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EDITOR'S COMMENTS

All praise due to the Almighty Allah who in His infinite mercy we held a successful 35th Annual Conference of our esteemed society tagged "Niger 2020". Moreover, the conference was not without the usual hiccups but gladly we surmounted all the challenges. Part of the challenges were the ASUU strike and bad roads en route Minna, Niger state which made the conference to be relocated to Raw Material Research and Development Abuja.

Despite the daunting challenges the conference was adjudged as one of the best as it recorded unprecedented attendance in dignitaries and presenters.

The keynote address speaker in the person of Prof. Mrs. Keziah Absalom delivered her lecture on the theme of the conference titled "The Blue Alternative for Sustainable Development in Nigeria Post COVID-19-The Role and Aquaculture and Fisheries" while the communique was prepared by the committee which was led by Dr. O.R. Oguntade.

The technical sessions were interactive and intellectually engaged. Presenters were asked questions on their presentations. The technical sessions were split into 4 thematic areas; Fish Biology and Aquaculture, Nutrition and post-harvest, Artisanal fisheries, Water quality and Fish diseases.

One hundred and thirty four (134) manuscripts were received and presented at the conference while only ninety seven (97) papers met the editorial guidelines for incorporation in the book of proceeding. Omitted manuscripts from the 2019 conference were also incorporated.

However, the editorial process was not without some hitches but were manged to accommodate variety of variations within acceptable standard.

I will like express appreciation to Mr. Jaafar Yusuf for assisting in the editorial work pre-during and post conference.

I also thank the FISON body most especially the Dr. Agbabiaka for his untiring support for the realization of the conference and the proceedings.

Abdullahi M.Orire PhD.

(Conference Secretary/Editor, Niger 2020)

ADDRESS BY THE NATIONAL PRESIDENT OF FISHERIES SOCIETY OF NIGERIA (FISON) Dr. L. A. AGBABIAKA, ON THE OCCASSION OF THE 34TH ANNUAL CONFERENCE TAGGED "EBONYI 2019" HOLDING IN ABAKALIKI EBONYI STATE FROM 28TH OCTOBER - 1ST NOVEMBER 2019.

Thank you.

AGBABIAKA. L. ADEGOKE. *Ph.D, Ffs, MNSAP*
National President (FISON)
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The State of Nigerian Fisheries and Aquaculture: A Socio-Economic Perspectives

Prof. Francis D. Sikoki, *Ffs*
National Coordinator, International Atomic Energy Agency (IAEA), Technical Cooperation Projects,
University of Port Harcourt,
P. M. B. 5323, Port Harcourt, Rivers State, Nigeria

A keynote address delivered at the 34th Annual Conference of the Fisheries Society of Nigerian, FISON, held from the 28th October to 1st November, 2019 at the International Conference Centre, Abakaliki, Ebonyi State, Nigeria.

Evaluation of growth performance of the predatory *Megalops atlanticus* reared in different culture systems

Okoro, C. B.*, Anwa-Udondiah, E. P., Ejiogu, I. N. and A. O. Olurole
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Abstract
Evaluating the nature of the trophic interactions between a predatory fish and potential prey within an enclosure is critical to its aquaculture development and management plans. In this study, the effect of the presence of tilapia within the culture environment of *Megalops atlanticus* and its influence on growth was investigated. The experiment was conducted in four 35 m^3 earthen ponds and designed as two treatments with two replicates each. One treatment was *M. atlanticus* monoculture (T_1) while the other was a polyculture of *M. atlanticus* and wild tilapia (T_2). Mean weight gains were 19.43 g for T_1 and 30.3 g for T_2 while the mean length gains were 4.85 cm for T_1 and 7 cm for T_2. Data obtained indicated that the impact of multi-species interactions within the pond ecosystem did not translate to higher *M. atlanticus* growth until the fifth month where it resulted in significantly greater growth at $P \leq 0.05$. The study demonstrated that *M. atlanticus* was able to utilize tilapia as additional food source as they attained larger sizes ranging from 18.91 – 48.94 g and 14.8 – 19.7 cm for weight and total length respectively, thereby providing a novel technique for Atlantic tarpon culture in freshwater ponds.

Keywords: *Megalops atlanticus*, growth performance, tilapia, earthen pond

Introduction
The Atlantic tarpon *Megalops atlanticus* is an economically important species and occurs in natural, subsistence, small commercial fisheries and aquaculture in portions of its distribution range (Adams *et al*., 2012). It is categorized as globally vulnerable by the International Union for Conservation of Nature (IUCN) due to factors such as the substantial loss of its habitat and evidence of regional declines, which raise concerns regarding long-term tarpon population stability (Adams *et al*., 2012). The greatest threats to tarpon habitats, according to Griffin *et al*. (2018), are in coastal areas (wetlands, rivers, estuaries, beaches).

Aquaculture provides an alternative to its sustainability and is aligned with conservation goals (Gouvello *et al*., 2017). Besides producing food resources, it can likewise restore and enhance threatened and endangered species (Froehlich *et al*., 2017). One of the mandates of the Nigerian Institute for Oceanography and Marine Research is the rational exploitation and utilization of species of fish and other marine forms of life. Therefore, in fulfilling this mandate, sustained research efforts over the years have been directed towards the biology and culture of different brackish and marine species, one of which is *M. atlanticus*.

Studies have been conducted on *M. atlanticus* culture potential (Anyanwu, 2004), distribution and seasonal abundance (Anyanwu and Kusemiju, 2006), resource ecology and fishery (Anyanwu and Kusemiju, 2007), tank culture (Okoro and Anwa-Udondiah, 2014) to mention a few. In developing its culture, its predatory nature and the impact on pond dynamics has not been well investigated. Hence, the aim of this study was to determine the effect of the presence of tilapia within the culture environment of *M. atlanticus* and its influence, if any, on growth.

Materials and Methods
Study location
Existing experimental earthen ponds (Plate I) measuring 7 m x 5 m x 1 m at the Nigerian Institute for Oceanography and Marine Research, Badore Research Centre (03° 36' 00.13"E 03° 36' 19.31"E), Lagos were cleared of surrounding bushes (Plate II) and desilted. Also, fencing and screening were done with bamboo, 0.7 mm mesh sized polyethylene netlon and 1.5 mm mesh sized netting (Plate III) to keep out reptiles and birds.



Plate I: Earthen pond [7 m x 5 m x 1 m] Plate II: Bush clearing Plate III: Ponds fenced and screened

Experimental fish
Four hundred mixed sex juveniles of *M. atlanticus* with initial mean weight and total length averaging 10.58±0.82 g and 12.12±0.45 cm respectively were collected from Lagos Lagoon and stocked (Plate IV) in four earth ponds designed as two treatments with two replicates each. One treatment was devoid of tilapia while the other was a polyculture of *M. atlanticus* and wild tilapia. Fish in both treatments were fed equally with the commercially available Coppens® feed throughout project duration.

Plate IV: Stocking of *M. atlanticus* juveniles

Data Collection
Water samples were taken prior to fish sampling from the water column. Tests for pH, alkalinity, total ammonium nitrogen (TAN) and nitrite nitrogen were carried out with Sera aqua-test kit.

Weight and length of sampled fish retrieved via seining were measured using a Mettler Toledo electronic balance (ME1002E) determined to an accuracy of 0.01 g and Wildco® fish measuring board (118-B30) to the nearest 0.1 cm respectively over a period of six months.

Statistical analysis
Data obtained from *M. atlanticus* monoculture and *M. atlanticus*/tilapia polyculture were compared using Two-Sample T-test in Minitab software Version 19.2020.1.0 (Minitab LLC for windows, 2020) statistical package and presented as mean±standard error of the mean. Differences between the treatment means were considered significant at $P < 0.05$.

Results and Discussion
Hydrological parameters
The mean values of water quality parameters such as pH, alkalinity, TAN and nitrite nitrogen with standard error of the mean (SEM) for the two treatments are shown in Table 1. Water parameters were not significantly ($P \leq 0.05$) different between treatments except for alkalinity.

Table 1: Mean values (±SEM) of water quality parameters

Parameters	T_1 – *M. atlanticus* monoculture	T_2 – *M. atlanticus* /tilapia polyculture
pH	6.92 ± 0.15^a	7 ± 0.22^a
Alkalinity (mg L^{-1})	38.75 ± 3.46^a	54.5 ± 4.76^b
Total ammonium nitrogen [TAN] (mg L^{-1})	0.98 ± 0.12^a	1.13 ± 0.27^a
Nitrite nitrogen (mg L^{-1})	0.09 ± 0.02^a	0.06 ± 0.01^a

Parameters were not significantly different ($p<0.05$) between treatments except foralkalinity.

The pH in this study was within the desirable range of 6.5 - 9.5 for most fish species according to Stone and Thomforde (2004). With regards to the total alkalinity (TA), T_1 water quality fell within the acceptable range of 20-400 mg/L for ponds while T_2 was within the desirable range of 50-150 mg/L. Nitrite nitrogen and TAN were both below the limits for fish culture in the two treatments as recommended by Boyd and Tucker (1998).

Growth performance
Growth parameters such as mean final weight for T_1 and T_2 were 30.01±3.38 g and 40.88±6.07 g respectively while the mean final length for T_1 and T_2 were 16.97±0.55 cm and 19.12±0.67 cm respectively. Thus, their respective mean weight gains were 19.43 g for T_1 and 30.3 g for T_2 while the mean length gains were 4.85 cm for T_1 and 7 cm for T_2. Figures 1 and 2 shows the monthly data for mean weight and mean length of wild sourced***M. atlanticus*** juveniles exposed to two culture conditions throughout the study period.

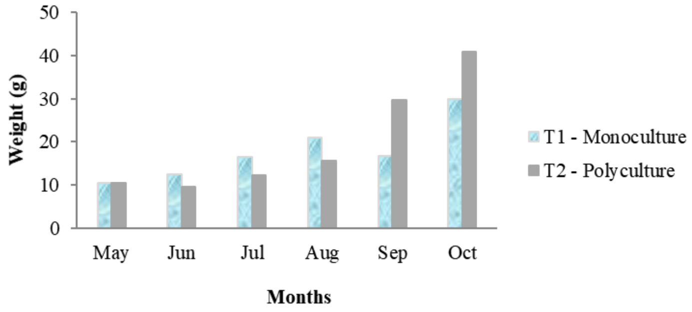

Figure 1: Monthly weight data for *M. atlanticus*

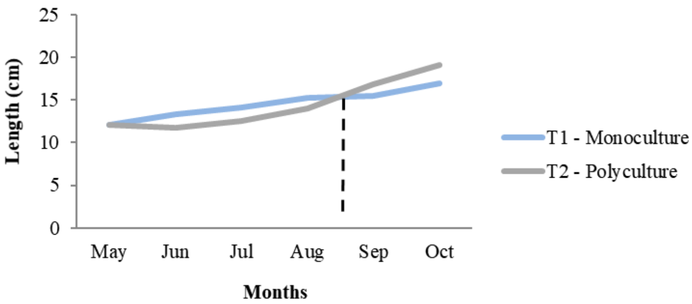

Figure 2: Monthly length data for *M. atlanticus*

There was significant difference ($p \leq 0.05$) between treatments in the month of September, which was the fifth month of study. The observed improved growth of T_2 appears to indicate the ability of *M. atlanticus* to utilize tilapia as additional food source especially as they attained larger sizes, i.e., 18.91 – 48.94 g and 14.8 – 19.7 cm for weight and total length respectively. The plausible explanation is supported by Hammerschlag *et al*. (2012) that the Atlantic tarpon is mainly considered as an ichthyophagus species. Overall, however, the mean weight gain for both treatments was low at this early life stage and this finding was corroborated by Wilson *et al*. (2019) with the result of a mark-recapture study in an altered mangrove habitat in Florida (USA) in which the juveniles were found to exhibit slow growth.

Being at a lower trophic level, tilapia has been cultured with predators (Mair and Little, 1991). Comparable studies involving the rearing of predatory fish species and tilapia include Yi *et al*. (2002) where an assessment of the efficiency of snakehead (*Channa striata)* in controlling recruitment of mixed-sex Nile tilapia (*Oreochromis niloticus*) in ponds was carried out in monoculture and polyculture set-ups, and Samad *et al*. (2017) in which the endangered carnivorous *Notopterus chitala* was domesticated in pond habitat with *Oreochromis niloticus*.

Conclusion

The study demonstrated that *M. atlanticus* exhibits improved growth when reared with tilapia in freshwater ponds, hence, providing a novel technique for its culture. This information is germane to potential farmers as a management tool to achieve optimum fish growth.

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Performance of African catfish (*Heterobranchus bidorsalis* and *Clarias gariepinus*) hybrid eggs and hatchlings in clay pot, plastic and glass aquarium

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Abstract
An indoor artificial hybridization of African catfish was carried out with one female *Clarias geriepinus* and one male *Heterobranchus bidorsalis* broodstock to compare the performance in three different culture medium: clay pot, plastic tank and glass aquarium. A total of 51,000 eggs were incubated in each of the three culture medium. The hatchlings were reared for a period of 56 days (8weeks) The result obtained from the experiment revealed that clay pot is the best media for incubation, hatching and rearing of hybrid African catfish (Heteroclarais) hatchlings as it gave the highest percentage survival of 96%. Specific growth rate of 2.90%, and mean weight gain of 0.85 g, while in plastic tank and glass aquarium the percentage hatchability, survival, specific growth rate, mean final length and weight gain were 57% and 81%, 76% and 88%, 2.92% and 2.81%, 4.57cm and 4.61cm, 0.86g and 0.75g respectively. There was a significant difference (p>0.005) in the hatchability, survival and growth rate (length and weight) among hybrid African catfish (Heteroclarais) hatchlings reared in clay pot, plastic tank and glass aquarium.

Key words: Hybridization, clay pot, plastic tank, glass aquarium and Heteroclarais

Introduction

Aquaculture has grown tremendously during the past two decades to becoming an economically important industry worldwide. Fisheries Aquaculture continues to grow faster than other major food production sectors although it no longer enjoys the high annual growth rates of the 1980s and 1990s (11.3 and10.0 percent, excluding aquatic plants). Average annual growth declined to 5.8 percent during the period 2000–2016, although double-digit growth still occurred in a small number of individual countries, particularly in Africa from 2006 to 2010.. The Clariids constitute an excellent food fish of high commercial value. In fact, the catfish species are very important to the sustainability of aquaculture industry in Nigeria (Owodeinde and Ndimele, 2011). Fish hybridization is now highly practiced in aquaculture. It is one of the genetic techniques which help to remove undesirable growth characteristics while retaining only the desirable ones. The process of hybridization helps the fish farmer to select desirable characteristics such as fast growth, food conversion efficiency and resistance to diseases which can increase the profitability of the farmer. It has been noted that fish farming is hardly practicable without availability of god quality fish seed (Chondar, 1980).

There are several culture mediums depending on the nature of the materials used for the production of such mediums. Several criteria are often considered for the selection of materials to be used for the construction, ease of cleaning and sterilization (Timmons *et al*., 2002). Also, the size of a particular holding media depends on the type of fish species involved, stocking rates of fish, water quality and economic consideration (Olagunju *et al*., 2007). Clay pot has been identified and used as a holding facility for the rearing of hatchlings as it provides an environment similar to the fish natural environment since clay is a natural substance that contains silicate and other soil properties (Williams *et al*., 1995). Fish can be grown in plastic tanks of nearly every shape and size. Plastic tanks are majorly rectangular and circular or oval in shape. Circular or oval tanks with central drains are easier to clean and enable easy water circulation than their corresponding rectangular ones (Britz, 2007).

Abayomi *et al.* (2010), stated that the need for the production of quality fish seed for stocking artificial pond and natural water bodies has been on the increase and fish seeds produced in the hatchery through artificial propagation constitute the only feasible method of producing sufficient quantity of fish seed. This research took into consideration the hybridization of *Clarias gariepinus* and *Heterobranchus bidorsalis* using three (3) incubation/culture medium: Clay pot, glass aquarium and plastic tank to compare the hatchability, growth and survival of the hybrid African catfish eggs and hatchlings in these three (3) culture medium.

Materials And Methods

The broodstocks were obtained from Jerubbal Fish Farm Ltd, Osere Ilorin, Kwara State and were selected on the basis of their morphological characteristics. The length and weight of each broodstocks were 29.00 cm and 1.0 kg for the female and 54.00 cm and 1.2 kg for male. They were transported to Fisheries Research laboratory Gidan Kwano Campus, Federal University of Technology Minna, Niger state and kept in separate pond for five days to acclimatize before the experiment.

Three (3) media (plastic tank and glass aquaria with dimensions of 60 cm x 30 cm x 30 cm in length, breadth and height and clay pot) were washed, rinsed with clean water, allowed to dry and were set indoor at the laboratory hatchery. 10 L of bore hole water was poured into the clay pot, plastic tank and glass aquarium respectively. Aerators were fixed in each hatchery media (incubators) for proper circulation of air for oxygen Hybridization was done using one (1) female (♀) *Clarias gariepinus* and one (1) male (♂)) *Heterobranchus bidorsalis.* The broodsctocks (gravid female and male) were weighed and injected intramuscularly with ovatide hormone at the rate of 0.5 ml/kg of the fish body weight. The injected brood fish were allowed a latency period of twelve (12) hours. They were kept in separate ponds filled with water. After the latency period the injected brood fish were taken out of the water. The genital opening of the female brooder was cleaned with tissue paper so as to avoid water contact with the eggs during stripping. The ovulated eggs were stripped manually and by gently applying pressure on the belly of the fish with hand over the abdomen toward the genitalia. Eggs were collected into a dry clean plastic bowl. The male brood fish was dissected to remove the testis. The testes collected were cleaned with tissue paper and the milt was macerated out onto eggs directly. Dry fertilization technique was used where the eggs and the milt were properly mixed with the aid of a feather. Saline (0.9% NaCl) solution was added to ensure maximum fertilization.

Fertilized eggs were spread on the kakaban (egg nest) in three different types of the experimental incubators: plastic tank, glass aquaria and clay pot, each replicated three times. Incubation was done under constant aeration and ambient temperature range of 25°C to 27°C. Percentage fertilization and hatching were determined during incubation. After hatching, the incubators were cleaned by siphoning out incubation water and egg cases. Percentage fertilization and hatching were determined and compared. The hatchlings were reared in the three experimental incubation and rearing medium. Hundred (100) hatchlings were stocked in each media and replicated three times. Survival of hatchlings and growth in the three experimental media were monitored for the eight (8) weeks duration of the experiment. The hatchlings were fed at 5% body weight with DE capsulated Artemia for 4 weeks and there after fed commercial diet of 0.2 mm–0.3 mm, 0.3 mm – 0.5 mm, 0.5 mm – 0.8 mm and 0.8 mm – 1.2 mm respectively as the fish size increased for another 4 weeks. Growth was determined by random sampling of 30 fry/tank from each media every two (2) weeks for average length and weight measurements. Cumulative mortality and survival were recorded daily. Percentage survival and specific growth rates (SGR) were calculated for each experimental media at the end of the experiment.

The water quality parameters mainly dissolved Oxygen (DO), water temperature and pH were determined and recorded during egg incubation and rearing of the hatchlings.

Calculation and Statistical Analysis: Date collected was used to calculate the following parameters.

$$\text{Percentage hatchability} = \frac{\text{No of hatchlings}}{\text{Total no of eggs fertilized}} \text{X100}$$

$$\text{\% unhatched} = \frac{\text{number of incubated eggs} - \text{number of hatched eggs}}{\text{Total number of eggs incubated}} \text{ X 100}$$

Weight gain (WTG) = Final weight – Initial weight

Length gain (LTG) = Final length — Initial Length

$$\text{Specific growth rate (SGR)} = \frac{\log_e W_2 - \log_e W_1}{T} \text{ x 100}$$

Where W_2 = Final weight of fish

W_1 = Initial weight of fish

Log_e = Natural log to base e

T = Experimental period in days.

$$\text{Survival (\%)} = \frac{\text{Number of survivors}}{\text{Initial number of fish}} \text{ X 100}$$

The data obtained were subjected to statistical analysis, using one-way analysis of variance (ANOVA) in SPSS version 20 for windows and significant difference were observed, means were separated with Duncan's Multiple Range Test at 5% level of significance.

Results

Table 1 Growth, Survival and Mortality Rates of Hybrid (Heteroclarias)

Parameter	Clay Pot	Plastic Tank Aquarium	Glass
Mean Initial Weight	0.02±0.00^a	0.02±0.00^a	0.02±0.00^a
Mean final weight	0.86±0.10^a	0.85±0.10^a	0.75±0.08^a
Mean initial length	0.07±0.00^a	0.07±0.00^a	0.7±0.00^a
Mean Final Length	4.90±0.36^a	4.57±0.39^a	4.61±0.60^a
% specific growth rate	2.90	2.92	2.81

Survival rate	96.00	76.00	88.00
% Hatchability	90%	57%	81%

Means with the same superscript letters in the same row are not statistically different at $p \leq 0.05$ by Duncan Multiple Range Test

Table 2 Mean Water Quality Parameters of Hybrid (Heteroclarias) Reared in Three Different Culture media for 8 Weeks

CULTURE MEDIUMS	D O (mg/l)	T (°C)	pH	E.C. (μs/cm)
Glass Aquarium	3.61 ± 0.31^{a}	25.67 ± 2.33^{a}	8.9 ± 1.42^{a}	414.00 ± 37.20^{a}
Clay Pot	2.12 ± 0.20^{a}	25.00 ± 2.01^{a}	8.7 ± 1.40^{a}	398.00 ± 36.40^{b}
Plastic Tank	2.80 ± 0.28^{b}	25.67 ± 2.32^{a}	8.7 ± 1.39^{a}	402.00 ± 37.02^{a}

Means with the same superscript letters in the same column are not statistically different at $p \leq 0.05$ by Duncan Multiple Range Test

Key: **T:** Temperature; **E. C.**: Electrical Conductivity

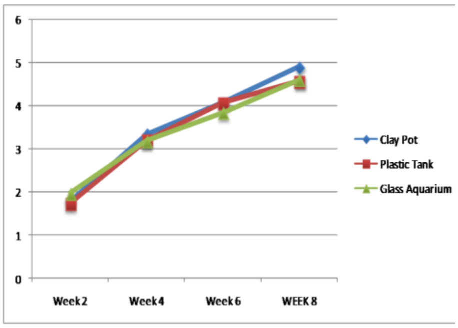

Figure 1: Bi-weekly Length increase in Hybrid African catfish *Heteroclarias* reared in three different culture media for 8 weeks

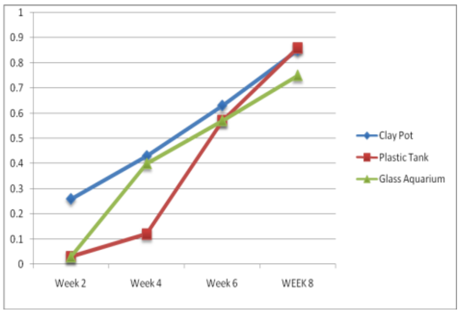

Figure 2: – Bi-weekly Body Weight Increase in Hybrid African catfish *Heteroclarias* Reared in three different culture media for 8 weeks

According to the result of this experiment (table 1), the specific growth rate of the hatchlings was higher in plastic tank (2.92%), followed by clay pot of (2.90%) while glass aquarium has the least (2.81%). The high growth performance in plastic tank might be as a result of increased metabolic activities as higher temperature were recorded in the three (3) treatments used during the experiment.

The higher percentage mortality recorded in the plastic tank (24.00%) and glass aquarium (12.00%) could also be attributed to the nature of the culture medium and cannibalism between the bigger fries (shooters) and the stunted ones which is in concord with the suggestion made by Tames and Horrath (1976). They stated that fries of the same size, species and age group should be stocked together to avoid cannibalism.

The water quality analysis carried out during the experimental period was paramount as it helped in determining the factors that influenced the hatchability, growth and survival of hybrid (Heteroclarias) hatchlings in the three culture medium (clay pot, plastic tank and glass aquarium) used for the experiment and also explains the reasons behind the differences in their performances. The discrepancies in the dissolved oxygen, pH, temperature and conductivity had a striking influence in the performance of hybrid (Heteroclarais) hatchlings in the three culture medium used for the experiment although their respective values are within the optimal range. These trivial disparities might be as a result of the nature and type of the materials used for the construction of this culture medium.

There was a significant different ($p<0.005$) in the hatchability, growth (length and weight) and survival of hybrids (Heteroclarias) hatchlings reared in clay pot, plastic tank and glass aquarium for eight (8) weeks.

Conclusion

The result achieved by this experiment is to increased productivity, survival and better growth performance of hybrid (Heteroclarias). It was concluded from this experiment that clay pot which had the highest percentage survival rate of 96.00% and a specific growth rate of 2.90% is the best media for incubation and rearing of hybrids (Heteroclarais) hatchling.

Recommendations

With regard to the prospects of the comparative study of the performance of Africa catfish (*clarias gariepinus* and *heterobranchus bidorsalis*) hybrid in clay pot, plastic tanks and glass aquarium under indoor hatching condition, I recommend that: Clay pot and glass aquarium are good medium for incubation, hatching and rearing of hybrid fish((Heteroclarias) larvae. Therefore its use should be encouraged for the production of aquaculture. Also more research should be carried out on the use of clay pot in rearing Africa catfish hybrid (Heteroclarais) hatchlings till adult stage and Clay pot should be restructure to a rectangular shape so as to support and enhance the free movement of fries as it could improve their growth performance.

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Standardization of *Clarias gariepinus* fingerlings using age, weight and length estimations

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Abstract
A study was conducted to estimate the range of weight / length as well as age at which a *Clarias gariepinus* fish can be said to be a standard fingerling. Artificial breeding was conducted using male and female brooders weighing 2.7Kg and 2.3Kg respectively. Offspring were managed through eight weeks in both indoor (glass aquarium) and outdoor (concrete tanks) facilities. Data on weight and length were obtained and recorded weekly. Physico-chemical properties of the water were also monitored and recorded. The study revealed that the age at which a *Clarias gariepinus* fish can be said to be a standard fingerling is after six weeks while the range of weight and length recorded were from 4.00 - 6.5g and 6.50 - 10.00cm respectively. The study recommends that hatchery operators raise *Clarias gariepinus* for a minimum of six weeks before selling to fish farmers – to reduce mortalities recorded at the fish farms and its multiplier effects on existing and intending fish farmers

Keywords: *Clarias gariepinus*, Catfish, Fingerling, Standardization

Introduction
Fingerlings are baby fish of between 1 – 2 months old for most fish species and usually "finger" length in size. They are the "seeds" for stocking of fish ponds, reservoirs and depleted open water bodies. They form the bedrock of fish farming industry (Madu, 2016). The demand for fingerlings in Nigeria was estimated at over 4.3 billion annually and less than 56 million was being produced (F.D.F., 2007). The availability of reliable source of fingerlings, especially of *Clarias gariepinus* and its hybrids is one of the criteria for a successful fish farming enterprise (Madu, 2004, 2014). Because fingerlings can be ready for sale from 6 - 8 weeks after breeding, this expect of the fish farming value chain is regarded as the "fastest revenue yielding" and thus should be "standardized" to avoid the continuous exploitation of quacks and its multiplier effects.

The African Catfish is a species of catfish of the family Clariidae and its scientific name is *Clarias gariepinus* which was named by Burchell in 1822. The physical changes in terms of weight and length or age of fish from the point of hatching to adult fish can be sub-divided into the following stages - Larvae / Hatchlings, Fry, Post-fry, Fingerlings, Juveniles and Adult fish. According to Olaoseibikan (2011) and Madu (2016), these stages are described as follows:

Larvae / Hatchlings – newly hatched eggs, from day 1 – 3 usually with yolk sac.

Fry – are fish seeds aged 4 – 28 days. They do not have yolk sac and accept artificial food – live feeds.

Post-fry – are fishes of 4 – 5 weeks old, the intermediate between fry and fingerlings. They are ready to accept artificial feed. They are not stable thus this stage is considered critical.

Fingerlings – are fishes of 6 – 8 weeks old. They accept artificial feed and are more stable at this age. They are considered the "seeds" for stocking.

Juveniles – are fishes of 8 – 10 weeks old, very stable and accept most artificial feeds.

