 0.703$, P < 0.05), although there were differences in some of their relative proportions.

There was a marked dry season increase in the *MFON* of Annelida and Orthoptera (cricket) and a wet season increase in that of Arachnida and Orthoptera (grasshopper). No significant seasonality occurred in the *MFON* of Hymenoptera (ant), unidentified adult insects, insect remains, mud and sand grains. Diet breadth was 10% higher in the dry season than during the rains.

Discussion

As a prelude, the present study established a preponderance of male *P. bibroni vis-a-vis* the females; and the level of significance of the $\chi^2 = 79.360$ at 0.001 probability, gives the impression that, the breeding males are polygamous and very active in-order to be able to contend for the available females. The feeding habits of *P. bibroni* in the perennial swamp ecosystem of Ikot Nkpene Village, resembled those of the frogs in general; and the food ingested closely reflected the prey available to them (Main and Calaby, 1957; Berry, 1966,

Lee, 1967). It is clearly an unspecialized and opportunistic feeding habits, but the food ingested is related to the size of the frog.

The proportion of stomachs of *P. bibroni* observed to contain food in this study, was markedly high. However, no literature was encountered for comparison with the present study. The preponderance of food objects from the stomachs of frogs collected during the study, contrasted the observations of the other authors (Blackith and Speight, 1974) that frogs feed little, if at all, during spawning.

The feeding intensity of female *P. bibroni* was significantly higher than that of the male. The precise reason for the difference is uncertain but could be linked to sex-related differential energy requirements, and most probably spawning-related, where the females would have to carry the male counterparts during *amplesus*. The seasonality in stomach fullness conditions of *P. bibroni* indicated a higher feeding intensity in the dry season than the rains.

Abundance of insects in Nigerian rain forest wetlands, occurs usually during on-set of the rains (March - May). Therefore, the dry season increase in feeding intensity of *P. bibroni* in this study could be linked to the increased availability of one of its principal food objects, the insects.

In this study, *P. bibroni*, fed principally on insects, forming together over 70.0% of the dietaries. Although mud and abiogenic sand were integral composition of the diets, this observation did not obscure the insectivore–carnivore feeding status of the frog. This finding is in agreement with the report that, the diets of *P. bibroni* comprised mainly spiders and orthopterans (cf. Amphibian web, 2005). The cannibalism on immature frogs observed among the *P. bibroni* in this study has not been previously reported for *Ptychadena bibroni* elsewhere.

The seasonal regimes in the relative importance of the objects eaten by *P. bibroni* from the study area were probably due to the temporal patterns in the availability and obtainability of the food objects in the perennial wetlands forest. Thus, the dry season increase in the relative importance of the insects could still be attributed to the peak abundance of insects usually observed during on-set of the rains (March – May) in Nigeria. In the report by Arun *et al.*, (2004) for instance, composition of the insect community has been reported to indicate prominent seasonal changes within habitats

than inter-habitat changes within a season. In the Nigerian rain forest ecosystem, many insect species are strictly seasonal indicators also in terms of anthropogenic disturbance and habitat quality (Alarape *et al*., 2015).

The observed sex-related divergence in food habit of *P. bibroni* probably reduces inter-sexual competition for food resources and is important for the perennial wetlands' ability to sustain large populations of the frogs. Various workers elsewhere have investigated the food and feeding habit of anurans from different parts of the world (cf. Blackith and Speight, 1978, Rödel, 2000; Mohneke *et al.*, 2010; Hirschfeld and Rödel, 2011). However, study of this Nigerian frog species remains scarce and limited. Data presented in this study, submits that *P. bibroni*, like other species of *Ptychadena* and many species of anurans, captures as prey, a range of organisms. Nevertheless, the species' feeding activity is considered high, considering that: the frog's month gape (which imposes a maximum size limit) and its sedentary and/or 'lay-in–wait' feeding habit, which restricts its prey capture area to a few square centimeters. Ogoanah and Uchedike (2011) reported *Hoplobatrachus occipitalis* in Benin City, Nigeria, to be a generalist feeder based on its wide diet; while at Ile-Ife, Nigeria, the same species was documented opportunistic feeder, ingesting varied food objects at its disposal (Ajibola *et al.,* 2016). For the bullfrogs, the wide variety of prey items suggests an opportunistic feeding behavior (Balint *et al.,* 2010).

In sum, the large proportion of non-empty stomachs observed in the specimens from the present study, is suggestive that the species examined is a frequent feeder; it could also be attributable to the dynamics of the perennial wetlands under study and its surrounding rainforest ecosystem. The success of the large population of this long-legged *P. bibroni* though may continue to be listed in the International Union for Conservation of Nature (IUCN) *least concern* catalogue, probable because the Nigeria's rain-forest ecosystem encompasses great biotopes inundated overwhelmingly by resource-richness. However, considering the potent anthropogenic activities *inter alia* agriculture, road construction, industrialization, urbanization including residential housing schemes, much of the countless habitats appear threatened. Therefore, rational and wise exploitation of the rain-forest is advocated if standing stock of the amphibians is to be sustained. In addition, much effort is still needed to identify, catalogue and conserve these amphibian populations in the rain-forest of Nigeria. The frog species in this study is a cheap protein source, and that the amphibians should exist in our backyards and gardens is something to be valued, cherished and protected jealously as nature's gift.

Acknowledgement

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The causes of and solutions to poverty in rural farming communities in Nigeria: A review

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Abstract

Poverty among rural farming communities is a serious challenge to food and nutrition security in Sub-Saharan Africa (SSA) and specifically in Nigeria. Land degradation caused by human-induced soil erosion, deforestation, over-grazing and other human activities, account for much of rural poverty occurring in Nigeria. Apart from low external inputs, land degradation brings about low productivity in subsistence farming, while also fostering land conversion to marginal agricultural lands with fragile soils. An urgent reversal of this trend is necessary in order to rescue from the cycle of poverty the rural populace, whose economic livelihood is directly dependent on land exploitation. Unfortunately, over half of Africa's rural poor are located on "low potential" and "fragile" lands. Other contributors to rural poverty in Nigeria are agricultural and economic policies of previous governments, which negatively affect farming communities. Worse still, most resource-poor farmers are unable to formally articulate their technology needs. The National Agricultural Research System (NARS), which is expected to contribute to agricultural development and rural poverty alleviation in Nigeria, is beset by enormous constraints of low funding, poor infrastructure, and instability in staff, policy, governance and institutional arrangements, all of which are not conducive to sustained agricultural growth. The various agricultural development and rural poverty alleviation programmes being embarked upon will be discussed.

Introduction

In Africa, the incidence of poverty has been increasing significantly for many years and Nigeria is not exempted. For instance, it is documented that the number of poor increased by about two-third between 1970 and 1985, and rose from 140 million (47% of the population) in 1985 to 265 million by the year 2000 (Aluyo, 2002). Recent evidence indicated that poverty in Africa and in all the regions of the world declined over the period 2005-2010. In Africa, the proportion of people living below the poverty line decreased to 40% in 2008 from 47% in 1990. In fact, virtually all African countries are known to be in poverty, and their people experience very poor living conditions. It is true there may be pocket of rich people in these countries, but vast majority of the people wallow in abject poverty.

Ndekwu, (1998) used per capital income as a measure of poverty, stating that African economies are generally poor. He explained that, in 1998, the African country with the highest GNP per capital income was South Africa with GNP per capital of US $2,290, when the world average was US $3,470. Out of the 10 poorest countries in the world in 1988, seven of them were in Africa. This ratio improved to 6 out of 10 in 1990 but deteriorated to 8 out of 10 in 1995. It is instructive to state, at this point, that poverty in extreme cases is a condition that dehumanizes people and reduces them to a sub-human level of destitution. Nigeria is the most populous country in Africa and the eight in the world with a population of over 170 million people by 2006 census with a nominal GDP of $207.11 billion and per capita income of $1,401; it has the second largest economy in 3 Africa (Salami, 2011). He also pointed out that the share of the total population living below the $1 a day on the threshold of 46% is higher today than in the 1980s and 1990s, despite significant improvements in the growth of GDP in recent years. In what seemed to be an overview of the incidence of poverty, he also observed that poverty is a world-wide problem that plague over one billion people in the world of about 6 billion people on earth, 1.3 billion earn less than US $370 a year (that is about US $1 a day). He simply put that in Nigeria, there is very high level of poverty.

A report by the World Bank (1996) showed that in 1985, about 43% of the population was living of three hundred and ninety-five naira a year in 1985 prices, the number declined to 34% in 1992. The World Bank report further noted that poverty increase between 1992 and 1995 was mainly due to adverse policy changes. To further strengthen the assertion that there is very high level of poverty in Nigeria, World Bank, (1998) revealed the percentage of household income spent on food from 1991 to 1997 is estimated to be 67.

What is then poverty?

Encarta, (2009) defined poverty as a condition of having insufficient resources or income. Furthermore, the author described poverty as the state of one who lacks a certain amount of material possessions or money. Fundamentally, poverty is a denial of choices

and opportunities, a violation of human dignity. It means lack of basic capacity to participate effectively in society, and implies not having enough to feed and clothe a family, not having a school or clinic to go to, not having a land on which to grow one's food or a job to earn one's living and not having access to credit. Poverty can also mean insecurity, powerlessness and exclusion of individual households and susceptibility to violence, and it often implies living in marginal or fragile environments, without access to clean water or sanitation. Whereas World Bank, (2001) refers to poverty as pronounced deprivation in well-being, and comprises many dimensions. According to World Bank (2001) poverty can be described as a point in an individual's life where he experiences lack of basic essential needs in his life. It is the state of experiencing lack and want, it is the process of having little or not enough aid and sustenance for one's self and family members. Poverty is the stage at which you get to and it seems like there is no other way to go, it is the feeling of helplessness and the point where an individual has nothing else to do and starts to think of negative things to do to himself or his family. Poverty is a self-destructive disease that eats into the mind of an individual and turns him or her inside out to reveal how naked they are inside (World Bank, 1996). Stated.

David, (2007) argues that some analysis of poverty reflects pejorative, sometimes racial stereotypes of impoverished people as powerless victims and passive recipients of aid programs. Poverty in its most extreme form is a lack of human needs such as adequate and nutritious food, clothing, housing, clean water and health services. Extreme poverty can cause terrible suffering and death, and even modest levels of poverty can prevent people from realizing many of their desires. The world's poorest people are many of those who live in developing areas of Africa, Asia, Latin America and eastern Europe struggle daily for food, shelter, and other necessities. They often suffer from severe malnutrition, epidemic disease outbreaks, famine and war.

Poverty in Nigeria and its causes

Odusola, (1997) indicates that critical factors responsible for these are rapid population growth or over-population which include: the use of poor or inappropriate technology, low growth rate of the economy, prevalence of inappropriate resource allocation, particularly in the public sector, and low rate of investment. The interaction of these variables places a large segment of the society in the vicious cycle of poverty. The rural areas and vulnerable groups, especially women and children, were affected more by the worsening poverty situation Nigeria experienced in the 1980s and 1990s, when the incidence of poverty

rose from 46.3 % of the population in 1985 to 65.5% in 1996. Odusola (1997) revealed available data indicating how majority of the poor are located in the rural areas. In 1985, 1992 and 1996 the share of the poor in the rural areas were 49.9%, 46.1%, and 67.8% respectively, making poverty largely a rural phenomenon using consumption and income (Table 1).

Table 1: Poverty trends in Nigeria by sector from 1980 - 1996

Year	Urban	Rural (%)
1980	17.2	28.3
1985	37.8	51.4
1992	37.5	46.0
1996	58.2	69.8

Source: Odusola, (1997)

Causes of poverty in Nigeria

According to Encarta, (2009) one of the causes of poverty in Nigeria is the country's production base that has remained narrow and weak. The Nigerian economy has remained largely dualistic and monolithic, in that her economy depends on one primary product for export. He maintained that the emergence of the oil sector led to the neglect of the agricultural sector, leading to unfavourable consequences on the overall national economy. The various austerity measure that were put in place by the various governments in the 1980s merely pushed many people further into poverty rather than produce the desired results. They, therefore accentuated the poor standard of living of the majority of the country's populace during the period, notably the rural dwellers. One of such measures was the Structural Adjustment Programme (SAP) launched in1986, with mixed results.

There is no one cause or determinant of poverty. On the contrary, combination of several complex factors contributes to poverty Encarta, (2009). They include low or negative economic growth, inappropriate macroeconomic policies, deficiencies in the labour market resulting in limited job growth, low productivity and low wages in the informal sector, and a lag in human resource development. Other factors which have contributed to a decline in living standards and are structural causes or determinants of poverty include increase in crime and violence, environmental degradation, retrenchment of workers, a fall in the real value of safety nets, and changes in family structures (Ajakaiye and Adeyeye, 1999) These factors are examined below:

Low economic growth performance

Growth of the economy is a must for poverty reduction. In developing countries such as Nigeria, growth that is employment generating and with export base is desirable in order to achieve growth that is poverty

reducing with equity. Although the economic performance of countries in the World has generally been highly volatile since the early 1980s, on the whole, growth rates have been low or negative, with overall declines in several countries. This is due, in part, to external shocks such as adverse changes in several countries' terms of trade, changes in global demand for exports and changes in global interest rates on developing countries external debt. All these are probably responsible for the increase in poverty level in various countries of the world. Extensive evidence links the importance of economic growth to poverty reduction (World Bank, 1990). For example, in Indonesia and Thailand poverty was reduced by between 30 and 40% during a twenty-year period in which annual growth rates were approximately 3% (investments in the social sectors also contributed). Accordingly, of a sample of countries, those that reduced poverty the least (for example, India and Sri Lanka) had growth rates of less than 1%. Growth can reduce poverty through rising employment, increased labour productivity and higher real wages it generates.

Macroeconomic shocks and policy
This has been a major cause of poverty in several countries of the world. As many economies in the world faced macroeconomic disequilibrium, mostly in the balance of payments due to expansive aggregate demand policies, terms-of-trade shocks, and natural disasters, it becomes necessary to undertake major policy reforms. In the process, such economies became vulnerable to poverty. Macroeconomic shocks and policy failure account for poverty largely because they constrain the poor from using their greatest asset "labour" (Sagbamah, 1997). He maintained that monetary policies adversely affect cost and access to credit by the poor, fiscal policy which results in retrenchment, lay-off and factor substitution; exchange rate policy which raises the domestic cost of production in an import dependent production system will affect the poor negatively. However, an exchange rate policy which boosts exports particularly those in which the poor are predominantly engaged (for example agriculture) will help reduce poverty. The urban poor, as a result of policy failure, are vulnerable to job losses resulting from job-cut-backs in the public sectors or from the decline of industries adversely affected by shifts in relative prices. They also lose from the removal of food subsidies and other welfare packages (Olayemi, 1994). Further, devaluation produced both negative and positive effects on equity and poverty incidence. On the negative side higher production costs of import, especially in import dependent economy usually result in declining capacity utilization rate in manufacturing and lay –off and retrenchment in the private sector all worsening poverty.

Labour market deficiencies
Okumadewa, (1997) stipulates that the poor's most abundant resource is their labour, a virile labour market is important to reducing poverty and income inequality. He buttressed that in most countries of the world, the majority of poor households participate in the labour market in one way or another, and thus poverty is a problem of low wages (in the informal sector), low labour returns to rural self-employment activities, underemployment, and in some cases, protracted unemployment. These problems are affected in different ways by deficiencies in labour market. The majority of the labour force work as paid employees in the private informal sector, followed by employees in the public sector. When there are deficiencies in labour market, the poor are affected by limited job growth and absorption capacity in the formal sector. Also, relatively high labour costs in the formal sector that lead to over expansion of a low-productivity informal sector, thus, putting downward pressure on wages in the informal sector (where many of the poor work), and limited opportunities for unskilled youth to acquire job training and skills can perpetuate a cycle of poverty.

Migration
Migration rates do reduce poverty especially when the majority of individuals who migrate are skilled workers. On the other hand, individuals who emigrate vacate jobs in labour markets. Thus, migration drains on skills. It reduces the pace of economic growth and thus, slows the process of overall job creation and affects the long-run development potential in a country (Jazaïry *et al.*, 1992).

Unemployment and underemployment
Okafor, (2011) stated that employment is a key determinant of poverty. He reiterated that gainful employment is important for individual to earn income and escape from "income" poverty. While generally in countries of the world the non-poor suffer from transitional or involuntary unemployment, the poor are faced with problems of structural unemployment due to lack of skills or extremely low educational levels, medical problems, geographical isolation (which affects some of the rural poor in general and the urban poor due to marginalization of persons living in high-crime neighbourhood) and in some countries, discrimination based on race or other attributes. Further, underemployment occurs largely in the informal sectors and results in low incomes for an important segment of the labour force, particularly in rural areas. He maintained that unemployment is due to slow economic growth than to the direct effects of imperfections in the labour market, although regulations affecting the formal sector are likely to induce more underemployment in the informal sector.

In poorer, rural areas, this mainly takes the form of seasonal unemployment and in urban areas those who have given up searching for work. High unemployment particularly affects youths, women, urban-dwellers, and those "queuing" for good jobs in the formal sector.

Human resources development

This is germane to human capital development and capability to escape from poverty. Continued investment in human capital with improvements in efficiency is necessary to sustain reduction in poverty changes in the labour market. Investment in people can boost the living standards of households by expanding opportunities, raising productivity, attracting capital investment, and increasing earning power: In addition, providing additional educational opportunities for adolescents may prevent some youths from becoming involved with gangs, drugs and violence, given the evidence linking the perpetrators of crime with school dropouts (Aiyedogbon and Ohwofasa, 2012).

Health problems and diseases

Ajakaiye and Adeyeye, (1999) posited that good health is basic to human welfare and a fundamental objective of social and economic development. They believed that poor health shackles human capital, reduces returns to learning, impedes entrepreneurial activities and holds back growth and economic development. Diseases cause poverty and vice versa. In most countries of the world, major diseases causing poverty are malaria, HIV/AIDS and other infections/diseases. In Nigeria for instance, AIDS prevalence is about 5.4% with an infected adult population of 2.6 million (Ajakaiye and Adeyeye, 1999). This will constrain availability and participation of this segment of the population in the labour market to earn income.

Debt burden

According to Obadan, (1997) in several developing countries of the world, debt burden is assuming increasing importance as a cause of poverty. In such countries, servicing of the debt has encroached on the volume of resources needed for socio-economic development. The productive sector such as agriculture, manufacturing, etc. are equally constrained. leading to low productivity, low capacity utilization, under employment and low purchasing power, thereby subjecting the masses of the people to abject poverty. He maintained that in Nigeria, at the end of December 2000 external debt stood at US$ 28.5 (about 80% of GDP), though, a debt pardon deal was brokered between Nigeria and her creditors (Paris Club) during the Obasanjo's regime, by 2011 debt portfolio was projected to represent 12% of GDP. Amount required to service this debt annually is enough to hamper

government expenditure for the provision of social and physical infrastructure for the poor.

Phenomenon of weak governance

According to Anusionwu, and Diejomoah, (1981) the persistence and pervasiveness of poverty in several countries has been linked to the lack of popular participation in governance and decision-marking as well as weak institutional base. This has led among other things to poor accountability, transparency in resource allocation, weak programme implementation and monitoring. Ultimately, development programmes are rendered ineffective. Poverty reduction initiatives are therefore ineffective and resources wasted.

Environmental degradation

Environmental degradation is a cause of accentuated poverty. At the same time, poverty itself can be a cause of environmental degradation. This reverse causality stems from the fact that for poor people in poor countries such as Nigeria, a number of environmental resources are complementary in production and consumption to other goods and services while a number of environmental resources supplement income most especially in time of acute economic stress (Falconer and Arnold, 1989). They argued that this can be a source of cumulative causations, where poverty, high fertility rates and environmental degradation feed upon one another. In fact, an erosion of the environmental resource base can make certain categories of people destitute even when the economy on the average grows.

In several countries of the world, inaccessibility of the poor to credit and resource inputs leave them with no choice order than to employ natural resources such as forests, woodlands and rivers in order to survive. Quite often, their continuous exploitation of these resources have led to stress/depletion and environmental degradation thereby making poor both agents and victims of unsatisfactory ecological practices. In most rural areas, developing countries fallow duration has declined to four to five years and in several instances as low as two years. Short fallow period is usually not adequate for regeneration of vegetation and the restoration of host nutrients; soil and water quality are therefore quickly depleted. Among the poor, frequent cutting of forest trees with low replanting rate has resulted in scarcity of fuel wood. Immediate effect of this is that poor households turn to alternative fuels such as crop residues, coconut husks, and rice hulls or elephant grass.

The smoke from these inferior fuels according to Cece, (1985), is often more poisonous than that of fuel wood, while emissions from all biomass fuels are known to be dangerous sources of air pollution in the house. Also, scarcity of fuel wood forces women to make what is

available burn slowly. WHO (1984) reckons that under slow burning conditions, wood fuels are capable of producing pollution concentrates higher than fossil fuels and subject the households to more smoke pollutants. The incessant cutting down of trees for firewood and charcoal have hindered prospect for increased yield and hasten the prospect of the creeping desert while profligate use of the country's resources by industries and industrial pollution from improper waste disposal has further exacerbated the plight of the poor. Other consequences of over exploitation of environment due to poverty are depletion of fish in the rivers and streams.

Violence and criminal activities

According to Ajakaiye, and Adeyeye, (1999) steady increase in crime and violence has degraded the quality of life to a varying extent in many counties of the world. Although individuals of all socioeconomic groups are affected, the urban poor are particularly vulnerable to these social problems. There are instances of shootings, gang killings, etc. Crime and violence have serious economic costs. For instance, an increasing proportion of public resources, which are already limited, is required to strengthen police enforcement, support the growing prison population, finance the demands place on the judicial system, and provide health care for persons injured by violence. Other costs include the expensive security systems and guards now required by businesses and homes, the loss in potential revenues from foreign investors and tourists who have sought other destination as a result of the threat of crime, and the migration of the urban middle class. Because of the heterogeneous nature of the poor, it is difficult to link poverty, crime and violence directly. However, the adverse social consequences of crime have been closely associated with poverty, for example, loss of lives at productive age and quantum loss of properties. Household determinants of poverty according to Ajakaiye and Adeyeye, (1999) include: age and education of different household members (head), number of income earners, household composition and size, assets owned by household, access to basic social services, sex, ethnicity of head, location variable (rural or urban), sector of employment, and remittances to households.

Effects of poverty amongst rural farming communities

According Encarta, (2009) the effects of poverty are serious, resulting in poor health conditions both in the males, females, youths and children. Children who grow up in poverty suffer more persistent, frequent, and severe health problems than children who grow up under better financial circumstances. Many infants born into poverty have a low birth weight, which is associated with many preventable mental and physical disabilities. Not only are these poor infants more likely to be irritable or sickly, they are also more likely to die before their first birthday. Children raised in poverty tend to miss school more often because of illness. These children also have a much higher rate of accidents than do other children, and they are twice as likely to have impaired vision and hearing, iron deficiency, anemia, and higher than normal levels of lead in the blood, which can impair brain function.

According to Brooks-Gunn and Greg, (1997) the levels of stress in the family have also been shown to correlate with economic circumstances. Studies during economic recessions indicate that job loss and subsequent poverty are associated with violence in families, including child and elder abuse. Poor families experience much more stress than middle-class families. Besides financial uncertainties, these families are more likely to be exposed to series of negative events and "bad luck," including illness, depression, eviction, job loss, criminal victimization, and family death. Parents who experience hard economic times may become excessively punitive and erratic, issuing demands backed by insults, threats, and corporal punishment. Homelessness, or extreme poverty, carries with it a particularly strong set of risks for families, especially children. Compared to children living in poverty but having homes, homeless children are less likely to receive proper nutrition and immunization. Hence, they experience more health problems. Homeless women experience higher rates of low-birth-weight babies, miscarriages, and infant mortality, probably due to not having access to adequate pre-natal care for their babies. Homeless families experience even greater life stress than other families, including increased disruption in work, school, family, relationship, and friendship.

In the end, poverty is a major cause of social tensions and threatens to divide a nation because of the issue of inequalities, in particular income inequality. This happens when wealth in a country is poorly distributed among its citizens. In other words, when a tiny minority has all the money. Brooks-Gunn and Greg, (1997) disclosed that the feature of a rich or developed country for example is the presence of a middle class, but recently we've seen even western countries gradually losing their middle class, hence, the increasing number of riots and clashes. In a society, poverty is a very dangerous factor that can destabilize the entire country. The authors further stated that the Arab Spring is another good example. In all of the countries concerned, the revolts started because of the lack of jobs and high poverty levels. This has led to most governments being overthrown.

Remedies to poverty in Nigeria

There is no easy answer to poverty eradication but that implementation of poverty related programmes must be shifted from politicians and civil servants to the poor themselves and groups they trusted. This involves bottom to top systematic approach which enables the rural people take decisions as it affects them hence they are full fledge adults. There are several ways of eradicating poverty especially among the rural communities. Some of these include:

Education

An educated child has a promising future, and not only a promising future, an educated child can bring succor to the table of the economy of Nigeria. In so many foreign countries, people invent things and break records. These will no doubt set the records of the economy of the country straight and a lot of people will benefit from such initiatives. Education in child helps to broaden the mentality of that child and makes the child to be a free-thinker in most cases. Education will help an individual to open one's mind to different opinions and settle for the best.

Vocational skills acquisition

The truth is that not everyone is meant to be in school, not everyone has the patience to be in school but does not mean that one has to be a nuisance and live off on bread crumbs thrown to one. The fact remains that, in whatever one does, one must strive for excellence, and it is not in any way compulsory that everyone must go to school to achieve their goals. Learning a trade and acquisition of skills will go a long way to eradicate poverty in the lives of so many people and in the economy at large.

It is recommended that the government should make provisions for private owned enterprises in the country, make provisions for indigenous farming, have a plan and budget for the economy and see through rule of law (nobody should be above the law), and using government officials to work in different parts of the country and make them know that the people come first in everything.

Local entrepreneur

Government should invest in the country, tries own resources. The government should desist from going abroad for every single thing and invest its money on its own resources. Make provisions for private owned enterprises in the country to encourage self-reliance amongst the teaming youths.

Indigenous farming

Indigenous knowledge must not be undermined in advent to eradicate poverty in the rural areas. The government should make policies with the provisions for indigenous farming for minimal income assessment.

Discountenance early child marriage

As much as anyone does not consider this to be one of the reasons to eradicate poverty it is. A child who is supposed to have a future and add to the growth of the economy of its country is forced into a marriage at a young age. This is done by a myopic and poverty stricken individual and in the end, such a child will be left with nothing other than what she has learnt from her parents and husband which is not even enough to carry on in the world.

Conclusion

Poverty is a big challenge to the aspiration of any nation. The low rate of participation in agricultural production as identified in several researches appears to be responsible to the poverty level among the rural farming communities. Agriculture as an employer of labour has been neglected in the past years by the rural people. Based on the fact that agriculture remains the only first class alternative to the sustainability of the growing population and to the economy of the nation, there are opportunities to be developed as a nation if the governments and individuals focus on maintaining a relatively increasing agricultural production. The development in agricultural sector is known to lead to the development of the total economy which was evident before the oil-boom era. Poverty can be kept at minimum in the country if we can go back to the base and take agriculture as a priority. This will minimize unemployment and reduce poverty greatly.

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Analysis of food safety practices utilized by roadside food vendors in Uyo Urban, Akwa Ibom State, Nigeria

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Key words:	Abstract
Food, safety practices, roadside food vendors	The study assessed food safety practices of food vendors in Uyo Urban, Akwa Ibom State. The objectives were to ascertain the attitude of respondents towards food safety and assess the food safety practices utilized in the study area. A two-staged sampling procedure was adopted to select a total of 105 respondents from Abak, Aka, Oron, Ikot Ekpene, Nwaniba, Calabar-Itu and Idoro Roads. Questionnaires and interview schedules were utilized for data collection. Data were analyzed using descriptive statistical tools such as percentage, frequency and means. Results on respondents' attitude to food safety revealed that 60 % of respondents exhibited positive attitudes towards food safety practice. It further showed that 50.48 % of the respondents had low level of food safety practices. The most prevalent food safety practices utilized were washing of hands with the mean of 2.30 and raw food items with the mean score of 2.26, before cooking but cooking utensils were not washed with hot water with mean score of 1.83 and hand gloves were not worn at proper times with mean score of 1.78. Food safety practices not utilized were gloves changes as needed ($\bar{x} = 1.58$), gloves used at proper time with mean score of 1.78 and constant finger nail cutting and cleaning with mean score of 1.74 and use of safe water for cooking with mean score of 1.76. The study recommended that more trainings for food vendors on personal hygiene to reduce the menace of food contamination.

Introduction

Food contamination is very common not only in developing countries but also in developed countries and the level of contamination is more pronounced when food is prepared in large quantities for a large number of people at the same time especially on roadside outlets, canteens and restaurants (Faremi *et al.,* 2018). Adewunmi *et al.,* (2018) posited that food vendors played significant roles in ensuring food safety throughout the chain of food production and storage. The effects of ingesting foodstuffs or drinks contaminated with micro-organisms or chemicals are food borne diseases. The issue of food safety has received much attention by agencies worldwide due to the threats of contracting food borne illnesses (WHO, 2015). Food borne diseases cover a wide range of illnesses and have become a growing public health concern in recent times (Dora-Liyana *et al.*, 2018). According of WHO, (2015), more than 200 diseases ranging from diarrhea to cancer are caused by food containing harmful bacteria, viruses, parasites and chemicals. This constitutes a huge cost on public health for most government worldwide.

Some studies (Samapundo *et al.*, 2015 and Lin *et al.*, 2014) have established that street food vendors exhibit poor practices in terms of food safety standards. According to Adewole (2017), many of these food vendors are mostly driven by money and are more concerned about money saving rather than issues of safety, quality and hygiene which affect their consumers. Lifestyle changes among residents in

Nigeria have encouraged food outlets and food vendors to thrive. Most working class people rarely cook at home due to demand on their time at their workplace which leaves them with little time to buy from market and prepare food always. Food vendors usually present large amount of ready-to-eat foods mostly sold by road sides (Adewole, 2017). Most food vendors who cannot afford a shop move around with their food inside a cart or wheelbarrow searching for and serving customers; while others operate at '*bukas'* in small stalls for their numerous customers.

These street foods seem to be sold at relatively cheap prices which attract a lot of low income earners, travelers and school children which make up majority of the population in Akwa Ibom State, especially Uyo Urban. There is need to ascertain the level of safety of foods prepared by these categories of people to achieve optimum health for citizens within the State and the country at large. Poor food handling practices among food handlers contribute to reduction in food keeping quality and rise in incidences of food borne illnesses (Aluko *et al.*, 2014). A global report by WHO (2015 and 2017) showed that 600 million people suffer worldwide from illnesses associated with poor food safety practices. From this figure, 420,000 people who died of which 125,000 were children below the ages of five. According to WHO (2017), it is estimated that 200,000 Nigerians die annually from food poisoning from food borne pathogens (especially *Escherichia coli* and *Salmonella*). Despite the fact that international food management agencies have already

provided guidelines to member countries about safe handling procedures and good manufacturing practices, the knowledge and perception of food product handlers on safe food handling in most developing countries, particularly Nigeria, remains largely unknown (Adesokan and Raji, 2014). Several incidences of food borne illnesses in developing countries remain unreported resulting in failure to provide information on the true dimension of food safety problems.

There seem to be a greater increase in the number of street food vendors in Uyo Urban who sell food items that are not regulated and operate haphazardly without being monitored as to what and how they prepare their foods. Education on food safety is necessary to reduce the incidence of food borne illnesses and this can be effective when the food safety practices of the residents in this study location are known. This study aims at providing information on the food safety practices of food vendors in Uyo Urban, Akwa Ibom State by examination of the socioeconomic characteristics of roadside food vendors, assessment of the attitude of food vendors toward food safety practices and examination food safety practices utilized by roadside food vendors in the study area.

Materials and methods

The study was conducted in Uyo Urban, Akwa Ibom State, Nigeria. A two-staged sampling random procedure was adopted for this study. The first stage was stratified sampling and the second stage was random sampling. In the first stage, Uyo urban was stratified based on the major roads and its adjourning streets. The major roads considered in this study were: Abak, Aka, Oron, Ikot Ekpene, Nwaniba, Calabar-Itu and Idoro Roads. In the second stage, random sampling was used to select 15 respondents from each of the major roads identified. Hence the study had a total sample size of 105.

Measurement of variables

The variables for the study were measured as presented below:
1. Socio-economic characteristics:
   (a) Gender: Male (1) Female (2).
   (b) Marital status: Single (1), Married (2), Divorce (3), Widow/Widower (4).
   (c) Type of structure: Stall (1), Tent (2), Open air (3), Wheel barrow/Truck (4).
   (d) Years engaged in food vending: <3 years (1), 3-5 years (2), 6-10 years (3), >10 years (4).
   (e) Level of education: None (1), Primary (2), Secondary (3), Tertiary (4).
   (f) Trading time: Morning (1), Evening (2), Throughout the day (3).
2. Attitude towards food safety practices: These were measured using Likert-type scale of four:

Strongly disagree (1), Disagree (2), Agree (3), Strongly agree (4).
3. Level of food safety practices: These were measured using Likert-type scale of three: Not practiced at all (1), Occasional practice (2), Always practice (3).

Questionnaire and interview schedules were used for data collection. Data generated were analyzed using percentages, frequencies, means and factor analysis.

Results and Discussion

Socio-economics characteristics of the respondents
Table 1 presented the results of the analysis of data obtained on socio-economic characteristics of the respondents. The result revealed that the highest proportion of the respondents were females (95), having a percentage (90.5 %) and male accounted for only 10 (9.5 %). This implies that majority of road side food vendors were mostly females. This finding is in agreement with the findings by Muyanja *et al.,* (2011) where majority of street food vendors were made up of women. With regards to marital status, Table 1 indicated that majority (66; 62.9 %) of the respondents was married and 29 (26.6 %) were single. Only 4 (3.8 %) were divorced and 6 (5.7 %) were widow/widower. This implies the burden of parenthood on majority of the respondents. Table 1 also showed that 54 (51.4 %) of the respondents had 3-5 years of experience in food vending business with 3 (29.5 %) having less than 3 years of experience while only 17 (16.2 %) had between 6-10 years of selling. The level of education of the respondents showed that majority (61; 58.1 %) had completed secondary education while primary education constituted 15 (14.3 %) and tertiary education accounted for 27 (25.7 %) of the vendors. This finding implies that the respondents are literates and can read information on food safety practices. This finding is in tandem with Chukuezi (2010). The trading time revealed that the majority of (61; 58.1 %) respondents sold throughout the day and 18 (17.1 %) in the morning as well as 26 (24.8 %) in the evening.

Attitude of food vendors towards food safety practices
As shown in Table 2, eight (8) attitudinal characteristics were provided to ascertain the respondents' attitude. The respondents had positive attitude on five (5) items, which had mean scores higher than the benchmark mean of 2.50 and negative attitude on three (3). These attitudes were positive for constantly keeping their surrounding clean with mean($\bar{x}$) score of 3.34, constantly covering hair while cooking and serving customer with mean score of 3.33, engaging a good waste disposal method (3.30) and not wearing jewelry when involving in cooking activities with mean score of 3.02. Attitude with negative responses were: wearing clean and smart

cloths when serving customer with mean score of 2.4, washing the hand properly after touching or receiving money with mean score of 2.3. These findings are in tandem with the findings of Valero *et al.*, (2016) who

reported that poor personal hygiene and inappropriate food handling practices by food vendors results in contamination.

Table 1: Socio-economic characteristics of the respondents

S/N	Variable	Frequency (f)	Percentage (%)
1	**Sex**		
	Male	10	9.52
	Female	95	90.5
2	**Marital Status**		
	Single	29	27.60
	Married	66	62.90
	Divorced	4	3.8
	Widow/Widower	6	5.7
3.	**Type of structure**		
	Stall	56	53.3
	Tent	22	21.0
	Open air	14	13.3
	Wheel barrow/truck	13	12.4
4	**Years engaged in food vending**		
	< 3 Years	31	29.5
	3-5 years	54	51.4
	6-10Years	17	16.2
	> 10 years	3	2.9
5	**Level of education**		
	Primary	15	14.3
	Secondary	61	58.1
	Tertiary	27	25.7
	None	2	1.9
6	**Trading time**		
	Morning	18	17.1
	Evening	26	24.8
	Throughout the day (all day)	61	58.1

Further analysis revealed that the respondents displayed positive attitude in maintaining a neat surrounding in their food vending ventures, proper disposal of waste and covering their hair frequently when cooking and serving customers. This result is supported by Dora-Liyana *et al.*, (2018), who posited that covering hair with hair cap helps to prevent cross-contamination of food because hair is a good medium for the culture and growth of micro-organisms (Faremi *et al.*, 2018).