Adult fish – these are fishes of over 12 weeks old

Generally fingerling production which can also be referred to as fish breeding, induced breeding, seed multiplication, fish seed propagation or fish hatchery management, involves a series of breeding and feeding practices which can be grouped under the following three major sequential operations (FAO 1997; Madu, 1989; Wedemeyer, 2001)

This refers to the procurement, care and maintenance of the parent stock (brooders). The broodstock can be best sourced from either the wild / natural waters or established fish farms. The sexes of the broodstock should be identified and stocked separately. For the brooders to be healthy, they must be fed well. Catfish requirement is 35 – 40%. The water quality parameters must be checked daily.

Induced Spawning and Hatching of Eggs

Fish are usually stimulated to release their eggs under controlled and conditions manipulated by hatchery operators. The major method which is commonly used is the artificial hormone induced spawning / stripping and artificial fertilization method. This method allows the hatchery operator to control almost all aspects of the breeding process.

Nursery Management of Hatchlings up to Fingerling Stage

This is the most delicate aspect of fingerling production because the percentage survival of the hatchlings could be zero if not properly handled. The newly hatched fish (hatchlings or larvae) are very delicate and must be handled with ultimate care. Some of the important factors that must be considered during nursery management include – Adequate stocking density, adequate food and feeding schedule, good water quality management, sampling and sorting to remove jumpers and measures to control of predators.

Materials and methods

Experimental Site: The study was conducted at the Hatchery Complex of the National Institute for Freshwater Fisheries Research (NIFFR) and Federal College for Freshwater Fisheries Technology both in New Bussa, Niger State, Nigeria.

Collection and Management of Broodstocks: Male and female brooders weighing 2.70kg and 2.30kg respectively were sourced from Awuru river in Niger state. Both fishes were properly checked to make sure they were gravid and allowed to acclimatize in holding tanks for one week before using them for breeding. During this period, the brood fishes were fed very well twice daily with 40% crude protein feed. This is to ensure production of many offspring during breeding.

Inducement, Collection of Eggs and Milt: The female fish was induced by injection of ovaprim® hormone at a dosage of 0.5ml/Kg of fish body weight. This was done using 2mm needle at an angle of around 35 degrees below the line of the fish towards the anterior part. This method is intramuscular. The fish was then allowed for the latency period (9 – 12 hours). After the period of latency the female fish stripped for collection of eggs by gently pressing the stomach with the thumb from the pectoral fin towards the genital opening and green-brownish eggs were being collected in a bowl as they easily ooze out until the eggs stop coming out. The only way to collect the milt (sperm) was to kill the fish, thus the fish sacrificed and the two testes carefully removed and dried with filter paper. The cream-white part of the testes lobes containing ripe semen were put into saline water.

Fertilization, Incubation and Hatching: The testes from the male fish was cut using blades in the saline water and then mixed with the eggs for one minute using a clean feather to allow fertilization. Distilled water was then added and again stirred for another one minute to complete the fertilization. Thereafter, the water and excess milt were decanted. The fertilized eggs were spread in a single layer on the kakabans placed in the breeding tank to avoid suffocation. The incubation water was supplied from the borehole and allowed to stay overnight and properly aerated using electric aerator to provide enough oxygen. After 24 hours the healthy developing eggs (greenish in color) started hatching, the kakaban was removed and some of the eggs which did not hatch (white in color) were siphoned away.

Indoor Management of Larvae and Fry

The larvae (hatchlings) were not fed until they were seen to have absorbed their York sacks after three days. The fry were then fed three times daily with zooplanktons trawled from the hatchery complex combined with commercial Artemia® from the fourth day until two weeks. During this period, jumpers were sorted out, removed and replaced weekly to avoid cannibalism and malnutrition of other fishes. The water quality was monitored to ensure its kept within acceptable aquaculture range and the oxygen demand was supplied using constant aeration. The tanks were siphoned daily and water replaced to the required level. After two weeks the fishes were transferred to prepared outdoor tanks at a stocking density of 200 fish / m2. The tanks were covered with 2mm mesh net to evade predators.

Outdoor Management of Post-Fry and Fingerlings: The post-fry fishes were fed three times daily with commercial fish feed (Coppens®) of 0.8 – 1.2mm. With progressive growth, the feed size was increased to 1.5mm and later 2mm size of feed was used for the last week.

Data Collection: The data (weight and length) collection was done weekly using sensitize weighing scale and meter rule. The data collection is only for the majority uniform sized fishes since the few jumpers and minors were removed from the experimental tanks and replaced from the pool.

Results and Discussion

Water Quality Parameters: The results of the mean water quality parameters as were recorded for the experimental duration of eight weeks are presented in table 1.1.

Table 1.1: Mean water quality parameters of experimental tanks (8 weeks)

Parameters	Mean	Range	Ideal Ranges
PH	7.16	7.0 – 7.6	6.50 – 9.00
Water Temperature (°C)	28.20	28.00 – 30.90	25.00 – 33.00
Dissolved Oxygen (mg/L)	8.96	6.20 – 9.10	5.00 – 9.00
Conductivity (µS/cm)	160	90 – 320	150 – 500

Data are expressed as Means of daily readings for eight weeks

From the results in the above table, the water quality parameters were all within the optimum range for the culture of the experimental fish (*Clarias gariepinus*) fingerlings.

Weight – Length Estimation

Results of weight and length as recorded for the experimental duration of eight weeks are presented on table 1.2.

Table 1.2: Weight and Length range of experimental fishes for eight weeks

Duration [Week(s)]	Weight Range (Grams)	Length Range (Cm)
1	0.50 – 0.60	Approx. 1.00
2	1.10 – 1.20	1.70 – 2.00
3	1.65 – 1.80	3.80 – 4.00
4	2.20 – 2.50	5.00 – 5.30
5	2.60 – 3.00	5.50 – 5.70
6	3.50 – 4.00	6.00 – 6.50
7	4.20 – 4.50	6.50 – 7.00
8	5.00 – 6.50	8.00 – 10.00

Performance of Fish during Study

Visual observation during feeding and sampling times revealed that the fishes became more active after 3 days as they were seen swimming up vigorously in search of food. It was also noticed that the few mortality of the fishes recorded started at this time and this can be attributed to the inability of the few fishes to adapt to the supplementary feeding after yolk sac absorption. It was noticed that from the 6th week, the fishes were very much active and very stable and this could be an indication that they have gone out from the "lag-phase" of growth. (Madu, 2008)

Conclusion

From the estimation study, it can be concluded that *Clarias gariepinus* fingerlings are fishes not less than six weeks old and ranging from 4.00 – 6.50g weight and 6.50 – 10.00cm length.

Recommendation

Study should be repeated using different stocking densities and different (bigger) culture medium to evaluate changes in water parameters and growth rate; since most farmers are likely to breed with higher density and bigger culture medium with thousands of fry. It is also recommended that outreach and awareness campaign be initiated and intensified by major stakeholders; especially for hatchery operators, fingerlings/fish seed mongers, fish farmers / intending farmers on the ideal size of fish to be procured and the dangers or consequences of procuring fishes below or within lag-phase of growth.

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Proximate analyses of sex reversed *Oreochromis niloticus* (Linnaeus, 1758) fry treated with different doses of 17 α methyl testosterone

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Abstract

Hormonal sex reversal technique which is widely used to produce single sex (all-male) species of *Oreochromis niloticus* is grossly faced with concerns and doubts about the adverse effects of 17 α-methyl testosterone on the consumer's health as well as the reliability of analytical methods used to quantify 17 α-MT residues in fish flesh. The use of hormone to produce fish has faced different restrictions in various countries. Hence, issues about food safety and residue evaluation have become necessary. In this study, different doses of hormone (40 mg, 60 mg, and 80 mg) were used to reverse the sex of *Oreochromis niloticus* fry. Thereafter, proximate analysis was conducted on sex reversed fry. The overall nutritional component was good which indicates that sex reversed fish using synthetic hormone is highly nutritive with crude protein (16.69 ± 0.287 to 18.69 ± 1.0045), lipid content (2.52 ± 0.1505 ^{a} to 3.06 ± 0.165 ^{b}) and moisture (73.56 ± 1.0525 ^{a} to 76.05 ± 0.125 ^{a}). Ash content varied significantly ($P<0.05$) between control and treatments (2.67 ± 0.0455 ^{a} to 3.18 ± 0.1575^{b}). Thus, the study established that after cessation of 17α-methyl testosterone treatment, fish flesh is safe for ingestion by man. Hence, guarantees the nutrient suitability of hormonal sex reversal *Oreochromis niloticus*.

Keywords: Proximate Analysis, *Oreochromis niloticus* and 17 α-methyl testosterone

Introduction

Hormones are chemical messengers that mediate cellular communications between different body cells through a hormone-receptor interaction which further initiate sequence of biological responses (Reins-Filho *et al.,* 2006). 17 α methyl testosterone is a synthetic androgen and anabolic steroid popularly used to produce monosex *Oreochromis niloticus* fish population. The use of hormones to produce monosex fish population has been commercially advantageous. This is done through dietary supplementation and incorporation of 17 α-methyl testosterone which regulates the development and maintenance of male characteristics in fish feed. The sex reversal is conducted within the initial development stage prior to gonadal sexual differentiation. Notwithstanding, this technology is faced with issues that resonate around the adverse effects of 17 α-methyl testosterone on consumer's health.

Oreochromis niloticus belongs to the family cichlidae and it is one of the most cultured fish around the world Ndiwa *et al.* (2014) which is as a result of its resistance to considerable levels of adverse environmental and management conditions (Wonmongkol *et al.*, 2018). They are highly prolific in nature, especially the female *Oreochromis niloticus* which exhibit very high fecundity, thereby expending all their biochemical energy in reproduction. These biological processes usually occur within 20 g to 30 g body weight (4-5 months old) of their supposed growing season Bentsen *et al.* (2017) and results to reduction in growth and over-population in culture systems (Medeiros *et al.,* 2007; Portz and Liebert, 2004). The quest of solving this challenge has necessitated several researches into production and growth performance of all-male *Oreochromis niloticus* since research has established that male *Oreochromis niloticus* grow and perform best than their female counterparts (Ajiboye, 2015; Abou-Zied, 2015; Bentsen *et al.,* 2017; El-Greisy and El-Gamal, 2012 and Olufeagba *et al.,* 2017). Different genetic and biotechnological approaches (like chromosomal manipulation, YY super-male technology, androgenesis and most recently, the use of phytobiotics) have been deployed to combat the negative impact of prolific spawning, with a focus on producing masculine *Oreochromis niloticus* in large commercial quantity (Iyiola, 2018; Omole, 2017); but sex reversal technology using 17 α MT have been the most potent and widely used to produce and grow an all-male *Oreochromis niloticus* population (Vinarukwong, 2018).

Apart from the fish farmer's income, it is imperative to monitor the nutritional integrity of hybrid and genetically manipulated fish (Sutharshiny and Silvashantiny, 2011). It is factual that nutritional indices (crude protein, crude fat, crude fibre, ash, NFE and moisture content) play a huge role in the deterioration of fish after harvest, during processing and storage; so, it is pertinent to ascertain the effect of synthetic products used in producing fish. Therefore, this present study assessed effect of varying doses of 17 α MT used to produce and grow all-male *Oreochromis niloticus* on the proximate composition of the fish flesh.

Materials and Methods

Study Area: The study was carried out in fish Genetics and Biotechnology wet laboratory and the outdoor tanks of the hatchery complex in National Institute for Freshwater Fisheries Research (NIFFR), New-Bussa, Niger State.

Experimental design: 20 *Oreochromis niloticus* broodstock (16 females and 4 males) of equal sizes were paired in a ratio of 4 female to 1 male and allowed to naturally spawn in a 75 cm by 90 cm happa net, placed in 2 x 2 x 1m^3 concrete tanks. Fry were collected post hatching and divided into four (4) groups (control, 40, 60 and 80mg) with a density of fifty (50) fry per aquarium.

Preparing of control and 17α-methyl testosterone diet: The control was fed with 0.2mm Coppens® while the three experimental feed were prepared with the addition of 40, 60 and 80mg/17α-MT/250g of feed. They were prepared by spraying the dissolved hormone in 66.4ml, 99.6ml and 132.8ml of 95% ethyl alcohol (C_2H_5OH) respectively, on the feed. After which, the mixture of the feed and hormone was dried on a foil paper under room temperature (25^{0}c). It was packed, sealed in an air tight container and refrigerated until use. The prepared feed was characterized as;

Diet (1): Control (untreated).

Diet (2): 40 mg of 17α-MT/250g of diet

Diet (3): 60 mg of 17α-MT/250g of diet

Diet (4): 80 mg of 17α-MT/250g of diet

Feeding: Experimental *Oreochromis niloticus* fry were fed with 17α-MT formulated feed while control group was fed with 0.2mm Coppens® without hormone for 28 days. The experimental fish were washed by allowing them to swim in normal aerated water for seven (7) days before transferring them into different 2 x 2 x 1m^3 outdoor concrete tanks. However, feeding continued with normal feed without hormone while fish treatments were collected seven (7) days later and were subjected to proximate analyses.

Laboratory Proximate Analysis of fish specimens

Fish specimens were subjected to proximate analysis as described by the Association of Official Analytical Chemists (AOAC 2000).

Moisture Content: This was determined using the AOAC method of proximate analysis. 5 g of homogenised fish sample was weighed in triplicate, into a silica dish and dried at 130 ^{0}c for 1 hour. The sample was cooled in a desiccator to room temperature and the loss in weight was calculated as a percentage as follows:

$$\% \text{ Moisture} = \frac{\text{Weight of sample before drying} - \text{Weight of sample after drying}}{\text{Weight of sample before drying}} \times 100$$

Crude protein: This was determined using micro Markham micro Kjedahl method (AOAC, 2000). Three steps which involve digestion, distillation and titration were followed using 3.5 g of fish sample which was grinded properly. 10 g of catalyst, 25 mL of concentrated H_2SO_4, and three glass beads were added. The contents were then digested with a mixture of powdered potassium sulphate, copper sulphate, and selenium mixed in the ratio of 94.8 : 5 : 0.2 until being clear. Contents were cooled and diluted and 100 mL of 40% sodium hydroxide was added. 50 mL of 4% boric acid was poured into a separate flask and connected to the distillation unit. The mixture was distilled and the distillate was collected into the boric acid containing 3 drops of indicator until the volume was above 150 mL. Ammonia was converted to ammonium metaborate and titrated with standardized 0.1 M hydrochloric acid. The percentage of protein was calculated using the below formula:

$$\% \text{ Protein} = \frac{(\text{titre vol sample} - \text{titre vol blank} \times 0.014 \times 0.1 \times 6.25)}{\text{Weight of sample used}} \times 100$$

Crude Fat: This was done according to Petroleum ether extraction method of A0AC, 2000. A 2 g fish sample was inserted into a predried porous thimble allowing rapid flow of petroleum ether. The sample was wrapped in filter paper, placed into the thimble, and covered with glass wool. Anhydrous ether was placed into a weighed boiling flask, which, together with the Soxhlet flask and condenser, was assembled into the Soxhlet apparatus. Fat was extracted into a Soxhlet extractor for 6 hours, by heating solvent in the boiling flask. The boiling flask with extracted fat was dried in an air oven at 100°C for 30 minutes, cooled in a desiccator, and weighed. The fat content was estimated as follows:

$$\% \text{ Fat} = \frac{\text{weight of flask and extracted fat} - \text{weight of empty flask}}{\text{Weight of sample used}} \times 100$$

Crude Fibre: Dried fish sample (protein, fat and moisture free) was boiled in dilute Sulphuric acid (1.25 %) for 30 minutes and filtered. The residue was further boiled in Sodium hydroxide (1.25 %) for 30 minutes and filtered.

The residue was dried, weighed and ashed at 550^0c for 6 hours. The ash was weighed and the difference in weight gave the amount of crude fibre in the fish sample.

Ash Content: Fish sample was subjected to a red hot muffle furnace temperature of 550^0c for 6 hours. The furnace was turned off to cool to 250°C before removal of sample. Sample was kept in a desiccator prior to weighing and the ash content was calculated as follows:

$$\% \text{ Ash} = \frac{\text{Weight of crucible and sample after ashing} - \text{empty weight of crucible}}{\text{Weight of sample before ashing}} \times 100$$

Nitrogen free extract: This was determined by ascertaining the difference between all other analysed proximate parameters (percentage components) and 100.

% NFE (wet basis) = % DM (100) - (% moisture + % EE + % CP + % ash + % CF)

Where: NFE = nitrogen free extract

DM = dry matter

EE = ether extract or crude lipid

CP = crude protein

CF = crude fibre

Statistical analysis: Statistical analysis was performed using SPSS software package version 17.0. The values were analysed by one-way analysis of variance (ANOVA): Post Hoc multiple comparisons followed by Duncan's multiple range tests. All the results were expressed as mean ± SEM and the P Values of 0.05 was used to determine significance.

Result

Table 1: Proximate composition (Mean ± SEM) of sex reversed *Oreochromis niloticus* fry treated with different doses of 17 α methyl testosterone

Parameters (%)	Control (mg)	40 (mg)	60 (mg)	80 (mg)
Moisture	75.60 ± 0.506^a	76.06 ± 0.827^a	76.05 ± 0.125^a	73.56 ± 1.0525^a
Ash	3.18 ± 0.1575^b	2.83 ± 0.0395^a	2.67 ± 0.0455^a	2.82 ± 0.0305^a
Crude fibre	0.17 ± 0.025^a	$0.2 \pm 0^{a,b}$	$0.23 \pm 0.025^{a,b}$	0.28 ± 0.025^b
Crude protein	16.82 ± 0.1495^a	16.69 ± 0.287^a	16.84 ± 0.5665^a	18.69 ± 1.0045^a
Crude fat	$2.98 \pm 0.1115^{a,b}$	$2.68 \pm 0.033^{a,b}$	2.52 ± 0.1505^a	3.06 ± 0.165^b
NFE	1.21 ± 0.1375^a	1.53 ± 0.5465^a	1.69 ± 0.6115^a	1.57 ± 0.2075^a

Values with the same superscript in the same row are not significantly different (P>0.05) while Values with different superscript in the same row are statistically significant (P<0.05)

Discussion

The moisture, protein, fat, crude fibre, nitrogen free extract (NFE) and ash contents of the fishes were determined using loss in weight, micro-Kjedahl, dry-ashing and solvent extraction methods as described by AOAC, 2000. The results for moisture content, Ash content, crude fibre, crude protein, crude fat and Nitrogen free extract are presented in table 1.

After prolonged drying, the differential moisture content between the control and experimental specimens varied from 73.56 ± 1.0525^a to 76.05 ± 0.125^a which is within the range of normal moisture content for *Oreochromis niloticus* in the studies of Gaber, (2000) (78.9 ±0.5 %), Bello and Oyelese, (2016) (71.36 %) and that of Boran and Karacam, (2011) (73.14 ± 0.10^e to 75.25 ± 0.14^a) but different from the values obtained by Akpambang, (2015) (68.05 (g/100g) (68.05%). This might be due to physiological reasons and changes in environmental conditions which might greatly affect the proximate composition of the fish. Moreover, the moisture content obtained in this study is within FAO (2010) and USDA (2010) permissible limits for fish and fisheries products of 78 – 90 %.

Ash content varied significantly (P<0.05) between control and experimental specimens (2.67 ± 0.0455^a to 3.18 ± 0.1575^b). This is in correlation with the normal ash content of *Oreochromis niloticus* (2.6 ± 0.2 %) in the studies of Gaber, (2000) but differs from the values obtained by (Akpambang, 2015).

Protein content varied from 16.69 ± 0.287^a to 16.84 ± 0.5665^a which suggest that *Oreochromis niloticus* fed with 17 α methyl testosterone is an adequate source of dietary protein; however, it was within the range obtained in the studies of Bello and Oyelese, (2016) (13.21 % to 32.56 %) and Akpambang, (2015) (21.28 to 21. 65). In the same development, crude fat in control and experimental fish samples varied between 2.52 ± 0.1505^a to 3.06 ± 0.165^b which is also in agreement with the normal lipid content of *Oreochromis niloticus* (Gaber, 2000). The obtained data from this study will supplement the information on the proximate analysis of sex reversed *Oreochromis niloticus*.

Conclusion

This study demonstrates a broad proximate analysis on the nutrient characteristics of hormonal sex reversed *Oreochromis niloticus,* and has established the nutrient suitability for the consumption of post-harvest hormonal sex revered fish; thus, it means that hormonal sex reversal technique using 17α-methyl testosterone has the potency of meeting the increase in demand for all-male tilapia. Hence, this study concludes that sex reversed *Oreochromis niloticus* and fish flesh treated with 17α-methyl testosterone is safe for post-harvest consumption.

Acknowledgement

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Comparison of haematological profiles of *Oreochromis niloticus* cultured in fibre tank and earthen pond.

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Abstract
The aim of the study was to compare the haematological parameters of Nile Tilapia (*Oreochromis niloticus)* cultured in a fibre tank using treated water and the fish cultured in earthen pond. Five fish (250±22.41g) from each culture systems were collected differently into containers. Blood samples were taken by caudal vein puncture using a 2ml sterilized syringe on a set of five into 2ml heparinized bottles and water samples were also analysed for physiochemical parameters. Analyses showed that the water temperature, dissolved oxygen (DO) and Nitrate were not significantly different ($p>0.05$) from each other but the water pH, ammonia (NH_3) and Nitrite were significantly different ($p<0.05$) from each other. The haematological indices revealed that the white blood cells (WBC), red blood cells (RBC) mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration obtained in the fish cultured in both systems were not significantly different from each other in spite of the variations in the values. The packed cell volume (PCV) and the haemoglobin level in the fish cultured in the pond were higher and were significantly different from each other ($p<0.05$). The study concluded that external stressors and the environment (culture system) could probably affect the blood parameters and the result could be used as a reference point in monitoring health and disease status of fish.

Keywords: Haematology, *Oreochromis niloticus*, Earthen pond, Fibre tank

Introduction
Fish has been reported to be the major source of protein for human, providing significant portion of nutrient to a large proportion of people particularly in the developing world (Ochokwu *et al*., 2014). Fish is a highly nutritious food, containing high amounts of proteins with high biochemical value for humans (Brenden *et al.*, 2003).The importance of fish as a less expensive dietary protein source cannot be over-emphasized especially in developing countries where livestock as sources of dietary protein (meat, egg and milk) are expensive and often beyond the reach of many (Eyo, 2005). According to Saliu and Salami (2010), *Oreochromis niloticus* is one of the most widely cultured species of tilapia in Africa and also a good fish for warm water aquaculture. Several studies have reported *Oreochromis niloticus* to spawn easily, to be used as a wide variety of natural food such as plankton, aquatic macrophytes, as well as artificial feeds. They tolerate poor water quality and grow rapidly in warm water temperatures (Saliu and Salamim 2010). However, all these attributes together with low input costs have made it one of the most widely cultured freshwater fish tropical and subtropical countries. Ezeri *et al.* (2004) reported that since fish are so intimately associated with the aqueous environment, their blood will reveal measurable physiological changes more rapidly than any other physiological assessment parameters. Therefore, haematology has been used as an index of fish health status in many fish species to detect physiological changes following different stress condition such as exposure to pollutants, diseases, heavy metal concentraton and poor water quality (Adesina, S.A, 2017). Several studies of haematological parameters have been carried out on fish to ascertain the normal range of blood, variation on age, sex and season and also determine the effect of disease condition on the fish (Jamalzadeh *et al*. 2009). However, the study was carried out to compare the haeamtological profiles of *Oreochromis niloticus* cultured in fibre tank using treated water and earthen pond.

Materials And Methods
Collection of Water and Fish
Fish and water samples were collected on the same day at Badore Research Centre, Nigerian Institute for Oceanography and Marine Research (NIOMR). The water temperatures were recorded immediately using mercury in glass thermometer and the water samples were collected from both culture systems (pond and fibre tank) into sterile sample bottles and transported to the laboratory for analysis. A total of 10 fish (250±22.41g) comprising of five each from the culture systems (pond and fibre tank) were collected into two different containers.

Water Quality Analysis
The water samples were analysed at Deparment of Biochemistry, Lagos State University Teaching Hospital for dissolved Oxygen (DO), pH, Nitate, Nitrite and Ammonia (NH_3) using pond lab test kit for fresh water analysis as described by Fanuel Jim *et al.* (2016).

Blood Collection and Haematolotogical Analysis
Blood samples were collected by caudal vein puncture using a 2ml sterilize syringes on a set of five *Oreochromis niloticus* from each culture systems (pond and fibre tank) into separate heparinized bottles. The blood samples were taken to Department of Biochemistry, Lagos State University College Hospital for determination of

haeamtology parameters. Hamatocrit (HCT) was determined by the microhaematocrit centrifugation technique. The haemoglobin concentration was determined with DrabkinIs reagent as reported by Adewole and Olaleye (2014). The red blood cell (RBC) and white blood cell (WBC) were determined a Neubauer counting chamber as described by Adegbesan (2016). The mean cell volume (MCV), Mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were determined according to the method described by Dacie and Lewis (2001).

Statistical Analysis

The data collected were reported as means ($\pm$ S.D) and subjected to analysis of variance (ANOVA) and Duncan's New Multiple Range Test ($p<0.05$) using the statistical software package SPSS 16.0

Result

Water Quality

The mean water temperature in the earthen pond was higher (28.4$\pm$0.40) (Table 1) than the water temperature recorded in the fibre tank (26.22$\pm$0.32) but was not significantly different ($p>0.05$) from each other). The water in both the culture system were slightly acidic and was significantly different ($p<0.05$). Analyses also showed that there were significantly differences ($p<0.05$) in the Ammonia (NH_3) and nitrite (NO_2) values recorded but there were no significantly difference in the Nitrate levels in both the cultured system ($p>0.05$).

Haematological indices

Analyses of the haematological indices in both cultured systems (Table 2) revealed that the white blood cell (WBC), red blood cell (RBC), mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were not significantly different ($p>0.05$) from each other in spite of the variation in the recorded values. Haematocrit (HCT) also known as packed cell volume (PCV) value recorded in the fish cultured in the pond was higher (19.6$\pm$0.42) than in the fish cultured in fibre tank (4.1$\pm$ 0.01), therefore, there was a significant different ($p<0.05$) between them. Also, the fish cultured in the pond had a higher Haemoglobin (HGB) (6.9$\pm$0.25g/dL) and was significantly different ($P<0.05$) from the value obtained for the fish cultured in the fibre tank (1.6$\pm$0.02).

Table 1: Mean Physiochemical parameters of the treated water in fibre tank and earthen pond

Treatment	Water temp. (^{0}C)	pH	Dissolved oxygen (mg/L)	Ammonia NH_3 (mg/L)	Nitrite (NO_2) (mg/L)	Nitrate (mg/L)
Pond water	$28.4^a \pm 0.40$	$5.86^a \pm 0.08$	$1.35^a \pm 0.04$	$23.5^a \pm 0.42$	$8.08^a \pm 0.04$	$2.21^a \pm 0.04$
Tank water	$26.22^a \pm 0.32$	$6.05^b \pm 0.04$	$1.45^a \pm 0.01$	$29.25^b \pm 0.21$	$12.71^b \pm 0.02$	$2.67^a \pm 0.03$

Means along the same column with same letter are not significantly different ($p>0.05$)

Table 2: Haematological parameters of *O. niloticus* cultured in fibre tank using treated water and earthen pond

Treatment	WBCx $10^{12}L^{-1}$	HCT (PCV) %	RBC x $10^{12}L^{-1}$	HGB (g/dl)	MCV (fl)	MCH (pg)	MCHC (g/dl)
Pond fish	$17.3^a \pm 0.24$	$19.6^a \pm 0.42$	$2.68^a \pm 0.00$	$6.9^a \pm 0.25$	$73.5^a \pm 2.03$	$25.7^a \pm 2.54$	$35.2^a \pm 1.10$
Tank fish	$20.4^a \pm 0.32$	$4.1^b \pm 0.01$	$0.56^a \pm 0.00$	$1.6^b \pm 0.02$	$74.6^a \pm 2.41$	$28.5^a \pm 0.41$	$39.0^a \pm 1.04$

Means along the same column with same letter are not significantly different ($p>0.05$)

KEYS: WBC- White blood cell, HCT- Haematocrit, RBC-Red blood cell, HGB-Haemoglobin, MCV- Mean cell volume, MCH- Mean cell haemoglobin, MCHC- mean cell haemoglobin concentration

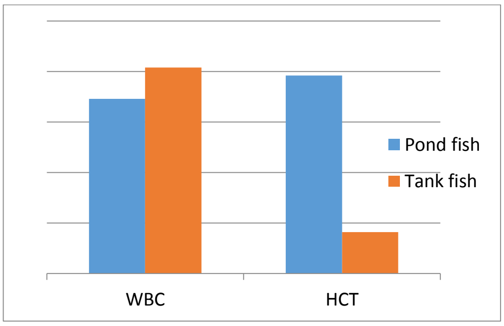

Figure 1

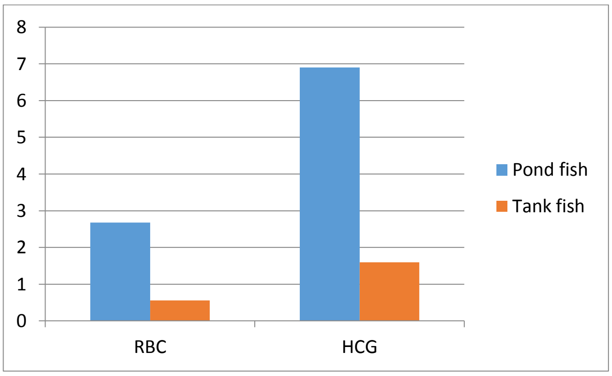

Figure 2

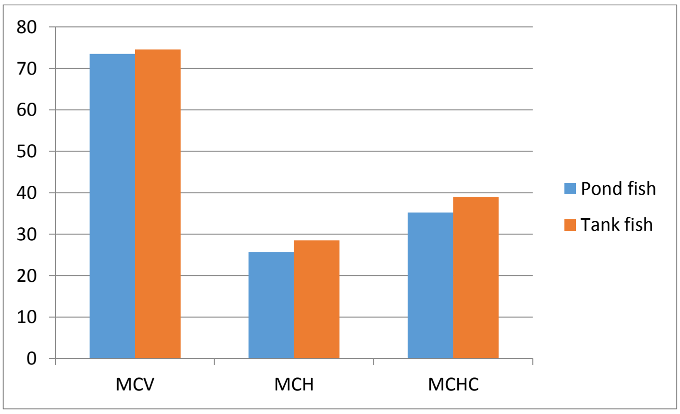

Figure 3

Discussion

Water Quality

Temperature of aquatic environment has been reported to be important for ensuring survival and normal metabolism of fish (Adewole and Olaleye, 2014). In both the culture systems, the water temperatures were within the recommended range (25^{0}C and 32^{0}C for optimum growth (Adewole and Olaleye, 2014). The pH of the water in the pond was slightly acidic and this could be as a result of interaction between atmospheric air and water during respiration process while the pH of the treated water in the fibre tank was within the acceptable range (6.0-8.0) for fresh water fishes (Olatunde, 2004). The low level of dissolved oxygen observed in this study could be attributed to the decomposition of uneaten feed and faecal matter because excess organic matter was reported to result in depletion of oxygen.

Haematology

Blood could be used as a means through which general condition of the animal body could be assessed. The white blood cell (WBC) value recorded in this study for both fish in the culture systems were within the range (17.65$\pm$0.81-29.75$\pm$0.49) reported for *O. niloticus* fed varying dietary maltose levels (Keri *et al.*,2012) but a lower range (1.04-2.39) was recorded for *C.gariepinus* fed with different experimental diet (Adewole and Olaleye, 2014). High level of WBC observed could be as a result of more release of cells to maintain homeostatics. The mean values recorded for haematocrit (HCT) and red blood cell (RBC) in the fish cultured in the pond were found to be lower than the values obtained by Adesina, S.A (2017) but agreed with the report of (Adewole and Olaleye,2012), also in accordance with the report of Adedeji and Adegbile (2011) for *Chrysicthes nigrodigitatus*. The increase in the red blood cell and HCT recorded in the fish cultured in the pond could be as a result of intake natural food. The haemoglobin concentration values obtained in the fish cultured in the pond was within the range (6.29g/dl) reported by Adam and Agab (2006) for *C.gariepinus* but was found to be lower than (4.63g/dl) reported for *O. niloticus* by Keri *et al*.(2012). The MCV, MCH and MCHC values obtained in this study were similar to those reported by Gabriel *et al*. (2014), Terry *et al*. (2000) and Nilza *et al. (*2003). According to Adewole and Olaleye (2012), factors that may have induced the variations include environmental conditions, sex, age and species of fish.

Conclusion

The study concluded that external stressors and the environment (culture system) could probably affect the blood parameters and result could be used as a reference point in monitoring health and disease status of fish.

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Some morphometric and meristic characteristic of cross between albino Clarias and normal *Clarias gariepinus*

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Abstract
A research was conducted in the department of Fisheries and Aquaculture Adamawa State Univesity Mubi to determine the morphometric and meristic characteristic of hybrid (cross between normal clarias and albino clarias through artificial breeding using the following matting combination. *Clarias ganiepinus* Albino male (♂) x *Clarias ganiepinus* Albino female (♀) , *Clarias ganiepinus* Albino female (♂) x *Clarais ganiepinus* normal male (♀),*Clarias ganiepinus* normal male (♂) x *Clarias ganiepinus* Albino female (♀) and Normal *Clarias gariepinus* male (♂) x Normal *Clarias gariepinus* female (♀).Ten (10) Morphometric and meristic characters were examined in samples from each mating combination. A total of 40 fishes were considered. Total length were measured using measuring board, weight were measured using sensitive weighing balance and others parameters were measured to the nearest 0.1mm with digital Vanier caliper, the meristic count were measured using hand lens and a dissecting microscope. From the result obtained, the intermediate morphological traits of the two different colored hybrids suggest that they are product of true fission of the genome of two different colored fishes, except for some of the hybrid especially the reciprocal hybrids of female Albino and normal male. All the morphometric and meristic characters are the same with their parent. The crosses of normal pigmented and albino *Clarias gariepinus* produces normal pigmented heterozygote with white and black patches on the body. Combine in the offspring and the offspring simultaneously demonstrates both parent phenotypes. The hybrid of female Albino and normal male (AA♀x NN♂), male Albino and female normal (AA♂ x NN♀) had brownish color when observed phenotypically. Therefore, this external features characteristic of both male and female used for each hybridization exercise seemed to have little to no influence to the external features of the resulting hybrid offspring

Key word: Normal clarias, albino clarias, morphometric, meristic and Mubi

Introduction
Morphometric and meristic analyses are part of important rigorous tools used to differentiate closely related species of organism having huge similarity indices of various parameters Naemm *et al.,*. (2005). Morphometric characters are not only essential to the understanding of the taxonomy but also the health of a species as well as its reproduction in an environment. The shape and structures are unique to each species and the variations in its features are probably related to the habit and habitat among the variant of the species Carpenter *et al.*,(1996). Although morphological characteristics are phenotypically plastic and are influenced seasonally by the physical environment factors during spawning and early juvenile stages of their life Austin, (1999). Morphometric assessment of fish species determines the inter relation between the body parameters like length, weight, fecundity and so on. It is also helps in the understanding of the relation between body parts Carpenter *et al.*, (1996) Morphometric assessment is also used in the identification of the differences in fish population. Onyia *et al.*, (2018) Buji *et al.*, (2008). Morphometric variation between stocks can form one of the bases for stock structure and may be applicable for studying a short-term, environmentally induced variation geared towards successful fisheries management Murtala (2002). These measurements are restricted to document the direction of the size of variation in fish stock. The measurement is believed to be a suitable technique for the recognizing the degree of reproductive maturation without sacrificing the fish Bookstein (1991). Generally, species of fish that have different origin is morphologically differentiated from each other. According to the reported works of Mamuris *et al*, (1998); Bronte *et al.*, (1999); Onyia *et al.*, (2018), analysis of phenotypic differences in morphometric characters or meristic counts is the method most commonly used to delineate stocks of fish. According to Onyia *et al.*, (2018) this is often being used in discrimination and classification studies by statistical techniques but despite the advent of techniques which directly considers the biochemical or molecular genetic variation, these conventional methods still play vital functions in stock identification even to date. The general health of a population of fish can be accessed through the growth features. So possible variations in the measurable and countable characters will reveal the adaptation to environmental condition, crossing viability and help in clarifying their identity. There has not been any previous documented morphological description of the interspecific hybrids of these species. On this background, it is necessary to determine the morphometric and meristic characteristic of cross between albino and normal Clarias.

Materials and methods

Offspring from mating combination of normal *Clarias* and Albino *Clarias* were obtained through artificial breeding of the following: *Clarias ganiepinus* Albino male (♂) x *Clarias ganiepinus* Albino female (♀), *Clarias ganiepinus* Albino female (♂) x *Clarais ganiepinus* normal male (♀), *Clarias ganiepinus* normal male (♂) x *Clarias ganiepinus* Albino female (♀) and Normal *Clarias gariepinus* male (♂) x Normal *Clarias gariepinus* female (♀).

Hatchlings from this mating combination were cultured for the period of one to determine the morphometric and meristic character. Ten (10) Morphometric and meristic characters were examined in samples from each mating combination. A total of 40 fishes were examined. The morphometric characters were measured using the conventional method described by Hubbs and larger (1958). The characters examined are: Total Length Standard Lengths, Weight, Head Width, girths, eye diameter, inter orbital distances, nasal barbel lengths, and maxillary barbell length. The other Morphometric character are dorsal fin length, dorsal fin height, caudal peduncle length, gap between adipose and dorsal fins, and fin length, and fin height, pectoral fin to pelvic fin, pelvic fin to anal fin, frontal fontanelle length, and occipital fontanelle width. Total length was measured using measuring board, weight was measured using sensitive weighing balance and others parameters were measured to the nearest 0.1mm with digital Vanier caliper, the meristic count were measured using hand lens and a dissecting microscope. The characters counted includes dorsal fin rays, pectoral fin rays, pelvic fin rays, and fin rays and caudal fin rays. All data obtained were subjected to one-way analysis of variance (ANOVA) (SAS), while mean were separate using fisher LSD.

Results and Discussion

The result of the measurement are shown in table1. The low mahalanobis square distance between the two different pigmented *Clarias* species indicated their level of similarities to each other. The mahalnob is square distance (D^2) between male Albino and female normal (AA ♂ x NN ♀) female Albino and male normal (NN♂ x AA♀), Albino male and Albino female. (AA♂ x AA♀), and normal male and female (NN♂ x NN♀) *C. gariepinus* including their offspring in f1 of the interspecific hybrid were not significantly different ($p<0.05$). This clearly indicate how extremely difficult it could be to distinguish this species from their interspecific hybrid using their morphological and meristic features. There are varying pattern of inheritance of some character by offspring of the various mating combination, the hybrid for the offspring of mating combination of Normal and Albino in F1 shows positive heterosis in the inheritance of brown eyes colour, head width, premaxillary width, and vomemine width in which case they possess different body color (brown) compared to the both parental width pink and black colored eyes. The head of all the mating combination shows the same flattered like the positive parent of C. *gariepinus species*. Therefore, this external features characteristic of both male and female used for each hybridization exercise seemed to have little to no influence to the external features of the resulting hybrid offspring except for the brown eyes and brown body observed in some offspring at the end of the research.

The interspecific hybrids however also show some level of positive heterosis in the inheritance of frontal fontanelle length similar to their parents as shown in (table 4.1) and also as a reflection of head length as shown in the same table which there were no significant differences in other cephalic traits between the interspecific hybrids and the parental. In the inheritance of the adipose fin length, the dorsal fin, shows no significant difference ($P<0.05$) in the hybrid of f1. The intermediate morphological traits of the two different colored hybrids suggest that they are product of true fission of the genome of two different colored fishes, except for some of the hybrid especially the reciprocal hybrids of female Albino and normal male (AA♀x NN♂), male Albino and female normal (AA♂ x NN♀) had brownish color when observed phenotypically as discussed earlier. The findings differed from report by Rothbard and Wohlfarth (1993), who reported that inheritance of albinism in grass carp, was the results of a cross between wild-type heterozygote male and albino female. Among the resulting progeny 52.0% fish were of wild-type color while 48.0% were albino. The crosses of normal pigmented and albino *Clarias gariepinus* produces normal pigmented heterozygote with white and black patches on the body Onyia *et al.*, (2018). The findings were relevant with the co-dominant and incomplete dominant cases reported by murtala (2000). One allele is not completely dominant over the other. There is a blending with the heterozygous offspring or both alleles contribute to the phenotype. Co dominant is a system in which alleles are from each homozygote parents. Combine in the offspring and the offspring simultaneously demonstrates both parent phenotypes. The finding agreed with the work of Maliszewski (1987) who stated that progeny from a wild female and yellow albino male were half wild and half brownish yellow. These reports do not conform to the work of Gomelsky *et al.*, (1996) on dihybrid crosses that investigated the colour ratios in progenies obtained after crossing of two-color and tri-color koi. Result show from that study that the white-red color complex and the presence of black patches in koi were inherited independently and the presence of black patches was controlled by the dominant mutation of one gene. Morphological abnormalities observed in some offspring of the mating combination, the skin of the albino cat fish tends to be harder than the normal color C. gariepinus, this was observed during breeding when ovaprim was injected to the females to the parent fish. Therefore, this mating combination seemed to have little to no influence to the external features of the resulting hybrid.

Table 1: Mean and Standard Error of Some morphometric characters of various mating combination for *Clarias gariepinus* normal and albino *Clarias*

Mating combination	NN♂ x NN♀	AA♂ x AA♀	NN♂ x AA♀	AA♂ x NN♀
Number sampled	10	10	10	10
Head width	4.21±0.32[b]	5.20±1.31[a]	4.80±0.35[b]	5.30±1.34[a]
Eye diameter	0.61±2.31[a]	0.52±1.31[b]	0.72±1.31[a]	0.51±1.33[b]
Occipital fontanelle width	0.61±2.31[a]	0.40±0.61[b]	0.60±0.83[a]	0.50±0.13[a]
Frontal fontanelle length	2.56±1.31[a]	2.13±0.22[b]	2.47±1.23[a]	2.12±0.21[b]
Pre maxillary width	2.61±1.32[a]	2.41±0.13[a]	2.00±0.23[b]	2.20±1.34[a]
Vomerine length	0.61±1.31[a]	0.32±1.34[b]	0.36±0.32[b]	0.52±0.35[a]
Vomerine width	1.80±0.43[a]	1.60±0.31[b]	1.5±0.23[b]	1.8±0.34[a]
Pelvic fin length	2.30±1.30[a]	2.10±2.30[b]	2.00±1.30[b]	2.41±1.31[a]
Caudal peduncles length	1.20±0.32[a]	1.32±0.36[a]	1.10±0.82[b]	1.00±0.31[b]

Mean in the same row with the same super script do not differ significantly ($P<0.05$).

Table 2: Mean and Standard Error of Some meristic characters of various mating combination for *Clarias gariepinus* normal and albino Clarias

Mating combination	NN♂ x NN♀	AA♂ x AA♀	NN♂ x AA♀	AA♂ x NN♀
Number sampled	10	10	10	10
Dorsal soft fin rays	70.50±0.30[a]	70.50±0.32[a]	70.50±0.32[a]	70.50±0.32[a]
Pectoral soft fin rays	10.50±0.33[a]	10.50±0.33[a]	10.50±0.33[a]	10.50±0.33[a]
Pelvic soft fin rays	12.50±1.31[a]	12.50±1.31[a]	12.50±1.31[a]	12.50±1.31[a]
Anal soft fin ray	55.00±1.41[a]	55.00±1.41[a]	55.00±1.41[a]	55.00±1.41[a]
Caudal soft fin rays	46.50±0.00[a]	46.50±0.00[a]	46.50±0.00[a]	46.50±0.00[a]
Number of spins in dorsal fin	0.0±0.00[b]	0.0±0.00[b]	0.0±0.00[b]	0.0±0.00[b]
Number of spins in pectoral fin	1.00±0.43[a]	1.00±0.43[a]	1.00±0.43[a]	1.00±0.43[a]
Number of spins in pelvic fin	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
Number of spins in anal fin	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]

Mean in the same row with the same super script do not differ significantly ($P<0.05$).

The mating combination are as following;

Clarias ganiepinus Albino male (♂) x *Clarias ganiepinus* Albino female (♀) ; *Clarias ganiepinus* Albino female (♂) x *Clarais ganiepinus* normal male (♀); *Clarias ganiepinus* normal male (♂) x *Clarias ganiepinus* Albino female (♀); Normal *Clarias gariepinus* male (♂) x Normal *Clarias gariepinus* female (♀).

KEYS:

NN----NORMAL *Clarias Gariepinus,* AA/NN---- ALBINO/NORMAL *Clarias Gariepinus*

NN/AA----NORMAL/ALBINO *Clarias Gariepinus,* AA----ALBINO *Clarias Gariepinus*

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Effects of using different water sources in the hatchability, growth and survival rate of *Clarias gariepinus* fry

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Abstract
A study was carried out to determine the effect of different water sources (borehole, well and stream) on the hatchability, growth performance and survival rate of *Clarias gariepinus.* A total of 494 eggs were incubated in three (3) plastic containers for each water source. The result shows significant differences ($p<0.05$) in hatchability rate under different water sources. Stream water has the highest hatchability rate of 447(64.4%), followed by well water with 374(53.89%), while borehole water recorded lowest hatchability of 293(42.21%). Eighty (80) hatched larvae were then placed in plastic container containing different water sources in triplicate and cultured for twenty eight days. Specific growth rate (SGR%) was highest (2.46 ± 0.11) in fry reared in borehole water. Survival rate was significantly highest (98.05 ± 3.79) in fry reared in well water. The result of some water quality parameters measured show that there was no significant difference ($p>0.05$) in temperature, pH and hardness of the three water sources but there was significant difference in dissolved oxygen, electrical conductivity, biological oxygen demand and total dissolved solids of the three different water sources. Therefore it can be concluded that stream water enhances the hatchability of eggs while well water greatly improved the growth performance and survival rate of Africa catfish (*Clarias gariepinus*) fry.

Keywords: Hatchability, *Clarias gariepinus,* Water sources, Growth performances, Survival rate

Introduction

The needs for the production of quality African catfish seed for stocking the fish ponds and natural water bodies has indeed increased steadily. Although, expansion of African catfish cultured in Nigeria is limited by poor water quality (Akinwole and Fatunbi, 2006).

Fishes are totally dependent on water and so, information on the availability of sources of water and the suitability of the physicochemical quality for fish production is indispensable. Water quality in aquaculture refers to anything in the water, be it physical, chemical or biological that affects the fish normal health and production performance (Balogun, 2015). Its quality directly affects feed efficiency, growth rates, the fish's health and survival. According to Archana and Nisar (2013), most fish kills, disease outbreaks, poor growth, poor feed conversion efficiency and similar management problems are directly related to poor water quality. To a great extent, the success of an aquaculture operation is dependent on water quality as such; water sources should be selected based on its suitability for efficient production of high quality aquaculture products. There is dearth of information on growth and survival rate of *Clarias gariepinus* fry using different water sources. Thus, most fish farmers and hatchery operators lack knowledge of the physico-chemical parameters of these water sources hence, they use any available water for fish breeding purposes which in turn affects hatchability, growth and survival of their fry. These brings about the need to provide relevant information on the water sources that will give the best hatchability and survival rate thereby making fingerlings readily available for fish farming.

Fish perform all of its activities in water; hence a huge success in production of fish particularly in the hatchery can be attained through proper water quality management (Oladosu *et al.,* 1999). Therefore, the need to assess the suitability of different water sources (borehole, well and stream) around Lafia metropolis for hatchery operation is inevitable

Materials and Methods

The experiment was carried out at the hatchery unit of the Department of Aquaculture and Fisheries Management fish farm, Faculty of Agriculture Lafia, Nasarawa State University. The three water sources are located within latitudes 08º35N, longitudes 06º32E and altitude 181.53 above sea level with a mean temperature of 34^0C, relative humidity of 40-86% and average day light of 9-12hours (NIMET, 2018). Quality broodstock were obtained from a reputable fish Farm in Lafia metropolis. The broodstocks were used for induced breeding to obtain fry that was used for the study. Water used for the experiment was obtained from well, borehole and stream from College of Agriculture Lafia stream. The water quality parameters from the three water sources was determined using Lamotte aquaculture testing kit (Model AQ-2 Code 3633-03).

Experimental Procedure

The experiment was carried out in three treatments in replicates comprising of: well water, borehole water and stream water for the period of 4 weeks. After the stripping and fertilization of the eggs, the eggs were spread on the spawning mat on equal proportion in three plastic bowls containing the three different water sources. Percentage hatchability was determined after 3 days.

Eighty hatched larvae were transferred to plastic bowl containing 30 litres of well, borehole and stream water. Their initial body weight was determined using a digital weighing scale. Feeding was done four times daily. Sampling was done at the beginning and ending of the experiment to determine the growth and survival rate of the fry in each treatment. Water quality parameters were determined using water testing kits during the experimental period. Water was changed fortnightly.

Data Collection

Data was collected on percentage hatchability, mean weight gain, percentage mean weight gain, specific growth rate and survival rate and was subjected to one way analysis of variance (Anova) using SPSS version 20. Significant mean differences was separated at 5% probability level.

Results and Discussion

The effect of different water sources on the hatchability rate of African catfish (*Clarias gariepinus*) is presented in Table 1. The result revealed that there were significant differences ($p<0.05$) in hatchability rate of *Clarias gariepinus* under different water sources .Stream water has the highest hatchability rate of 95.02%, followed by well water with 79.79% while borehole water recorded lowest hatchability of 74.42 The result of this study is in line with the findings of Olaniyi *et al.,* (2018) who reported highest hatchability rate in catfish spawned in stream waters. It is also similar to that of De-Graaf *et al*. (1995) when breeding *C. gariepinus* in the republic of Congo in different water sources, recorded 59% in stream water. .

Result of growth performance of *Clarias gariepinus* fry cultured under different water sources is presented in Table 2.The result shows that there was a significantly different ($p<0.05$) among the water sources. Percentage weight gain (%) revealed that the highest percentage weight gain 184.00±12.50 was obtained in *Clarias gariepinus* fry reared in well water, followed by 177.41±3.09 in borehole water while the lowest percentage weight gain 55.44±7.37g was recorded in stream water.

Results of specific growth rate (SGR%) shows that *Clarias gariepinus* fry reared in borehole water has highest SGR of 2.46±0.11, followed by 2.18±0.13 in well water while the lowest SGR of 1.54±0.12 was recorded in stream water.

The result of survival rate indicates that *Clarias gariepinus* fry reared in well water has the highest survival rate of 98.05±3.79 followed by borehole water with 97.25±5.29, while stream water has the lowest survival rate of 93.11±10.21. Growth parameters (weight gain, percentage weight gain and specific growth) of *C. gariepinus* fry was highest in borehole water. The result of this present study is contrary to the results of Olaniyi *et al.,* (2018) who obtained better growth in catfish spawned in stream water. This may likely due to variation in physico-chemical parameters of water sources in different region, which may determine the growth rate.

Mean physico-chemical parameters of water from three different sources (borehole, well and stream) is presented in Table 3. Water quality is an important pre-requisite for a successful hatchery operation. The water quality parameters obtained in this study were within the favourable and recommended range for fish breeding and culture.

Conclusion and Recommendations

The importance of water quality to fish production cannot be overemphasized as fish is a poikilothermic animal as such the sources of water for it reproduction is very important. The present study of using different water sources (Borehole, Well and stream water) in Ombi II area of Lafia Nasarawa state revealed that stream water is the better source of water for hatchability, while well water is best for growth performances and survival rate.

Table 1: Effect of different water sources on hatchability rate of African catfish (*Clarias gariepinus*)

Parameters	Borehole water	Well water	Stream water
Number of eggs	494±0.00[a]	494±0.00[a]	494±0.00[a]
Number of hatched eggs	291.00±9.06[c]	308.00±0.08[b]	363.00±3.06[a]
No. of whitish (unfertilized) eggs	103.00±3.52[c]	108.00±2.65[b]	112.00±5.57[a]
No. of fertilized eggs	391.00±9.54[a]	386.00±12.49[b]	382.00±4.00[b]
Fertilization rate	74.14±7.01[b]	78.13±0.13[a]	77.32±3.51[a]
% hatchability	74.42±1.97[c]	79.79±7.96[a]	77.32±13.04[a]

Means with different superscript along the row are significantly different ($p<0.005$)

Table 2: Growth performance of *Clarias gariepinus* fry cultured under different water sources

Parameters	Borehole water	Well water	Stream water
Initial weight (g)	1.86	1.50	1.93
Final weight (g)	5.16	4.26	3.00
Weight gain (g)	1.77±0.90[b]	1.84±0.75[b]	5.54±0.45[a]
Percentage weight gain (%)	177.41±3.09[ab]	184.00±12.50[a]	55.44±7.37[b]
Specific growth rate	2.46±0.11[a]	2.18±0.13[ab]	1.54±0.12[b]
Survival rate (%)	97.25±5.29[ab]	98.05±3.79[a]	93.11±10.21[b]

Means with different superscript along the row are significantly different ($p<0.005$)

Table 3: Mean value of the physico-chemical parameters of water from three different sources

Water sources	Parameters						
	T^{0}C	**pH**	**DO (ppm)**	**Hard ness (ppm)**	**EC (µs/cm)**	**BOD (ppm)**	**TDS (ppm)**
Bore-Hole Water	29.17± 1.26[a]	5.67± 0.76[a]	4.53± 0.49[b]	1.27± 0.31[a]	71.67± 7.64[a]	4.47± 0.50[a]	25.67± 1.53[a]
Well Water	27.00± 1.00[a]	6.63± 0.32[a]	6.53± 0.35[a]	1.57± 0.25[a]	35.67± 3.06[b]	2.27± 0.31[c]	15.00± 1.73[b]
Stream Water	27.33± 1.53[a]	6.50± 0.50[a]	6.23± 0.93[a]	1.43± 0.25[a]	70.33± 2.52[a]	3.27± 0.39[b]	24.17± 2.26[a]
Gran mean	27.83	6.27	5.77	1.42	59.22	3.33	21.61
SEM	0.43	0.19	0.21	0.09	1.65	0.14	0.62

Note: mean values with the same superscript along the same column are not significantly different ($p>0.05$).

Table 4: Recommended range of physico-chemical parameters for freshwater fish in the tropics

Parameters	Borehole water	Well water	Stream water	Recommended range
Temperature (^{0}C)	29.17	27.00	27.33	15-35 (WHO, 1999; FEPA, 1991)
pH	5.67	6.63	6.50	6.0 – 9.0(WHO, 1999; FEPA, 1991)
DO (ppm)	4.53	6.53	6.23	5.0 – 7.0 (WHO, 1999; FEPA, 1991)
BOD (ppm)	4.47	2.27	3.27	<4.0 (WHO, 1999; FEPA, 1991)
Hardness (ppm)	1.27	1.57	1.43	20 – 150(WHO, 1999)
TDS (ppm)	25.67	15.00	24.17	<600 (WHO, 1999)
EC (µs/cm)	71.67	35.67	70.33	2000 (WHO, 1999; FEPA, 1991)

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Spawning periodicity and fecundity in *Coptodon guineensis* reared in sheltered systems

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Abstract
Coptodon guineensis breeders were maintained in 0.5 m^3 capacity plastic tanks in a sheltered setting. Their spawning periodicity was determined over a ten-month period for parents and progeny. Initial mean weight, standard length and total length of the breeders averaged 131.61 g, 15.6 cm and19.3 cm respectively. Results of the study indicated that *C. guineensis* spawned thirteen times with production that varied from 820 to 1,587 eggs per spawn. This study found that the monthly spawning periodicity of parent broodfish of *C. guineensis* (1.00±0.26) were not statistically different from those of their progeny (1.17±0.40) in sheltered systems, p = 0.736.

Keywords: Guinean tilapia, *Coptodon guineensis*, Breeders, Spawning

Introduction
Tilapiine cichlids have become one of the most commercially important groups of cultured fish produced annually in a range of countries (e.g. Thailand, Taiwan, China, Philippines, Belgium, USA, Egypt and Ghana). However, poor broodstock productivity, owing to low fecundity and asynchronous spawning cycles remain some of the most significant outstanding constraints affecting commercial tilapia production and its future expansion (Coward and Bromage, 2000; Suloma and Ogata, 2006; Obwanga *et al*., 2018).