However, negative attitudes were displayed by the respondents wearing clean and smart clothes when serving customers. The implication of this result is that the respondents were not careful to select and wear clean clothes at all times when carrying out their businesses. Dirty clothes can serve as a source of food contamination. This position is also supported by Lestantyo *et al.*, (2017) and Abdullah and Siow (2014) who stated that apart from being adequately knowledgeable about food safety, attitude is another crucial factor that may influence the food safety behavior and practice of food vendors.

Table 2 further showed that the respondents exhibited negative attitudes in wearing of hand gloves while cooking. Although it is appropriate for food handlers

to put on hand gloves, doing so during the cooking process will be a herculean task but this can be replaced by proper hand washing from time to time while cooking. Similarly, the respondents further exhibited negative attitudes towards washing hands after touching money. The implication of this is that the level of food contamination by respondents who failed to wash their hands after touching money before handling food was likely to be high as dirty money can be a source of food contamination. In a related study, Lin *et al.*, (2014) findings showed that street food vendors had no knowledge of the need to rewash their hands with soap and clean water after handling money.

Statistics on attitude of food vendors towards food safety practices

Summary on attitude towards food safety practices revealed that majority (66; 62.5 %) of the respondents' attitude towards food safety practices were all very positive while (39; 37.5 %) showed negative attitude towards food safety practices generally (Table 3). This result implies that majority of the respondents expressed positive attitude towards food safety practices. This result corroborates the finding of Soares *et al.,* (2012) and Malavi *et al.,* (2017).

Table 2: Attitude of food vendors towards food safety practices

Attitudinal Variables	Strongly Agree		Agree		Strongly Disagree		Disagree		Mean	Remark
	F	(%)	F	(%)	F	(%)	F	(%)		
I like wearing clean and smart cloths when serving customers.	35	33.3	12	11.43	19	18.10	39	37.1	2.4	NA
I wash my hands properly after touching or receiving money.	26	24.76	14	13.33	30	28.57	35	33.33	2.3	NA
Before I engage in cooking and serving activities I wash my hands.	34	32.38	32	30.48	17	16.19	22	20.95	2.7	PA
I do not wear jewel when involved in cooking activities	30	28.6	54	51.4	15	14.3	6	5.7	3.02	PA
I constantly wear hand gloves when engaged in cooking activities	13	12.38	24	22.86	44	41.90	24	22.86	2.2	NA
I engaged a good waste disposal method	41	39.0	56	53.3	7	6.7	1	1.0	3.30	PA
I constantly keep my surrounding clean	54	51.4	43	41.0	7	6.7	1	1.0	3.34	PA
I constantly cover my hair while cooking and serving customers	46	43.8	50	47.6	7	6.7	2	1.9	3.33	PA

N/B: F = Frequency; Mean ≥ 2.50 = Positive Attitude (PA); Mean< 2.50 = Negative Attitude (NA)

Table 3: Attitude index range of respondents

Attitude index range	Interpretation of range	Frequency	Percentage (%)
0.00-2.49	Negative attitude	39	37.5
2.50-4.00	Positive attitude	66	62.5

Level of safety practices

Table 4 revealed that among the variables of safety practice based on a three point Likert type scale with a benchmark mean score of 2.0 and above indicating practice, washing of hand before cooking ranked highest with a mean score of 2.30. The next was cleaning and sanitizing with a mean score of 2.27. This is followed by carefully washing of food items to be cooked ($\bar{x}$= 2.26). Table 4 has also shown that respondents washed their hands before cooking. This was a good food safety practice that can help reduce health hazards associated with food borne diseases. Similarly, respondents also practiced regular cleaning and sanitizing of cooking and serving equipment. This result aligns with the conclusion of Dora-Liyana *et al.,* (2018) that a high percentage of food handlers displayed good practices on cleaning the work area at the end of their duties. Othman, (2015) posited that inadequate cleaning and sanitation of equipment surfaces result in the formation of biofilms which are potential sources of food contamination.

It is further shown in Table 4 that respondents practiced proper washing of food items before cooking them. The implication is that this practice further reduces the level of food contamination which is better for the overall wellbeing of the consumers. This result is in agreement with Addis and Sisay (2015) that the use of contaminated raw materials and ingredients for cooking result in food contamination. Furthermore, variables such as washing utensils with hot water ($\bar{x}$ = 1.83), gloves used at proper time ($\bar{x}$ = 1.78) and changing glove when necessary ($\bar{x}$ = 1.58) had the

lowest mean scores. These practices had the potential of reducing health risk from eating road side locations. Result from Table 4 also showed that although the respondents cleaned their cooking utensils, they did not do so with hot water. This implies that the micro-organisms on the utensils which can be inhibited/killed with hot water will still be attached to those utensils and multiply to cause further contamination. Results further showed that respondents did not observe the practice of using gloves at proper times nor change hand gloves when necessary. This result is compatible with the result reported in the findings of Reboucas *et al.,* (2016).

Statistics on the level of safety practices

The summary on level of food safety practices indicated that majority 53 (50.48 %) of the respondents were classified low practiced level while 52 (49.52 %) of the respondents were classified under high practiced level (Table 5). This result implies that a little above half of the respondents had of low practice on food safety. This finding supports the finding of Ofuebe (2015) who reported that most food vendors adhere to recommended principles of food safety practices. This finding, however, is in contrast with the finding of Mulugeta and Bayeh (2012) that most of the food handlers exhibited poor hygiene practices.

Conclusion

The study concluded that there was low level of food safety practices by the food vendors in Uyo Urban. Based on the current findings, the respondents

displayed positive attitude in environmental hygiene but major aspects of their personal hygiene such as washing of hands after handling money, wearing clean clothes and hand gloves, were ignored. It is further concluded that the respondents washed their hands and food items before cooking and cleaned their cooking utensils although not with hot water.

Table 4: Level of safety practices

Safety Practice Variables	Always practice		Occasionally practiced		Not practice		Mean	Remark
	F	%	F	%	F	%		
Constant finger nail cutting and cleaning	25	23.8	50	47.6	30	28.6	1.95	Not practiced
Use of safe water for cooking	17	16.2	69	65.7	19	18.1	1.98	Not practiced
Carefully washing of food items to be cooked	28	26.7	76	72.4	1.0	1.0	2.26	Practiced
Cooking the food adequately	30	28.6	59	56.2	16	15.2	2.13	Practiced
Reheating of food items before sale	35	33.3	59	51.4	11	10.5	2.23	Practiced
Covering of food items against flies	33	31.4	64	61.0	8	7.6	2.24	Practiced
Food sold from tray with covering	25	38.1	52	49.5	28	26.7	1.97	Not practiced
Reheating of leftover food	26	24.8	72	68.6	7	6.7	2.18	Practiced
Not speaking while serving	20	19.0	60	57.1	25	23.8	1.95	Not practiced
Serving food with fork/spoon	29	27.6	40	38.1	36	34.3	1.29	Not Practiced
Refrigerated leftover food	25	23.8	61	58.1	19	18.1	2.06	Practiced
Proper washing of utensils with soap and water	38	36.2	51	48.6	16	15.2	2.21	Practiced
Washing of utensils with hot water	20	19.0	47	44.8	38	36.2	1.83	Not practiced
Drying utensils with cloths	19	18.1	63	60	23	21.9	1.94	Not practiced
Washing of hands before cooking	41	39	54	51.4	10	9.5	2.30	Practiced
Constant changing of washing water	30	28.6	50	47.6	25	38.1	2.03	Practiced
Covering of all containers	23	21.9	56	53.3	26	24.8	1.97	Not practiced
Cleaning and sanitizing	29	27.6	75	71.4	1	1.0	2.27	Practiced
Gloves used at proper time	32	30.5	18	17.1	55	52.4	1.78	Not practiced
Gloves changes as needed	10	9.5	41	39	54	51.4	1.58	Not practiced

N/B: F = Frequency; Mean ≥ 2.0 = Practiced; Mean ≤ 2.0 = Not Practice

Table 5: Level of safety practices of the respondents

Index Range	Interpretation range	Frequency	Percentage (%)
0.00–1.99	Low practice	53	50.48
2.00–3.00	High practice	52	49.52

Recommendations

Based on the findings of this study, the following recommendations were made:

- Training on personal hygiene and usage of food safety supplies such as hand gloves, sanitizers and paper towels should be considered in efforts towards improving food safety in the study area.
- Proper documentation and licensing of food vendors in the study area is recommended for easy monitoring of food safety practices.
- Non-governmental organization and academics should engage in more action-oriented researches in compiling data that will identify and profile the nature of food safety practices in the study area.
- Formulation of "food vendors" cooperative is also advocated, this will enhance and aid in effective food safety education.

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Evaluation of the hazards and safety friendliness of medical waste handlers in care facilities in Uyo Metropolis, Akwa Ibom State, Nigeria

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Medical waste handlers, care facilities, medical wastes, hazards, knowledge, safety

Abstract

Wastes are materials with differing regards but may be termed hazardous depending on its source. Healthcare wastes are generally mixed with infectious components, demanding special handling to ensure safety. A structured questionnaire was administered on the primary waste handlers within care facilities to investigate the knowledge on hazards and their safety friendly status. The study focused on the demographic qualities of medical waste handlers, assessed knowledge capacity provided for routine waste handling and examined the safety friendly status of waste handlers. A sample size of 134 respondents constituted the target population. Descriptive statistics including frequency counts and percentages were used to analyze the collected data. Findings showed that females (74.6 %) were more in number and majority of the waste handlers (39.6 %) were found within the age bracket of 26 to 32 years. Holders of Secondary Certificate (68.7 %) had the highest population. Handlers with service years not exceeding five (80.6 %) ranked the highest. The waste handlers who had never attended any training sessions on waste management (57.5 %) formed the higher population; among those that had attended, majority were not exposed to trained waste instructor while very few (1.8 %) were trained up to about four times. The knowledge level of fact among waste handlers about medical waste showed majority (61.2 %) at average level, but with outstanding lapses which endangers even the handlers, safety is not guaranteed. There is a glaring demand for up to date information alongside regular training sessions for waste handlers, especially in the midst of unstable health conditions prevalent in the contemporary society.

Introduction

Healthcare facilities are designed to undertake various activities relating to and accommodating all medical challenges presented. Medical activities including research, diagnosis, analysis, treatment and management lead to generation of differs wastes. The wastes from care facilities fall into groups like domestic, medical and infectious wastes (Manyele, 2004 and Hegde *et al*., 2007). Among these, the infectious wastes pose great challenges to life and the physical environment. In line with related reports, it is observed that wastes produced in health care facilities in developing countries have raised serious concerns because of the various treatments and final disposal practices accorded them. Public health and the environment receive negative impacts due to non-adherence to standards of treatments and final disposal of the wastes. In addition, pathological (infectious) and hazardous healthcare wastes, when inappropriately managed become the source of nosocomial infections and pose serious occupational health risks to those who care for the patients, as well as to those who participate in the management of the wastes within and outside the healthcare facility (Diaz *et al*., 2005 and Yadav, 2001).

Each year, relatively large quantities of potentially infectious and hazardous wastes are generated in healthcare facilities. Healthcare workers are exposed to various medical wastes such as blood and other body fluids as part of their day–to–day activities at the healthcare facilities. In most cases, they are not adequately protected in the course of executing their daily responsibilities. As such, healthcare workers face the risk of infections due to blood or other liquid-borne pathogens through percutaneous injuries with contaminated sharps, contamination through the feco–oral route and also contamination through airborne transmission (Diaz *et al*., 2005). As found in related records, wastes as generated in care facilities range from general or communal wastes (Cannata *et al*., 1992); to pathological or anatomical wastes, sharp wastes, pharmaceutical wastes, radioactive wastes and chemical wastes (Chandra, 1999 and Soncuya *et al*., 1997). For the purpose of choosing the most appropriate waste handling method, hazardous chemical waste is considered to be waste when it is toxic, corrosive, flammable and genotoxic (Soncuya *et al*., 1997), but wastes generated from care facilities are generally combinations of hazardous chemical wastes as well as infectious wastes with differing compositions, potency and quantity of microbes. Pathogens present in waste can enter and remain in the air within the hospital for a long period, in form of spores or as pathogens themselves. This can result in nosocomial infections or occupational health hazards. These infections can be contacted by patients and their

attendants. When waste that has not been pretreated is being transported outside the hospital, or dumped openly, pathogens can enter the atmosphere, contaminate the soil, accumulate in the food chain, etc. or remain in the ambient air. An individual can experience multiple exposures through the food, air and drinking water.

The effect on the general population can mainly be through: chronic exposure (when individuals are exposed over a prolonged time to small amounts of substances in groundwater, the food chain and the air) or acute exposure (when individuals are exposed for a shorter period to larger amounts). The exposure to medical pathogens mostly are occupational, that is, when medical or healthcare givers and waste handlers come into contact with significant volumes of infectious waste and any reactive products (Kaiser *et al.*, 2001 and Soncuya *et al.*, 1997). The occupational health effects of medical and other hazardous wastes depend on the duration of exposure and the dose of toxic components that enters the worker's body from the waste. Unmanaged hospital waste constitutes hazard to the personnel because it contains toxic chemicals and pathogens ready to enter the human body through different routes (Babayemi and Dauda, 2009). These include ingestion, inhalation and dermal absorption or through skin openings. The worker's face and hands are the most affected skin areas and need maximum protection, which in reality are mostly inadequately protected. Water-soluble toxic chemicals can be absorbed throughout the body since the human metabolism operates on a water-based chemistry (Manyele, 2004) and personnels in care facilities are largely exposed to this. Hospital wastes can be managed through proper handling of waste during generation, collection, storage, transport, treatment and disposal. Improper handling of wastes comprises several unsafe actions such as: handling without personal protective equipment, poor storage (e.g. high temperature conditions combined with prolonged storage times before treatment), manual transport for longer distances, use of uncovered containers instead of closed plastic bags, exposure times beyond acceptable limits, lack of workers and equipment decontamination procedures, etc. which can result in a number of adverse conditions; including: pollution and disease outbreak (e.g. cholera, typhoid, dysentery, infective hepatitis, polio, ascariasis, hook worm diseases, etc.); breeding of vermin and pests (e.g. mosquitoes, houseflies, ants, cockroaches); increase in tetanus spores; nosocomial infections, AIDS, Hepatitis B and C, etc.); reduced aesthetics (sludge water, refuse, etc.); create intolerable nuisance of sight and smell) (Yadav, 2001 and Manyele, 2004).

Although very little disease transmission from medical wastes had been documented, both the America Dental Association (ADA) and Centre for Disease Control (CDC) recommend that medical waste disposal must be carried out in accordance with regulations (Hegde *et al.,* 2007). Therefore, to ensure clean and healthy human and physical environment, we require segregated collection, safe transportation and storage, environmentally sound treatment and disposal of medical wastes in ecofriendly manner in addition to maximally trained and protected waste managers. As necessary as training could be, regular assessment and systematic monitoring increases the efficiency of waste control procedure. Monitoring of waste management within care facilities can be used to ensure medical waste safety friendly status, especially among those directly responsible for waste handling.

Life in recent times is regulated on the level of information or understanding that is available. Ignorance at times has been the cause of many mishaps, especially in areas where science has been able to proffer useful and up to date explanations on natural occurrences. In most cases, issues that were in time past considered mysterious have been unveiled by relative knowledge. Health related conditions fall within these categories that have been made simple through medical information in

the contemporary society. Thus, care facilities have been provided to meet the needs of people, even animals, down with various forms of medical challenges. A modern hospital is a complex, multidisciplinary system which consumes thousands of items for delivery of medical care and is part of the physical environment. The various operations within each hospital generate a lot of wastes, mainly termed 'medical', 'biomedical' or 'clinical wastes'; and refers to any solid, fluid and liquid or liquid waste, including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological samples, even the animal waste from slaughter houses or any other similar establishment (Chandra, 1999). It could be observed that health or medical-related activities seem to be the major sources of clinical wastes. The different types of medical waste pose different dangers depending on their nature (Cannatta *et al.,* 1992). Often times, the management of these wastes is delegated to poorly educated and untrained labourers, who perform most activities without proper guidance and insufficient protection (Kaiser *et al.*, 2001) which lead to improper handling of hospital wastes (Das *et al.*, 2001). These are conditions that reduce the safety friendliness of waste handlers and expose susceptible human population and the physical environment to contaminants. Observation of the waste handler's composition in most of health facilities in the study area reveals mostly poorly educated and trained for the job task. The manner and art of their job performance require reassessment of the waste handlers risk exposure and safety perception in the course of routine pathological

wastes management task. Ignorance and carelessness can be undesirable if job protocol is mishandled. The study was geared towards needs assessment and safety gaps as basis for empirical evidence for future planning and reformation. Thus, it became necessary to answer the following research questions. Who are in charge of the management of these wastes? How knowledgeable and technically prepared are they? and what is the level of safety at their disposal? This paper intends to evaluate the demographic characteristics of the medical waste handlers, assess the knowledge on capacity provided for waste handlers as well as assess the safety friendly status of waste handlers in care facilities.

Methodology

The study was conducted in healthcare facilities within Uyo metropolis: University of Uyo Teaching Hospital (UUTH) and St. Luke's Hospital, Anua. The Uyo metropolis which accommodates the administrative centre of the State lies within Uyo Local Government Area. This is one of the largest in Akwa Ibom State. This area shares contiguous geographical boundaries. It is located on latitude 50^0 N and longitude 80^0 E. The area is within the equatorial rainforest belt. It is a tropical zone that has vegetation of green foliage of trees, shrubs, oil palm trees, etc. The study area has an estimated population of about 409,573; having 203,113 males and 206,460 females respectively. It has a land mass of about 218 km. This study adopted a purposive sampling procedure to evaluate knowledge on hazards and the safety friendly status of medical waste handlers in the two healthcare facilities within the metropolis. A total of 134 waste managers drawn from the care facilities, made up the target population. Primary data were collected using structured questionnaire to reflect the specific objectives of the study. Data were analyzed using descriptive statistics particularly percentages and frequency counts.

Results

Demographic characteristics of medical waste handlers

The study of the demographic characteristics of waste handlers on Table 1 showed that for Item 1, the female handlers at 74.60 % were more than their male counterparts at 25.40 %. Comparing the two hospitals, UUTH were higher in the two gender (7.9 % males and 52.2 % females) than in St Luke's hospital (7.5 % males and 22.4 % females). This may be an actual reflection of the workforce in which more female population is observed to serve in hospitals; more so, women are known to be soft-minded, a condition that suits the expectations of patients, making their presence much desired. Also, the various activities involved in the nature of their job appear to be similar

to house-keeping chores, they seem to adjust better on their occupational responsibilities.