Guinean tilapia *Coptodon guineensis*, is a euryhaline fish that usually lives in brackish waters in river mouths and lagoons along the West African coast, from Angola to Morocco (Agnèse *et al*., 2018) and possesses high adaptation capacity in high salinity variations (Diankha, 2018). It can be differentiated phenotypically from other cichlids by the prominent black "tilapia" mark on the dorsal fin (Campbell, 1987) and its bicoloured caudal fin (Nobah *et al*., 2006).

The species is exploited for food and supports both small-scale subsistence and commercial fisheries. It has been identified as a potential species for aquaculture in Nigeria (Olopade *et al*., 2018). The objectives of this study were to determine the spawning periodicity and estimate batch fecundity (number of eggs per spawn) of the cichlid in sheltered systems.

Materials and Methods
Experimental design and set-up
Twenty sheltered 0.5m^3 capacity square plastic tanks were utilized for this study which lasted for ten months.

Source of experimental fish
Parental specimens used were obtained from a private farm in Eti-Osa Local Government Area of Lagos State. Initial mean weight, standard length and total length averaged 131.61 g, 15.6 cm and 19.3 cm respectively.

Spawning studies
Single pair sets comprising male and female fish according to methods by Keremah and Ndah (2013) were reared separately for parental specimens and their progeny samples. Production of offspring was obtained from both generations and count of spawns undertaken for both throughout study duration.

Measurement of biometric indices
Weight and lengths of study samples along with batch assessment of their resultant spawn were undertaken with a Mettler Toledo electronic balance (ME1002E) determined to an accuracy of 0.01 g and Wildco® fish measuring board (118-B30)to the nearest 0.1 cm respectively.

Statistical analysis
Data obtained from parental and their progeny samples were compared using Two-Sample T-test in Minitab software Version 19.2020.1.0 (Minitab LLC for windows, 2020) statistical package and presented as mean±standard error of the mean. Differences between the treatment means were considered significant at $P \leq 0.05$.

Results and Discussion
Results of this study are based on examination of periodic spawnings and batch fecundities of Guinean tilapia parental (Plate I) and progeny samples paired using a 1:1 sex ratio. In total, thirteen spawning (Plate II) cycles were obtained with production that varied from 820 to 1,587eggs per spawn.

Results

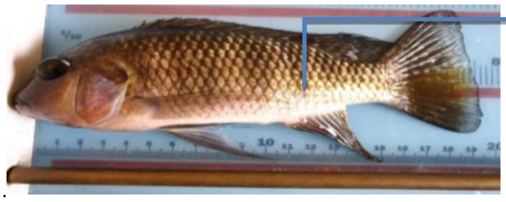

Plate I: *Coptodon guineensis* showing distinguishing features

Plate II: Eggs of parental broodfish
Spawned on 11th February 2020 [n = 1,458]

Plate III: Eggs of six months old progeny
Spawned on 10thApril 2020 [n = 1,392]

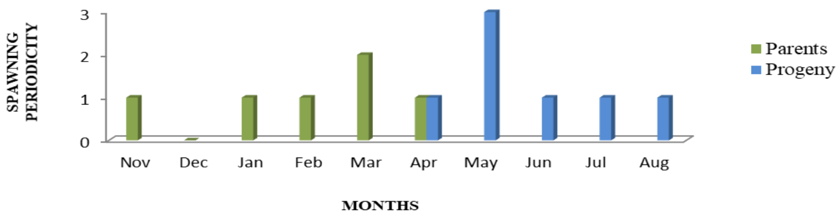

Figure 1: Monthly spawning periodicity of *C. guineensis* from November 2019 to August 2020

Although *C. guineensis* has been described as a nest building (composed of series of holes) substrate spawner, which holds true when they are in estuaries, lagoons or earth ponds, it was however observed during the course of this study that in tanks, the spawned eggs were attached to one side of the square-shaped plastic tanks, a reproductive behavioural modification reported by Keremah and Ndah (2013) for Guinean tilapia in glass aquaria where they placed their eggs on the sides. Similar observations were noted by Legendre and Ecoutin (1989), where in concrete tanks the eggs were simply laid on the wall to which they adhered. The outcomes of these studies are indicative of *C. guineensis*' great capacity to adapt its reproductive behaviour to the environment as stated by Keremah and Ndah (2013).

On hatching, the parents were also observed to constantly reposition the wrigglers, which are non-mobile yolk-sac larvae, in the darkest part of the tank away from light which affirms parental direct care behaviours found in some cichlids. The act of close guarding by parents was corroborated by Snekser and Itzkowitz(2019)in their study of the substrate brooding species, Convict cichlid *Amatitlania nigrofasciata*. Awata and Kohda (2004) reported on other parental care patterns of another substrate brooding cichlid *Julidochromis ornatus* which still hinges on guarding of broods by both parents.

Spawning by the same pairs, as shown in Figure 1, occurred occasionally multiple times monthly with each cycle lasting for two to four weeks. This was in agreement with Isaac-Harry (1986) who reported that the Guinean tilapia is relatively fecund and a multiple female spawner. Fagade (1979) also reported that they reproduce all year round in West African regions. Additionally, the age and size at first sexual maturity was determined to be six months old (Plate III) and 9.6 cm total length respectively, however, Legendre and Ecoutin (1989) obtained slightly different results and indicated that in culture, they became sexually mature between 7 and 9 months. Legendre (1983) under culture conditions in enclosures found first sexual maturity in females of 15.4 cm.

This study found that the monthly spawning periodicity of parent broodfish of *C. guineensis* (1.00±0.26) were not statistically different from those of their progeny (1.17±0.40) in sheltered systems, $p = 0.736$. The high frequency of spawning recorded in the month of May when compared with what obtained in the other nine months interestingly agrees with the findings of Mireku (2012) that Guinean tilapia presented a maximum reproductive activity in May with sustained spawnings during the rainy season in Brimsu reservoir, a man-made water resource in Ghana. As regards fecundity value, which is another indicator of reproductive performance, the author determined it to be from 1,968 to 4,016 eggs, an outcome relatable to the present work.

Conclusion

C. guineensis shows good aquaculture potential in sheltered tanks by having relatively good fecundity in relation to size. What it lacks in terms of number of offsprings per batch, it compensates for by frequent spawning.

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Reproductive indices of female *Clarias gariepinus* fed different inclusion levels of fertility enhancing seed powder

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Abstract
The study was carried out for 56 days, to evaluate the reproductive indices of *Clarias gariepinus* fed varying inclusion levels of Fertility Enhancing Powder. Five experimental diets were produced with locally available ingredients with the following inclusion levels of powder; 0.5g/kg, 1.0g/kg, 1.5g/kg, 2.0g/kg, representing diets 1,2,3,4 and 5. Diet 1 which is the control has zero inclusion. The results showed that effect of FESP on the growth though differ marginally but has no significant difference (p>0.0). The inclusion level that records the highest weight gain is 0.015 in diet 4 (D_4), which reduces in the inclusion level of 0.02. The control diet which has 0g of inclusion level has gained weight higher that diet 2 and diet 3 which has 0.005 and 0.01 respectively. The standard length has no significant difference (p>0.05) in all the diets that contain some level of inclusion; even though the diet 5 has recorded marginal difference. The control diet which contain 0g inclusion has a significant difference in terms of standard length, fecundity, percentage fertilization. Hatching rate showed a significant improvement with progressive increase in the concentration of FESP in the diets. The control diet (D_1) has 66.75% fertilization rate, and increase steadily to 76.75%, 83.25% and 95% in diet 2, diet 3, diet 4 and diet 5, which has 0.005, 0.01, 0.15 and 0.02g inclusion levels respectively. The percentage hatchability also showed a remarkable increase in the diet containing different levels of inclusion. The control diet had 50% hatchability. Diet 2, diet 3, diet 4 and diet 5 had 55%, 66.75%, 76.25% and 88.25% respectively, indicating that the FESP had improved fertility and hatchability of the sample. Finally, one can reasonably deduce that the FESP had no significant effect on growth i.e. weight gain and length increase, but had a significant effect on fertility and hatchability

Keywords: Egg quality, fertility enhancer, Inclusion levels *Clarias gariepinus*

Introduction
African aquaculture has come a long way since it was first introduced over 50 years ago. However, aquaculture development in Africa has followed a long and bumpy road. Initial high interest in the innovation of farming fish rapidly dwindled during the 1960s as over-expectations were not met and many enterprises were abandoned. Yet a positive perception of aquaculture's potential role remained (Reig *et al*., 2019).

Egg quality or oocyte developmental competence can be defined as the ability of the egg to be fertilized and subsequently develop into a normal embryo (Bobe and Labbé, 2010). Similar definitions have been given by other investigators (Kjörsvik *et al.,* 2003; Brooks *et al.,* 1997) to stress that characterization of several features of early developmental success such as embryo survival or the lack of abnormal development is needed to assess egg quality.

The current trend is the use of organic aquaculture to produce both fingerlings and table size fish. FESP could be an answer. It is common knowledge in most fish hatcheries to experience unfertilized and unhatched eggs due to egg quality. There is need to Improve on the number of fertile and hatched eggs, in order to increase fingerlings production. Hence, the search to discover any organic substance that would not have any side effects on the broodstock. Over the years, medicinal plants and fruits such as *Azanza garckeana*(Onyia et al.2015), *Kigelia Africana*(Adeparusi *et al.,* 2010,), *Garcinia kola* seed(Dada *et al.,* 2010, Dada, 2012) have been used to determine its effects on fish egg quality and fertility of *Clarias gariepinus.* Therefore it is necessary to find out through this research the effect of different inclusion levels of FESP powder meal on the egg quality and hatchability of female *Clarias gariepinus.*

Materials and Methods
Study Area
The research was carried out at the Fisheries Department research farm of The Modibbo Adama University of Technology, Yola, Adamawa State. The state is located on latitude 9.20-9.33ºN, longitude 12.30-12.50 ºE and on altitude of 185.9m (Canback Global Income Distribution Database, 2014).

Preparation of feed containing different inclusion levels of Fertility Enhancing Seed Powder

Fish feed ingredients were locally obtained from Jimeta Market. Fish feed of 40% Crude Protein was formulated. The Fertility Enhancing Seed Powder was ordered from distributors in Yola, Adamawa State. Five different diets were formulated from the practical ingredients.

The control diet was produced without FESP, and the other four Diets contained the following inclusion levels of FESP; 0.5g/kg(D2), 1.0g/kg(D3), 1.5/kg(D4), 2.0/kg(D5) respectively and was pelletized. The experimental diets were formulated to contain 30% Crude Protein. Phytochemical analysis of the FESP was carried out.

Collection and Acclimatization of Experimental Fish

30 brood stocks (15 males and 15 females) were collected from the Research Farm of the Fisheries Department, Modibbo Adama University of Technology Yola. The brood stocks were divided into five experimental groups (3 males and 3 females per treatment) representing five nutritional treatments and fed for 56 days.

Growth and egg quality performance of experimental fish

The weight, length, percentage fertilization, hatchability, GSI% and PGSI were calculated

Fertilization rate

$$\% \text{ Fertilization} = \frac{Number\ of\ fertilized\ eggs}{total\ number\ of\ egges} X\ 100$$

Hatchability rate

$$\% \text{ Hatchability} = \frac{Number\ of\ whitish\ eggs}{Total\ Number\ of\ hatchlings} X\ 100$$

GSI% = Weight of gonad/ Body weight of fish x 100

PGSI = Weight of stripped eggs/ Body weight of fish before stripping x100

Statistical Analysis

Data obtained were subjected to one way ANOVA to test for significant differences using SPSS software.

Results and Discussion

The result of this study showed the qualitative and quantitative composition of fertility enhancing seed powder and contains Tannins, Saponins, Alkaloids, Flavonoids, Glycosides, Carotenoids, Steroids, Cynogenic Glycogens, Xanthone and Phenols. These were obtained from a mixture of ginseng, Tumera and Sesame.(Table 1). The results of FESP agree with the work of some authors that plants contain safer and cheaper chemical compounds such as alkaloids, flavonoids, pigments, phenols, terpenoids, steroids and essential oils that possess diverse range of bioactivity (Cook and Samman, 1996; Velioglu *et al*., 1998; Iwalewa *et al*., 2007).

Table 1: Qualitative and Quantitative Phytochemical Composition of Fertility Enhancing Seed Powder (FESP)

Phytochemicals	Qualitative	Quantitative(g/100g)
Tannin	++	2.43
Saponins	++	2.33
Alkaloids	++	2.27
Flavonoids	++	2.12
Glycosides	++	2.2
Carotenoids	+	0.17
Steroids	+++	4.13
Cyno. Glycogens	+	0.16
Xanthose	+	0.24
Phenols	+++	21.47

Keys: + = Slightly Present, ++ = Present, +++ Highly Present, -- Absent

The control diet which certain 0g inclusion has a significant difference in terms of length, fecundity, percentage fertilization and hatching rate showed a significant improvement with progressive increase in the concentration of FESP in the diets. The control diet (D_1) has 66.75% fertilization rate, and increase steadily to 76.75% 83.25% and 95% in diet 2, diet 3, diet 4 and diet 5, which has 0.005, 0.01, 0.15 and 0.02g inclusion level respectively. The same trend followed in percentage hatchability also showed remarkable increase with increase in the inclusion levels. The control Diet had 50% hatchability and diet 2, diet 3, diet 4 and diet 5 had 55%, 66.75%, 76.25% and 88.25% respectively, indicating that the FESP have improved fertility and hatchability of the sample. This agrees with Dada *et al.* (2013) who reported that medicinal and wild fruits have the potentials to enhance reproductive indices of *C. gariepinus* broodstock. High fecundity values were obtained from the diet 5 with 2.0g/kg of CMPP, it also have the highest fertilization and hatchability rate when compared with control which had the least in both fertilization and hatchability, similar result was also reported by Dada *et al.* (2013) and Adeparusi *et al.* (2010).

The higher the inclusion level of FESP the higher the fecundity rate of *C. gariepinus* eggs. This agreed with (Dada, 2013) who used *Sesamum indicum* to improve the fecundity of *C. gariepinus.* The increase in the fecundity in this research could be attributed to the presence of xanthone and biflavonoid in the CMPP powder. (Dada *et al.,* 2013) and (Onyia *et al.,* 2015) reported that xanthone and biflavonoid is a potent antioxidant that can possibly increase the production of oestrogen which is the major hormone necessary in the production of matured and viable eggs in the ovary of the female fish. Also essential oils, Saponins and Phytosterols present in the FESP can increase fecundity. The highest sperm volume and count was highest in the diet containing 2.0g/kg of FESP medicinal plant compared to control which had no FESP. This has proved that FESP medicinal Plant contain pro-fertility property and can effectively be exploited to increase both fecundity, sperm for quality fish seed production (Adedeji *et al.,* 2006).

Table 2: Reproductive Indices of *Clarias gariepinus* Fed Different Inclusion Levels of Fertility Enhancing Seed Powder(FESP).

Parameters	D1	D2	D3	D4	D5
Weight of fish(g)	850^{b}	700^{e}	750^{d}	800^{c}	950^{a}
Length of fish(cm)	34^{d}	36^{b}	35^{c}	33^{e}	40^{a}
Weight of eggs(g)	61.11^{c}	51.4^{e}	69.3^{b}	56.2^{d}	137.1^{a}
Number of eggs in 1g	625^{d}	708^{c}	736^{b}	600^{e}	792^{a}
Total number of eggs	$38{,}193^{c}$	$36{,}391^{d}$	$51{,}005^{b}$	$33{,}720^{e}$	$108{,}979^{a}$
Egg diameter(mm)	1.0^{a}	1.0^{a}	1.0^{a}	1.0^{a}	0.8^{b}
% Fertilization	63^{d}	80^{c}	84^{b}	NA	96^{a}
% Hatchability	55^{d}	75^{c}	79^{b}	NA	90^{a}
GSI (%)	7.19^{c}	7.34^{c}	9.24^{b}	7.03^{d}	14.43^{a}
PGSI	0.077^{d}	3.76^{a}	1.108^{b}	1.076^{c}	0.001^{e}

Means with different superscripts are significantly different ($p<0.05$)

Conclusion

Base on the findings of this study it could be inferred that FESP is very rich in antioxidants which has influence on nutrient bioavailability, metabolism and other physiological process o but has no significant effect on weight gain and length. FESP increase fecundity, fertilization and hatchability in *C. gariepinus* broodstock. The best inclusion level was in the diet containing 2.0g/kg of FESP medicinal plant compared to control which had no FESP. This has proved that FESP medicinal Plant contain pro-fertility property and can effectively be exploited to increase both fecundity, egg quality for fish seed production.

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Growth performance of monosex cultured *Clarias gariepinus* Juveniles in concrete flow-through and stagnant water tanks.

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Abstract:
One hundred and forty-four *Clarias gariepinus* juveniles were stocked in eighteen concrete flow-through and stagnant water tanks. Stocking density was sixteen fishes per 2 by 2 metre square tank. *Clarias gariepinus* juveniles were fed with Coppens at 5% of their body weight till the end of experiment. Duration of experiment was fifty-six (56) days. Mixed sex *Clarias gariepinus* juveniles in flow-through tanks (CMXF) and Mixed sex *Clarias gariepinus* juveniles in stagnant tanks (CMXS) served as the control. The mean initial weight was taken as 1.23±0.00(g). The highest mean final weights was 4.84±0.07(g) for mixed sex *Clarias gariepinus* juveniles in flow-through tanks (CMXF) and mixed sex *Clarias gariepinus* juveniles in stagnant tanks (CMXS). Female *Clarias gariepinus* in flow-through tanks (CGFF) of monosex culture, showed highest SGR of 2.41±0.03(g). *Clarias gariepinus* females in flow-through tanks (CGFF), performed best among the monosex tanks with Performance Index value 6.27±0.15. Survival rate was 100±0.00% in female *Clarias gariepinus* flow-through tanks (CGFF), female *Clarias gariepinus* stagnant water tanks (CGFS) and mixed sex *Clarias gariepinus* in flow-through (CMXF) and stagnant tanks (CMXS).

Keywords: *Clarias gariepinus*, juveniles, monosex, mixed sex, flow-through, stagnant water.

Introduction

The African catfish *Clarias gariepinus* has grown in popularity globally, as a culture specie (Abdel-Hay, 2019). Farmed commercially or susbsistently. (Dauda *et al.,* 2018), *Clarias gariepinus'* ability to air-breathe makes it thrive in the temperate and tropical climates. Amongst its other abilities are hardiness, feeding on many natural prey, high fecundity, and tolerating poor water conditions (Abdel-Hay, 2019). Culturing fish of a single sex or monosex population is a most important tool to prevent unwanted reproduction in fish tanks, while ensuring the farmer can select and culture only faster growing sex of fishes (Robert *et al.,* 2019). Fishes reared in enclosures must be fed adequately for maximum yields, as good nutrition is important for fishes to grow well and grow fast to attract fish sellers, thereby yielding income for the fish farmers (Omoruwou and Edema, 2011).This study was undertaken to assess and compare growth performance of monosex cultured *Clarias gariepinus* in two culture systems. These research findings will add to previously documented studies by various authors, since effective fishery management entails documenting vital information about length, weight and growth of fish stocks under study (FAO, 2006).

Materials and methods

Study area, source of experimental fish and water source

The study was carried out using the outdoor concrete tanks of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger State. New Bussa is located at latitude 9°53′N and longitude 4°31′E coordinates (Wikipedia, 2016). Juveniles of *Clarias gariepinus* were obtained from the hatchery unit of NIFFR New Bussa. NIFFR's Kigera Dam supplied water for this research.

Experimental design

Experimental design was a 2X3X3 factorial design

Experimental procedure

Eighteen tanks measuring 2 m x 2 m=4 m ^{2} were used for this experiment. Three treatments were triplicated for both flow-through and stagnant water tanks totaling eighteen tanks. Stocking density was sixteen juvenile *Clarias gariepinus* fishes per 2 x 2 m^2 tanks. Through a mechanism involving a PVC pipe for the flow-through tanks, water was constantly flowing into the tanks via an inlet, while also flowing out via an outlet. The PVC pipe was installed at the length of 1.5inch diameter, proportional to the experimental water depth and fitted to each tank to enable excess water drain out. Water was left at ¾ depth in all of the flow-through tanks, flowing 24 hours of the day. The same flow-rate of water through the inlets was the same flow-rate of water via the outlets. There was bi-weekly manual exchange of water in the stagnant water tanks, every sampling day.

Growth parameters

Survival Rate (SR) = number of fish stocked – number of mortalities (Pauly,1980).

$$\% \text{ Survival} = \frac{\text{number of broodstock survivors at the end of study}}{\text{number of juveniles stocked at the beginning of the study}} \times 100$$
(Pauly,1980).

$$\text{Specific Growth Rate \% day (SGR)} = \frac{\log_n \text{final weight} - \log_n \text{initial weight}}{\text{Time (days)}} \times 100$$

(von Bertalanffy,1938).

FCR= Total weight of dry feed offered / Total weight gain (Wijkstrom, 1989).

$$\text{PI} = \frac{\text{Survival rate X Final mean weight (g)} - \text{Initial mean bodyweight (g)}}{\text{Rearing duration in days}}$$

(Munro and Pauly,1983).

Physico-chemical parameters

The water quality parameters which were measured, at stocking and at every two weeks till last sampling were: pH, DO, Water temperature, Conductivity.

Data analyses

Data collected during this experiment were subjected to statistical analysis using analysis of variance (ANOVA). T-test was used to compare growths in the flow-through and stagnant water tanks. Duncan Multiple Range Test (DMRT) was used for mean separation and the differences were determined at level of significance ($p < 0.05$) (Duncan, 1955). Data were also subjected to analysis for regression.

Results

Table 1: Length-Weight Relationship Regression of *Clarias gariepinus* cultured in flow-through and stagnant water tanks

Sex	Rearing Tanks: Flow-Through			Stagnant water		
	Intercept (a)	**Growth Pattern (b)**	**Coefficient of determination (R^2)**	**Intercept (a)**	**Growth Pattern (b)**	**Coefficient of determination (R^2)**
Clarias gariepinus						
♀	0.65	1.47	0.82	0.69	1.57	0.92
♂	0.91	1.85	0.80	0.58	1.38	0.86
♂+♀	0.94	1.89	0.89	0.79	1.79	0.89

♀= Female, ♂= Male, ♂+♀=Male and Female (control)

Table 2: Growth Performance of *Clarias gariepinus* cultured in flow-through and stagnant water tanks

Treatments	Growth Performance Indices: **MIW (g)**	**MFW (g)**	**MWG (g)**	**%WG**	**SGR (g/day)**	**FCR**	**FCE**	**PI**	**% Survival**
Clarias gariepinus									
CGFF	1.23±0.00	4.82±0.08^{a}	3.51±0.08^{a}	28.64±0.95^{a}	2.41±0.03^{a}	3.08±0.00	14.82±0.10^{a}	6.27±0.15^{a}	100.00±0.00^{a}
CGFS	1.23±0.00	4.20±0.08^{b}	2.98±0.05^{b}	24.42±0.73^{b}	2.20±0.02^{b}	3.08±0.00	14.74±0.13^{a}	4.42±0.24^{b}	83.33±5.51^{b}
CGMF	1.23±0.00	4.67±0.12^{a}	3.45±0.12^{a}	28.12±0.10^{a}	2.38±0.04^{a}	3.08±0.00	14.92±0.06^{a}	6.16±0.22^{a}	100.00±0.00^{a}
CMXF	1.23±0.00	4.84±0.07^{a}	3.61±0.06^{a}	29.45±0.67^{a}	2.45±0.02^{a}	3.08±0.00	14.15±0.17^{b}	6.45±0.11^{a}	100.00±0.00^{a}
CGMS	1.23±0.00	4.20±0.11^{b}	2.97±0.11^{b}	24.27±0.20^{b}	2.19±0.05^{b}	3.08±0.00	14.15±0.17^{b}	5.00±0.50^{b}	93.75±6.25^{ab}
CMXS	1.23±0.00	4.84±0.07^{a}	3.61±0.06^{a}	29.45±0.67^{a}	2.45±0.02^{a}	3.08±0.00	14.92±0.06^{a}	6.45±0.11^{a}	100.00±0.00^{a}
SEM	*0.00*	*0.23*	*0.28*	*0.31*	*0.21*	*0.00*	*0.26*	*0.19*	*0.20*

Means in the same column (for each section) with different superscript are statistically different ($p<0.05$).

Treatments: [1] CMXS and CMXF Treatment *Clarias gariepinus* Mixed sex Stagnant water and Flow-through (control), [2] CGMF Treatment *Clarias gariepinus* Male Flow-through and CGFF Treatment *Clarias gariepinus* Female Flow-through, [3] CGMS Treatment *Clarias gariepinus* Male Stagnant water and CGFS Treatment *Clarias gariepinus* Female Stagnant water. MIW=Mean Initial Weight, MFW=Mean Final Weight, MWG=Mean Weight Gain, WG=Weight Gain, SGR=Specific Weight Gain, FCR=Food Conversion Ratio, FCE=Feed Conversion Efficiency, PI= Performance Index, SEM=Standard Error of Mean.

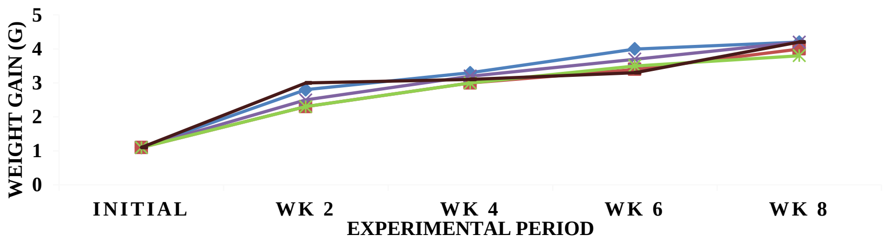

Figure 1: Growth patterns of *Clarias gariepinus* females, males and mixed sex cultured in flow-through and stagnant water tanks.

Table 3 Mean Morphometric Measurements and Condition Factor of *Clarias gariepinus* cultured in flow- through and stagnant water tanks

Specie/Sex	Morphometric Measurement and Condition Factor			
	Total Length (cm)	**Standard Length (cm)**	**Weight (g)**	**Condition Factor (K)**
Clarias gariepinus				
♀	6.18±0.23	5.38±0.23	2.83±0.18	2.01±0.15
♂	6.37±0.24	5.57±0.24	2.97±0.20	1.87±0.13
♂+♀	6.09±0.30	5.29±0.30	2.98±0.30	2.09±0.19

♀= Female, ♂= Male, ♂+♀=Male and Female (control)

Table 4 Water Quality Parameters of the cultured *Clarias gariepinus* in flow-through and stagnant water tanks

Species/Treatments/ Sex	Water Quality Variables			
	Temp (ºC)	**pH**	**DO (mg/L)**	**Conductivity (µS/cm)**
Clarias gariepinus				
CMXF	31.36±0.14[a]	8.20±0.12[a]	8.48±0.21[a]	236.00±14.70[c]
CGFF	30.64±0.13[c]	7.18±0.04[c]	4.40±1.28[c]	340.00±6.32[b]
CGFS	31.06±0.11[ab]	7.34±0.18[c]	5.80±0.67[bc]	328.00±37.20[b]
CMXS	31.06±0.11[ab]	7.74±0.22[b]	7.96±0.34[a]	208.00±13.60[c]
CGMF	30.68±0.13[bc]	7.24±0.02[c]	8.76±0.36[a]	322.00±17.20[b]
CGMS	30.54±0.19[c]	7.18±0.08[c]	7.12±0.60[ab]	436.00±16.00[a]
SEM	*0.32*	*0.46*	*0.34*	*0.79*

Means in the same column (for each section) with different superscript are statistically different (p<0.05).

Treatments:
[1] CMXS and CMXF Treatment *Clarias gariepinus* Mixed sex Stagnant water and Flow-through (control),
[2] CGMF Treatment *Clarias gariepinus* Male Flow-through and CGFF Treatment *Clarias gariepinus* Female Flow-through,
[3] CGMS Treatment *Clarias gariepinus* Male Stagnant water and CGFS Treatment *Clarias gariepinus* Female Stagnant water.