With reference to Item 2, 29.10 % of the respondents were between the age range of 19–25 years, 39.60 % being the highest, were between 26-32 years, 16.40 % were between 33–39 years and 14.90 %, the lowest, were between 40-46 years. The age ranges of 19-25, 26-32, 33-39 and 40-46 years were higher in UUTH (24.6, 26.9, 10.4 and 8.2 %) than in St Luke's hospital (4.5, 12.7, 6.0 and 6.7 %) respectively. The range of 19-46 years reflect active persons within service ages and represents the economic group of any society.

Item 3 showed that 21.60 % of the respondents were holders of Primary Six Certificate, 68.70 % were School Certificate holders, 8.20 % were holders of OND/NCE and 1.50 % of the respondents were holders of another certificate not specified. Primary Six holders were higher in St Luke's hospital (11.9 %) than in UUTH (9.7 %). However, SSCE/GCE holders were higher in UUTH (50.7 %) than in St Luke's hospital (17.9 %). It is important to note that others (OND/NCE and others) were absent in St Luke's hospital but were 8.2 % and 1.2 % respectively in UUTH. The majority of the holders being School Certificate holders, the work force is poorly and less skillfully educated.

On Item 4, 80.60 % of the respondents were within 1-5 years of service, 12.70 % had served between 6 -10 years, 5.20 % were within 11-15 years of service and 1.50 % were within 16-20 years of service. Respondents who had worked between 1 and 5 years was highest in UUTH (62.7 %) and least in St Luke's hospital (17.9 %). The job durations of 6-10 and 11-15 years were higher in St Luke's hospital (8.2 and 3.0 %) than in UUTH (4.5 and 2.2 %) respectively. It was observed that duration job of 16-20 years was the same (0.7 %) in both hospitals. The decline in population as service years increased shows a temporary nature of the job. It reflects lack of job satisfaction, thus, at promising opportunities, handlers move on leaving a lesser population behind.

Assessment of knowledge on capacity provided for waste handlers

Knowledge is an important resource in all aspects of human endeavor. In the health sector, with varying conditions of life's issues, adequate knowledge is essential. Waste management also, being skills demanding, requires keeping abreast with latest information on related issues. On Table 2, Item 1 showed that 57.5 % of the handlers had not attended any training on waste management while 42.5% seemed to have received, at least, some forms of management training. Waste handlers in St Luke's hospital who had not attended any training were more (29.1 %) than those in UUTH (28.4 %). The number of respondents who had attended any formal training in UUTH was higher (41.8 %) than that of St Luke's Hospital (0.7 %).

For Item 2a, 22.8 % were trained by the Heads of Units, 76.8 % were trained through facility programme and 1.8 % were trained by USAID. Training by heads of unit was the only type of training and higher in St Luke's hospital (100.0 %) than in in UUTH (21.4 %). St Luke's hospital had no hospital or USAID training for waste handlers while UUTH had both (76.8 % and 1.8 %) respectively. This is largely inadequate as waste handling should be considered very crucial to healthcare delivery. Waste contains high risk pathogens, which should be handled under premium conditions. Yet, in addition to other wastes lumped together, these poorly trained workers are expected to intercept the occurrence and transmission of infection through basic hygienic activities.

Item 2b showed that 56.1 % had just one training session, 24.6 % were trained twice, 12.3 % had up to three training sessions, 1.8 % were trained up to 4.00 times and 1.8 % had received training up to 8.00 times. In St Luke's hospital, only one training session was obtained. This was different in UUTH where 1.00, 2.00, 3.00, 4.00 and 8.00 times training had been carried out with their corresponding relative frequencies: 54.4, 24.6, 12.3, 1.8 and 3.5 % respectively. There was the absence of skilled education on waste management concept neither any record of short or conventional training except for a day or two. It is certain that none of the facilities had ever put in place regular training sessions for handlers of special wastes. The administration might assume common knowledge would be sufficient for this responsibility, showing negligence in proper waste management.

Table I: Demographic characteristics of hospital waste handlers

Item	Variables	Hospital		
		St Luke's **Frequency(%)**	**UUTH** **Frequency(%)**	**Total** **Frequency(%)**
1	**Sex**			
	Male	10(7.5)	24(7.9)	34(25.4)
	Female	30(22.4)	70(52.2)	100(74.6)
2	**Age**			
	19-25	6(4.5)	33(24.6)	39(29.1)
	26-32	17(12.7)	36(26.9)	53(39.6)
	33-39	8(6.0)	14(10.4)	22(16.4)
	40-46	9(6.7)	11(8.2)	20(14.9)
3	**Educational status**			
	Primary six	16(11.9)	13(9.7)	29(21.6)
	SSCE/GCE	24(17.9)	68(50.7)	92(68.7)
	OND/NCE	-	11(8.2)	11(8.2)
	Others	-	2(1.5)	2(1.5)
4	**Duration on the job**			
	1-5 years	24(17.9)	84(62.7)	108(80.6)
	6-10 years	11(8.2)	6(4.5)	17(12.7)
	11-15 years	4(3.0)	3(2.2)	7(5.2)
	16-20 years	1(0.7)	1(0.7)	2(1.5)

N/B: N=134

Table 2: Responses on capacity building on medical waste hazards

Item	Variables	Hospitals		
		St Luke's	**UUTH**	**Total**
1	**"Have You Attended Any Training on Waste Management?**			
	No	39 (29.1)	38 (28.4)	77 (57.5)
	Yes	1 (0.7)	56 (41.8)	57 (42.5)
	Total	**40 (29.9)**	**94 (70.1)**	**134 (100.0)**
2a	**"What is the name of your trainer?"**			
	Heads of units	1 (100.0)	12 (21.4)	13 (22.8)
	Hospital	-	43 (76.8)	43 (76.8)
	USAID	-	1 (1.8)	1 (1.8)
	Total	**1 (100.0)**	**56 (98.2)**	**57 9100.0)**
2b	**"Specify the number of times trained"**			
	1.00	1 (100.0)	31 (54.4)	32 (56.1)
	2.00	-	14 (24.6)	14 (24.6)
	3.00	-	7 (12.3)	7 (12.3)
	4.00	-	1 (1.8)	1 (1.8)
	8.00	-	2 (3.5)	2 (1.8)
	Total	**1 (100.0)**	**56 (98.2)**	**57 (100.0)**

Safety friendly status of waste handlers in care facilities

From Table 3, the responses showed that there is an average awareness on the dangers relating to medical wastes. One hundred and twenty-three respondents agreed that there were medical wastes that had toxic substances. Of these numbers, nine respondents did not know while two said there were no toxic substances. A total of one hundred and twenty-three waste handlers agreed that pollutants from medical wastes can affect human health. Eleven of them expressed their ignorance on whether there are pollutants that can affect human health while eight said the pollutants cannot affect. The one hundred and twenty-three waste handlers affirmed that human contact with medical wastes should be reduced. Six had no idea on the subject matter whereas fourteen of them responded that there should be no reduction of human contact with medical wastes. Forty-one respondents agreed that waste handlers were not affected by medical wastes. Six respondents did not know but eighty-seven argued that there was no way were waste handlers could be affected by medical wastes.

Twenty-three respondents responded positively that medical wastes were like household wastes. Only two indicated their lack of knowledge on the difference between medical and household wastes while a hundred and nine respondents acknowledged that medical wastes were not like household wastes. One hundred and twenty-one respondents affirmed that people exposed to medical wastes can be affected. Four respondents had no knowledge about this safety friendly status whereas seven respondents responded that people exposed to medical wastes cannot be infected.

Discussion

The understanding and ability to diagnose, manage and control pathological conditions lie within the wealth of knowledge acquired over time (Altin *et al*., (2003) and Bassey *et al.,* (2009). Wastes are very crucial components within care facilities, an understanding of its management procedures safeguards both personnel and the general public (Das *et al.*, 2000 and Canneta *et al.*, 1992). Pathological conditions are indications of exposure to hazardous compounds or components. These hazardous substances may be generated through several routes, one of which is mismanaged wastes. In healthcare facilities, wastes are generated in massive forms and there is the need for proper medical waste management. In this regard, medical waste handlers are important resource in healthcare delivery. Their responsibilities are needed to intercept the occurrence of and transmission of infection within the hospitals through basic hygienic activities. According to Ndidi *et al.,* (2009), cross infection is a threatening factor in healthcare delivery as handling of hospital waste is risky due to the presence of infectious components, which if not properly managed, result in nosocomial infections, the efficient input of medical waste handlers promotes aesthetic and medical conditions in this sector.

The representation of 74.6 % of the respondents as females, shown by the data is a reflection of normal gender population found in care facilities. Most care-givers tend to be largely of the female population. So, the task of keeping the care facilities neat and infection-free in their hands, remains assuring. These tasks seem an extension of home life, so they fit in naturally. The male population of 25.4 % is not needless, the herculean aspect of waste management becomes their duty. The age range of waste handlers represents the economic group of any society. The highest population of 39.6 % which falls between 26-32 years are active persons within service age range, but are daily exposed to occupational hazards (Diaz *et al*., 2005). As health attendants, they help to keep away re-occurrence of avoidable infection.

With majority of the waste handlers, 68.7 %, being School Certificate holders, the management of hospital waste, in agreement with Kaiser *et al.,* (2001), is left in the care of poorly and less technically educated persons, who have not been exposed to skilled training on basic waste management concepts. Thus, it is common to observe open combustion of these wastes with little or no regards to its effect (Kaiser *et al*; 2001).

There is no record of short or conventional training except for a day or two sessions, a duration deemed too short to sustain the intensity of their responsibility. It portrays lack of commitment to proper waste management by care administrators.

Table 3: Responses on safety friendly status of waste handlers

S/N	Safety Friendly Status	Don't know	No	Yes
1	Medical wastes are toxic substances	9	2	123
2	Pollutants from medical wastes can affect human health	11	8	123
3	Human contact with medical wastes should be reduced	6	14	123
4	Waste handlers are not affected by medical wastes	6	87	41
5	Medical wastes are like household wastes	2	109	23
6	People exposed to medical wastes can be infected	4	7	121

In developing countries such as Nigeria, the international policy that the generator of waste is responsible for the proper management, treatment and disposal of waste is yet to be implemented and the notion that waste is the responsibility of the government authorities has not enabled waste generators to appreciate the negative impact of improper waste disposal (Das *et al*; 2000; Ndidi *et al;* 2009). This situation in the Nigerian society tends to promote laxity, exposing both the handlers and the larger public to unquantified risks. A larger population of the respondents, 80.6 %, could be described to be at their early stages of service and it appears these handlers do not remain for long. Waste handling demands technical skills, but as much as 57.5 % of the respondents, who are primarily saddled with the management responsibilities, had no exposure on relevant training. Learning could be by experience, which a lesser population 1.5 % may have acquired, though not enough for this duty. Therefore, majority of them are inadequately trained and will definitely affect their output. This was outstanding in handlers from St Luke's hospital which had the only trainee, receiving rudimentary instructions on expected outcomes. Such conditions indicate lack of technical information relating to their duty, expected hazards and effect on the environment. There could also be an underestimation of wastes, in volume and toxicity, from dental units (Morenikeji, 2010; Treasure *et al*., 1997) and others without proper training. Such knowledge gaps may lead to hazardous exposures of the patients, care-givers, visitors, neighbouring communities and healthcare experts as well as workers to chemicals, injuries and unsuspecting ill-health; this is in line with situations reported from Tanzania (Manyele, 2004).

The lack of adequate waste instructors in care facilities suggest the need for the recruitment of sufficient technical personnel, who would design related curriculum to enhance dissemination of standard information to all stakeholders within the hospital community, with detailed attention on the handlers. The more frequently waste handlers are taken through training sessions, the more enforcement of standard procedures, and better understanding of the concepts would be guaranteed. The training builds up the intellectual capabilities of handlers, Blenkharn (2006) and Lee *et al.,* (2004); thus the higher the knowledge gained, the more safety tendencies would be exhibited by waste handlers, Abor (2007) and Coker *et al.,* (2009). Safety is the primary objective of waste management and can never be overemphasized. Proper knowledge upholds safety operations and this sustains the immediate as well as the extended environment with all life forms within it. Thus, waste handlers' status of safety friendliness lies in the depth of knowledge acquired on all issues surrounding medical wastes.

There are still some lapses as indicated in the lack of idea by some responses and those who claim ignorance on the risk involved. Though these responses may be attributed to comprehension inabilities or out-right literacy incompetence and expose those respondents who relied on opinions of others. There is need for an up-to-date information on wastes and possible implications due to any form of irregularities regarding waste material handling (Malik *et al.,* 2007 and Tressure *et al*., 1997). This may explain cases where some litters of neglected wastes were observed in the facilities. This should not be; yet it is common to observe open combustion of hospital wastes within and out of care facilities. Information on the dangers of indiscriminate waste handling is of utmost importance. Safety would be guaranteed when all categories of staff are taken through intermittent and regular training on safe management of medical waste, in appropriate language/medium and in an acceptable manner (Blenkharn, 1995; Chandra, 1999). The efficiency of effective waste handling relies on team approach. When handlers are well informed, attitude to waste handling would change, extra care would be maintained, procedures would be followed and demand for safety would increase.

Conclusion

Care facilities are designed to accommodate all activities in respect of health delivery. The care delivery is aided by medical experts who undertake all professional and medically-skilled procedures. These procedures are trailed by massive forms of waste generation. Medical wastes in the contemporary society have been subjected to improper management operations which constitute hazards to personnel and the environment. In recent times, there has been recorded and confirmed cases of infectious disease outbreaks in Nigeria that demands premium care, mere body contacts constitute serious threat to a person's safety and more cases, though minor, are still looming. All these end up at care facilities with various wastes, alongside the infectious components generated. These should not be left in the hands of untrained attendants. As much as Wastes handlers are needed to support the disposal of these wastes, they need relevant information on the various risks attributed to their mismanagement. They also need to be adequately equipped on information regarding the hazards and safety operations of wastes without which, the handlers as well as the physical and human environments would not attain sustainable safety.

Ethical Approval

All authors declared that verbally informed consent was obtained from the respondents which was evident by their willingness to participate in the survey and complete the questionnaire. The survey study had

committee considerations and received written consent from the University of Uyo Teaching Hospital (UUTH) and verbal approval from the management of St Luke's Hospital, Anua, Uyo Local Government Area. The study was conducted in accordance to the tenets of the Helsinki Declaration of 1964 as amended in 2000.

Competing Interests

Authors have declared that no competing interests exist.

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Income generating activities of rural women in Akwa Ibom State, Nigeria

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Income generating activities, rural women, constraints, Akwa Ibom State

Abstract

The study assessed rural women involvement in various income generating activities in Akwa Ibom State, Nigeria by specifically examining their socio-economic characteristics, ascertaining their income generating activities as well as their income generation and constraints. Data were collected from 192 respondents using questionnaire method and analyzed using percentages, mean scores and ranks. Results revealed the mean age of respondents to be 43 years and 58.3 % of them were married. The findings further showed their different income generating activities to include crop planting, agro-processing, trading, animal rearing and foodstuff retail business. Farming was their primary occupation (73.0 %) and highest household size of 1-5 persons (53.1 %). The severest constraint as revealed by the study was poor road networks (x = 1.92). It was recommended that sufficient agro-inputs be made available to rural women from the State Ministry of Agriculture and good road network be constructed by the government at all levels.

Introduction

All living things need food to satisfy hunger and nourish the body (Fawehinmi and Adeniyi, 2014). Access to a nutritionally balanced diet comprising all essential ingredients is therefore necessary for one to enjoy a healthy life (Oyebanyo, 2013). There is therefore the need for individuals, households and nations to be food secure. Dafwang (2014) opined that food security means that all people at all times have physical and economic access to adequate amounts of nutrition, safe, and culturally appropriate foods which are produced in an environmentally sustainable and socially just manner and that people are able to make informed decisions about their food choices. Income generating activities cover trading carpentry, tailoring, teaching, welding, farming, etc.

Akpabio (2005) and Yayaha (2010) stated that women play multiple indispensable roles as food producers and processors, domestic chore workers, income generators and household caregivers. They perform nearly two-third work hours and make up between 60-80 % of the agricultural labour force in Nigeria. Ben (2015) added that women make up 65 % of the field workers in farms, comprise 60 % of the contractual workers in the fruit sector and 50 % of the field workers for vegetables and 90 % of the packers. Reported that women raise fish and crustaceans, make and repair nets and traps, assist men in launching and beaching operations, sorting and getting the hail and process and market their catch. The author further added that women are food processors and preparers. They are universally responsible for food preparation for their families and engage in various stages and steps of processing these foods for both domestic and market consumption. Asa and Archibong (2016) opined that despite concerns by government all over the world in ensuring that every household can, at least, provide three square meals for their family, food insecurity continues to be a major developmental

problem across the globe, undermining people's health, productivity and often their very survival.

Nigeria has a total land mass of 98.3 million hectares of land for agricultural practices, but less than 60 % of this has been utilized so far as a result of the nation's continued dependency on crude oil as the major source of income. This continued neglect of the agricultural practices is linked to lack of interest in agriculture and inadequate funding, thereby, resulting in continued food shortages among individuals and households.

Inadequate or lack of wages, pest and diseases, drought, corruption, low yield, inadequate access to markets, inadequate control of asset resources, the nature and number of income generating activities engaged in; to a great extent, influence household food security (Harvest Help Report, 2003). The ability of a household to command adequate food resources and engage in highly rewarding income generating activities primarily influence food security of the households.

Income generating activities of poor people are often complex and diverse (Olawepo, 2010). For rural people, agriculture and other natural resource-based activities may play an important role but rural households also diversify into other activities, some of which are linked to agriculture and natural resource sector, while others are not. The income generating strategies may include subsistence production for consumption or small-scale production for the market.

Inhabitants of rural Nigeria earn their income from diverse sources and as well, hold all their wealth in the form of various assets, or use their assets for diverse activities (Asa, and Ebong, 2016). They do so to reduce risks and properly respond to household shocks. Author further added that involvement in income generating activities help in tackling poverty and ensuring access to enough income and food. It was against this background that this research was

undertaken to determine the income generating activities of rural women in Akwa Ibom State by identifying their socio-economic characteristics, ascertaining their income generating activities, determining their income and identifying the constraints to income generating activities in the study area.

Methodology
Study area
The study was conducted in Akwa Ibom State (AKS) of Nigeria. The State lies between latitudes 4.33' and 5° 33' North and longitudes 7° 25 and 8° 25 East. It has a land mass of 7,245,935km². It shares borders with Cross River State to the East, Abia State to the North and Rivers State to the West. The State with Uyo as a capital is structured into thirty-one Local Government Areas (LGAs). According to the 2016 population census figures, the population of the State was 3,920, 208, out of which 2,044,510 were males while 1,875,698 were females (Nigerian Population Census (NPC), 2006). Ibibio, Annang, Oron, are the major languages while others include Ekid and Andoni which are spoken by a minute population of the State.

The State lies within the topical zone of Nigeria. Its vegetation is green foliage of trees and shrubs. It basically has two main seasons: rainy and dry seasons. The rainy season extends between April and October with a record of annual rainfall of between 2000 and 3000 milliliters. The dry season commences from November and runs to March. Agriculture is the main economic activity in the State engaging both the young and the aged. Soils in the State are fertile and suitable for all year round cultivation of crops. The major crops produced in the state include maize, cassava, plantain, banana, cocoyam, etc. and are produced in almost all the LGAs. Cultivation of tree crops is largely supported by the soils in the State, hence the cultivation of oil palm, cocoa, kolanut, rubber, coconut and citrus. It is the largest grower of oilpalm in the country. Livestock species reared in the State are goats, pigs, sheep, poultry and grass cutters as well as crayfish, shrimps and snails (Ministry of Agriculture and Natural Resources, AKS, 2013).

Data collection
Primary data derived from interviewing respondents was used for this study. Structured questionnaires divided into sub-sections reflecting the specify objectives of the study was used to elicit information from women in the rural areas of Akwa Ibom State using home/farm visits and personal interviews.

Sampling techniques
A multi-stage sampling procedure was used in selecting the samples for the study. The first stage involved the purposive sampling of the three out of the six Agricultural Development Project (ADP) Zone in Akwa Ibom State, namely: Abak, Etinan and Oron Zones. Purposive sampling was used to select the three ADP Zones at this stage in order to capture the differences in the income generating activities inherent in the various zones.

The second stage involved the simple random selection of two blocks from each ADP Zones as follow: Ikot Ekang and Ekparakwa blocks in Abak Zones; Etanan and Mbiaso blocks in Etinan Zone and Mbo and Okobo blocks in Oron Zone. This resulted in a total of six blocks from the three ADP Zones. The third stage involved the simple random selection of two cells from each of the selected blocks of the sampled ADP Zones; resulting in a total of twelve cells.

The fourth stage involved a simple random selection of two villages from each of the cells. This resulted in a total of twenty-four villages. Furthermore, eight women were randomly selected from eight different households from each of the villages. This resulted in a total sample size of one hundred and ninety-two respondents.

Analytical techniques
Descriptive and inferential statistics were used to analyze collated data. Specifically, frequency, percentages, mean and ranks were used to analyzed the data.

Results and Discussion
Socio-economic characteristics of the respondents
Socio-economic characteristics of rural women in Akwa Ibom State, the result of the statistics regarding the socio-economic characteristics of rural women in Akwa Ibom State in Table1 showed a mean age of 43 years. According to FAOSTAT (2006), 15-64 years of age are considered as the economic productive or active age. The marital status of respondents revealed that 58.3 % were married, which corroborated with Asa (2007) who reported a high percentage (67.3 %) of married couples among rural women in AKS. Ekong (2010) buttresses this fact by his assertion that getting married is a highly cherished value among rural dwellers in Nigeria not only because of the need for children and continuation of the family name, but also because in some areas, women form a vital source of unpaid family labour. For educational level, 33.3 % had secondary education, 32.3 % had primary education, 26 % had no formal education while 8.3 % had tertiary education which agrees with Asa and Ebong (2016). This indicates that most of the respondents had one form of educational qualification or the other and were therefore literates and could diversify in their income generating activities. Farming were their primary occupation (73 %) with a mean household size of 6 persons. This finding agrees with Bassey et al., (2012) who had a similar result of 6 persons and therefore concluded that the average household size of rural farmers in AKS comprised of six persons.

Income generating activities of rural women in Akwa Ibom State
The results in Table 2 showed income generating activities engaged in by rural women in the study area.

It is clearly showed that 15.98 % of the respondents engaged in crop farming, 14.96 % in agro-processing, 12.60 % in trading, 10.4 % in animal farming, 9.55 % in foodstuffs retail business, 6.58 % in cooked food, 5.92 % in dress making and 6.34 % in hair dressing, etc. Most of the respondents were involved in agricultural related ventures such as crop farming, agro-processing, trading, and animal farming. This result is consistent with Olawoye (2002) and Okoro

(2004) who, in separate studies, noted that the major income generating activities of rural women were crop farming, livestock rearing and trading. The respondents' significant involvement in these activities is to meet their household income. Their involvement in transportation business (0.17 %), fruit gathering (0.25 %) and salaried jobs (2.11 %) were low.

Table 1: Socio-economic characteristics of rural women in Akwa Ibom State, Nigeria

Characteristics	Categories	Frequency	Percentage	Mean
Age (years)	21-40	79	41.1	
	41-60	112	58.3	
	61-80	0	0	43
	81-100	1	0.5	
Marital	Single	25	13	
	Married	112	58.3	
	Widowed	34	17.7	
	Divorced/Separated	21	10.9	
Educational	No formal education	50	26.0	
	Primary Education	62	32.3	
	Secondarily Education	64	33.3	
	Tertiary	16	8.3	
Primary occupation	Farming	140	73.0	
	Business/trading	23	12.0	
	Civil service	19	10.0	
	Others	10	5.2	
Household size	1-5	102	53.1	
	6-10	83	43.2	
	11-15	7	3.6	

n=179

Income earned by the respondents from income generating activities
As shown in Table 3, the average monthly income of the various income generating activities were as follow: salaried jobs (₦11082.76), foodstuffs retail (₦10364.00), hair making (₦10014.10), transportation (₦9000.00), selling of cooked foods (₦7914.63), gathering of fruit (₦6666.67), fuel wood collection (₦6085.71) and animal farming (₦1270.97).
The result showed that salaried jobs, traditional healthcare had significantly high average monthly income. This implied that salaried jobs and traditional health care had the most attractive income in the study area, though it employed a very few of the respondents.
On the other hand, animal farming (₦1270), fuel wood collection (₦6085.71) and fruit gathering (₦6666.67) had least average monthly income. This results disagrees with Idowu and Akerele (2011), who posited that income generated from rural farming households mostly come from farm activities than non-farm income generating activities. The low average income earned from animal farming is as a result of inadequate/lack of processing storage facilities for and the resultant poor prices of animal products in the study area. Farming activities and deforestation for timber has caused the disappearance

of forest and its resources and hence, low income generation capacity from fuel wood collection and fruit gathering.

Constraints to income generating activities of rural women in Akwa Ibom State
Table 4 clearly stated the constraints to income generating activities of rural women in AKS, Nigeria. The severest constraints to income generating activities being poor road network (x=1.86), lack of credit loan facilities (x=1.80), inadequate processing/storage facilities (x= 1.74), and insufficient land for farming (x=1.72). The result agrees with Okoro (2004) who reported that insufficient capital/credit facilities were some of the most severe constraints to income generating activities in AKS. The result is also in consonance with Asa (2007) who reported that pests and diseases were one of the severest constraints to income generating activities of rural women. The rural areas of the State were characterized by absence of good road network. This has made the movement of people and agricultural commodities to and fro markets and farms very costly and difficult leaving the farmers to struggle with low farm gate prices and spoilage of perishable goods; resulting in huge losses (Yahaya, 2010).

Table 2: Distribution of respondents based on income generating activities

Income generating activities	Frequency	Percentage
Agro processing	177	14.96
Crop planting	189	15.98
Animal farming	123	10.40
Transportation health care	47	3.97
Trading	149	12.60
Transportation business	2	0.17
Fuel wood collection	34	2.87
Fruit gathering	3	0.25
Hired labour	40	3.38
Dress mating	70	5.92
Hair making	75	6.34
Salon job	25	2.11
Drinking parlour business	55	4.65
Foodstuff retail business	113	9.55
Total	1183	100

n=192

Table 3: Income earned from income generating activities by the respondents

Income activities	Generating total monthly income (₦)	Average monthly income (₦)	Rank
Agro-processing	2163500.00	12086.60	4
Crop farming	2312500.00	12366.31	3
Animal farming	157600.00	1270.97	15
Traditional healthcare	955000.00	19100.00	2
Trading	1607000.00	1108276	6
Transportation	36000.00	9000.00	11
Fuelwood collection	21300.00	6085.71	14
Fruit gathering	20000.00	6666.67	13
Selling of cooked food	649000.00	7914.63	12
Hired labour	406500.00	9238.64	10
Dress making	644700.00	9238.64	9
Hair making	711000.00	10014.10	8
Salaried jobs	1064200.00	39414.81	1
Drinking parlours	669000.00	11736.84	5
Foodstuffs	1181500.00	10364.08	7

Note: Rank 1 is the income glaciating activities with the highest average monthly income while rank 15 is the activity with the least average monthly income

Table 4: Constraints to income generating activities of respondents

Constraint	Not a Constraint	Minor Constraint	Major Constraint	Mean	Rank
Policy inconsistence by Government	47*(24.5)**	106*(55.2)**	39*(20.3)**	0.96	9
Ethnic and religious conflict	57(29.7)	116(60.4)	19(9.9)	0.80	12
Pests and diseases	11(5.7)	4(2.1)	177(92.2)	1.86	2
Insufficient land for farming	21(10.9)	12(6.3)	159(82.8)	1.72	5
Inadequate agro-inputs	37(19.3)	93(48.4)	62(32.3)	1.13	7
Poor marketing Channels	57(29.7)	110(57.3)	25(13.0)	0.83	10
Lack of production information	123(14.1)	30(15.6)	39(20.3)	0.56	17
Lack of credit facilities	10(5.2)	19(19.9)	163(84.9)	01.80	3
Inadequate extension services	74(38.5)	80(41.7)	38(19.8)	0.81	11
Poor road network	5(2.6)	5(2.6)	182(94.8)	1.92	1
Low soil fertility	34(17.7)	17(8.9)	141(73.4)	1.56	6
Inadequate processing and storage facilities	17(38.5)	16(8.3)	15.9(82.8)	1.72	4
Use of crude Technologies	91(47.4)	85(44.3)	14(7.3)	0.07	13

Industrialization	121(63.0)	54(28.1)	17(8.9)	0.46	19
Long distance to Markets	77(40.1)	31(16.1)	84(43.8)	1.04	8
Political/regulating actions	140(72.9)	48(25.0)	4(2.1)	0.29	20
Poor pricing of Produce	114(59.4)	57(29.7)	21(10.9)	0.52	18
Low salaries	127(66.1)	19(9.9)	46(24.0)	0.58	16
Poor working condition in civil service	120(62.5)	29(15.1)	43(22.4)	0.60	15

Note: ∗ and ∗∗ = frequencies and percentages respectively; rank 1 is considered the most severe constraint while rank 20 is considered the least severe constraint

Conclusion and Recommendations

In conclusion, we have deduced that income the respondents earned from the income generating activities directly influenced the welfare of their household. Farming was their major income generating activity, showing more involvement in agriculture than any other income generating activity. Even though salaried jobs (government and private) was the most economically significant income generating activity in the study area, the opportunities of getting involved was few. Poor road networks, pests and diseases, lack of credit/loan facilities and inadequate processing/storage facilities were the severest constraints to income generating activities of the respondents in the study area.

Therefore, the income generating activities of the rural women of Akwa Ibom State can be positively influenced by the following recommendations:

- Government should make available sufficient agricultural inputs such as fertilizers, improved crop and animal seeds, agro-chemicals at subsidized rate, to boost their income, since they are involved in agro-related income generating activities.
- Provision of access roads in the rural areas should be made a priority by government at all levels. This is based on the fact that poor road network was the severest constraints to income generating activities.

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Evaluation of the potency of ethanol extracts of *Nypa fruticans* against *Culex quinquefasciatus* and *Aedes aegypti* larvae: An exploratory study

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Abstract

Diseases transmitted by *Culex quinquefasciatus* and *Aedes aegypti* are still a scourge. The objective of this research was to evaluate the potency of crude ethanol extracts of the leaf, rhizome and root of nipa palm, *Nypa fruticans* in static bioassays, against *Cu. quinquefasciatus* and *Ae. aegypti* larvae. Extract concentrations tested were 0.15, 0.30, 0.45, 0.60 and 0.75 % w/v each, at an exposure period of 72 hours. Each concentration had four replicates, in separate assay cups. The control which consisted of water (100 ml) was also replicated. Each experimental set up had 20 third instar larvae each. Each mosquito species was tested separately. At the end of experiments, only one larval mortality of *Ae. aegypti* exposed to 0.30 % w/v of the leaf extract was observed at 48 hr exposure period. Phytochemical screening revealed the presence of alkaloids and anthraquinones (free and combined) in the root extract only. Other compounds detected were saponins, tannins, flavonoids, terpenoids and cardiac glycosides. However, their concentrations in the different extracts varied. Results obtained revealed that the extracts of *Nypa fruticans* used in this study were not potent larvicides against *Cu. quinquefasciatus* and *Ae. aegypti* mosquitoes. However, the search for potent natural products against these mosquito species should continue.

Introduction

One of the challenges of man from ancient times has been that of curbing the menace of insect-borne diseases. In spite of advancement in technology and concerted efforts of the health sector in many tropical countries, control of certain insect-transmitted diseases has remained a nagging issue.

Mosquitoes cause severe global health problems as vectors of several important diseases. These diseases are transmitted through the bites of infected female mosquitoes. They occur throughout the tropical and temperate regions and several species are vectors of organisms or agents responsible for various debilitating and stigmatizing diseases (Service, 2012). Mosquito-transmitted diseases remain a major source of morbidity and mortality globally (WHO, 2017). Besides serving as vectors of disease, mosquitoes are such troublesome biters, constituting nuisance. Even when they do not transmit disease, they can make outdoor activities intolerable.

Malaria, filariasis, yellow fever, dengue, Japanese encephalitis, chikungunya and zika are some of the diseases vectored by different mosquito species. The mosquito species, *Culex quinquefasciatus* has been incriminated in the transmission of lymphatic filariasis, a disease that often progresses leading to a condition known as elephantiasis. *Cu. quinquefasciatus* also transmits encephalitis. *Ae. aegypti* is also a vector of lymphatic filariasis and is reported to be the principal vector responsible for yellow fever, dengue and dengue haemorrhagic fever transmission in tropical countries (WHO, 2017). *Ae. aegypti* is also responsible for the transmission of zika and chikungunya.

Different strategies have been devised to reduce the prevalence of insect-borne diseases in endemic regions of the world, but these strategies still have their limitations. Before the discovery of synthetic insecticides, some herbal products were used as natural insecticides. However, the discovery, development and use of synthetic chemicals over shadowed the use of natural products. The extensive use of synthetic insecticides has resulted in environmental hazards and the development of physiological resistance in insect vector species. These have necessitated the need for search and development of environment-friendly, biodegradable, cost effective and efficient methods of insect vector control.

Some indigenous plant based products are very promising against mosquitoes and can be used as repellents or insecticides (Ukpong *et al.*, (2016) and Ubulom *et al.*, (2019b)). They owe their efficacy to the phytochemical compounds present in them. Phytochemicals with larvicidal activity occur in the leaves, stems, roots, seeds and oils of plants (Kishore *et al.*, 2011). They are said to offer a safer alternative to synthetic chemicals. Obomanu *et al.*, (2006) reported that these natural insecticides are often less toxic and do not accumulate chemical residues in flora, fauna and soil. Ubulom *et al.*, (2013) reported on the larvicidal potentials of aqueous and ethanol extracts of the leaf and stem of *Senna alata,* against *Anopheles gambiae, Cu. quinquefasciatus* and *Ae. aegypti.* The larvicidal efficacy of ethanol leaf and seed extracts of *Picralima nitida* in the control of *Cu. quinquefasciatus* and *Ae. aegypti* has been documented by Ubulom and Ekong, (2016). Opara *et al.*, (2017) evaluated the activity of the stem bark extracts of *Sacoglottis gabonensis* against larvae of *Cu. quinquefasciatus* and *Ae. aegypti* and reported that the ethanol and aqueous extracts of *S. gabonensis*

stem bark were potent against *Cu. quinquefasciatus* and *Ae. aegypti* and concluded that the extracts of this plant could be harnessed in the formation of potent bio-insecticides against mosquitoes.

Nypa fruticans (Wurmb), commonly called nipa palm belongs to the family Arecaceae. It is the only member of the genus *Nypa,* forming monotypic taxa (Jian *et al*., 2000). It is adapted to muddy soils along rivers and estuaries and has ability to tolerate infrequent inundation, provided the soil does not dry out for too long (Hossain and Islam, 2015). Research by Udofia and Udo (2005) revealed that some residents of coastal communities of Akwa Ibom State, Nigeria consider nipa palm a nuisance because it hinders their main economic activity- fishing. This is a cause for concern, owing to the fact that these coastal dwellers are predominantly fishermen particularly as the coastal communities are yet to find beneficial uses of nipa palm.

However, various uses of this invasive palm have been documented, especially outside Nigeria (Hamilton and Murphy, 1988; Das*et al*., 2000; Udofia and Udo, 2005; Hossain and Islam, 2015). In Bangladesh and India, newly developed shoots of nipa palm are used as vermicide against parasitic intestinal worms (Hossain and Islam, 2015).

Very few empirical studies on the uses of nipa palm have been carried out in Nigeria. These include Udofia and Udo (2005) and Ebana *et al*., (2015). Ebana *et al.,* (2015) specifically reported on the antimicrobial activities of extracts of *N. fruticans.* Generally, there is a paucity of information on the potency of nipa palm against insect vector species. A survey of Okorombokho, a coastal community and nipa palm invaded wetland ecosystem of Eastern Obolo Local Government Area, Akwa Ibom State, Nigeria by Ubulom *et al*., (2019a) revealed the presence of some vector species, including *Cu. quinquefasciatus* and *Ae aegypti*. The objective of this research therefore was to evaluate the efficacy of ethanol leaf, rhizome and root extracts of *N. fruticans* against larvae of *Cu. quinquefasciatus* and *Ae. aegypti.*

Materials and methods
Collection and identification of experimental plant
Nipa palm, *N. fruticans* (Figs. 1 and 2) was collected from Okorombokho, Eastern Obolo LGA, Akwa Ibom State, Nigeria in November, 2017. It was authenticated by Prof. M. E. Bassey, a plant taxonomist in the Department of Botany and Ecological Studies, University of Uyo, Nigeria. The parts of the *N. fruticans* used for the research were the leaves (Fig. 1) and the rhizome (Fig. 2a) and roots (Fig. 2b).