Discussion
There was no significant difference (p>0.05) in mean initial weights (MIW) and mean final weights (MFW), for *Clarias gariepinus* in monosex and mixed sex culture throughout the treatments. Performance Index (PI) values indicated no significant difference (p>0.05), in mixed sex and monosex culture of *Clarias gariepinus* species, throughout the treatments at the end of fifty-six (56) days. The b-values in this study indicated *Clarias gariepinus* grew negatively allometric with values less than 3, in agreement with Anyanwu *et al.*, (2007) who reported b-values of 2.84, 1.27 and 1.88 for females, males and mixed sex of *Clarias gariepinus* in a recirculating system. Growth patterns indicated fast growth in the first two weeks of the study. The female monosex flow-through tanks

showed progressive growth from week two, dipping slightly in week four then continuing steadily till week eight. The stagnant water tanks in monosex culture and the mixed sex culture progressed steadily from stocking till week eight. Condition factor in this study showed *Clarias gariepinus* were in a good condition of health (Anwa-Udondiah and Pepple, 2011). This result agreed with Chandra and Jhan (2010) who recorded condition factor for *Channa punctata* in the range of 1.05-1.89.

Conclusion

Growth per day was highest in the monosex female *Clarias gariepinus* flow-through tanks, closely followed by themixed sex *Clarias gariepinus* tanks. Growth per day was lowest in the monosex male stagnant water tanks of the *Clarias gariepinus.* The highest percentage survival from the study was seen, in the monosex female *Clarias gariepinus* flow-through tanks; followed by the mixed sex tanks holding same specie. Performance Index values were similar for monosex and mixed sex culture of *Clarias gariepinus*. The monosex female flow-through tanks for the cultured *Clarias gariepinus*, performed best among the monosex treatments. Condition factor for the cultured *Clarias gariepinus* in flow-through and stagnant water concrete systems showed values of more than 1. Water quality parameters were at normal ranges throughout the study.

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The Role of Aquaculture in Enhancing Nutrition and Food Security in the World

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Abstract
Food security is one of the major approaches to develop socioeconomic status of the populace in any country in the world, so as to defeat malnutrition, which is ravaging the world. In different parts of the world, especially in the developing and under developed countries, many people are still facing the problem of hunger. Hence, the human nutrition deficiencies focus on the importance of animal protein in their regular diet. To overcome this problem, many families across the world are now consuming fish as their major source of protein. Fish in most areas are available, highly nutritious and cheapest protein sources, which serves as a valuable supplement in most family diets by providing essential vitamins, proteins, micronutrients, and minerals, for the poor people living in the rural areas. Aquaculture is playing a vital role in the developing countries in national economic development, and global food supply. Food and agricultural organization (FAO) declared that aquaculture has the sustainable capacity to create a developmental goal for the country economy and enhance human welfare in both urban and rural communities.

Keywords: Aquaculture, fish, food, nutrition, protein

Introduction

Aquaculture is the rearing of fish, and other aquatic organisms for consumption. Fish provides more than 4.5 billion people with at least 15% of their average per capita intake of animal protein. Fish is an excellent nutrition, providing essential amino acids, essential fatty acids, vitamins and minerals in an easily accessible form. Fish's unique nutritional properties make it essential to the health of billions of consumers in both developed and developing countries. Fish are very efficient converters of feed into high quality protein – in fact far more efficient than most terrestrial livestock system in growth performance (FAO, 2005). Through fish-related activities (capture, processing and trading), fish contribute substantially to the income and therefore to the food security of more than 10% of the world population, essentially in developing and emergent countries (Gachucha *et al*., 2014). Yet, limited attention has been given so far to fish as a key element in food security and nutrition strategies at national level and in wider development discussions and interventions. As a result, the tremendous potential for improving food security and nutrition embodied in the strengthening of the fishery and aquaculture sectors is missed. Global demand for fish is growing due to a combination of population growth, urbanization and increasing wealth. However, the ocean fisheries cannot increase yields without destroying the fish stocks on which they depend. The inevitable conclusion is that aquaculture must fulfill its potential as a means of supplying fish for consumers and fill the growing gap between supply and demand. It is the only option we have to meet the growing demand for seafood while maintaining wild fishery harvests at sustainable levels.

Food security can be described as secure access to enough food at all times for everyone (Food and Agriculture Organization (FAO, 2005). A person needs adequate health, good environment, and food for their survival, which is therefore closely linked to the economic and social health of a nation, society, and individual. The community-level food security is an essential matter to grow up the nation economically. Developing countries often lacking the resource, with the growing population, require adequate amount of food supply demands for food security and safety. Food security concerns are of utmost importance to developing countries in different parts of the world, where a large percentage of its population are poor and a large amount of total household expenditure is devoted to food (Gachucha *et al.*, 2014). The aquaculture sector has an important role to play as a high proportion of rural dwellers population around the globe depends heavily on this sector for its livelihood and income (FAO, 2005). The objective of this article is to review how an aquaculture sector plays a key role in food security at the household and national levels.

The challenge of feeding the world

Food is one of humanity's top ten problems for the next 30 years. The trends of global demographics show us that the world population is growing and will continue to grow. It is around 7.2 billion today and by 2050, it will reach 9.8 billion: 2.6 billion more mouths to feed. About 90% of this growth will be in Asia and Africa. Life expectancy at birth is projected to rise from 68 years today to 76 years in 2050. Nigeria is projected to be the world's third most populous country by the year 2050, according to a 2017 report by the UN Department of Economics and Social Affairs. The report said "by 2050, the third most populous country will be Nigeria, which currently ranks seventh, and which is poised to replace the United States after China and India. (FAO, 2005)Today, half of all people worldwide live in cities. About the same percentage is poor, living on less than US $2 a day. In 2050, urbanization would have increased to 70% of the world population, making more people dependent on fewer farmers for their food. At the same time, per capita incomes are projected to be a multiple of today's. Food follows the flow of mouths and money. Rising incomes would lead to a shift in dietary patterns, as these new consumers would choose to eat more protein-rich meals with meat and fish (Kalirajan, 1990).

Feeding more than 9 billion wealthier and longer-living mouths in 2050 would require raising overall food production by at least 70%. Therefore, to overcome the challenge of feeding the world in 2050, more food would have to be produced over the next decades than has been produced during the past 10,000 years combined. About 36 million people die every year due to hunger (Gasperini and Maguire, 2001). Protein deficiency is one of the major nutritional problems in the developing world (Latharn, 1997). There is an estimated one billion people suffering from protein deficiency and malnutrition. Therefore, new methods of feeding the underfed world population, especially in the less developed countries, have to be developed. Those methods that will guarantee a continuous protein supply require most serious attention since most malnutrition cases have been found to be a result of protein insufficiency (Gachucha *et al*., 2014).

Aquaculture role in Food Security

Aquaculture plays a significant role in the world food economy. Fisheries related activities are sources of employment for about 200 million people who depend directly on it for their livelihoods (Kudi *et al.*, 2008). Fish consumption is the primary source of protein for some 950 million people worldwide and represents an important part of the diet of many more especially poor segment of the society (Bhatia and Green, 2008). Globally, fish provides about 16% of the animal protein consumed by humans and are a valuable source of minerals and essential fatty acids. Fish is the primary source of omega-3 fatty acids in the human diet.Omega-3 fatty acids are critical nutrients for normal brain and eye development of infants, and have preventative roles in a number of human illnesses, such as cardiovascular disease, depression, and other mental illnesses (Belton and Thilsted, 2014). Fish production is also playing an important role on food security through its contribution to overall food supplies for the general population. Another impact that must be eminent is aquaculture's participation in the food security of the poor, those most susceptible to malnutrition. However, the major impact of aquaculture on world food supplies is conveyed in the aggregate tonnage figures increased from the year 2016 to 2018 (FAO, 2018). Fish provide the main source of animal protein to about 1 billion people globally. Food security does not just concern food production. It can be defined as the physical and economic access to sufficient, safe, and nutritious food to meet dietary needs (Gasperini and Maguire, 2001). Fisheries are an important part of food security, particularly for many poor people in developing countries. In low-income food deficient countries, they make up 22% of animal protein consumption overall. In coastal areas and around major river systems, the dependence on fish is usually higher (Kawarazuka and Bene, 2010).

Conclusion

Global demand for fish is growing due to a combination of population growth, urbanization and increasing wealth (Beveridge *et al*., 2013). A key factor driving up the demand for fish is the spreading recognition of fish as excellent nutrition, providing highly digestible proteins, essential fatty acids, vitamins and minerals in an easily accessible form. On the supply side, however, the traditional source of fish from the wild catch cannot be increased above today's levels or we will deplete stocks. In fact, we may need to reduce the catch further to be sustainable. Therefore, aquaculture must fulfill its potential as a means of supplying fish for consumers and fill the growing gap between supply and demand. In addition, it must do so in a sustainable way, with sustainable feed raw materials and minimal environmental impact, and it must be recognized and accepted as a valid provider of excellent food.

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FISH DISEASES

Gills and intestinal parasites of elephant snout fish *Mormyrus rume* (Valenciennes, 1847) at Uke River, Karu Local Government Area, Nassarawa State, Nigeria.

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Abstract

Both wild and farm fish are potential host of various parasitic species that cause grater mortalities. The normal growth of fish is affected by the parasites that lives on the fish if highly infested. *Mormyrus rume* are increasingly becoming important in the aquarium business and aquaculture, thus the need arises for a better knowledge about the nature and control of parasites affecting them. A total of one hundred and ten (110) samples of different sizes of *Mormyrus rume* were collected at different dates at Uke River, Karu Local Government Area of Nasarawa State between July and September, 2019 from local fishermen. The fish were transported in a cooler containing ice to the Zoology Laboratory of Nasarawa State University, Keffi for gills and intestinal parasites examination. Forty-two (42) were found to be infected with parasites and the total number of parasites recovered were sixty-nine (69). Parasites isolated were *Eimeria spp*, *Procamallamus spp*, *Dactylogyrus spp*, *D. latum* and *B. claviceps*. Apart from Eimeria spp that was recovered from gills, the rest parasites were recoverd from the instestine. The highest number (50) of parasites species isolated was *Procamallamus spp*, followed by *Dactylogyrus spp* (9) while *Eimeria spp* and *B. claviceps* parasites isolated were four (4) each and the lowest number (2) of parasites isolated was *D. latum*.

Keywords: Gills, intestinal, parasites, *Mormyrus rume* and Uke River

Introduction

Fishes form a highly successful group of animals comprising of more than 40,000 species inhabiting all the seas, rivers, lakes, dams, muddy waters, brackish waters, estuaries and all places where there is water . Fish serve as a good source of animal protein for man and his livestock. A break down showed, fish accounts for more than forty percent of the protein diet of two– third of the global population (Eyo (1992) and FAO (1999) reported wild and farm fish as potential host to various parasitic species that cause greater mortalities. It has been reported that at least one parasite is hosted by approximately 50 to 90% of freshwater fishes (Eissa *et al.,* 2012). Losses resulting from these parasites are at high densities under existing conditions and, if left uncontrolled, may lead to catastrophic proportions (Abbas *et al.,* 2014). The normal growth of fish is affected by parasites that lives on the fish if highly infested. Parasites not only effect the survival of fish directly by reduced condition (fish size), changing the behavior, further susceptible to infection, but also lowered swimming ability, decrease their growth rate and increase mortalities (Piasecki, 2004). Disease is an important factor militating against fish production. Many diseases are closely linked to environmental deterioration and stress, once the environment is disturbed, the organisms under such culture systems are stressed (SEAFDEC, 1999). Fish parasites result in economic losses not only mortality but also from treatment expenses, growth reduction during outbreak of diseases and this militates against expansion of aquaculture.

Mormyrus are increasingly becoming important in the world's aquarium business and in aquaculture; thus the need arises for a better knowledge about the nature and control of parasites infecting them.

Materials And Methods

Study Area

This study was carried out in Uke, Karu Local Government Area of Nasarawa State. It is located in the North central of Nigeria with an area of 2,640km^2 and population density of 110.6km^2. It is about 26km South East of Abuja, the countries capital with Lat. 8.92^{o}N and Long. 7.7^{o}E.

Fish sampling

A total of hundred and ten (110) samples of different sizes of *Mormyrus rume* were collected at different dates at Uke River, Karu Local Government Area of Nasarawa State between July- September, 2019 from the local fishermen by the river bank and were transported in coolers containing ice blocks (to reduce bio-autopsy) to the Zoology laboratory of Nasarawa State University Keffi for analysis.

Identification and Measurement of Fish Samples

The fish were identified using Olaosebikan and Raji (2004) and Holden and Reed (1972). The total lengths, standard lengths and body weights were measured using standard methods described by Olatunde (1977). Colored pictures were used in identifying the species of *Mormyrus rume*. The total (TL) and standard length (SL) of each fish were measured in centimeters (cm) using meter rule, while weight was taken in grams using an electronic meter balance and triple beam balance. The sexes were determined by internal examination, with eggs in female and milt sac in male.

Parasites Examination

Examination of Gills for Parasites

Specimens were categorized as Juveniles, sub adults and adults according to Ugwuzor 1987Aken'Ova (1999) . The heads of fish were cut – open with scissors and gills were exposed and placed in different Petri dishes and were observed with hand lens and dissecting microscope for parasites. 4mls of saline solution was added to a cyst removed from gill arch and filament, and were pressed on a slide and cover with a cover slip for observation on light microscope. The collected parasites were conserved in 10% formalin. For identification of monogeneans, specimens were stained with Gomori's tichome and mounted in slides with Canada balsam, or directly mounted in Hoyer's medium. Digeneans were stained in acetic casmine and nematodes were clarified in Amman's Lactophenol, and mounted in permanent slides with Canada balsam. Copepods were mounted in slides with Hoyer's medium and isopods were observed immersed in 70% ethanol in petri dishes under the stereomicroscope.

Examination of Gut for Endoparasites

Fishes were dissected to expose the alimentary canal using the techniques of Omeji *et al.* (2015). The alimentary canal was removed and sectioned into various parts; oesophagus and stomach, intestine and rectum. The gut was used for parasitic examination because this is where food is most abundant for parasites. Parasites were identified to species level using the keys to describe by Paperna (1996). The parasites identified were counted and recorded.

Data Analysis

Descriptive statistics was used to determine prevalence of intestinal and gills parasites

Prevalence was calculated as:

$$\text{Prevalence} = \frac{\text{Number of hosts infected}}{\text{Total number of hosts examined}} \times 100$$

Result

One hundred and ten (110) fish sample were examined for gill and intestinal parasite. 42(38.2%) fish sample were found to be infected with parasites while 68(61.8%) were not infected. Parasites isolated from the fish samples were from Protozoa, nematode, Trematode and Cestode taxonomic group. Protozoa was represented by *Eimeria spp*, Nematode parasites were *Procamallanus spp*, Trematode were represented by *Dactylogyrus spp.*, while Cestode parasites were represented by *Diphyllobothrium latum and Bothriocephalus claviceps.*

The prevalence and intensity of parasites infestation of *Mormyrus rume* in relation to sex is shown in Table 1. Forty seven (47) male fish and sixty-three (63) female were examined for the gill and intestinal parasites. Fifteen (15) male representing 31.9% of male were infected and twenty-seven (27) female representing 47% of female were infected with the parasites. Total numbers of parasites isolated were sixty-nine (69) with twenty-two (22) parasites isolated from male and forty-seven (47) parasites isolated from the female fish. The frequency and distribution of gill and intestinal parasites of *Mormyrus rume* is presented in Table 2. Four (4) *Eimeria spp* parasites were isolated from two (2) fish all from gills with the percentage incidence of 4.8%. Fifty (50) *Procamallamus spp* parasites were recovered from thirty-three (33) fish from the intestinal tract with percentage incidence of 78.5%. *Dactylogyrus spp* isolated were nine (9) from two (2) fish in the intestine with incidence of 4.8%. Two (2) *Diphyllobothrium latum* were isolated from two (2) fish in the intestine with 4-8% incidence while four (4) *Bothriocephalus claviceps* parasites were recovered from three (3) fish in the intestine with incidence of 7.1%.

Table 3 shows the prevalence and intensity of parasites infection in relation to body weight of the *Mormyrus rume.* The highest number (15) of parasites recovered were from the fish with the body weight range of 1 – 50g followed by the fish with body weight range of 301 – 350g with twelve (12) parasites recovered. The least number (2) of parasites isolated were from the fish with the body weight range of 351 – 400g. The fish with the body weight range of 251 -300g and 501 -550g were found not to be infected with parasites. The prevalence and intensity of parasites infestation in relation to standard length of *Mormyrus rume* is shown in Table 4. The highest number (20) of parasites were isolated from fish with standard length range of 5 – 10cm from fourteen (14) fish followed by the fish with standard length range of 21 – 25cm with seventeen (17) parasites from eight (8) fish, while the least number (3) of parasites were recovered from fish with standard length range of 31 – 35cm from two (2) fish.

Table 1: Prevalence and intensity of infection of gills and intestinal parasites on *Mormyrus rume* in relation to sex at Uke River.

Sex	No. examined	No. infected	No. of parasites Recovered	Incidence (%)
Male	47	15	22	35.7
Female	63	27	47	64.3
Total	110	42	69	100

Table 2: Frequency and distribution of gills and intestinal parasites of *Mormyrus rume* at Uke river.

Parasite species	Taxonomic group	Total No. of parasites recovered	No. of infected	location of parasites	Incidence (%)
Eimeria Spp.	Protozoa	4	2	gill	4.8
Procamallanus Spp.	Nematoda	50	33	intestine	78.5
Dactylogyrus Spp.	Trematoda	9	2	intestine	4.8
D. latum	Cestoda	2	2	intestine	4.8
B. claviceps	Cestoda	4	3	intestine	7.1
Total		69	42		100

Table 3: prevalence and intensity of parasites infestation on *Mormyrus rume* in relation to body weight of the fish at Uke River.

Weight (g) d	No. examined	No. infected parasites recovered	Total No. of	Rate of infection (%)
1-50	15	9	15	21.4
51-100	17	5	9	12.0
101-150	8	3	3	37.57.1
151-200	13	6	10	53.314.3
201-250	20	4	8	25.009.5
251-300	4	0	0	0.00.0
301-350	13	7	12	53.816.7
351-400	5	1	2	20.02.4
401-450	5	4	5	80.09.5
451-500	8	3	5	37.57.1
501-550	2	0	0	0.0
Total	110	42	69	100

Table 4: Prevalence and intensity of parasites infestation on *Mormyrus rume* in relation to standard length of the fish at Uke River.

Standard Length(cm)	No. examined	No. infected	Total no. of parasites load	Rate of infection (%)
5-10	27	14	20	51.0
11-15	12	3	5	25.0
16-20	15	9	15	60.0
21-25	26	8	17	33.3
26-30	21	6	9	28.6
31-35	9	2	3	22.2
Total	110	42	69	62.73

Discussion

This study shows a high prevalence of 38.0% recorded for this fish (*M. rume*) parasite which is relatively higher than the 22.33% recorded in the lower and upper Benue River Nigeria (Uruku *et al*., 2017). It is how ever lower when compared with 48.63% previously recorded in same region (Omeji *et al*., 2015). The variation in rate of parasitism could also be attributed to abiotic and biotic conditions of the environment where this study was carried out (Eyo *et al*., 2013).

Different parasites belonging to different taxonomic groups, namely Protozoa (*Eimeria variabilis*), Cestodes (*Bothriocephalus claviceps* and *D. latum*), nematodes (*Procamallanus spp.)*, and monogenetic Trematodes (Dactylogyrus sp.) were observed and identified to be present in different locations of the fish studied (Mormyrus rume). Number of nematodes isolated was higher than cestodes, trematode and protozoas. Nematodes are known to occur in body cavities or found penetrating subcutaneous tissue, these findings agrees with that of Akinsanya *et al.* (2007).

The recovery of these parasites from different locations (gill and intestine) in this investigation is not surprising as they have been recorded in other species (Paperna, 1996; Omeji *et al*., 2014). However, it was observed in this study that the intestine had more parasites than the gills, this could be attributed to the presence of digested food. It is associated with the fact that digestion activity takes place in the intestine resulting in the release of parasite ova/cysts in food particles. Few parasites were found on the gills which could be as a result of the continuous movement of water current over the gills which may not encourage establishment and survival of parasites there. Marcogliese (2002) reported that most parasites inhabit the intestine due to their general feeding habits. This also agrees with Omeji *et al*. (2011).

There was a significant difference ($p<0.05$) in prevalence between male and female M. rume, the prevalence recorded on the female fish could be due to the physiological state of the females as most gravid females could have had reduced resistance to infestation by parasites. In addition, their increased rate of food intake to meet there food requirements for development of their eggs might have exposed them to more contact with the parasites which subsequently increased their chances of being infested. This observation agrees with Emere and Egbe (2006) and Omeji *et al*.(2015).

The highest rate of parasite infection is obtained in the bigger fish with weight of (401-450g), (1-50g), and 151-200g. Mohammed (1999) reported that prevalence was found to increase as the fish grew, and that could be attributed to the longer time of exposure to the environment by the body size. The difference in the parasite load could be attributed to the random selection of the specimen, this agrees with the findings of Olorin and Somorin (2006)and Akinsanya *et al* . (2008). The similar observation had been made by Ekanem *et al*. (2011) and Omeji *et al.* (2014).

The length classes within the range of 5-20cm recorded the highest prevalence of parasitic infection, this might be attributed to low immunity in smaller sized fish and also random selection.

The effects of parasites on fish host in the wild may be difficult to isolate and quantify. However, studies of fish in captivity or under culture conditions have provided much information about the effects of parasites on the fish survival. It is evident that parasites can act as severe pathogens causing direct mortality or rendering the fish more vulnerable to predators. It is recommended that this study should be continued and widened for greater number of fish species as are found in many Nigerian diets.

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Sensitivity of Bacteria Isolated from Smoked *Clarias gariepinus* Treated with Scent leaf (*Ocimum gratissimum*) Juice

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Abstract
Bacteria growth and activity are the major cause of changes in fish freshness which results in unattractive change in food characteristics such as flavours and odours. This paper evaluates the sensitivity of bacteria isolated from smoked *Clarias gariepinus* to different concentrations of scent leaf (*Ocimum gratissimum*) juice and commercial antibiotics. The bacteria isolated from the samples were *Staphylococcus aureus, Bacillus subtillis, Escherichia coli, Enterobacter* species and *Klebsiella* species. *B.subtillis* was the most abundant (90.0%) in the fish samples throughout the five weeks of storage while *Enterobacter* species was the least (1.0%) occurring bacteria. Sensitivity results revealed that *B. subtillis* was resistant to aqueous and ethanoic extract of *O.gratissimum* with inhibition zone of 8mm and 11mm respectively while *Klebsiella* species was intermediate to ethanoic extract with inhibition zone of 14mm. Both organisms were susceptible to Ciprofloxacin (Commercial antibiotics). It was noticed that aqueous extract of *O. gratissimum* had total inhibitory effect on bacteria isolates. The result from this study showed low microbial count which was within the range for smoked fish.

Keywords: Quality, bacteria, scent leaf, *Clarias gariepinus*

Introduction

Fish is one of the protein foods that need careful handling (Eyo, 2002). This is because fish spoils easily after capture due to the high tropical temperature which accelerates the activities of bacteria, enzymes and chemical oxidation of fat in the fish. Fish preservation and processing slowdown or prevents enzymatic, bacterial, and chemical deterioration and maintain the fish flesh in a condition as near as possible to that of fresh fish (Bate and Bendall, 2010).

Ocimum gratissimum, popularly referred to as scent leaf because of its aroma, is commonly used as spices for food or soup preparation in Nigeria (Akinjogunla *et. al*., 2009). It is a medicinal plant which has been used traditionally for the treatment of various infections (Abdullahi, 2012).

Ocimum gratissimum is used throughout West Africa as antimalarial and anti-convulsant. The crushed leaf juice is used in the treatment of convulsion, stomach pain and catarrh. Oil from the leaves has been found to possess antiseptics, antibacterial and antifungal activities (Edeoga and Eriata, 2001). *O. gratissimum* has been reported earlier with in vitro activity against some bacteria and dermatophytes. In vitro activity of the ethanolic crude extract, ethyl acetate, hexane, chloroform fractions, essential oil, and eugenol of *O .gratissimum* was studied using an agar dilution susceptibility method towards 25 isolates of *Cryptococcus neoformans*.

Materials and Methods

18kg sub-adult *Clarias gariepinus* of 250g average weight and Scent leaf (*Ocimum gratissimum*) were obtained from the Department of Fisheries Technology Fish Farm. 5.6kg of scent leaf was plucked from the tree, washed with clean water and air dried. Juice was obtained by grinding the leaf with a meat grinder, after grinding, the juice was pressed through a fine cloth, collected in clean bowl and the shaft was discarded. The volume of juice extracted was 2000ml. The juice was kept in ice box prior to use to prevent or reduce rate of chemical reactions. The fish were killed, gutted, washed with clean water and allowed to drain. Subsequently, they were divided into six equal parts to be treated with scent leaf juice. Five parts were soaked in 0.2%, 0.4%, 0.6%, 0.8% and 1.0% v/v scent leaf solution for 5minutes respectively and the control was soaked in 1.0% v/v brine solution. The fish were drained and smoked using NIOMR smoking kiln for 10-15 hours at a temperature ranging from 75-85^{0}C. After smoking, fish were allowed to cool, packed in polythene bags and stored in carton box prior to analysis. This was done to mimic commercial practices. The samples were drawn weekly from control and treated samples for five (5) weeks. Smoked fish samples were analysed for Total Bacterial Count (TBC) on Nutrient Agar, Isolation of Microorganisms from the stock culture and Sensitivity of bacteria to scent leaf extract and commercial antibioticsas described by (Kirby 2003).

Results

The microbial load of bacteria isolated from smoked fish samples treated with solution of *O. gratissimum* juice is presented in Table 1. The total bacteria count ranged from 0.0×10^6CFU/g to 18.0 x 10^6CFU/g for the treated samples. The result showed that smoking and treatment with solution of *O. gratissimum* juice drastically reduced microbial load on the fish samples. Table 2 revealed the occurrence of bacteria isolates in the fish sample with the control smoked sample harbouring all the bacteria isolates. *Staphylococcus aureus, Bacillus subtillis, Esherichia coli Enterobacter* species and *Klebsiella* species. *B. subtillis* was the most abundant (90.0%) in the fish samples throughout the five weeks of storage while *Enterobacter* specieswas the least (1.0%) occurring bacteria through the five weeks of storage. Table 3 revealed antibacterial activities of *O. gratissimum* against bacteria isolated from fish samples. It showed that *B. subtillis* was resistant to aqueous and ethanoic extract of *O. gratissimum* (8mm and 11mm inhibition zone) while *Klebsiella* species was intermediate (14mm inhibition zone) to ethanoic extract. Both organisms were susceptible to Ciprofloxacin (Commercial antibiotics).Table 4 showed minimum inhibitory concentrations (MIC) of *O. gratissimum* against bacteria isolates. The result revealed that 25% and 50% of *Klebsiella* speciesand *B. subtillis* was inhibited by ethanoic extract of *O. gratissimum* respectively. Aqueous extract of *O.gratissimum* inhibited 50% and 100% of *Klebsiella* species and *B. subtillis* respectively. Table 5 showed minimum bactericidal concentration of (MBC) of *O. gratissimum* against bacteria isolates. The result revealed that ethanoic and aqueous extracts of *O. gratissimum* have total inhibitory effects on *B. subtillis.*

Table 1: Average bacteria count of fish samples during storage at ambient temperature

Treatment	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5
			TBC× 10^6cfu/g			
Fresh fish	56.0	ND	ND	ND	ND	ND
Control	18.0	15.0	11.0	12.0	9.0	6.0
T1	13.0	12.0	10.0	7.0	3.0	2.0
T2	15.0	11.0	8.0	5.0	2.0	1.0
T3	10.0	9.0	7.0	3.0	0.0	0.0
T4	5.0	4.0	6.0	4.0	0.0	0.0
T5	2.0	3.0	2.0	2.0	0.0	0.0

TBC = Total bacteria count cfu = Colony forming unit ND = Not Determined

Table 2: Occurrence of bacteria in smoked cured fish sample

Treatment	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5
Fresh fish	*B. subtillis* *S. aureus* *Klebsiella sp.* *Escherichia coli*	ND	ND	ND	ND	ND
Control	*B. subtillis*	*B. subtillis* *Escherichia coli* *S. aureus*	*Escherichia coli,* *S. aureus*	*B. subtillis* *Klebsiella sp*	*B. subtillis*	*B. subtillis* *Klebsiella sp*
T1	*B. subtillis* *Enterobacter species*	*B. subtillis* *Klebsiella sp.*	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis* *Klebsiella sp*
T2	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis*
T3	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis*	Nil	Nil
T4	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis*	Nil	Nil
T5	*B. subtillis*	*B. subtillis*	*B. subtillis*	*B. subtillis*	Nil	Nil

ND- Not Determined

Table 3: Antibacterial Activities of *O. gratissimum* against bacteria isolated from fish samples

Organisms	Ethanoic Extract of *O. gratissimum*	Aqueous Extract of *O. gratissimum*	CPX
	Zone diameter (mm)/Extracts		
Klebsiella species	14	10	27
Bacillus subtilis	11	8	25

CPX: Ciprofloxacin (10µg/ml)(Control)
Resistance = 0 – 12
Intermediate = 13 – 18
Susceptible = 19 – above (CLSI, 2012).