Preparation of Ethanol Extracts of *Nypa fruticans*
Ethanol extracts of the leaf, rhizome and root of *N. fruticans* were prepared in the Post Graduate Laboratory of the Department of Pharmacognosy and Natural Medicine, University of Uyo, Nigeria. Fresh specimens of these parts were separately washed

thoroughly, using water. This was followed by chopping them into tiny pieces and shade-drying on laboratory Tables for 14 days. After shade-drying, each part was separately pulverized using manual grinders. Pulverized specimens were stored separately in dry, sterile, labeled plastic bags. Weights of the pulverized specimens were determined, using the triple beam balance (2610 g capacity), prior to maceration. The solvent used for maceration in this study was ethanol (50 %). The volume of solvent used for maceration was that sufficient to completely immerse the dry powder. Maceration lasted for 72 hours, with periodic stirring. Maceration (cold extraction) was preferred because it is a process that preserves phytochemical components that are thermolabile.

After maceration, repeated filtration was carried out separately for each plant part, thrice using sterile muslin cloth and twice using sterile filter funnel, Whatman No. 1 filter paper and non-absorbent cotton wool. After filtration, the entire volume of supernatant was concentrated *in vacuo,* using a rotary evaporator at a temperature of 40 ºC. Concentrated extracts were preserved in a refrigerator prior to use.

Phytochemical screening of ethanol extracts of *N. fruticans*
This involved the qualitative screening of the ethanol leaf, rhizome and root extracts of *N. fruticans*. The extracts were separately tested for the presence or absence of the following phytochemical compounds: alkaloids, flavonoids, tannins, saponins, terpenoids, cardiac glycosides and anthraquinones (free and combined). Standard procedures described by Sofowora (2006) and Evans (2009) were used for the tests.

Test for alkaloids
(i)   A quantity of 0.5 g of each extract was separately stirred with 5 ml of 1 % aqueous hydrochloric acid (HCl) on a steam bath and then filtered. The filtrate (1 ml) was treated with 3 drops of Dragendorff's reagent. Turbidity or precipitation with this reagent was taken as evidence for the presence of alkaloids in the extract, being tested (Evans, 2009).

(ii) The procedure was repeated by adding Mayer's reagent to 1 ml of filtrate, instead of Dragendorff's. The presence of a precipitate was regarded as evidence for the presence of alkaloids (Evans, 2009).

Test for flavonoids
Shinoda reduction test described by Sofowora (2006) and Evans (2009) was used to determine the presence or absence of flavonoids. A solution of each extract was separately prepared by adding 5 ml of distilled water to 0.5 g of each sample in a test tube. The mixture was shaken well to obtain the solution. This was followed by filtration. Three (3) pieces of magnesium metal were added to each filtrate, followed by three (3) drops of concentrated hydrochloric acid. The formation of an orange, red,

crimson or magenta colouration was taken as evidence for the presence of flavonoids.

Test for tannins
A quantity of 0.5 g of each extract was separately stirred with 10 ml of distilled water and filtered.

Three (3) drops of ferric chloride reagent was separately added to 2 ml of each filtrate. A blue-black, green or blue-green precipitate was taken as evidence for the presence of tannins (Evans, 2009).

Fig. 1: The leaves of *N. fruticans*

Fig. 2: The rhizome and roots of *N. fruticans*; *Note: A – Rhizome and B - Roots*

Test for saponins
Froth test
The ability of saponins to produce froth in aqueous solution was used as screening test for this group of compounds. A quantity of 0.5g of each extract was separately shaken vigorously with 5ml distilled water in a test tube. Frothing that persisted on warming was taken as evidence for the presence of saponins (Sofowora, 2006).

Sodium bicarbonate test
As a confirmatory test for saponins, a quantity of 3ml of 5% sodium bicarbonate and 2ml of Fehling's solutions A and B were added to 0.5g of each extract and boiled. The presence of a brown precipitate was

regarded as evidence for the presence of saponins in the extract (Evans, 2009).

Test for terpenoids
Liebermann's test was used to determine the presence or absence of terpenoids in each extract. Three (3ml) chloroform was added to 0.5g of each extract and filtered. A quantity of 10 drops of acetic anhydride was added to the filtrate and then 2 drops of concentrated tetraoxosulphate VI acid (H_2SO_4). A pink colour at the interphase was an evidence for the presence of terpenoids (Evans, 2009).

Test for cardiac glycosides
The presence of cardiac glycosides in the extracts was determined using Salkowski test. A quantity of

0.5g of each extract was dissolved in 2ml chloroform. One (1) ml concentrated tetraoxosulphate VI acid (H₂SO₄) was carefully added by running the acid down the side of the test tube. A reddish-brown colour at the interphase indicated the presence of aglycone portion of cardiac glycosides (Sofowora, 2006).

Test for anthraquinones
The detection of anthraquinones was done using Borntrager's test. The test was used to determine the presence or absence of free and combined anthraquinones.

Test for free anthraquinones
The test for free anthraquinones was carried out by shaking each extract with 10ml benzene and then filtered. Five (5) ml of 10% ammonia solution was added to the filtrate. The mixture was shaken and the presence of a pink, red or violet colour in the ammonia (lower) phase indicated the presence of free hydroxyl anthraquinones.

Test for combined anthraquinones
For the determination of combined anthraquinones, 5g of each extract was separately boiled with 10ml aqueous tetraoxosulphate VI acid (H₂SO₄) and filtered, while hot. The filtrate was shaken with 5ml benzene. The benzene layer was separated and 10% ammonia solution (half the volume of the benzene layer) was added to the separate benzene layer. A pink, red, or violet colouration in the ammonia phase (lower layer) was taken as evidence for the presence of anthraquinone derivatives.

Experimental mosquito species
Third instar larvae of *Cu. quinquefasciatus* and *Ae. aegypti* were used for the experiments reported in this research. They were obtained from the Malaria Vector Research Laboratory and Insectary, Department of Animal and Environmental Biology, University of Uyo, Nigeria.

Bioassays
All bioassays were carried out in the Malaria Vector Research Laboratory, Department of Animal and Environmental Biology, University of Uyo. The method used for the determination of the larvicidal activities of the extracts was adopted from that described by WHO (2005).
A stock solution of each extract was prepared by adding 100ml of tap water to 5g of extract in a 250ml sterile beaker and mixed thoroughly. Graded concentrations of each extract were obtained from the stock solution. These were 0.15, 0.30, 0.45, 0.60 and 0.75% w/v. Heat was applied to each extract solution, over a water bath at a temperature of 40°C for 2 minutes, after which the extracts were removed and left to cool for 30minutes, before assays were carried out. The essence of heat application to extract solutions was to reactivate metabolites that may have suffered inactivation due to refrigeration.

Four replicates were set up for each concentration. Each test/extract solution was transferred into sterile plastic assay cups, to which larval nutrients were added. This consisted of a pinch each of fine Quaker oats. The controls which were also replicated consisted of 100ml water and larval nutrient only. Twenty (20), third instar larvae of *Cu. quinquefasciatus* were exposed to each bioassay medium. The same was done using third instar larvae of *Ae. aegypti*. The control experiments also had 20 larvae each of the different species. Both the test and control experiments were maintained at room temperature (27± 2°C). Observations were made after 24, 48 and 72hours and the larvicidal activity of each extract was determined by counting the number of dead larvae each day, until the end of the experiment. Larvae were considered dead when they did not move and did not respond to stimulus with a Pasteur pipette.

Results
The results obtained from the study are presented in Tables 1, 2 and 3.

Results of phytochemical screening of *N. fruticans*
Qualitative screening of ethanol leaf, rhizome and root extracts of *N. fruticans* revealed the presence of some phytochemical components (Table 1). Based on the intensity of the observed reactions of the extracts to test chemicals and reagents the results of screening were presented as + (trace/low concentration), ++(moderate), +++(abundant) and -(negative/not detected).

Results of assays with ethanol extracts of *N. fruticans*
Ethanol extracts of the leaf, rhizome and root of *N. fruticans* had no noticeable toxicity sign on larvae of *Cu. Quinquefasciatus* and *Ae. aegypti* (Tables 2 and 3). In other words, the extracts did not exert any observable deleterious effect on the larvae even at the highest concentration (0.75% w/v) of extracts used in this study (Table 2). Toxicity signs such as immobility, mortality, disintegration of integument, change in the colour of larval integuments, etc. were not observed in this study. Larvae of both species exposed to test and control experiments were observed to wriggle actively throughout the duration of the experiment. However, larvae of *Cu. quinquefasciatus* were observed to be more active and agile than those of *Ae. aegypti*. Larvae exposed to the ethanol extract of the rhizome were more active than those exposed to the other ethanol extracts. Few larvae in the control set up and in the rhizome extract metamorphosed into 4th instar larvae, after the 72hr exposure period. Thus, the ethanol extracts of *N. fruticans* used in this study did not demonstrate growth inhibitory potentials either.
Only one larval mortality was observed (at 48h exposure period), when 20, third instar larvae of *Ae. aegypti* were exposed to 0.30% w/v (replicate 2) of

ethanol extract of the leaf (Table 3).   The findings obtained from this study did not lend data to probit analysis which is often required in toxicity studies.

Discussion

Some of the phytochemical compounds detected in the ethanol leaf, rhizome and root extracts of *N.* *fruticans* have been reported to exhibit larvicidal potentials. Alkaloids obtained from other plants have been reported to possess mosquito larvicidal activity (Talontsi *et al*., (2011) and Ghosh *et al*., (2012). However, alkaloids were detected in low concentration (trace amount) in the root extract only. This may account for its inability to elicit larvicidal activity.

Table 1: Phytochemical constituents of ethanol leaf, rhizome and root extracts of *Nypa fruticans*

Phyto-constituents	Test	Lf	Rh	Rt
Alkaloids	(i) Dragendorff's test	-	-	+
	(ii) Mayer's test	-	-	+
Flavonoids	(i) Shinoda's reduction test	+++	++	+++
	(ii) Magnesium metal test	+++	++	+++
Tannins	(i) Ferric chloride test	+	+	++
Saponins	(i) Froth test	+	+	+
	(ii) Sodium bicarbonate test	+	+	+
Terpenoids	(i) Liebermann's test	+	+	+
Cardiac glycosides	(i) Salkowski's test	++	+++	+++
Anthraquinones				
- Free anthraquinones	Borntrager's test	-	-	+
- Combined anthraquinones	Borntrager's test	-	-	+

+++ = Abundant; ++ = moderate; + = trace; - = Absent/not detected; Lf = Leaf; Rh = Rhizome; Rt = Root

Table 2: Larvicidal assay results of exposure of *Cu. quinquefasciatus* larvae to ethanol extracts of *N. fruticans*

Control/Extract conc. (%w/v)	Total No. of Larvae exposed	Leaf Extract Exposure period (hr)				Rhizome Extract Exposure Period (hr)				Root Extract Exposure period (hr)			
		24	48	72	Total	24	48	72	Total	24	48	72	Total
Control (100ml water)	80	0	0	0	0	0	0	0	0	0	0	0	0
0.15	80	0	0	0	0	0	0	0	0	0	0	0	0
0.30	80	0	0	0	0	0	0	0	0	0	0	0	0
0.45	80	0	0	0	0	0	0	0	0	0	0	0	0
0.60	80	0	0	0	0	0	0	0	0	0	0	0	0
0.75	80	0	0	0	0	0	0	0	0	0	0	0	0

Table 3: Larvicidal assay results of exposure of *Ae aegypti* larvae to ethanol extracts of *N. fruticans*

Control/Extract conc. (%w/v)	Total No. of larvae exposed	Leaf extract exposure period (hr)				Rhizome extract exposure period (hr)				Root extract exposure period (hr)			
		24	48	72	Total	24	48	72	Total	24	48	72	Total
Control (100ml water)	80	0	0	0	0	0	0	0	0	0	0	0	0
0.15	80	0	0	0	0	0	0	0	0	0	0	0	0
0.30	80	0	1	0	1	0	0	0	0	0	0	0	0
0.45	80	0	0	0	0	0	0	0	0	0	0	0	0
0.60	80	0	0	0	0	0	0	0	0	0	0	0	0
0.75	80	0	0	0	0	0	0	0	0	0	0	0	0

Saponins and tannins extracted from other plants have also been shown in separate studies to be lethal to mosquito larvae. Wiesman and Chapagain (2006) reported that saponin extracted from the fruit of *Balanites aegyptiaca* ('desert date') resulted in 100% mortality of larvae of *Ae. aegypti*. Exposure of larvae of *Ae. aegypti* and *Cu. pipiens* to a commercial saponin mixture extracted from *Quillaja saponaria* bark resulted in 100% larval mortality, of both species (Pelah *et al*., 2005). Saponins detected in low concentrations in the three extracts used in this study were probably not sufficient to cause larval mortality.

Khanna and Kannabiran (2007) detected tannins in the crude extracts of the root of *Hemidesmus indicus* and in the leaves of *Gymnema sylvestre*. They reported that the larvicidal effect of those extracts on *Cu. quinquefasciatus* could be due to the presence of tannins in the extracts. Other reports on tannins and saponins as mosquito larvicides are documented by Garcia da Silva *et al*., (2004) and Deore and Khadabadi, (2009). The presence of tannins in nipa palm is corroborated by the reports of Burkill (1966) and Fong (1992). Burkill (1966) also reported on the low concentration of tannins in the leaves of nipa

palm and added that its tannins are not of good quality. These may explain why the tannins in this plant could not cause larval mortality.

The larvicidal potential of flavonoids extracted from other plants against mosquito species have been reported by Joseph *et al.*, (2004), Saxena *et al.*, (2013) and Munhoz *et al.*, (2014). Screening of *N. fruticans* revealed that flavonoids were abundant in the leaf and root extracts whereas they were present in moderate concentration in the rhizome extract but could not elicit larvicidal potency. This again may be attributed to the quality. Further investigation is thus required to substantiate this. Some biological activities of the extracts of *N. fruticans* have been reported. Ebana *et al.,* (2015) documented a report on the antimicrobial efficacy of the leaf, mid-vein and husk extracts of nipa palm.

Results obtained from this study revealed that extracts of *N. fruticans* at the various concentrations used did not exhibit any larvicidal potential. Mortality of only one larva of *Ae. aegypti* observed could be accidental or it could be that the larva was in a morbid state, even before commencement of the experiment, since other larvae in the same experiment were still active. The nutritional value of nipa palm has been reported. For example, the sugary sap that is tapped from the palm and the aromatic tea that is brewed from the leaves (Hossain and Islam, 2015). It is probable that larvae obtained some form of additional nutrients from the extracts, since most of them remained agile and wriggled actively throughout the duration of the experiment. This necessitates further investigations.

Conclusion

Some indigenous plant based products are very promising against mosquitoes and could be used as insecticides and/or repellents. This initial study on the evaluation of the efficacy of ethanol extracts of the leaf, rhizome and root of *N. fruticans* against larvae of *Cu. quinquefasciatus* and *Ae. aegypti* revealed that extracts of *N. fruticans* did not hold larvicidal potential against the test mosquito species. However, the results of this study should be taken as preliminary, requiring further investigations.

Our world today is still plagued by diseases and some of these are caused by organisms which are mosquito-borne. Larval management is a promising strategy for mosquito control. Larvae inhabit specific areas and can be more easily controlled because treatments provide control before biting adults appear and disperse from the breeding sites. Thus, the search for and development of repellents and insecticides that are environment-friendly, biodegradable and effective should be intensified.

Acknowledgements

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Characteristics of soils along a toposequence in Kaffinkoro, North Central Nigeria and its relationship to potential agricultural land use

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Abstract

A toposequence in Kaffinkoro, North Central Nigeria was studied to establish its influence on soil properties and potential agricultural use. In order to characterize and classify the soils, three pedons were dug along the toposequence at the crest, middle slope and valley bottom. The soils were characterized in terms of their morphological, physical and chemical properties. The soils were generally medium to coarse textured. The distribution of clay content increased with soil depth for all pedons. The soils were strongly to moderately acidic (pH 4.4 to 5.6). The highest concentration of organic carbon occurred at the valley bottom and decreased with depth in all the pedons studied. Base saturation was low at the crest and middle slope and medium at the valley bottom. At the sub-group level, the soils at the crest were classified as Typic Hapludults which correlated as Haplic Acrisols. The valley bottom soils were classified as Histic Humaquepts and Histic Cambisols. The soils at the slope and valley bottom were preferred for economic arable cultivation whereas the soils at the crest were middle most suited for forestry and wildlife. Strict measures to prevent soil erosion at middle slope and replenish lost nutrients are required for enhanced productivity of these soils.

Introduction

Soil's topography plays a major role as one of the factors that influences pedogenesis and in the process that dictates the distribution and use of soils on the landscape (*Esu et al.,* 2008). Landscape position influences effective rainfall, drainage and erosion. Topography influences water velocity on a slope, variation in drainage conditions and deposition materials. This causes a series of changes in soil properties such as horizon differentiation, textural contrasts, changes in soil depth and chemical properties (Hall and Olson, 1991).

Lack of information on the soil resources of any region contributes to the problem of soil degradation and that of world food crisis, due to wrong use and poor management of land resources on different terrains. Inadequate information on the potentials of our soil resources is a major constraint limiting agricultural development in Nigeria. Land characteristics and soil information must be combined effectively to manage our soil for enhanced agricultural productivity. Upland soils deteriorate rapidly due to erosion and fertility depletion. There is thus the need to study soils on different terrains of a toposequence, classify them for proper understanding of the relationship between landscape and soil properties to enhance soil management. Studies on soil classification and landscape relationship in the extensive agricultural soils in Kaffinkoro, North Central Nigeria are scarce. This, however, necessitates the present study with the specific objectives of characterizing, classifying and recommending appropriate management measures aimed at enhancing the productivities of the soils.

Materials and methods

This study was carried out on a toposequence located in Kaffinkoro, Kaffinkoro Local Government Area of Niger State. Kafffinkoro lies around longitude 6° 0' and 5° E and latitude 9° 03' and 10° 0' N (Fig. 1). The geology of the study area consists of basement complex (Ogunwale *et al.,* 2002). The monthly temperature value is always around 27 °C, though with little variations. The annual rainfall ranges from 1750 – 2500 mm. The relative humidity in the study area varies from 50-60 % during the month of January, to about 60-70 % in July (Federal University of Technology, Minna, 2015). The vegetation of the study location is woody savanna; grasses account for 80 % of the vegetative cover while the shrubs and trees account for about 20 %. Arable farming was identified as the commonest land use type in the study area.

Sampling techniques

The identified toposequence was stratified into the crest, middle slope and valley bottom. Three (3) profile pits were excavated; each representing the crest, middle slope and valley bottom toposequence.

Field work

The profile pits were dug at the most representative points of observation representing the various strata of the toposequence. The soil profiles were described according to the FAO (2006) guidelines. Soil samples were taken from the different genetic horizons of the

profile pits for routine chemical analysis, determination of soils physical parameters and other fertility indices.

Laboratory analysis

Particle size analysis was determined by the pipette method (Gee and Bauder, 1986). Soils erodibility index was estimated by evaluating the ratio of sand and silt contents to clay content (Hudson, 1995). Evidence for argillic (Bt) horizon was obtained by determining the ratio of illuvial to eluvial clay.

Soil pH was determined in a 1:2.5, soil:water suspension (Thomas, 1996). Organic carbon was determined by the dichlomate wet oxidation method (Nelson and

Sommers, 1996). Total nitrogen was determined by the macro kjeldahl digestion procedure (Bremner, 1996). Exchangeable cations, extracted into IM ammonium acetate solution were measured by versenate titration method (Ca^{2+} and Mg^{2+}) and by flame photometry (Na^+ and K^+). Exchangeable acidity (H^+ and Al^{3+}) was determined by the 1M KCl extraction procedure (Juo, 1979). Available phosphorus in the soil was determined by the Bray 2 methods, using a solution of IM NH_4F and 0.5 M HCl in distilled water as the extractant (Kuo, 1996). The cation exchange activity class was determined by estimating the ratio of CEC by NH_4OAc at pH 7.0 to clay content.
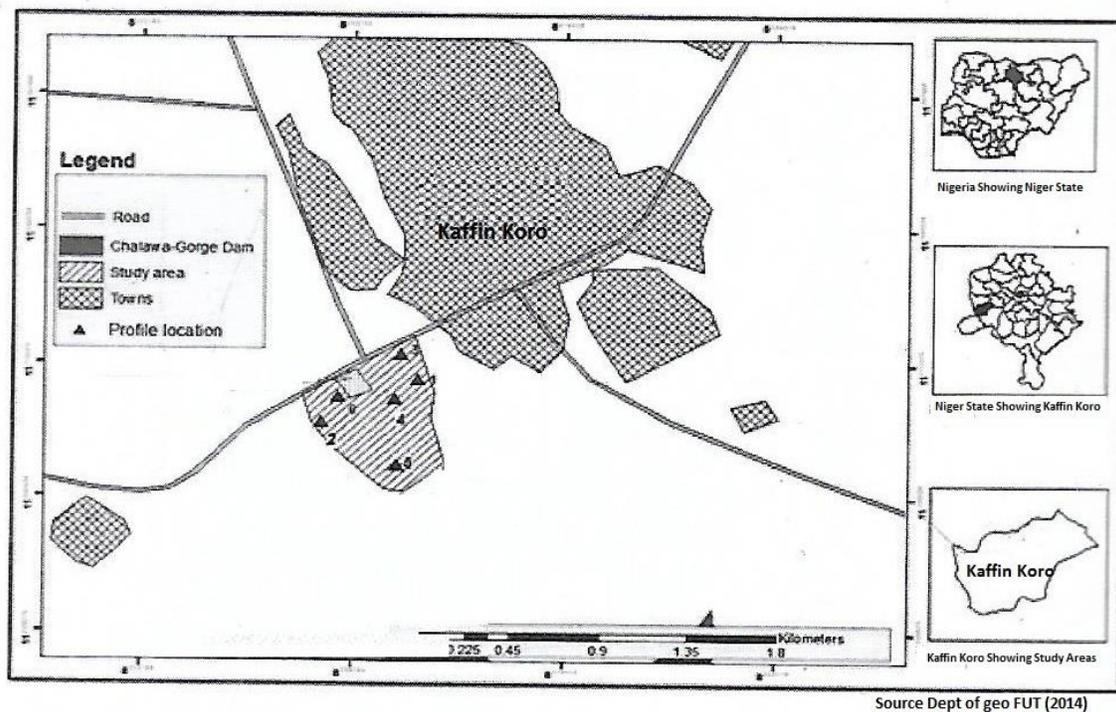

Fig. 1: Map of study area showing the sampling stations in Kaffinkoro, Kaffinkoro Local Government Area of Niger State, Nigeria (Insert: Map of Nigeria showing the location of Niger State and Kaffia)

Results and Discussion
Morphological characteristics

Under moist conditions, the soils at the crest were characterized with dark brown (7.5YR 3/2) surface soils over reddish brown (5YR4/4) sub soils (Table 1). The soils at the middle slope had dark reddish brown (5YR3/3) epipedons over reddish brown (5YR4/4) to reddish yellow (5YR6/6) endopedons. The valley bottom soils were characterized by very dark greyish brown (10YR 3/2) surface soils over grayish brown (10YR5/2) to gray (10YR6/1) sub soils. The sub soils of

valley bottom were mottled throughout their entire depth with yellow brown (10YR5/4) mottles due to seasonal fluctuations of the water table. However, the soils at the crest had reddish (2.5YR4/6) sub soil mottles indicating the presence of weathering minerals. Morberg and Esu (1991) and Akamigbo *et al.,* (2002) reported similar colours for soils of similar landscape positions. Weak to moderate, fine to medium crumb and granular structures characterized the soils at the crest and middle slope while sub soils at the valley bottom had moderate medium to coarse prismatic structures.

The dry consistence of these soils indicated soft surfaces over slightly hard sub soils over friable to firm sub soils characterized to moist consistence of the soils in the study area. Under wet conditions these soils had non-sticky, non-plastic or slightly-sticky, slightly plastic top soils over sticky-plastic sub soils.

Table 1: Morphological characteristics of soils along a toposequence in Kaffinkoro

Horizon	Designation	Horizon major root thickness (cm)	Colour Mottles Pores	Texture Horizon	Structure	Dry	Moisture	Wet
			Crest					
AP	cm	0-20 mc	7.5YR3/2, Db cw	SCL	1F crumb	S	l	ns-np
AC	Cf	20-46 cm	2.5YR3/4, Drb gw	SCL	1M granular	Sh	vfr	ns-np
BCt1	mm	46-82 cm	5YR4/4, Rb cw	SCL	1F crumb	Sh	f	s-np
BCt2 P V	cc	82-133 cm	5YR4/4, Rb	SC	1F crumb	Sh	f	s-
			Middle slope					
AP	cm	0-27 fm	5YR3/3, Dbr cw	SL	1F crumb	S	l	ns-np
BCt1	ff	27-43 fm	7.5YR4/4, B gw	SCL	2M crumb	Sh	vfr	ns-np
BCt2 P	cf	43-88 cf	5YR4/4, Rb gw	SC	2C granular	Sh	f	s-p
Ct V	fc	88-151 cf	5YR6/6, Ry	SC	2C granular	Sh	f	s-p
			Valley bottom					
AP	cf	0-20 cc	10YR3/2, VDgb as	SCL	2M granular	h	vf	ns-np
Bt1	fvf	20-45 ff	10YR5/2, Gb gw	SCL	2M granular	vh	fr	ns-np
Bt2 V	fc	45-71 fvf	10YR6/1, G	SCL	2M granular	vh	f	s-sp

1. Colour: Db = Dark brown, Drb = Dark reddish brown, B = brown, Ry = Reddish yellow, VDgb = very Dark grayish brown, Gb = Grayish brown, G = Gray, R = Red, Yb = Yellowish brown.
2. Mottles: ffd=few fine distinct, cmd =common medium distinct.
3. Structure: 1 = weak, 2 = moderate, 3=strong, f = fine, m = medium.
4. Texture: SCL = Sandy Clay Loam, SC = Sandy Clay, SL= Sandy Loam.
5. Consistence: S= Soft, Sh = Slightly hard, vh = very hard, h = hard, vfr = very friable, fr = friable, l = loose, f = firm, ns = non sticky, np = non plastic, s = sticky, p = plastic, ss = slightly = sticky, sp = slightly plastic.

Physical characteristics

The soils along a toposequence in Kaffinkoro LGA were characterized with sandy clay, loam, sandy loam and sandy clay. The medium to coarse texture of these soils is due to their granite origin which according to Webster and Wilson (1980) weathered into coarse textured soils. These soils had high soil erodibility index in the range 1.6 to 5.3 (Table 2). These values are higher than the critical limit of 1.0 suggested by Kinell (1981) for coarse textured soil. Thus, making these soils vulnerable to sheet and gully erosions. The erosion severity is higher at the crest and middle slope to slope steepness. This finding corroborates that of Hudson (1995) who suggested that soils with high erodibility index are easily eroded. Total sand content dominated other soil

separates in all the pedons studied with values ranging from 43-71 g kg^{-1} (Table 2). There was a progressive increase in clay content with soil depth in all pedons studied with total sand content highest in top soils. This, however, indicates the argillic or kandic sub-surface diagnostic horizons. Silt content was generally low (10-19 g kg^{-1}) in all pedons. This observation also collaborates the work of Atofarati *et al.,* (2012) on two toposequence at Ileoluji, Ondo State, Nigeria.

Chemical characteristics

The pH of the soils in the study area ranged from 4.4 to 5.6; averaging 4.6 in the crest, 5.2 in the middle slope and 4.8 in valley bottom topographic position (Table 3). These values are rated strongly to moderately acid. The

strongly to moderately acidic reactions of these soils maybe caused by the high rainfall experienced in these localities and further complicated by the coarse textured nature of these soils permitting extensive leaching of basic cations.

Table 2: Physical Characteristics and Soil Erodibility Index of Soils along a Toposequence in Kaffinkoro, L.G.A.

Horizon designation erodibility	Horizon depth (cm)	Coarse sand (%)	Fine sand	Total sand (%)	Silt (%)	Clay	Textural (%)	Soil Class Index
				Crest				
Ap	0-20	46	19	65	14	21	SCL	3.8
BC	20-46	42	15	57	17	26	SCL	2.8
BCt1	46-82	37	14	51	19	30	SCL	2.3
BCt2	82-133	31	43	43	19	38	SC	1.6
				Middle slope				
Ap	0-27	40	31	71	13	16	SL	5.3
BCt1	27-43	38	17	55	15	30	SCL	2.3
BCt2	43-88	36	5	51	13	36	SC	1.8
Ct	88-151	46	14	50	18	32	SC	2.1
				Valley bottom				
AP	0-20	46	20	66	10	24	SCL	3.2
Bt1	20-45	42	19	61	12	27	SCL	2.7
Bt2	45-71	36	18	54	14	32	SCL	2.1

Keys: SCL = Sandy Clay Loam, SC = Sandy Clay, SL = Sandy Loam

Table 3: Chemical Properties of soils along a Toposequence in Kaffinkoro L.G.A

Horizon Designation	Depth (cm)	pH (H₂O)	Org. C	Org. M gkg⁻¹	Total N	Ca⁺	Mg²⁺ cmol kg	K⁺	Al³⁺	H⁺	EA	Avail P	BS	CEC
						Crest								
Ap	0-20	4.80	17.90	30.90	1.40	1.30	1.6	0.12	Trace	7.50	7.50	4.40	29.00	0.10
BC	20-46	4.60	16.10	27.80	1.10	0.70	1.2	0.08	Trace	5.60	5.60	3.30	26.70	0.10
BCt1	46-82	4.40	9.90	17.10	0.60	0.60	1.0	0.06	Trace	7.10	7.10	3.10	19.30	0.10
BCt2	82-133	4.60	6.70	11.60	0.40	0.60	0.8	0.60	Trace	6.00	6.00	3.00	20.00	0.03
						(Middle Slope)								
Ap	0-27	5.60	19.20	33.10	2.30	2.10	2.6	0.16	Trace	9.00	9.00	10.10	35.30	0.30
BCt1	27-43	5.50	11.40	19.70	1.60	1.10	1.2	0.10	Trace	4.20	4.20	5.20	36.90	0.10
BCt2	43-88	5.00	9.70	16.70	0.90	1.00	0.6	0.05	Trace	5.60	5.60	4.80	23.30	0.04
Ct	88-151	4.60	6.10	10.50	0.50	1.00	0.8	0.05	Trace	6.40	6.40	3.90	26.40	0.10
						(Valley Bottom)								
AP	0-20	4.60	32.10	55.30	4.10	3.60	4.3	1.20	Trace	6.60	6.60	9.60	58.10	0.40
BCt1	20-45	4.60	23.80	39.80	3.60	3.20	4.0	1.11	Trace	9.50	9.50	7.00	46.80	0.30
BCt2	45-71	5.10	16.30	28.10	3.40	2.60	3.7	0.80	Trace	6.00	6.00	5.50	54.40	0.20

Key: SA = sub – Active; A = Active

Values of soil organic carbon ranged from 6.1 to 32.1 gkg⁻¹; averaging 12.7 gkg⁻¹ for soils at the crest, 11.6 gkg⁻¹ at the middle slope and 24.1 gkg⁻¹ for soils at the valley bottom. The values were rated medium for soils at the crest and middle slope but high for soils in valley bottom locations. The high organic carbon in soils at the valley bottom may be due to increased organic matter deposition and subsequent mineralization. High organic carbon levels especially in top soils of middle slope may be due to the redistributive effect of slope (Esu *et al.,* 2008).

Total nitrogen ranged from 0.4 to 4.1 gkg⁻¹; averaging 0.9, 1.3 and 3.7 gkg⁻¹ for soils at the crest, middle slope and valley bottom respectively (Table 3). These values

are rated low for soils at the crest, medium for soils at the middle slope and high for valley bottom soils. The high total nitrogen level at the valley bottom may be due to its high organic carbon content which according to Konnovora *et al.,* (1966) accounts for about 90 to 98 % of total nitrogen.

Almost the exchangeable cations, sodium ranged from 0.04 to 0.06 cmolkg⁻¹, averaging 0.05 cmolkg⁻¹ for soils at the middle slope and valley bottom (Table 3). These values are rated low in the entire study area. Exchangeable potassium ranged from 0.05 to 1.20 cmolkg⁻¹, averaging 00.08 cmolkg⁻¹ for soils at crest, 0.09 cmolkg⁻¹ for soils at the middle slope and 1.04 cmolkg⁻¹ for valley bottom soils (Obiora and Umeji,

1995). These values are rated high for valley bottom soils but low for crest and middle slope soils. Exchangeable magnesium ranged from 0.6 to 4.3 cmolkg^{-1}, average 1.2, 1.3 and 4.0 cmolkg^{-1} for soils at crest, middle slope and valley bottom respectively. These values are rated medium for valley bottom soils but low for crest and middle slope soils.

Among the exchangeable cations, calcium and magnesium dominated over potassium and sodium. This finding collaborates that of Enwezor (1981). High soil mineral nutrient (exchangeable bases) observed in top soil horizons are probably due to nutrient biocycling (Ogunwale *et al.,* 2002). The medium to high levels of exchangeable cations observed in soils of valley bottom locations may be due to erosional deposition of sediments containing solutions of these cations.

The results of the cations exchange capacity (CEC) of soils in the study area indicated medium level (8.23 cmolkg^{-1},) for soils at the valley bottom but low for soils at the crest (2.08 cmolkg^{-1} and middle slope (2.85 cmolkg^{-1}).

The exchangeable acidity in the study area ranged from 2.6 - 9.0 cm. The exchangeable acidity was due majorly to exchangeable H$^+$. However, with trace levels of exchangeable Al^{3+}.

Values of available phosphorus in the study area ranged from 3.0 to 10.1 mgkg^{-1}; averaging 3.5, 6.0 and 7.4 mgkg^{-1} at the crest, middle slope and valley bottom respectively. These values were all rated low. The low available phosphorus level encountered in the study area collaborates the finding Eshett (1987) who remarked that most Nigerian soils have low phosphate reserves due to high phosphorus fixation.

Base saturation in the study area ranged from 20.0 to 58.1 %, averaging 23.8 % for soils on crest 30.5 % for soils of middle slope positions and 53.1 % for soils of valley bottom. These values of base saturation were rated low for soils of crest and middle slope but moderate for soil of valley bottom locations.

Taxonomic classification of soils

The soils in the study area are classified using the USDA Soil Taxonomy (Soil Survey Staff, 2010) and correlated with the FAO/UNESCO legend of World Reference base (FAO/UNESCO, 2014).

Soils of crest and middle slope have translocated clay in B-horizon (Bt) as evidenced by clay skins and ratios of illuvial: elluvial clay greater than 1.5. This signified the presence of argillic horizon. These soils also had low supply basic cations and base saturation less than 35 % by ammonium acetate method. They are therefore, classified as Ultisols (Soil Survey Staff, 2010). These soils are further classified as Udults due to their accuracy under Ustic soil moisture regime, at the sub order level. The soils at the crest were further classified as Hapluduts at the great group level and as Typic

Hapludults at the sub group level which correlate approximately as Haplic Acrisols (FAO/UNESCO, 2014).

The soils at the middle slope were classified Plinthudults at the great group level due to presence of Plinthic materials in their sub soils and as Typic Plinthudults at the sub order level. The FAO/UNESCO equivalent of Typic Plinthudults is Plinthic Acrisols.

The valley bottom soils were characterized by histic epipedons and a cambic endopedon. These soils also had medium levels of base saturation with poorly developed horizons. These properties qualified the placement of these soils under the Inceptisol Soil Order (Soil Survey Staff, 2010). These soils occurred under Aquic conditions and were thus classified Aquepts at the sub order level. At the great group level, they were classified Humaquepts due to their possession of hustic epipedons. These soils were further classified as Histic Humaquepts at the sub group level and correlated approximately as Humic Cambisols (FAO/UNESCO, 2014).

Potential agricultural landuse of the soils

Soil erosion and low pH (high acidity) are the most important factors limiting potential agricultural land use in the study area for extensive food crop production. Specific remarks are made for the three strata of the toposequence representing the land terrain types.

Soils of the Crest

The soils of the crest have slope varying 14 – 17 %. These soils are moderately deep with gravelly sandy clay sub soils and sandy clay loam surface soils. Due to the inherent low soil fertility status, steep slope and erosion hazard, most soils belonging to this land type are unsuitable for intensive food, crop production, particularly large scale mechanized farming. These soils can be used for forestry and wild life. Alternatively, terracing farming can be adopted.

Middle Slope

The soils on middle slope have slope varying 7-17 %. These soils also possess sandy loam over sandy clay textures, becoming gravelling in the sub soil from about 40 cm depth downward with plinthites. Soils of this land type have slightly better quality for food crop cultivation primarily because of better overall fertility status and moderate slope steepness. These soils are probably more suited for arable crops and economic tree crops or forest trees.

Valley Bottom

Soils of this land type occurred on 0-3 % slope. These soils are poorly drained, grayish, deep and sandy clay loam textured. Potential rice cultivation in these small hydromorphic valleys is high. However, the temporary water logging of these soils may limit growth of upland

crops such as yam, cassava and maize. The valley bottom soils may also be used as grazing land with planted pasture species such as *Stylosanthes (*legume) and *Andropogon (*grass) which tolerates soil acidity and low soil fertility status.