Table 4: Minimum Inhibitory Concentration (MIC) of *O. gratissimum* against bacteria isolated

Organisms	Ethanoic Extract of *O. gratissimum*	Aqueous Extract of *O. gratissimum*	CPX
	MIC (%)/Extracts		
Klebsiella species	25	50	6.25
Bacillus subtilis	50	100	6.25

Table 5: Minimum Bactericidal Concentration (MBC) of *O.gratissimum* against bacteria isolated

Organisms	Ethanoic Extract of *O. gratissimum*	Aqueous Extract of *O. gratissimum*	CPX
	MBC (%)/Extracts		
Klebsiella species	50	100	12.5
Bacillus subtilis	100	100	12.5

Discussion

Total bacteria count (TBC) is one of the key indicators in the field of hygiene management. It indicates how many microorganisms present in a sample. The TBC values obtained in this study decreased with storage time and treatment with *O.gratissimum* juice. Samples treated with 0.6%, 0.8% and 1.0% solution of *O. gratissimum* juice recorded the low TBC values (10.0, 5.0 and 2.0 x 10^6 CFU/g) compared to Control, T1 and T2 (18.0, 13.0 and 15.0 x 10^6 CFU/g) respectively. The values obtained in T3, T4 and T5 were within the recommended values of 5 x 10^5 CFU/g and 10^7 CFU/g (ICMSF, 1986). Adeosun (2016) reported a value of 4 x 10^2 CFU/g for smoked *Clarias gariepinus* stored at ambient temperature for 24 weeks. Ehizibolo *et al.* (2007) reported a 44.6% prevalence rate for *Staphylococcus aureus* in smoked catfish and tilapia sold in Jos, Nigeria. Since lower values of TBC were recorded in T3, T4 and T5, it showed that *O. gratissimum* juice has bactericidal properties and can be used in preservation of fish which may not have adverse effect on public health.

The antimicrobial activity exhibited by plant against bacteria has been reported by many researchers (Mostafa *et. al.*, 2018; Akinpelu *et. al.*, 2015). Gupta *et. al.*, (2010) studied antibacterial activity of five ethanolic and aqueous plant extract against *S. aureus, Pseudomonas aeruginosa* and *B. subtilis* and their results showed that the ethanolic extracts of four plants (*Achyranthes aspera*, *Cynodon dacynodon*, *Lantanacamara* and *Tagetes patula*) were effective against all tested microorganisms with minimum inhibitory concentration (MIC) ranging from 25 to 125mg/ml. In this study, sensitivity of bacteria isolates to ethanoic and aqueous extracts of scent leaf juice revealed that the bacteria were susceptible at 25% and 50% respectively for *Klebsiella* species and 50% and 100% respectively for *Bacillus subtilis* for minimum inhibitory concentration. While values of 50% and 100% respectively were recorded for K*lebsiella* species and 100% total inhibition was recorded for *Bacillus subtilis* for minimum bactericidal concentration. The antibacterial activities of *O. gratissimum* against bacterial isolated from fish samples revealed that *B. subtilis* was resistant to ethanoic and aqueous extracts at 11mm and 8mm inhibitory zone respectively. *Klebsiella* speices was resistant to aqeous extract (10mm) and intermediate to ethanoic extract (14mm). The use of antimicrobial agents in aquaculture and then the possibility of antibiotic resistance among the bacteria flora from fish have been identified (Midtvedt and Lingass, 1992).

Conclusion

The *Ocimum gratissimum* juice has bactericidal properties, bacteria isolates were susceptible to the minimum inhibitory concentration and minimum bactericidal concentration of aqueous and ethanol extract of scent leaf juice.

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Microbial Composition of Effluent and Fish Samples from Selected Water Bodies and Farms in Lagos State, Nigeria

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Abstract
This study was undertaken to assess the extent of pollution in some water bodies by assessing the microbial composition of water, sediment, and fish from selected water bodies around Lagos State, Nigeria. Water, sediment, and fish samples were collected from eight sites within Lagos states to assess the level of pollution. The samples were analysed for total heterotrophic bacteria, Vibrio, Salmonella and Shigella, Staphylococcus, coliforms and *E.coli* to assess the level of pollution of these water bodies. The Total Heterotrophic Count (THC) of the water and sediment samples ranged between 6.0 x 10^1- 1.8 x 10^5cfu/ml for water and between 1.3 x 10^5 and 25.0 x 10^5cfu/ml for sediment, while that of fish was between 10.8x 10^4 and 25.0x 10^6cfu/ml. The total coliform count was between 20 - >1800/ 100ml. *E.coli* and Vibrio were present in all the samples. Lower bacteria counts were recorded in places with relatively low human activities while higher counts were obtained in places with relatively high human activities and fish farming. This has shown the negative effects of anthropogenic activities on our water bodies.

Keywords: Water, Lagoon, bacteria, pollution

Introduction

Water occurs naturally on the surface of the earth. It is of utmost importance to all living things (i.e. plant, animal, and man) (Ajewole, 2005) and it is one of the major habitats of bacteria and source of bacterial contamination (Zhang *et al*., 2009). Lagos is a metropolitan city, and it is confronted with a lot of environmental issues because of the large population. It harbours the Lagos, Epe, Lekki and Badagry Lagoons. The metropolitan nature of Lagos attracts a lot of human activities such as washing, fishing, aquaculture, mining, transportation *etc*. which occurs along the lagoons, thereby rendering most of the lagoons polluted as a result of the influx of wastes from these domestic and industrial activities. Okoye *et al.* (2010), reported that the Lagos lagoon receives effluents of domestic sewage, industrial wastes, wood wastes, fumes from automobiles, petro-chemical wastes, and wastewater from thermal plants. It has also been reported that Coastal lagoons and shallow water bodies are prone to nutrient enrichment as a result of anthropogenic activities and this in turn lead to poor water quality (*Roseli et al*., 2009). The population growth and the industrialization of Lagos has led to the pollution of the lagoon by various contaminants, thereby leading to microbial succession and some of these microorganisms are of public health concern (Ajayi and Akonai, 2005). These organisms might contaminate the fish and fishery products from these lagoons which could be a source of health hazards to the final consumers of the products if not properly processed.

This study was undertaken to assess the extent of pollution in some water bodies by assessing the microbial composition of water, sediment, and fish from selected water bodies around Lagos State, Nigeria. It was also done to assess the extent and impact of environmental pollution associated with fish farming in the selected sites using microbial indicators.

Materials and Methods:

Study Sites: Eight sampling sites were selected within Lagos state. Four of the sites (A, B, G and H) has relatively low human activities, while the other four sites (C, D, E and F) were sites of relatively high human activities including fish farming.

Collection of Samples: Water, sediment and fish samples were collected from the 8 selected sites within Lagos State. The water samples were collected into sterile plastic bottles (1L), the sediment samples were collected with a Van Veen grab sampler and scooped into sterile zip lock bags while the fish samples were collected into sterile polythene bags. The samples were kept in ice boxes and taken to the laboratory. The samples were analysed within 24hr after collection.

Isolation of Microorganisms: The samples were serially diluted, and microbes were isolated using the pour plate method (Harrigan and McCance, 1976). Synthetic media were used for the isolation of organisms according to the APHA (1989) method and the media were prepared according to the manufacturers' instructions.

Enumeration of Total Heterotrophic Count: This was done by plating out aliquots of the serially diluted samples on Nutrient agar in duplicates. The plates were inverted and incubated at 35°C for 18- 24hrs.

Enumeration of Total Coliforms: This was done using the Most Probable Number (MPN) method. Aliquots of the serially-diluted samples were inoculated into Lauryl Sulphate Broth (LSB) and incubated at 35°C for 24- 48hrs.

Samples from tubes with gas production were then inoculated onto Eosine Methylene Blue (EMB) Agar and incubated at 35°C for 18- 24hrs.

Detection of other Organisms of Public Health Importance: The presence of other microbes of public health importance were done by plating out aliquots of the serially-diluted samples on Salmonella Shigella Agar (SSA), Thiosulphate Citrate Bile Salt (TCBS) Agar, Manitol Salt Agar (MSA) and Eosine Methylene Blue (EMB) Agar for the detection of *Salmonella* and *Shigella*, *Vibrio*, *Staphylococcus* and *E.coli* respectively.

Identification of Isolates

The isolates obtained were identified using cultural/macroscopic characteristic, microscopic characteristics, and biochemical characteristics. The identities of the isolates were determined according to standard procedure with the use of the Bergy's Manual of Systematic Bacteriology (Krieg and Holt, 1984).

Results

A total of one-hundred and twelve bacterial isolates were obtained. They were identified to belong to the genera *Salmonella* (16), *Shigella* (6), *Vibrio* (11), *Staphylococcus* (12), *Bacillus* (16), *Escherichia* (23), *Serratia* (11), *Pseudomonas* (11) and *Aeromonas* (6).

The Total Heterotrophic Count (THC) of the water and sediment samples recorded ranged between 6.0×10^{1}- 1.8×10^{5}cfu/ml for water and between 1.3×10^{5} and 25.0×10^{5}cfu/ml for sediment samples (Table 1). The total coliform count of the water samples ranged between 20 to more than 1800 MPN/100ml of sample as shown in Table 2. The growth and presence of other organisms of public health importance are as shown in Table 3, '-' indicates no growth on the medium while '+' indicates growth i.e. the presence of the organism being tested for. The THC and the growth of other organisms of public health importance from the fish samples are shown in Table 4. The THC for the fish samples ranged between 10.0×10^{4} and 25.0×10^{6}cfu/ml.

Table 1: Total Heterotrophic Count (THC (cfu/ml)) of Water, Sediment and Fish Samples

Stations	Water (cfu/ml))	Sediment (cfu/ml))	Fish (cfu/ml)
A (Agbowa)	1.8×10^{5}	12.5×10^{5}	1.8×10^{5}
B (Erepoto)	1.5×10^{4}	1.3×10^{5}	25×10^{6}
C (Fish farm 1)	2.4×10^{3}	6.0×10^{4}	16.1×10^{4}
D (Fish farm 2)	2.1×10^{4}	2.0×10^{5}	15.8×10^{4}
E (Badore)	5.0×10^{2}	2.4×10^{5}	10.0×10^{4}
F (Liverpool)	1.1×10^{3}	4.2×10^{5}	24.0×10^{5}
G (Ajido)	6.0×10^{1}	22.0×10^{5}	14.5×10^{4}
H (Gbagi)	7×10^{1}	25.0×10^{5}	6.0×10^{4}

Cfu: colony forming unit.

Table 2: Total Coliform Count of Water from Different Stations Using the Most Probable Number (MPN) Method

Station	Total Coliform (MPN/100ml)
A (Agbowa)	45
B (Erepoto)	20
C (Fishpond 1)	>1800
D (Fishpond 2)	>1100
E (Badore)	1600
F (Liverpool)	>1800
G (Ajido)	40
H (Gbagi)	210

Table 3: Microbial Growth from Water Samples on Selected Media

Station	SSA	TCBS	MSA	EMB
A (Agbowa)	+	+	+	+
B (Erepoto)	-	+	+	+
C (Fishpond 1)	+	+	+	+
D (Fishpond 2)	-	+	+	+
E (Badore)	-	-	-	+
F (Liverpool)	-	+	+	+
G (Ajido)	-	+	-	+
H (Gbagi)	-	+	-	+

+ indicates growth or presence; - indicates no growth or absence

Table 4: Microbial Growth from Fish Samples on Selected Media

Fish Sample	Growth on SSA	Growth on TCBS	Growth on MSA	Growth on EMBA
A (Agbowa)	_	+	+	+
B (Erepoto)	_	+	+	+
C (Fishpond)	+	+	+	+
D (Fishpond)	+	+	+	+
E (Badore)	+	+	+	+
F (Liverpool)	+	+	+	+
G (Ajido)	+	+	+	+
H (Gbagi)	_	+	+	+

+ indicates growth or presence; - indicates no growth or absence

Discussion:

The results obtained indicated that the microbial load of the different Lagoons in Lagos is relatively high. Kolm *et al*., (2007), reported that high microbial load in water bodies might be due to the availability of organic matter as a result of influx of organic matter from anthropogenic activities. The isolates obtained are similar to those reported by Njoku *et al*., (2015); Ajayi and Akonai (2005). The total coliform count obtained was similar to that of Nandita De *et al*, (2015), who reported a total coliform count of 20 to >1800 MPN/ 100ml from Lagos Lagoon water. The total coliform count was very high in some stations such as Liverpool, Badore and the water bodies close to the two fish farms sampled. Liverpool sampling station is a popular fish market in Lagos, where trawlers discharge some of their products; therefore, the high count recorded could be due to the anthropogenic activities taking place in those stations as coliforms are indicator of faecal contamination. However, low count was recorded in some of the stations that are relatively far from human activities and therefore less anthropogenic activity. This can also be used to assess the extent of organic pollution along the lagoons. Ajayi and Akonai (2005); Kamaldeen and Wahab (2011) also reported high coliform counts from some stations along Lagos lagoon and suggested that the high count might be due to the discharge of sewage into the water, they further opined that the lagoon is relatively unsafe for swimming and other recreational activities. *Vibro* species, *Staphylococcus spp* and *E. coli* were isolated from all the stations, the presence of Vibrio species such as *Vibrio cholerea* could lead to an outbreak of cholera while presence of *E. coli* can cause some other gastrointestinal tract disorder. *Salmonella* and *Shigella* species were detected in some stations but absent in others. Consumption of water or fish contaminated with *Salmonella* can cause typhoid fever and some other salmonella infections. Ajayi and Akonai also suggested that the presence of *Bacillus* spp might be due to the ability of the genus to survive in adverse environment. It could therefore be stated that the presence of these organisms could have adverse effects on the fishing communities and other rural and urban dwellers. This position was earlier opined by Prescott *et al*, (2002) where it was stated that consumption of food products contaminated with pathogenic organisms could have adverse effects on consumers of such products.

Conclusion:

The results obtained from this study shows that the lagoons in Lagos are highly polluted. The presence of Vibro, Salmonella, Shigella and other coliforms in water, sediment and fish samples from Lagos water deserves special attention of public health analysts and there is a need for proper processing of fish products from these stations to prevent water and food-borne infections.

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FISH NUTRITION

Effects of Replacing Soybean with Beniseed, *Sesame indicum* Seed Meal on Some Haematological parameters Of *Clarias gariepinus* Juveniles.

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Abstract
This study investigated the effects of sesame seed meal (SSM) substitution for soybean meal (SBM) on the haematological parameters of *Clarias gariepinus* juveniles for 8 weeks. Three hundred (300) apparently healthy juveniles with initial average weight of 80.59g, were randomly stocked in 15 plastic tanks fed with 0, 25, 50, 75 and 100% substitution level. Blood samples were obtained for haematological analysis using standard methods. Haematological parameters also showed that red blood cell (RBC), haemoglobin (HGB) and haematocrit (HCT) were decreasing while white blood cell (WBC), lymphocytes (LYM), mean cell haemoglobin concentration (MCHC) and platelets (PLT) increased with increasing inclusion level. Fish fed with 75 and 100% SSM showed significant changes ($P > 0.05$) in all the parameters from the control (0%) SSM. Hence, the inclusion of sesame seed meal up to 25% is recommended in the diet of *Clarias gariepinus*, since this inclusion level did not exhibit any negative effect on haematology.

Keywords: *Clarias gariepinus*, Sesame seed meal, Soybean, Haematology

Introduction

Fish nutrition experts world over and particularly in Nigeria have considered the procurement of alternative protein sources for inclusion in fish diet to partially or completely replace fish and soybean meals (Stickey *et al.*,2006). More than half of world food fish are produced through aquaculture which in turn is heavily dependent on aquafeed input (FAO, 2012). Feed production must be able to sustain growing world fish demand and dependent on protein and energy sources like fishmeal, fish oil and soybean meal which has become costly in international markets (Hardy, 2010). Soybean is presently the most used plant protein in fish feed production and contains around 48 % crude protein (Salze *et al.,* 2010). Soybean as a multipurpose raw material is competitively scarce and expensive for aquaculture in sub-Saharan African (Ayinla, 2007; Azaza *et al.,* 2009), hence the need to seek alternatives to both fishmeal and soybean meal.

Sesame indicum(family: Pedaliaceae) grown all over tropical and sub-tropical world and are main sources of essential amino acids such as lysine and methionine (El-Adawy & Monsour, 2011). The seed is reported to have about 41–58 % oil, 18–25 % protein and 13–17 % carbohydrates (Yusuf et *al*., 2008). However Ochang *et al* (2014) reported about 41.60% crude protein composition in Sesame seed procured from Ikwo market, Ebonyi state, Nigeria higher than those reported for seeds in other parts of the world. The replacement of soybean meal with *Sesamum indicum* feed meal and soybean is expected to reduce the high cost of feed which is one of Nigeria's major problems in fish farming and also provide some health benefit to fish. According to Mahdieh *et al.* (2014) sesame seeds help to reduce the level of body cholesterol, prevent diabetes, asthma, anaemia, reduces constipation, helps in maintaining strong bones and helps in detoxification of the liver.

Blood analysis is a valuable means of evaluating the physiological condition of cultured fish with respect to determining the effect of diets and other stress factors of fish health (Bello-Olusoji *et al.,* 2006). According to Wepener, (1997) haematology, growth rate, oxygen consumption, biochemical, behavioural and physiological changes of fish are used in determining the toxicity of pollutants. Bhatti *et al*. (2009) reported that the intake of various dietary components has measurable effects on blood constituents. Blood parameters have been adjudged important criterion for assessing the quality and suitability of feed ingredients in farm animals (Maxwell *et al*., 1990). Animashahun *et al.* (2006) suggested that the comparison of haematological profile with nutrient intake may provide a base line for either increasing or reducing certain nutrients for different population groups. The African catfish, *Clarias gariepinus* is a choice species for aquaculture because of its possession of several qualities such as ability to tolerate low dissolved oxygen, withstand handling stress, high disease resistance, rapid growth rate, and its acceptability to variety of feed items (Adewolu, 2008). Fagbenro and Davies (2004) reported that *Clarias spp* have high propensity to consume wide variety of supplementary feeds which makes it possible to combine a variety of conventional and non-conventional ingredients for formulating its diet.

The general shortage of fish meal, groundnut cake and soybeans necessitate to crave for an alternative ingredient for use in aquaculture feeds production with focus on plant produce that are not in serious demand by human for consumption (Ingweye *et al*., 2010). This study investigates the effects of sesame seed meal diet on some haematological parameters of *Clarias gariepinus* juveniles

Materials and Methods

Experimental site
The study was carried out in the wet laboratory of the Department of Fisheries and Aquatic Science, Cross River University of Technology (CRUTECH), Obubra Campus.

Experimental Fish
Three hundred and fifty apparently healthy post fingerlings of *C. gariepinus* were procured from Farmosas family farm in Calabar, Cross River State, Nigeria. They were put in 20 litres jerry cans and transported by Car to the wet laboratory, Department of Fisheries and Aquatic Science. They were batch weighed and put in aquaria, acclimated for two weeks before the commencement of the research. During the period of acclimation the fish were fed at 5% body weight with blue crown feed with a crude protein of 40% twice daily and discontinuous 24 hours prior to commencement of the experiment. This was done to eliminate variation in weight due to residual food in their gut, prepare the gastrointestinal tract for the experimental diets and to increase the appetite of the fish.

Collection and preparation of sesame seed meal (SSM)
The Beniseed (*Sesamum indicum*) was purchased from Adun market, Ofodua, Obubra Local Government Area of Cross River State. The beniseed was sieved to remove dirt and sand, washed and sun dried for 3 days. The beniseed was grounded in a hammer mill and the oil remove using a catalyst n- hexane as recommeneded by Enujiugha & Akanbi (2005). The proximate composition of the Sesame seed meal before and after oil extraction is shown in table 1

Table 1. Proximate composition of sesame seed meal before and after oil extraction

Parameter (%)	**Before oil extraction**	**After oil extraction**
Moisture content	3.8	2.6
Crude protein	22.1	28.2
Crude fibre	5.9	8.8
Lipid	44.1	16.8

Preparation of experimental diets
The isonitrogenous diets of approximately 39% crude protein were formulated using the Pearson's square method. The beniseed cake meal was included to replace varying quantities of soybean in the diets Table 2. The feed ingredients were grounded separately to fine powder using the hammer mill. Each ingredient was weighed into a bowl and all were mixed together properly. Boiled water was then added to the mixture and stirred to obtain a consistent dough which was passed through a pelleting machine to produce a 0.5mm pellets. Thereafter, the feed was sundried for 4 days, then stored in an airtight plastic container and kept until the time for use.

Table 2: Ingredients composition of formulated diets (% Dry weight)

Ingredient (g/100g)	**D1 (0%)**	**D2 (25%)**	**D3 (50%)**	**D4 (75%)**	**D5 (100%)**
Blood meal (80% CP)	10	10	10	10	10
Fishmeal (64%CP)	25	25	25	25	25
Soybean meal (42%CP)	30	22.5	15	7.5	0
Beniseed cake (28%CP)	0	7.5	15	22.5	30
Maize (11%CP)	27	27	27	27	27
Soybean oil	3	3	3	3	3
Vit/min premix	3	3	3	3	3
Binder	2	2	2	2	2
Total	100	100	100	100	100
Calculated Crude protein	**39.36**	**39.37**	**39.17**	**38.97**	**38.92**

Experimental design and procedure
A completely randomized design (CRD) with five treatments in three replicates (5 x 3) was used. The 15 labelled aquaria were randomly allocated with 20 fish each on the five treatment diets (D1, D2, D3, D4 and D5) in triplicate. The initial total body weight () and total length () noted and other measurements were taken fortnightly for 56 days. Feeding was carried out twice daily, 8:00 – 8:30am, and 5:00 – 5:30pm.

Blood Collection and Haematological Analysis
Blood samples were collected at the 8th week of the experiments following the procedure of Schmitt *et al* (1999). Blood of 2ml were collected from caudal peduncle with the aid of a 2ml sterile plastic syringe fitted with 0.8 x 38mm hypodermic needles. The blood was collected in triplicates into sample bottles containing ethylene diamine tetra acetic acid (EDTA) as anti-coagulant. The blood was rocked gently in the bottle to allow thorough mixing of its content. The samples were preserved in a cooler containing ice block and thereafter transported to University

of Calabar Teaching Hospital (UCTH), haematology Department for analysis within six hours after collection. The haematological parameter determined were Red blood cell (RBC), White blood cell (WBC), Platelet (Pt), Pack cell volume (PCV) Haemoglobin (Hb) and Differential counts. The mean corpuscular volume (MCV) mean corpuscular haemoglobin (MCH) and the mean corpuscular haemoglobin concentration (MCHC) were calculated from the data using standard formulae (Lee *et al;* 1998). The direct measurements of erythrocyte value (Packed cell volume PCV, Haemoglobin Hb, and Red blood cell RBC), absolute erythrocyte indices (MCH, MCV and MCHC) were calculated. The platelets, white blood cell and differential count (neutrophils and lymphocytes) were analysed as described by Ochei & Kohlkater (2003).

Statistical Analysis
The data collected were subjected to one way analysis of variance (ANOVA) using SPSS version 20. Comparison among diet means for each parameters were carried out using Turkeys honest significant different (HSD) at significant level of 0.05 according to Zar, (1999).

Results
Haematological parameters
The result of the haematological indices of *C. gariepinus* fed graded levels of sesame meal-based diets is presented in Table 4. The mean values of RBC (3.18 - 2.41 x 10^{12}cells/L), HGB (14.4 – 13.90 g/l) and HCT (32.12 – 28.82%) decreased from D1 (0%) to D5 (100%) of SSM substitution level. the values of WBC (5.16 – 99.01 x 10^{9}cells/L), platelets (9.00 – 12.67 x 10^{9}cells/L) and LYM (59.16 – 81.64%) increased progressively from fish fed D1 to D5 respectively. the values of the erythrocyte indices MCHC (43.93 – 56.73g/l), MCH (56.83 – 70.93 pg) and MCV (121.33 – 133.33fl) also increase with increase in SSM substitution level. The study also revealed that fish fed with D5 (100% SSM) showed significant changes whereas those fed D2 could not show differences with those fed the control diet (D1).

Table 4: The mean value of the some haematological parameters of *C. gariepinus* fed graded levels of sesame seed meal (SSM) for 8 weeks

Parameters	Diets (%)				
	D1 (0%)	**D2 (25%)**	**D3 (50%)**	**D4 (75%)**	**D5 (100%)**
Red blood cell (10^{12}cells/L)	3.18 ±0.2^{a}	3.71 ±0.91^{a}	2.57 ±0.13^{ab}	2.71 ±0.35^{ab}	2.41± 0.8^{ab}
Haemoglobin HGB (g/l)	14.4 ± 0.42^{ab}	16.2 ±0.23^{a}	15.17± 0.43^{a}	14.37±0.59^{ab}	13.9± 0.1^{ab}
Haematocrit (%)	38.12 ± 2.14^{b}	40.35 ±2.62^{ab}	35.13± 1.25^{a}	32.48±3.21^{ab}	28.82±3.38^{c}
White blood cell(10^{9}cells/L)	95.16 ±0.4^{b}	97.37 ±0.23^{ab}	98.12 ±0.43^{a}	98.12 ±1.0^{a}	99.01 ±0.1^{a}
Lymphocytes(%)	59.16±0.2^{c}	65.73 ±0.74^{bc}	69.26 ±0.8^{ab}	75.64±2.93^{ab}	81.64 ±1.0^{a}
Mean cell haemoglobin concentration (g/l)	43.93±1.92^{c}	45.23 ±1.26^{bc}	45.37±3.12^{bc}	47.5 ± 1.74^{b}	58.73 ±3.3^{a}
Mean cell haemoglobin (pg)	56.83±2.32^{c}	59.4 ±1.74^{bc}	59.13±3.73^{bc}	61.87± 3.82^{b}	70.93±2.25^{a}
Mean cell volume (fl)	121.33 ±2.32^{c}	125.67±2.24^{bc}	126 ±3.73^{b}	128.33±1.82^{b}	133.33±1.25^{a}
Platelets (10^{9}cells/L)	9.00 ±2.00^{ab}	9.33± 2.12^{ab}	10.67±1.22^{ab}	11.33 ±2.82^{a}	12.67 ±1.15^{a}

Mean with the same superscript under the same row are not significant at (P< 0.05)

Discussion
Haematological parameters
The applications of haematological techniques have proved valuable for fishery biologist in assessing the health of fish and monitoring stress responses (Osuigwe *et al.*, 2005). Haematological parameters of fish are affected by a range of factor which includes size, age, physiological status, environmental conditions and dietary regime. The changes in the various parameters recorded although some were still within the recommended level showed that they were affected by the increase in the substitution level of the diet. This study showed a decrease in the values of RBC, HGB and HCT while the values of WBC, LYM, PLT, MCV, MHCH and MCH increased with increasing levels of SSM replacement. This was in agreement with the findings of some researchers who use plant sources on *C. gariepinus* (Ochang *et al*., 2014; Adesina, 2017; Okey *et al*., 2018). However, Babale (2016) rather reported an increase in these parameters on *C. gariepinus* adults fed graded levels of water melon, *Citrullus lanatus* seed cake diet. The range of the RBC, 3. 18 - 2.41 x 10^{12}cells/L, HGB, 16.20 - 13.90g/l and 28.82 – 40.35% recorded in this study compared favourably with those of some researchers who fed *C. gariepinus* with graded levels of plant based diet (Babale, 2016; Adesina, 2017).The increase in the red blood cell and haemoglobin concentration in fish fed 25% SSM diet may be attributed to the increase in the size of the fish as a result of growth and metabolic activities. The increased might also be due to the release of new RBCs from the erythropoietic tissue to improve the oxygen-carrying capacity of fish blood with resultant higher values of erythrocyte count as observed by Alkahem *et al*. (1998). Conversely, haemoglobin contents and erythrocyte counts tend to increase with length and age of the fish (Babale, 2015). The reduction in the RBC and HGB concentration in fish fed diets above 50%

substitutions levels SSM, contained lower quality protein, due to residual metabolites such as the anti-nutritional compounds which probably affect blood production. Reduction in the concentration of the PCV and RBC in the blood usually suggests the presence of toxic factor which has adverse effect on blood formation resulting to anaemia (Oyawoye & Ogunkunle, 1998). It has been reported that haematocrit and haemoglobin values vary according to deficiency of essential nutrients, environmental conditions, growth status, and anti-nutritional factors (Lim & Lee, 2009). Increase in the concentration of WBC, LYM, PLT, and all the erythrocytes indices in this study was in an agreement with the finding of several research who fed *C. gariepinus* with plant base protein sources (Fagbenro *et al*., 2010; Adesina, 2017). The increase in WBC, LYM and PLT as SSM increased in the diet could be attributed to residual anti-nutrients present in the feed, and also increase in leucopoiesis as a way of fighting stress induce substances in the body system of the fish (Gabriel *et al.*, 2004). Douglas & Jane (2010) stated that their amount has implication in immune responses and the ability of the animal to fight infection.

The mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV) of fish in this study were significantly higher in fish fed with 100% SSM and are comparable with values earlier reported by previous researchers (Adedeji & Adegbile, 2011; Umaru, 2015). The MCHC, MCH and MCV are useful in the diagnosis of anaemia in most animals (Cole, 1986). The observed lower haemoglobin levels and increased MCV, MCH and MCHC as the inclusion level of SSM increased in this study may be due to abnormal maturation of the red blood cell. The value of MCV as an estimate of the volume of RBCs indicates the status or size of the RBCs and reflects normal or abnormal cell division during RBC production (erythropoiesis). Larsson *et al.* (1985) attributed increase in MCV to swelling of the RBCs due to hypoxic condition (low oxygen condition), impaired water quality, somatic stress or macrocytic anaemia (swelling of RBCs) in fishes exposed to metal pollution. Reduced MCV could be linked with shrinkage of RBCs either due to hypoxia or microcytic anaemia (shrinkage of RBCs) as earlier reported by Adesina (2008) and Alwan *et al.* (2009). Higher MCH indicates a good volume of haemoglobin which indicates effective oxygen transportation in the bloodstream for healthy wellbeing of the fish (Diyaware *et al*., 2013).

Conclusion

Haematological analysis revealed that 25% and 50% substitution of soybean with SSM in the diets had no adverse effect ($p>0.05$) on the blood parameters and physiology of the fish. Therefore inclusion of SSM in the diets of *C. gariepinus* should not exceed 50% level of substitution.

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Dietary Effects of Pineapple (*Anana comosus*) Crush Waste on the Proximate Composition of *Clarias gariepinus* Juveniles

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Abstract
The effect of pineapple (*Anana comosus*) crush waste on the proximate composition were analysed in *Clarias gariepinus*. Juveniles with a mean weight of 19.01 ± 0.20g consisting of five treatments was conducted to investigate the nutrient utilization and growth response of *Clarias gariepinus.* Pineapple is produced in very large quantities in the tropical countries as a large amount of waste is generated which is disposed into the environment leading to pollution during the course of processing into the various end products. The fish were fed with varying dietary levels of pineapple crushed waste (PCW) as a replacement for maize. Five diets with PCW inclusion at 0% (Diet 1), 25% (Diet 2), 50% (Diet 3), 75% (Diet 4) and 100% (Diet 5) were formulated. The experiment was carried out in fifteen hapa nets of 1m x 0.5m x 0.5m in a concrete tank of 10m x 5m x 1.5m filled with water to two-third of the hapa net. Fifteen fish were stocked per hapa in triplicate and the fish were fed twice daily at 5% of their body weight for the period of 70 days. The proximate analysis revealed the highest value for crude protein of 43.96% in Diet 1 while the lowest (41.08%) in Diet 5. The inclusion of PCW increased the nitrogen free extract as the control diet (Diet 1) recorded 43.45% and Diet 2, 44.52%. Ether extract ranged between 5.46 and 6.00%. Ash content of the experimental diets varied between 5.50% in Diet 1 and 6.00% in Diet 5. It was however observed that the nitrogen Free Extract (NFE) and ash content increased as the level of PCW increased. The values for crude protein were not significantly different (p>0.05) though Diet 1 had the highest value of 43.06%. Diet 1 had the highest value of 84.02% dry matter content and crude fibre (8.53%) and this trend decreased in the diets as PCW inclusion level increased. The pH was alkaline throughout the experimental period with values ranging between 7.00 and 8.69. Values for conductivity level of the water ranged from 101µs - 254µs. NH3-N also varied from 0.03mg/l to 0.39mg/l. Dissolved oxygen ranged between 7.20mg/l and 10.70mg/l while water temperature ranged between 29.5 and 32^{OC}. The results suggest that the inclusion of *Anana comosus* can improve the quality of *C. gariepinus* juveniles without negative effects on the fish.

Keywords: *Anana comosus*, Proximate composition, Water Quality, *Clarias gariepinus*

Introduction

Aquaculture in Africa is gradually developing and expanding, including fish and shell fish species that are known sources of animal protein, with a marked impact on human health and wealth (FAO, 2009, FAO, 2010, FAO, 2012, Anyanwu *et al.,* 2017). *Clarias gariepinus* is a mud catfish of the family Clariidae has been reported to have high potentials for culture because of its high growth rate, large size, good flesh quality, tolerance to poor water quality, efficiency in feed conversion, acceptance of relatively cheap feeds, ability to withstand high stocking density, high resistance to diseases and acceptance to consumers (Aminu, 1992, Ayo-Olalusi, 2013, Michael *et al.*, 2014, Alatise *et al.*, 2016, Ikwuemesi *et al.,* 2017). It is more valued compared to Tilapia in several parts of Nigeria. Its high cost has been attributed to the scarcity of its juveniles which has been described as the major bottleneck for the development of a commercial culture of the fish (Hogendoorn, 1980, Mebude *et al.,* 2014, Anyanwu *et al.*, 2017, Agwu *et al.,* 2017). *C. gariepinus* is an omnivore which is able to feed on a wide variety of food items other than fish (Reed *et al*., 1967, Ayinla and Faturoti, 1990, Idodo-Umeh, 2003, Olaosebikan and Raji, 2014). It also feeds on smaller fish like tilapia, frogs and other benthic items (Viveen *et al.*, 1985, Idodo-Umeh, 2003, Olaosebikan and Raji, 2014). It recognizes food by smell and touch especially when feeding at night or in high turbid or muddy water (Viveen *et al.,* 1985). The two parameters are interwoven; fish feeding and water quality management affect each other. The level of feeding of the stocks affects the water quality and the level of water quality affect the feeding performance of fish in the pond (George, 2001). During the processing of pineapple and extraction of the juice, a large amount of waste is generated which is being discarded and most times foul the environment. To control the wastage of these industrial materials, there is a need to explore its potential as feed material as to see if its value could be increased by converting it into useful products for fish (Udoh, 1981). Pineapple is produced in very large quantities in the tropical countries. During the course of processing into the various end products, a large amount of waste is generated which is disposed into the environment leading to pollution. In Nigeria, the cultivation of Pineapple has increased over the years. This study is therefore, targeted at investigating the dietary effects of pineapple crush waste (*Anana comosus*) on the water quality parameters and proximate composition of *Clarias gariepinus* juveniles.

Materials and Methods

Experimental site

The experiment was carried out at the outdoor research concrete tanks of the Department of Aquaculture and Fisheries Management (10m x 5m x 1.5 m) University of Agriculture, Abeokuta Ogun State, Nigeria. The concrete tanks used for the experiment were prepared by washing thoroughly with water and left to dry. It was then filled with water before the hapa nets were set. The experimental fish were thereafter stocked.

Preparation of test ingredients

The feedstuff, pineapple crush waste (PCW) used for this research was sourced from a Pineapple Processing Factories in Kainji, Niger State. The pineapple crush waste was sun dried to a constant weight and crushed using hammer mill in the feed mill to finer particle size that can be picked up by *C. gariepinus* juveniles.

Experimental fish and management

Juveniles of *C. gariepinus* used for this research were collected from Tuns and Partners Fish Farm, Abeokuta after attaining a mean weight of 18.0g. The fish were transferred by using plastic bowls to the experimental concrete tank where they were acclimatized before the experiment commenced. Fifteen (15) hapas nets (net diameter of 0.1mm) each measuring 1.0 x 0.5 x 0.5m were used. Each of the hapa was suspended with Kuralon rope into water in the concrete tank 10 x 5 x 1.5 m to a level of about two-third of the height of the hapa. The juveniles were acclimatized for one week after which the juveniles that survived were randomly stocked at 15 juveniles per hapa. The fish were starved for 48 hours before feeding commenced to empty their gastro – intestinal tract of residual feeds or ingesta. The juveniles were weighed before stocking into the hapas in triplicate. The fish were fed at 5% of their body weight twice daily at 9.00am and 6.00pm. The total weight of the fish in each hapa were offered weekly and the quantities of feed given were adjusted with the weight increase. The experiment lasted 10 weeks.

Dietary preparation

The determined proximate composition of the pineapple crushed waste used in this study compared to that of maize is shown in Table 3. Five diets were formulated from the pineapple crush waste (PCW) by replacing maize as an energy source at 0% (Diet 1), 25% (Diet 2), 50% (Diet 3), 75% (Diet 4) and 100% (Diet 5) inclusion levels (Table 1).

Determination of physico-chemical parameters

The physico-chemical parameters were taken weekly:

pH: The pH of water samples collected from the tank was measured using pH meter (Model: Hanna Instrument Model No: HI 8915 ATC).

Water temperature: Water temperature was measured with a mercury-in-glass thermometer to a depth of 5cm. It was measured in degree centigrate (^{O}C).

Dissolved Oxygen Concentration: The dissolved oxygen concentration was measured with a dissolved oxygen meter of Model: Oxguard Hardy MK11. It was measured in milligrams per litre (mg/L).

Conductivity: Conductivity was measured using the Hach Conductivity Meter. The conductivity of the water samples was measured in μohms/cm.

Determination of ammonia: Ammonia content of the water was measured by the distillation method using Nessler's reagent. A distillation unit with a 500ml round bottled flask and Liebig condenser was set up. 100ml of ammonia – free water was poured into the Liebig condenser. A spatula full of magnesium oxide was added and then the trapped air in the distillation unit was steamed out after which about 75ml of the distillate was allowed to accumulate in the receiving beaker. Distillation was then stopped and the unit allowed cooling. 75ml of effluent water was then introduced into the distillation flask and the first 50ml of distillate collected. Thereafter, 1ml of Nessler's reagent was added to the distillate which was allowed to stand for 10 minutes for colour to develop. After this, the amount of ammonia present was measured in the spectrophotometer at 550 wave length.

Statistical Analysis

Data from the research were subjected to Analysis of Variance (ANOVA) using PROC General Linear Model of SAS (1998), using the model

$$Y_{ij} = \mu + A_i + \sum_{ij}$$

Where

Y_{ij}	=	Observation on parameters
μ	=	Overall mean
A_i	=	Effect of i^{th} level of PCW inclusion (i = 1- 5)
$\sum_{ij}$	=	Random residual error normally distributed with zero mean variance δ^2e.

Results

Analysis of the Pineapple Crush Waste (PCW)

The result of the proximate composition of the pineapple crush waste (PCW) is shown in Table 2. The crude protein content of the PCW was 3.28%, Ash content was 8.20%, Crude fibre 1.28%, Ether extract 1.08%, Dry matter 8.00%, Moisture content 92.00 and Metabolizable Energy 3.53Kcal/g.

Proximate Composition of Experimental Diet.

The proximate composition of experimental diets (Table 3) showed that the crude protein was highest in diet 1 (0% PCW inclusion) with the value of 43.96%, and the lowest in diet 5 (100% PCW inclusion) with the value of 41.08%. The inclusion of pineapple increased the nitrogen free extract diet, 46.17% in Diet 5, 44.52% in Diet 2, 45.44% in Diet 3, 45.82% in Diet 4 and 43.44% in Diet 1. The ether extract ranged from 5.46% – 6.00% (Table 3). The ash content ranged between 5.50% (Diet 1) and 6.00% (Diet 5), Crude fibre ranged between 1.10% (Diet 1) and 1.29% (Diet 5) as depicted in Table 2.

Proximate Composition of carcass.

The values of chemical parameters of the fish carcass for both initial and final body composition is presented in Table 4. There was a remarkable difference ($P < 0.05$) between the final and the initial values of crude protein, dry matter, and nitrogen free extract crude fibre content of the fish. Fish from diet 1 had the highest value of 8.53% of crude fibre and the trend decreased as the level of inclusion of PCW increased. The reverse was noticed in the ash content of the fish samples from the various diets. The highest value of 12.23% was recorded from fish feed diet 5. The value decreased as the level of inclusion of PCW decreased in the diets. For Nitrogen Free Extract (NFE), a similar trend was noticed. The highest value of 21.73% of NFE was recorded from fish feed Diet 5. The value of Nitrogen Free Extract decreased as the level of inclusion of PCW decreased in the diets i.e. 21.71%, 21.65&, 21.60% and 21.58% for diets 4, 3, 2 and 1 respectively.

Parameters of the water in the experimental concrete tank

Table 5 shows values on water parameters (pH, conductivity, NH_3-N, Dissolved Oxygen and temperature). The pH was alkaline throughout the experiment. It increased from 7.32 to 8.89 in week 9. Fluctuations in the conductivity level of the water was also noticed. The least of 101µs/cm was noticed in week 9 and the highest in week 6 (254 µs/cm). There was variation in the conductivity levels during the study period. The concentration of NH_3-N also varied, the highest value was observed at week 4 (0.39mg/l) and the lowest at week 1 (0.03mg/l). The values of Dissolved Oxygen (DO) fluctuated throughout the experiment. DO range was between 7.20mg/l at week 8 and 10.70mg/l at week 2. Values for water temperature ranged between 29.5 and 32°C.

Discussion

The values of the proximate analysis of the various diets of pineapple crush waste are in line with the works of other researchers Balogun *et al*. (1992), Ayinla (1991) and Agwu *et al.* (2017). Calculated crude protein content of the diets indicated that they met the optimal dietary protein level required by *C. gariepinus*. Faturoti *et al*. (1986) reported 40% optimal dietary protein level for juveniles of *C. gariepinus* while Ayinla (1991) opined a level of 33.5%, Balogun *et al*. (1992) reported 37.5% and Alatise *et al.* (2016) reported 36% crude protein for juveniles to adult for the same species.

Table 1: Percentage composition of the experimental diets for *Clarias gariepinus* juveniles

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
	0%	25%	50%	75%	100%
Yellow maize	26.00	19.50	13.00	6.5	-
Pineapple Crush Waste (PCW)	-	6.5	13.00	19.50	26.00
Groundnut cake (GNC)	15.0	15.0	15.0	15.0	15.0
Soybean meal	24.50	24.50	24.50	24.50	24.50
Fish meal	31.00	31.00	31.00	31.00	31.00
Vitamin premix	0.25	0.25	0.25	0.25	0.25
Vegetable oil	0.50	0.50	0.50	0.50	0.50
Starch solution	1.00	1.00	1.00	1.00	1.00
Oyster shell	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Table 2: Proximate analysis of the experimental diets for *Clarias gariepinus* juveniles

Nutrients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
	0%	25%	50%	75%	100%
Metabolizable Energy (Kcal/g)	3.66	3.64	3.63	3.62	3.61
Dry matter	60.05	61.08	64.26	66.0	63.04
Crude protein	43.96	42.96	42.20	41.65	41.08
Ether extract	6.00	5.76	5.58	5.50	5.46
Ash	5.50	5.60	5.60	5.80	6.00
Crude fibre	1.10	1.16	1.18	1.23	1.29
Nitrogen free Extract	43.44	44.52	45.44	45.82	46.17

Table 3: Proximate composition of pineapple crush waste (PCW) and maize for *Clarias gariepinus* juveniles

Nutrients	PCW	Maize
Metabolizable Energy (Kcal/g)	3.53	3.41
Dry matter (%)	92.0	90.0
Crude protein (%)	3.28	10.0
Ether extract (%)	1.08	4.0
Ash (%)	8.20	1.3
Crude fibre (%)	1.28	2.7
Moisture content (%)	8.0	12

Table 4: Proximate Composition (%) of carcass of *C. gariepinus* fed pineapple crush waste

Diets	Crude Protein		Dry Matter		Ether Extract		Crude Fibre		ASH		Nitrogen Free Extract	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
1	32.98	43.06	60.90	84.02	13.96	14.79	6.10	8.53	10.50	12.04	19.36	21.58
2	42.48	43.03	71.08	83.61	14.00	14.78	6.16	8.52	11.60	12.07	18.84	21.60
3	34.21	42.90	64.26	82.79	14.08	14.76	6.18	8.50	10.60	12.13	17.14	21.65
4	38.00	42.89	66.0	81.77	14.26	14.73	6.13	8.48	10.80	12.19	21.81	21.71
5	33.00	42.85	63.04	81.56	14.50	14.72	7.19	8.47	10.00	12.23	19.35	27.73

Table 5: Average weekly water parameters of the experimental concrete tank

Week	pH	Conductivity (µs/cm)	NH_3-N (mg/l)	DO (mg/l)	Temperature (°C)
1	7.32	165	0.03	10.3	30.5
2	7.24	231	0.32	10.7	32.0
3	10.95	183	0.19	10.4	31.0
4	8.38	215	0.39	9.6	31.0
5	7.00	252	0.40	9.4	31.0
6	7.17	254	0.20	9.1	32.0
7	8.69	172	0.03	7.6	29.5
8	7.01	212	0.06	7.2	29.5
9	8.89	101	0.10	9.3	30.0
10	8.10	157	0.04	10.5	31.0

The Crude protein level was lower than that recorded by Akegbejo-Samsons (1999) and Obasa *et al*. (2004) since their feed substitute were more of protein compared to pineapple crush waste. Ikwuemesi *et al*. (2017) also reported a crude protein value of 40% in their study at Michael Okpara University, Umudike. A contrary value of 60% was reported by Agwu *et al.* (2017). This variation could be attributed to the different diets used for the experiments. The same reasons could be attributed for percentage ash and ether extract.

Variations in water pH, Conductivity, NH_3-N, DO and temperature during the period of the study were all within the acceptable tolerant range recommended for fresh water fish culture as reported by Omoregie *et al*. (1991), Davies *et al.* (2008) and Davies *et al.* (2013). This therefore did not have any significant effect on the performance of the *C. gariepinus* fingerlings during the experimental period. The variation recorded in the cost of feeding the *C. gariepinus* in each diet was as a result of the varying number in each diet due to mortality and their feed intake which was affected by the palatability of the feed. This observation was also noticed by Vivien *et al*. (1995), Davies *et al.* (2013). This was also seen in the varying revenue and profit generated from the *C. gariepinus* fingerlings from the various diets which is a function of the total number that survived till the end of the experiment and their final weight.

Conclusion

The two parameters under consideration are in tolerable range which does not have adverse effect on the culture of *Clarias gariepinus* invariably can improve the production.

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Effect of storage on nutritive value of Eco float and vital commercial Fish feed

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Abstract
This study was carried out to assess the effect of storage on nutritive value of commercial fish feed using two commercially manufactured fish feeds named; Eco Float and Vital feeds stored at room temperature. The feed samples were purchased from a retail outlet in Sokoto State Central market. The result obtained showed the reduction in fish feed quality as a result of the increase in storage period with a significant difference ($P<0.05$) in all the nutritional components. The results, however showed no significant difference ($P<0.05$) between the nutritional and mineral components of the fish feed samples during the period of storage slight changes were observed in the proximate and minerals composition due to increasing storage period. The study recommended additional periods should be put in to consideration to ascertain the effects of nutrients loss as a result of prolonged periods of storage of two commercial feeds (Eco float and Vital Feeds).

Keyword: commercial feeds, mineral contents, proximate composition, storage

Introduction

As aquaculture production becomes more and more intensive in Nigeria, fish feed will be a significant factor in increasing the productivity and profitability of aquaculture (Akinrotimi *et al*., 2007). Commercially manufactured fish feed are important part of modern commercial fish farming, providing the balance nutrition needed by farmed fish. The feed, in the form of granules or pellets, provide the nutrition in a stable and concentrate form, enabling the fish to feed efficiently and grow to their full potential (Orire and Sadiku, 2014). The need to intensify culture of fish, so as to meet the ever increasing has made it essential to develop suitable dietary fish production either in supplementary forms for ponds or as complete feed in tanks (Olukunle, 2006). The cost of feeding in fish farming represent about 60-80% of the total cost of raising fish to table size (Adekunle *et al.,* 2012). Commercial fish feed in Nigeria are often imported floating feeds and as a result of high cost producing such diet are usually expensive, creating a large margin compared to when locally produced sinking feed are used. Although most fish farmers often use a combination of both types, about 15% floating feed and 85% sinking feed (Lovell, 2013). Fish feed plays an important role in the production of fish at a satisfactory level. It is also necessary to meet seasonal peak supply and to increase shelf life of fish Feeds so that feed produced during lean period can be supplied during the production period (Lovell, 2013). If it is not stored properly then some microbial and environmental alteration will occur (Lovell, 2013). Fish farmers buy commercial feed stored for different period of time between production storage and usage loss may occur on nutritive value of these stored feeds. Therefore, there is an urgent need to access the actual nutritive value of the commercially stored fish feed available to the fish farmers. Various studies have reported significance reduction and increase in nutrients in fish feeds as a result of storage (Lovell, 2013). However, dearth of information on the nutritive changes in Eco float and Vital feeds as a result of storage was noticed. The aim of this study was to determine the effect of storage on proximate and minerals composition of stored commercial fish feed.

Materials And Methods

Experimental Site

The research was carried out at Agricultural Chemical Laboratory of Usmanu Dan Fodiyo University Sokoto. Sokoto is located in the extreme North West of Nigeria; near the confluence of Sokoto River and River Rima. The state is within the longitude 11° 30-130° 50E and latitude 4°-6° 40N (Wikipedia 2018). Sokoto State is located in the dry Sahel surrounded by sandy savannah and isolated hills with an annual average temperature of 28.3°C. There are two seasons; the Dry and Wet season. Dry season begins in from October to April and extends to May/June in some parts. Wet season starts in May and ends September to October. Harmattan is experienced between November and February. Heat is more severe around March and April.

Samples collection

One (1) kg each of the Commercial Fish Feeds (Eco float and Vital feeds) were purchased from a retail outlet in Sokoto Cental market Sokoto State, Nigeria with manufacturing and expiring dates noted in both feeds and stored in an airtight polythene bags for a period of 8 weeks before the proximate analysis.

Method of Fish Feed Storage

The fish feeds were stored in an airtight condition which was created by tying the bag with a rope to provide a simple airtight storage condition. The choice of these methods of fish feed storage for this study was based on the packaging style of the fish feed manufacturers.

Chemical Composition of Sample Materials

The moisture content was determined by drying in an oven at 100-105^{o} to constant weight (AOAC, 2000). The crude protein content was evaluated by digestion of the sample. Nitrogen determination was done using a spectrophotometer as described by Devandra (1989) and the crude protein was obtained by multiplying the quantity of nitrogen by the coefficient 6.25. Total lipids were determined by continuous extraction in a Sox let apparatus for 8 hours using hexane as solvent, ash by incinerating in a furnace at 550^{0}C, crude fiber by sequential hot digestion of the defatted sample with dilute acid and alkaline and carbohydrate was calculated by difference of 100 with the sum of all contents obtained (AOAC, 2000).

Mineral Analysis

A number of methods, ranging from simple manual to automatic complex procedures, have been developed for the determination of various cations in plant extract. The methods make use or the simple forms of the common instruments generally available in analytical laboratories examples: colorimeters, flame photometers and atomic absorption spectrophotometers (AOAC, 1970).

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and, the treatment means were separated for significant differences following the procedure of Duncan's Multiple Range Test (Steel and Torrie, 1980). All the analyses were carried out using the computer software Statistical Package for the Social Sciences Version 9.0 for windows (SPSS, 2007)

Results And Discussion

Proximate composition of commercial Fish Feeds

Result showed that there were significant difference in the proximate composition in the fish feed samples, for all the parameters measured which implied that there was a general and progressive reduction in the composition as a result of the increasing storage period, though this varied in the degree with the different storage periods. Among the various storage period employed, week 8 was found to have more reduction in the nutritional composition of the fish feed storage. As reported in (Solomon, 2016), that reduction in protein content during the storage period could be attributed to increase in the moisture level of the feed. Increase in moisture also reduces the proximate composition of fish feeds. The study on the proximate composition of the feeds revealed that the moisture content significantly increased during the storage period for both fish feeds. This finding was similar to that finding made in Oladele and Osipitan (2011) who found that increase in moisture content of fish feed occurred during storage but attributed it to the presence of storage fungi. Conkova *et al*., (2006) also viewed that fungal growth, mycotoxins production and climatic condition; especially temperature and humidity plays an important role in the reduction of the nutritive value of stored fish feed. Also similar finding by FAO (1987) indicated that environmental factors such as moisture, relative humidity, temperature, light and oxygen causes deteriorative changes and losses in stored feed and feedstuff. High moisture levels in stored feed result in loss of quality of the due to growth of microorganisms. Hossen *et al*., (2011) reported significant increase in NFE (carbohydrate) content with prolonged storage period which could be due to changes of other proximate composition such as crude protein, crude fiber, crude lipid and ash contents. In the same vein, Nwabueze and Nwabueze (2011) investigated that the quality of fish feed and hygienic levels of technological processes employed during feed formulation determine the level of risk of microbial contamination aided by temperature.

Mineral composition of commercial fish feed

The mineral compositions of two different fish feeds samples were reported in the present study (Eco float and Vital fish feeds) stored under the same conditions at room temperature .A decreasing trend in the minerals composition of both fish feed samples was observed generally from week 0 (initial week) to week 8 of the storage period. However, based on the result of the study a reverse trend was obtained which indicated that the results are at variance with each other probably due to the time interval of the storage period employed .The calcium, magnesium, sodium, potassium and phosphorus content of both fish feeds sample in this research study showed a significant decrease with increasing storage period.

Halver and Hardy (2002) reported that dietary minerals deficiency was reported to retard growth, abnormalities, bone deformities, anorexia and eventually death and the presence of high concentration levels of minerals therefore implies possibility of poor growth and digestibility. The reduction in the minerals composition is similar to the findings made by FAO (2001) that the levels of the fish feed minerals composition will be more reduced with increasing storage period. Hossen *et al*. (2011) also reported that changes in the chemical composition and nutritive value of fish feed during storage.

Table 1: Proximate composition of commercial fish Feed

Parameters %	ECO float feed/ No of weeks				
	(0) Initial	(2)	(4)	(6)	(8)
Moisture	8.00±0.01^{bc}	5.67±0.33^{a}	7.67±0.33^{b}	8.00±0.01^{bc}	8.67±0.33^{c}
Ash	8.00±0.08^{c}	8.00±0.06^{c}	7.33±0.33^{bc}	6.67±0.33^{ab}	6.33±0.33^{a}
Fiber	4.00±0.02 ^{a}	4.00±0.01^{a}	3.67±0.33^{a}	3.67±0.28^{a}	3.33±0.33^{a}
Crude lipid	7.67±0.33^{c}	6.00±0.02^{a}	6.00±0.01^{a}	6.00±0.00^{a}	5.67±0.33^{a}
Crude protein	33.67±0.33^{c}	32.67±0.02^{bc}	32.33±0.33^{b}	31.67±0.28^{a}	31.00±0.57^{a}
NFE	41.00±0.01^{a}	44.33±0.33^{b}	45.67±0.32^{c}	47.67±0.33^{d}	49.00±0.57^{e}
Parameters %	Vital feed				
Moisture	7.33±0.17^{c}	4.83±0.67^{a}	5.83±0.67^{b}	7.17±0.67^{c}	8.67±0.27^{d}
Ash	8.33±0.17^{c}	8.17±0.67^{c}	7.17±0.67^{b}	6.67±0.17^{ab}	6.33±0.17^{a}
Fiber	3.33±0.67^{b}	3.33±0.67^{b}	2.83±0.67^{ab}	2.67±0.67^{a}	2.33±0.67^{a}
Crude lipid	7.17±0.17^{c}	5.17±0.67^{b}	4.67±0.67^{ab}	4.33±0.67^{a}	4.17±0.69^{a}
Crude protein	31.61±0.28^{c}	30.83±0.21^{bc}	29.90±0.18^{ab}	29.49±0.25^{a}	29.23±0.56^{a}
NFE	45.69±0.46^{a}	47.81±0.54^{b}	50.77±0.39^{c}	52.13±0.34^{d}	53.27±0.45^{d}

Means with the same superscript along the column indicate no significant (P>0.05) difference.