Conclusion

Soils vary considerably on a toposequence and influence their agricultural potentials. Soils at the crest of the toposequence studied were generally considered unsuitable for extensive food crop cultivation. The soils on middle slope and valley bottom are probably more suited for economic arable crop cultivation. Strict measures to prevent soil erosion and replenish lost soil nutrients are required for enhanced productivity of soils in the study area.

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Hatchability, fecundity and survival rate of African catfish, *Clarias gariepinus* eggs treated with formalin as disinfectant

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Fecundity, hatchability, survival, *Clarias gariepinus*, eggs, formalin

Abstract

In trying to find lasting solutions to an increase in fish egg hatchability, the effect of formalin was investigated on the hatchability, fecundity and survival rates of *Clarias gariepinus* eggs in a commercial hatchery. Matured female brood fish weighing between 700-900 g body weight were procured and treated with a single dose of hormone (Ovaprim) and hand-stripped for eggs after a minimum latency period of twelve hours at water temperatures of between 25 and 29 ^{0}C. Stripped eggs were treated with formalin concentrations of 0.5 ml/l, 1 ml/l, 1.5 ml/l and a control of 0 ml/l. Fecundity, percentage survival and hatchability were determined. One-way Analysis of Variance was used as statistical tool for the analysis. Data obtained were pooled from the replicate and mean values were calculated per treatment. Duncan Multiple Range Test was also used for mean separation. Results in fecundity showed that fecundity did not differ significantly ($P > 0.05$) 166,232.2, 172,984.2, 163,143.6 and 169,987.4 between control and other treatments of 0.5 ml, 1 ml and 1.5 ml/l. However, results showed that percentage survival and hatchability differed significantly ($P < 0.05$) amongst treatments as the highest concentration of 1.5 ml/l recorded the highest survival rate (97.10[c]) and highest body weight gain (5.93[b]). Percentage survival and hatching differed significantly ($P < 0.05$) between 0.5 ml and 1.5 ml concentrations (94.21[b] and 97.10[c]) and (96.11[b] and 97.78[b]) respectively. Percentage cumulative mortality were 11.53 % for the control, 7.15 %, 6.18 % and 4.51 % respectively for 0.5 ml, 1 ml and 1.5 ml. It is concluded that formalin is a very good anti-fungal agent.

Introduction

The demand for fish fingerlings for aquaculture is on the increase in Africa and has made hatchery propagation of culturable fish species important (Yiza *et al*., 2014). Fungal infection on eggs causes disease problem which results into egg mortality, reduces hatching of fertilized eggs and survival of larvae (Jung, 2004). The external surface of fish eggs is easily colonized by bacteria, such as *Flavobacterium* sp., *Pseudomonas* sp., *Aeromonas* sp. and *Vibrio* sp. (Miguez and Combarro, 2003, Madsen *et al*., 2005). Eggs are externally disinfected at the green and/or eyed-stage to minimize the possibility of infection by bacteria, fungi or parasites.

Formaldehyde was described by Alexander M. Butleroo in 1854 (Walker, 1964). It was first used in fish culture by Le'ger (1909) to control *Costia* on trout. Formalin which can chemically be identified by the formula (CH_2 (OH)2 and HO. (CH_2O) n. H), is a generic term which describes a solution of 37 % formaldehyde gas dissolved in water (Akpoilih and Adebayo, 2010). According to Jung (2004), solutions of formalin for use on fish should contain 10 to 15 % methanol, which inhibits formation of para formaldehyde, a highly toxic compound (Stuart, 2010). Jung (2004) reported that formalin is extremely effective against most protozoans as well as some monogenetic trematodes through bath, flush or flowing

treatment methods. Formalin is also one of the most commonly used chemical treatments for fungal control in fish hatcheries and effective in the control of fungus on eggs without adverse effects on hatchability and post-hatching survival as reported by Pedersen *et al*., (2008). Formalin has also long been a traditional treatment of fish ectoparasites, even though it is a highly toxic compound. However, the use of formalin to treat fish eggs as in *Clarias gariepinus* before incubation has not been a common practice in Nigeria by fish breeders and hatchery operators. African catfish, *Clarias gariepinus* is a specie with high economic value in Nigeria (Teugels, 1986) and is widely cultured owning to its hardiness, fast growth and highly priced food fish (Adewumi and Olaleye, 2011; Agbebi *et al*., (2013) and Awodiran and Afolabi, (2018). The efficacy of various disinfection methods has been studied using many different species of fish eggs (Salvesen *et al*., (1997), Grotmol and Totland (2000), Peck *et al*., (2004) and Stuart (2010).

Formalin is widely used for treating fungal infection on fish eggs in intensive aquaculture operations to improve the hatchability and survival of larvae but there is problem of appropriate concentration of chemical and period of time the treated eggs are to be in contact with the chemical before incubation in order to reduce potential toxic effect on fish (Yiza *et al*.

2014). The aim of this research was, therefore to determine the effect of formalin solution on African catfish, *Clarias gariepinus* egg.

Materials and methods
Procurement and acclimatization of experimental fish
Ten (10) samples, (5 males and 5 females) gravid *Clarias gariepinus* brood stock size ranging from 600-950 g total body weight (TBW) were procured from the University of Calabar fish farm. They were then acclimatized for seven days in holding indoor concrete tanks of 1000 L water carrying capacity of indoor hatchery in the Hatchery Unit of Amon-Amon Farm, Ugep. Test fish were fed *ad libitum* with commercial feed containing 35 % crude protein. The brood stocks were examined for gonad development according to the method of Blythe *et al*., (1994) and Yisa *et al*., (2010). The acclimation of the brooders was done for adaptation to test laboratory condition such as light, duration of light and dark period and ambient temperature, which were critical to maturation and spawning of eggs in captivity. Males were examined for rigid and reddish infusion of the genital orifice and for females, genital orifice for reddish infusion, distension of the belly and release of eggs when gentle pressure was applied on the abdomen. The selected samples were properly maintained separately before being used for breeding.

Preparation of test solution
Concentrated formalin was bought from local chemical stores in Ikom - Calabar Road, Ugep in preparation for the experiment. Formalin solution was prepared by diluting 0.5 ml with 99.5 ml, 1 ml formalin into 99 ml and 1.5 ml in 98.5 ml of distilled water respectively. Milt was obtained by sacrificing the male and testis removed, cleaned with cotton wool to remove all the stained blood and then kept in a clean petri dish and thereafter macerated to squeeze out milt.

Breeding procedure
The acclimatized matured female brood fish were treated with a single dose of hormone (Ovaprim) according to the method of Goudie *et al*., (1992) and hand-stripped for eggs after a minimum latency period of twelve hours at water temperature of between 25-29 °C. The eggs were treated with formalin concentrations of 0.5 ml, 1 ml, 1.5 ml and 2.0 ml with a control of 0 ml for 15 minutes to determine the effective concentration that could reduce *Saprolegnia* growth and other infections (resulting from dead and unfertilized eggs and stickiness of the eggs or other fungal infections), threshold concentration for formalin on the eggs as well as the hatching and survival of larvae. Incubator made of net happa with kakabarns, placed inside plastic tanks filled with clean water were used for this purpose. Fertilized eggs were spread in a monolayer on the kakabarns in the incubator. Aeration was maintained by flow through system. The happa were constructed from a coated nylon net with 1.5 mm mesh size. After hatching was completed the happa with un- hatched eggs and shells were lifted out of the incubation tank and washed.

The eggs were removed after 15 minutes and placed in five (5) litres transparent plastics, replicated thrice, for each concentration of formalin, with each replicate receiving the treated eggs. The fifteen plastics, each filled with 3 litres of water, were aerated two days before fertilization to enable the eggs utilize dissolved oxygen for fertilization and survival of the hatched larvae. Fertilization was done by mixing the milt and eggs together gently with a plastic spoon for 2-3 minutes. Each treatment was replicated three times. Small quantity of saline solution was then poured onto the eggs to avoid sticking together. The fertilized eggs were rinsed with distilled water and taken to the incubator for incubation.

Based on the results of the preliminary test, the same breeding procedures were conducted for the definitive test by collecting fertilized eggs from another set of gravid female, which were fertilized with the milt of the remaining male pair. The eggs were also subjected to similar treatment procedures as in the preliminary test, but with formalin concentrations of 0.5 ml/l, 1 ml/l, 1.5 ml/l and a control of 0 ml/l. After yolk absorption, the hatchlings were fed with decapsulated artemia. Water quality parameters including temperature, dissolved oxygen, pH and conductivity were monitored and maintained at optimum levels.

Determination of hatching rate
Fecundity, percentage survival and hatchability were determined according to methods described by Oyelese (2006) using the formulae:

$$Fecudity = \frac{TW\ of\ stripped\ eggs\ \times TN\ of\ eggs\ in\ subsample}{weight\ of\ eggs\ in\ subsample}$$

Where TW = Total weight and TN = Total number

$$Percentage\ Hatchability = \frac{No.\ of\ Hatched\ larvae}{No.\ of\ eggs\ incubated} X100$$

Determination of survival rate
Percentage survival was determined by counting the total number of survived larvae after formalin treatment after one week and expressing such as a percentage of the total hatched larvae in each replicate tank. Mathematically, it is expressed as:

$$Percentage\ survival = \frac{total\ number\ of\ survived\ larvae}{total\ number\ of\ hatched} X100$$

Statistical analysis
One-way Analysis of Variance (ANOVA) was used as statistical tool for the analysis. Data obtained were

pooled from the replicate and mean values and were calculated per treatment. Duncan Multiple Range Test (DMRT) was also used for mean separation. All differences in mean values of parameters were determined at P = 0.05 level of significance.

Results

The mean cumulative survival rates, percentage body weight and fecundity were shown in Tables 1-6 below. The fecundity, percentage survival and hatchability from the brood stocks of *Clarias gariepinus* were presented in Table 1. It showed that fecundity did not differ significantly (P > 0.05) 166,232.2, 172,984.2, 163,143.6 and 169,987.4 between control and other treatments of 0.5 ml, 1 ml and 1.5 ml/l. Results showed that percentage survival and hatchability differed significantly amongst treatments as the highest concentration of 1.5 ml/l recorded the highest survival rate and highest body weight gain. Results also showed that percentage survival and hatching differed significantly (P < 0.05) between 0.5 ml and 1.5 ml concentrations (94.21^b and 97.10^c) and (96.11^b and 97.78^b) respectively.

Tables 2 - 5 showed the cumulative mortality and survival rates that were recorded for 8 weeks of rearing *C. gariepinus* from the period of incubation in glass tanks. Percentage cumulative mortality was 11.53 % for the control for treatment 0 ml formalin with an initial stock of 280 eggs per tank. The highest mortality (11.53 %) was recorded in treatment one (control) with a percentage cumulative survival of 88.47 % as showed in Table 2. There was a progressive increase in the percentage cumulative mortality from week one to week eight and a corresponding progressive decrease in percentage cumulative survival of the eggs of *C. gariepinus*.

In the initial stock of 280 eggs of *C. gariepinus* at treatment 0.5 ml formalin, the percentage cumulative mortality obtained was 7.15 % whereas the percentage cumulative survival was 92.84 % (Table 3).

Table 4 showed the low percentage cumulative mortality of 6.18 % with a corresponding high percentage cumulative survival of 93.82 % in a formalin treatment of 1.0 ml to 280 eggs in the tank.

The lowest percentage cumulative mortality of 4.51 % and the highest percentage cumulative survival of 95.49 % were recorded for one hundred and eighty eggs of *Clarias gariepinus* treated with 1.5 ml of formalin (Table 5).

Mean Total Body Weight (TBW) gain differed significantly (P<0.05) between 0 ml (4.75^a) and 1.5 ml (5.93^b) as shown in Table 6. The other treatments (0.5 and 1 ml) showed a progressive increase in their TBW but were not significantly different (5.03^a and 5.24^a) respectively. In the control, only the TBW of the seventh week (9.52^b) was significantly different from all other weeks at p<0.5. Under the treatment 0.5 ml, four weeks were statistically different from the other four weeks as revealed by the two separate superscripts (a and b) at a probability level of 0.5. In the treatment 1 ml, the eight weeks were unevenly partitioned into three weeks with superscript a and five weeks with superscript of b depicting significant differences at p<0.5. At treatment 1.5 ml level, three distinct significant differences grouped the eight weeks into superscripts a, b and c at p<0.5.

Table 1: Mean fecundity, % fertilization and % hatching of *Clarias gariepinus*

Parameters	Control	0.5 ml	1 ml	1.5 ml
Fecundity	166,232.2	172,984.2	163,143.6	169,987.4
Incubated	180	180	180	180
% Survival	91.01^a	94.21^b	94.82^b	97.10^c
% Hatched	92.78^a	96.11^b	96.67^b	97.78^b

Values carrying different superscripts on the same row differed significantly from each other (p<0.05).

Table 2: Mean cumulative mortality and survival rates and percentages for *Clarias gariepinus* fry eggs treated with 0 ml formalin (control) and reared in glass aquarium tank for 8 weeks

Period (Weeks)	Mortality	% Cumulative mortality	Survival	% Cumulative survival
		Initial stock per tank 280		
1	13	7.22	167	92.78
2	14	7.78	166	92.22
3	17	9.44	163	90.56
4	19	10.56	161	89.44
5	24	13.33	156	86.67
6	24	13.33	156	86.67
7	27	15.00	153	85.00
8	28	15.56	152	84.44
Mean		11.53		88.47

Table 3: Mean cumulative mortality and survival rates and percentages for *Clarias gariepinus* fry eggs treated with 0.5 ml formalin and reared in glass aquarium tank for 8 weeks

Period (weeks)	Mortality	% Cumulative mortality	Survival	% Cumulative survival
		Initial stock per tank 280		
1	7	3.88	173	96.11
2	9	5.00	171	95.00
3	11	6.11	169	93.88
4	13	7.22	167	92.77
5	14	7.77	166	92.22
6	15	8.33	165	91.66
7	17	9.44	163	90.55
8	17	9.44	163	90.55
Mean		7.15		92.84

Table 4: Mean cumulative mortality and survival rates and percentages for *Clarias gariepinus* fry eggs treated with 1.0 ml formalin and reared in glass aquarium tank for 8 weeks

Period (Weeks)	Mortality	% Cumulative mortality	Survival	% Cumulative survival
		Initial stock per tank 280		
1	6	3.33	174	96.66
2	7	3.88	173	96.11
3	9	5.00	171	95.00
4	11	6.11	169	93.88
5	12	6.66	168	93.33
6	14	7.77	166	92.22
7	15	8.33	165	91.66
8	15	8.33	165	91.66
Mean		6.18		93.82

Table 5: Mean cumulative mortality and survival rates and percentages for *Clarias gariepinus* fry eggs treated with 1.5 ml formalin and reared in glass aquarium tank for 8 weeks

Period (weeks)	Mortality	% Cumulative mortality	Survival	% Cumulative survival
		Initial stock per tank 180		
1	4	2.22	176	97.78
2	5	2.78	175	97.22
3	7	3.88	173	96.11
4	8	4.44	172	95.56
5	9	5.00	171	95.00
6	9	5.00	171	95.00
7	11	6.11	169	93.89
8	12	6.67	168	93.33
Mean		4.51		95.49

Table 6: Mean total body weight gain of *Clarias gariepinus* fry eggs treated with formalin with 0.5 ml, 1 ml, 1.5 ml and control reared in glass aquarium tanks for 8 weeks

Parameter	Weeks	Control	0.5 ml	1 ml	1.5 ml
	1	0.0068[a]	0.0073[a]	0.0071[a]	0.0069[a]
	2	0.034[a]	0.044[b]	0.043[b]	0.055[c]
	3	0.67[a]	0.69[a]	0.72[a]	0.89[b]
	4	3.35[a]	4.14[b]	4.32[b]	5.35[c]
	5	5.23[a]	6.96[b]	7.13[b]	8.35[c]
TBW (g)	6	6.80[a]	7.66[b]	7.84[b]	9.19[c]
	7	9.52[b]	8.43[a]	9.41[b]	10.03[c]
	8	12.38[a]	12.31[a]	12.42[a]	13.54[b]
	Mean	**4.75[a]**	**5.03[a]**	**5.24[a]**	**5.93[b]**

Values with different superscript on the same row differed significantly from each other (p<0.05); TBW = Total Body Weight

Discussion

It was observed that percentage mortality was very low in this present study as compared to documented studies such as Pedersen *et al*., (2008). Percentage survival and hatching was highest in treatment four (97.78[b]), followed by treatment three (96.67[b]) and treatment two (96.11[b]). The lowest survival rate was recorded in the control (92.78[a]) which is far higher than the work of Akpoilih and Adebayo (2010), who reported 65 % and 69 % survival in their study effect of formalin on the hatching rate of eggs and survival of larvae of the African catfish, *Clarias gariepinus*.

The high rate of hatchability and survival agrees with the work of Pedersen *et al*., (2008) who reported that formalin is one of the most commonly used chemical treatments for fungal control in fish hatcheries and effective in the control of fungus on eggs without adverse effect on hatchability and post-hatch survival. The low mortality recorded in all the treatments was indicative of the fact that formalin has effectively reduced fungi infection on eggs and larvae of *Clarias gariepinus*. This result corroborated the report of Akpoilih and Adebayo (2010) where they recorded percentage survival to be high (85.53±9.56a) as compared to their control. Though their survival rate may be lower than that of the present experiment, it might be attributed to other factors such as physico-chemical parameters, stress as a result of handling, egg and milt quality and viability which might be a major decider of a high rate of hatchability and thereby increasing the chances of high survival (Yisa *et al*., 2012). Mean total body weight was highest in treatment four. This shows that fungi infection on the fry drastically reduced hence free from disease problem, which facilitate their growth rate. This finding agrees with the assertion that fungal infections are difficult to treat and prevent, having a wide range of temperature tolerance from 30 to 33 ºC, reflecting the thermal preferences of host (Pickering and Willoughby, 1982).

Conclusion

It was shown that formalin is a very good anti-fungal agent. The survival of fish fry at the end of the experiment in treatment four which is the highest concentration was significantly different from the control. There were no observations of any form of fungal growth such as *Saprolegnia* in the highest concentration as a result of dead and unfertilized eggs, but there were some minor growths in the control which might be the reason for the reduction in survival value as compared to other treatments. The highest concentration was most effective. It is necessary to ascertain the highest admissible level of formalin which will not be harmful to fish eggs and fry. Therefore, the authors recommend that further studies be conducted on higher concentrations to ascertain the maximum admissible toxicant concentration (MATC) of formalin to fish both fry and adult. This will help regulate the use of the substance in aquatic environments and fish farms.

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