Note: NFE, nitrogen free extract

Table 2: Mineral Components of commercial Fish Feed

	ECO float feed/ No of weeks				
Parameters (mg/kg)	(0) initial	(2)	(4)	(6)	(8)
Sodium	37.83±0.33[b]	36.67±0.83[b]	35.83±1.67[ab]	35.83±0.83[ab]	32.50±1.44[a]
Magnesium	2.43±0.03[c]	2.42±0.03[c]	2.31±0.02[b]	2.26±0.02[ab]	2.20±0.03[a]
Calcium	1.07±0.03[c]	1.03±0.33[c]	0.92±0.17[b]	0.87±0.02[ab]	0.80±0.08[a]
Potassium	17.33±16.67[b]	16.83±14.09[b]	16.67±44.09[ab]	15.33±44.09[a]	15.67±33.33[a]
Phosphorus	5.76±0.09[b]	5.73±0.02[b]	5.68±0.01[b]	5.63±0.02[b]	5.48±0.05[a]
Parameters (mg/kg)	Vital feeds				
Sodium	29.83±0.17[c]	28.33±1.67[bc]	26.67±0.83[bc]	25.83±0.83[ab]	23.33±0.83[a]
Magnesium	1.37±0.03[b]	1.36±0.02[b]	1.23±0.02[a]	1.18±0.02[a]	1.13±0.04[a]
Calcium	0.77±0.33[b]	0.73±0.03[b]	0.63±0.02[a]	0.62±0.02[a]	0.57±0.02[a]
Potassium	14.33±16.67[bc]	14.67±16.67[c]	14.33±16.67[bc]	13.83±16.67[b]	13.16±16.69[a]
Phosphorus	5.32±0.01[b]	5.31±0.01[b]	5.26±0.01[b]	5.20±0.02[ab]	5.08±1.19[a]

Means with the same superscript along the column indicate no significant ($P>0.05$) difference.

Conclusion And Recommendation

The results of proximate and mineral analysis obtained from this study conclude that, long time storage reduces the nutritional value of commercial fish feeds. Statistically, there were significant difference ($P<0.05$) between the initial and final weeks data collections for all the feed samples analyzed. High temperature also affects the rate of loss and damage in feeds, High temperature in feeds may occur not only because of environment and the way in which they are stored but because of the heat generated by the growth of fungi and insects. Fish feed cost is the largest single expensive item. Therefore, even a small reduction in wasted feed can significantly affect production cost and directly impact the bottom line profitability. Awareness creation and training should be given to the farmers on better and improved fish feed storage techniques in order to reduce the loss of fish feed due to long terms storage.

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Effect of garlic (*Allium sativum)* as feed additive on the performance and survival of African catfish (*Clarias gariepinus*)

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Abstract
A 56 days feeding trial was conducted to evaluate the effect of replacement of synthetic vitamin-mineral premix with wet and dry garlic on the performance of *Clarias gariepinus* fingerlings (2.16g±0.04). Three diets were formulated at 45% crude protein with inclusion of garlic (wet and dry forms) at 5% replacement level of the synthetic vitamin-mineral premix. There were significant differences ($p<0.05$) in the growth performance of the fishes. Diet containing 5% dry garlic had the best growth performance in terms of specific growth rate, mean weight gain, protein efficiency ratio and feed conversion ratio than the control diet. Therefore, the use of dry garlic at 5% inclusion level has the potential of improving on the growth performance of catfish.

Keywords: natural, additive, catfish

Introduction
Natural products of animals, plants and microbial sources have been used by man for thousands of years either in the pure forms or crude extracts to treat many diseases (Parekh and Chanda, 2007). Garlic (Allium sativum) has been used to enhance development of domesticated animals and fish (Megbowon et al., 2013). and treatment of infections (Shalaby et al., 2006).

The fresh bulb contains alliin, allicin and volatile oils. Allicin (diallyl-thiosulfinate) is the most abundant compound representing about 70% of all thiosulfinates present or formed in crushed garlic (Block, 1992; Han *et al*., 1995), it also gives garlic its distinctive pungent smell (Williamson, 2003). It also contains 33 sulfur compound, vitamins and minerals (Gruenwald, 2004) and trace elements (selenium & germanium), zinc, iron, potassium, fibre and water (Skidmore-Roth, 2003). When the garlic clove is crushed, the odorless compound alliin is converted to allicin, via the enzyme allinase. The allicin is a major antioxidant and scavenging compound, as recent studies revealed that other compounds such as polar compounds of phenolic and steroidal origin, which offer various pharmacological properties without odor and are also heat stable play stronger roles (Lanzotti, 2006).

The most abundant sulfur compound in garlic is the alliin (S-allyl-l-cysteine sulfoxide), which is present at 10 and 30 mg/g in dry and fresh respectively due to alliin loss to dehydration during drying (Mohammed, 2007 and Lawson, 1998). Garlic contains 17 amino acids: lysine, histidine, arginine, aspartic acid threonine, swine, glutamine, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tryptophan and phenylalanine (Josling, 2005).

Good nutrition in animal production systems is essential to economically produce a healthy, high quality product as against synthetic products. The current study seeks to evaluate the effect of wet and dry garlic as feed additives in the diet of *Clarias gariepinus* fingerlings.

Materials And Methods
Experimental site
The research was carried out in the laboratory of Water resources, Aquaculture and Fisheries Technology at the Federal University of Technology Minna; Niger State Gidan kwano campus.

Formulation of Experimental Diets
Maize, soya beans, fish meal, synthetic vitamin-mineral premix and fresh and dry garlic were obtained from Kure Ultra-Modern market, Bosso local government area of Niger state, Nigeria. All ingredients were ground into powdery form using a corn mill machine. The proximate chemical composition of feed ingredients and diets were estimated by the methods described by the (AOAC, 2000) for crude protein, lipid, ash, dry matter, fibre and nitrogen free extract contents (Tables 1 and 3) . Three experimental diets were formulated at 45% crude protein level and 5% garlic (wet and dry) replacement level of the synthetic vitamin-mineral premix using the Pearson square method (Table 2). The ingredients were thoroughly mixed together by hand. Warm water was added to the premixed ingredients and homogenized to a dough-like paste. The diet was sun dry for 4 days and stored in an airtight container throughout the experiment.

TABLE 1: Proximate Analysis of Experimental feed stuff

Feed stuffs	% crude Protein	% Lipid	% Moisture	% Crude fibre	% Ash
Maize	12.43	10.09	9.00	2.00	1.50
Soyabean	35.50	21.05	10.60	30.50	3.50
Fish meal	67.45	13.04	11.48	0.95	11.75
Dry garlic	17.65	0.93	4.50	3.25	1.35
Wet garlic	8.56	0.86	67.98	0.79	1.44

TABLE 2: Composition of experimental diets

Ingredients	Control diet	5% dried garlic-based diet	5% wet garlic-based diet
Maize meal	74.65	74.65	74.65
Soyabean meal	187.70	187.70	187.70
Fish meal	187.70	187.70	187.70
Dried garlic	0.00	25.00	0.00
Wet garlic	0.00	0.00	25.00
Synthetic Vitamin-mineral premix	25.00	0.00	0.00
Oil	25.00	25.00	25.00
Total	500.05	500.05	500.05

TABLE 3: Proximate Composition of experimental diets

Diets	% Crude protein	% Lipid	% Moisture	% Ash
Control diet	45.09	11.15	14.98	13.15
Dried garlic-based diet	44.73	13.28	9.76	16.15
Wet garlic-based diet	44.90	12.26	8.18	6.50

Experimental fish and Its management

One hundred and eighty (180) *Clarias gariepinus* fishes with an average body weight of 2.16g were used for the experiment. The fishes were transported in a plastic container and acclimatized for 5 days preceding the experiment. The experiment was carried out in 9 round plastic tanks (20cm x 10cm). Fishes were allotted at the rate of 20 fishes per tanks in triplicate of randomised design. The fishes were fed thrice daily at 3%, 5% and 7% body weight throughout the experiment for 56 days. Feacal matter and excess feed were siphoned out from the experimental tanks daily while water quality parameters were monitored.

Data collection and analysis

The weight of individual fish was determined with a weighing balance (citizen M300). The experimental tanks were examined on daily basis to remove dead fish and feacal matter. Data on fish growth characteristics were recorded fortnightly to generate the following growth parameters;

Specific growth rate (SGR) $\frac{\ln_e W2 - \ln_e W1}{T2 - T1} \times \frac{100}{1}$

where: W2 = Weight of fish at time T2 (final),

W1 = Weight of fish at time T1 (initial) and T1 and T2 are represented in days.

Feed conversion ratio (FCR): $\frac{\text{Total feed consumed by fish (g)}}{\text{weight gain by fish (g)}}$

Weight gain: Final weight of fish — initial weight of fish

Protein efficiency ratio: $\frac{weight\ gain}{protein\ fed}$; Protein fed= $\frac{\%\ CP}{100}$ x feed fed

Survival rate = $\frac{initial\ number\ of\ fish - final\ number\ of\ fish}{initial\ number\ of\ fish}$ x $\frac{100}{1}$

Apparent net protein utilization=$\frac{P2-P1}{total\ protein\ consumed}$ x $\frac{100}{1}$;
Where, P1 is the protein in fish carcass (g) at the beginning of the study and P2 is the protein in the fish carcass (g) at the end of the study.

Statistical Analysis
All data collected were subjected to one-way analysis of variance (ANOVA) using Minitab package (MINTAB release 2018). Means were separated by Duncan's multiple range tests as outline by Steel and Torrie (1980).

Results
Table 4 illustrates the growth and feed consumption of *Clarias gariepinus* fingerlings fed diets containing synthetic and natural additive (dried and wet garlic). The result obtained indicated significant differences ($p<0.05$) in certain cases among the treatments. There were no significant differences ($p>0.05$) in mean initial weight for all treatments. Also, the mean feed consumed did not show significant difference ($p>0.05$) among treatments. However, the dried garlic-based diet (diet II) gave the best values for mean final weight, specific growth rate, protein efficiency ratio, apparent net protein utilization and lowest feed conversion ratio. The trend was shown in figue 1 where the growth pattern was higher for dried garlic-based diet followed by synthetic and then the wet garlic-based diet respectively. The survival percentage was higher for wet-garlic-based diet than other treatments including the control diet.

Table 5: Growth parameters for *Clarias gariepinus* fingerlings fed with synthetic and natural additives for 56 days

Growth parameters	Diet I (Control diet)	Diet II (5% dried garlic-based diet)	Diet III (5% wet garlic-based diet)	SD±
Mean initial weight (g)	2.14±0.01^{a}	2.17±0.06^{a}	2.17±0.01^{a}	0.04
Mean final weight (g)	4.13±0.29^{b}	4.77±0.15^{a}	3.81±0.12^{b}	0.20
Mean weight gain (g)	1.99±0.27^{b}	2.60±0.19^{a}	1.64±0.12^{b}	0.20
Mean feed consumed (g)	6.72±0.34^{a}	6.80±0.28^{a}	6.34±0.22^{a}	0.28
Feed conversion ratio	3.41±0.34^{a}	2.62±0.11^{b}	3.87±0.17^{a}	0.22
Protein efficiency ratio	0.50±0.21^{b}	0.86±0.04^{a}	0.58±0.02^{b}	0.12
Specific growth rate (%/day)	1.17±0.11^{a}	1.41±0.10^{a}	1.00±0.06^{b}	0.09
Apparent net protein utilization (%)	1.67±0.57^{c}	2.29±0.02^{b}	3.03±0.68^{a}	0.42
Survival (%)	50	50	67	

Row means with different superscripts are significantly different at ($p<0.05$).

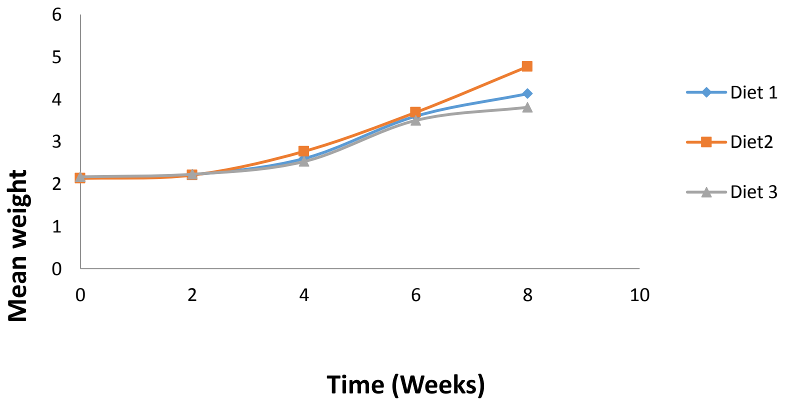

figure 1: Growth response of *Clarias gariepinus* fed with 5% dried and wet garlic

Discussion

When medicinal plants are used in fish diets, one of the challenges is feed acceptability by fish (Rodriguez *et al.*, 1996), this is in contrary to the finding in this research where garlic based diets were acceptable like the control diet to the fish. Garlic has been reported to promotes growth, enhances immunity, stimulates appetite, and strengthens the control of bacterial and fungal pathogens (Shubha, 2014) this is in agreement with the results obtained from fish fed garlic as it gave the best growth performance in terms of growth and survival due to its antioxidant properties (Megbowon *et al.*, 2013; Rahman, 2003). The present results were in contrast with those obtained by (Sahu *et al*., 2007) who reported that feed conversion ratio (FCR) in fish fed with 0.5%, 1% garlic powder/kg diet was not significantly different as compared with those in the control. In addition, Horton *et al*., 1991; Freitas *et al*., 2001) reported that garlic did not affect growth performance in livestock fed diet containing garlic because of the pungent smell which may lead to lower diet palatability contrary to the finding from this research where dried garlic as feed additive enhances nutrient utilization as revealed in the protein efficiency ratio (PER) than wet garlic, this could be attributed to the concentration of allicin in the additive.

Conclusion

The study indicated that dried garlic at 5% inclusion level can be used to improve fish growth, nutrient utilization and survival there by reducing dependency on synthetic vitamin-mineral premix.

Recommendation

Fish farmers can use dried garlic as natural additive in the diet of catfish for growth enhancement.

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Growth performance, hematology and intestinal microflora of *Clarias gariepinus* (BURCHELL, 1822) fingerlings fed turmeric (*Curcuma longa*) supplemented diets

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Abstract
The effects of different supplementation levels of dietary turmeric (*Curcuma longa*) powder on growth and survival, hematology and intestinal microflora of *C. gariepinus* fingerlings was investigated in this study. Five isonitrogenous (%CP) and isocaloric diets were supplemented with turmeric powder at 0%, 0.75%, 1.5%, 2.25% and 3.00% denoted as CTR, T2, T3, T4 and T5 respectively. Turmeric supplemented diets did not have any significant effect ($p > 0.05$) on the percentage weight gain, final weight and survival rate (%) of *Clarias gariepinus* fingerlings when compared to fish fed the control diet with 0% concentration of turmeric powder. The blood parameters were recorded to be highest in the control diet (CTR) and decreased across the treatments. Significant differences ($p < 0.05$) were observed in the white blood cell count of fish fed T3, T4 and T5. The highest bacteria load was recorded in fish fed control diet (CTR) and the lowest was recorded in fish fed T5. The total bacteria load in fish decrease across the treatment with the highest (3.70±0.10) recorded in fish fed the control diet (CTR) and the lowest (1.33±0.15) bacteria load found in fish fed T5. The result of the present study shows that the turmeric supplemented diets does not enhance the growth performance of *C. gariepinus* fingerlings. Furthermore, the blood parameters of the fish showed the diet does not improve the innate immune response of the experimental fish. However, the high survival rate of the fish throughout the experimental period is attributed to antimicrobial properties which provide better relative protection against pathogen.

Keywords: Turmeric, growth, hematology, intestinal microflora, antimicrobial, pathogen

Introduction
The use of various herbs and medicinal plants has a long history. They have been used since ancient times, especially in oriental countries, as remedial measures against various animal and human ailments. However, the intensification of livestock production and the advent of antibiotics led to a decline in their usage and less interest in providing scientific bases to their effects (Makkar *et al*., 2007). Turmeric (*C. longa* L.) botanically related to ginger (Zingiberaceae family), is a medicinal plant extensively used in medicine. It is a perennial plant with pyriform or oblong rhizomes, which are often branched and brownish-yellow in colour. Turmeric is used as a food additive (spice), preservative and colouring agent in Asian countries, including China and South East Asia. Curcumin (diferuloylmethane), the active constituent of Turmeric, is responsible for the yellow colour, and comprises curcumin I (94%), curcumin II (6%) and curcumin III (0.3%). It has been found to be antibacterial (Lutomski *et al.*, 1974), antiprotozoan (Shankar *et al.,* 1979), antiviral (Mazumdar *et al*., 1995), antioxidant (Sharma *et al.,* 1976; Joe *et al.,* 1994), antitumor (Deeb *et al.,* 2003), and anticarcinogenic (Chen *et al.,* 1998). This study was conducted to determine the growth performance, hematology and intestinal microflora of *C. gariepinus* fingerlings fed turmeric (*C. longa* L.) supplemented diets at varying inclusion levels.

Materials and Methods
C. longa rhizome was purchased from a local market in Abeokuta, Ogun State. Identification and authentication were done at the Department of Plant Physiology and Crop Protection, Federal University of Agriculture, Abeokuta. The turmeric (*C. longa*) was peeled and grounded into powdery form using Kenwood electric Blender (BL440 – UK).

Collection and Acclimatization of Experimental Fish
One hundred and fifty *C. gariepinus* fingerlings with an average weight of 1.20±0.00g were bought from a reputable fish farm in Obantoko, Abeokuta. The fish were acclimatized for two weeks in plastic troughs after which they were batch-weighed and randomly distributed numbering 10 fish per trough. The fish were starved for 24 hours to maintain a uniform stomach condition and to induce their appetite prior to the commencement of the experiment.

Formulation of Experimental Diets

Five isonitrogenous diets were formulated containing varying levels of turmeric (*C. longa* L.) at 0%, 0.75%, 1.5%, 2.25%, 3.00% designated as T1, T2, T3, T4, and T5 respectively. The diets were formulated to provide 40% crude protein using basal diets. All ingredients were milled to small particles sizes and weighed with a weighing top balance (Model PB-8001). The ingredients were thoroughly mixed in a container and pelletized with a Horbart A-200T pelleting machine. The diets were sundried and stored in air-tight polythene bags to avoid rancidity. The bags were labeled and stored in the refrigerator (-4^{0}C) prior to the commencement of the experiment.

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

INGREDIENT	CTR (%)	T2 (%)	T3 (%)	T4 (%)	T5 (%)
Fish Meal	26.88	26.94	27.01	27.04	27.12
Soyabean Meal	26.88	26.94	27.01	27.04	27.12
Groundnut Cake	13.44	13.47	13.51	13.52	13.56
Maize	25.05	24.15	23.31	22.40	21.45
Vegetable Oil	5	5	5	5	5
Vitamin Premix	1	1	1	1	1
Dcp	0.5	0.5	0.5	0.5	0.5
SALT	0.25	0.25	0.25	0.25	0.25
Methionine	0.5	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5	0.5
Turmeric	0	0.75	1.5	2.25	3
Total	**100**	**100**	**100**	**100**	**100**

Vitamin-mineral premix constituents: Vitamin A: 8,000,000 iu, Vitamin D3: 1,600,000 iu, Vitamin E: 6,000 iu, Vitamin K: 2,000mg, Thiamine B1: 15,000mg, Riboflavin: 4,000mg, Pyridoxine: 15,000mg, Niacin: 15,000mg, Vitamin B12: 10mg, Pantothenic acid: 5,000mg, Folic Acid: 500mg, Biotin: 20mg, choline chlorine: 200g, Antioxidant: 125g, Manganese: 80g, Zinc: 50g, Iron: 20g, Copper: 5g, Iodine: 1.2g, Selenium: 200mg, Cobalt: 200mg (Source: Hi-Nutrients International Ltd, 2017).

Experimental Procedure

The fish were stocked into fifteen 60-litre capacity rectangular plastic troughs that has been cleaned thoroughly with water and net sponges and disinfected with salt solution. The fish were stocked at a density of ten (10) fish per trough in three replicates per treatment. Fish mortality was recorded daily and weekly weight gain was carried out using electronic weighing balance. Aerator (RESUN ACO-003, China) was used to ensure adequate and constant supply of dissolved oxygen for the fish throughout the experimental period. Fish were fed at 5% body weight daily in two equal meals between 08.00 to 09.00 and 17.00 to 18.00 hrs with the experimental diet throughout the study period. Water quality parameters such as temperature, pH, dissolved oxygen, ammonia and nitrate concentration were monitored throughout the study using Hanna Aquaculture Photometer (HI989106 model).

Growth Performance Analysis

The growth and nutrient utilization indices were evaluated as described by Fasakin *et al.,* (2003).

Mean Weight Gain = Final Weight Gain – Initial Weight Gain

Specific growth rate = (Loge W_2 – Loge $W_1 \times 100$) ÷ T

Feed Conversion Ratio (FCR) = Feed Intake (g) ÷ weight gain (g)

Percentage Weight Gain (PWG) = (final weight gain – initial weight gain) x100

Protein Efficiency Ratio = Weight Gain / Protein Fed

Apparent Net Protein Utilization = Protein Gain/ Protein Fed $\times$ 100

Intestinal Microflora

Bacteria count: estimation of total bacteria count in gut samples was done according to method of Miles and Misra (1985). Bacteria culture, isolation and identification were carried out and identified according to the method of bacteria identification by Cowan and Steel (2003).

Heamatological Analysis

At the end of the experiment, three fish from each tank were randomly taken for quick blood sampling before the fish were weighed to reduce the incidence of handling stress on the fish. Blood (1–2 ml, depending on fish size) was collected from the vertebral blood vessels towards the caudal peduncle of each fish using separate heparinized syringes. The following blood parameters were analysed and recorded: Parked Cell Volume, Haemoglobin, Red Blood Cell, White blood cell, Mean Cell Volume, Mean Cell Haemoglobin, Mean Cell Haemoglobin Concentrate, and Lymphocyteas described by (Blaxhall and Daisley, 1973)

Data Analysis

Experimental design used was the completely randomized design with equal replicates. All experimental data were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS) Package 22.0 at P-Level of < 0.05. New Duncan's Multiple Range Test was used to compare differences among individual means.

Results

Growth Performance, Nutrient Utilization Parameters and Survival Rate

The growth performance, nutrient utilization parameters and survival rate of *C. gariepinus* fingerlings fed turmeric (*C. longa* L.) in this study are presented in Table 2. In all treatments, growth performance reduced with increment in percentage of turmeric in the experimental diets. Significant differences were observed in the final mean weight (FMW), percentage weight gain (PWG), feed intake (FI), feed conversion rate (FCR), Daily growth rate (DGR), protein efficiency ratio (PER), Apparent Net Protein Utilization (ANPU). No significant differences were observed in the Initial Mean Weight (IMW) and Survival of Experimental fish.

The highest FMW (9.51 ± 1.33) was observed in fish fed control diet (CTR) and the lowest FMW (6.78 ± 1.56) was observed in fish fed T5. The percentage weight gain of experimental fish decreased with the increment in inclusion of turmeric (*C. longa*) in experimental diet. Fish fed the control diet (CTR) has the highest PWG (6.93 ± 111.18) and the lowest PWG (6.78 ± 105.82) was recorded in fish fed T5. Similar trend was recorded for the daily growth rate in which the highest (0.15 ± 0.03) was recorded in fish fed control diet (CTR) and the lowest DGR (0.09 ± 0.02) was recorded in fish fed experimental diet 5 (T5). The feed conversion ratio (FCR) was best (1.02 ± 0.01) in fish fed the control diet (CTR) and fish fed T5 had the least FCR (2.03 ± 0.01).

Table 2: Growth response and nutrient utilization parameters of *C. gariepinus* fingerlings fed various levels of Turmeric (*C. longa*)

PARAMETERS	CTR	T2	T3	T4	T5
Initial Mean Weight (g)	1.20 ± 0.00	1.17 ± 0.06	1.13 ± 0.06	1.13 ± 0.12	1.17 ± 0.12
Final Mean Weight (g)	9.51 ± 1.33^{a}	9.10 ± 1.53^{ab}	7.41 ± 0.65^{ab}	7.32 ± 1.12^{ab}	6.78 ± 1.56^{b}
Mean Weight Gain (g)	8.31 ± 1.34^{a}	7.93 ± 1.49^{ab}	6.27 ± 0.57^{ab}	6.18 ± 1.07^{ab}	5.61 ± 1.49^{b}
Percentage Weight Gain (%)	6.93 ± 1.18^{a}	6.78 ± 105.83^{a}	5.55 ± 43.73^{ab}	5.44 ± 73.53^{ab}	4.80 ± 1.33^{b}
Feed Intake (g)	8.50 ± 1.38^{a}	8.41 ± 1.62^{ab}	7.80 ± 0.78^{b}	8.96 ± 1.38^{ab}	11.41 ± 3.07^{a}
Feed Conversion Rate	1.02 ± 0.01^{e}	1.06 ± 0.02^{d}	1.24 ± 0.02^{c}	1.45 ± 0.31^{b}	2.03 ± 0.01^{a}
Daily Growth Rate	0.15 ± 0.03^{a}	0.14 ± 0.03^{a}	0.11 ± 0.01^{ab}	0.11 ± 0.02^{b}	0.09 ± 0.03^{b}
Protein Efficiency Ratio	2.44 ± 0.03^{e}	2.35 ± 0.05^{d}	2.01 ± 0.04^{c}	1.72 ± 0.04^{b}	1.23 ± 0.01^{a}
Apparent Net Protein Utilization	95.53 ± 1.08^{a}	90.85 ± 2.17^{b}	88.55 ± 0.92^{bc}	86.35 ± 0.81^{bc}	84.62 ± 4.67^{c}
Survival (%)	100.00 ± 0.00	90.00 ± 10.00	96.67 ± 5.77	100.00 ± 0.00	90.00 ± 0.00

^{a,b,c,d}mean values in the same row with different superscript are significantly different ($p<0.05$)

Hematological profile of *C. gariepinus* fingerlings

The results of blood parameters of *C. gariepinus* fingerlings fed varying level of Turmeric *C. longa* in terms of Packed cell volume (PCV), Heamoglobin (HB), White blood cells count (WCB), Red blood cell count (RBC), Neutrophil (NEUT), Lymphocytes (LYM), Eosinophil (EOS), Monocytes (MON) are presented in Table 3. Blood parameters are recorded to be highest in the control diet (CTR) and decrease across the treatments. Significant differences were observed in the white blood cell count of fish fed diet 3 (T3), diet 4 (T4) and diet 5 (T5). Similarly, the percentage neutrophil (NEUT) content in the blood of fish across the treatment is significantly different at ($p<0.05$).

Table 3: Hematological Parameters of *C. gariepinus* fingerlings fed turmeric *C. longa* diets

PARAMETERS	CTR	T2	T3	T4	T5
PCV (%)	30.00 ± 0.00	29.00 ± 1.00	28.00 ± 2.00	26.00 ± 0.00	26.00 ± 4.00
HB (G/DL)	13.33 ± 3.51	9.70 ± 1.47	9.70 ± 2.56	8.70 ± 3.32	8.66 ± 3.29
RBC (X 10^{12}/L)	2.84 ± 0.66	2.71 ± 0.86	2.66 ± 0.66	2.47 ± 0.55	2.43 ± 0.50
WBC (X 10^{3}/L)	19.2 ± 2.66^{a}	16.00 ± 5.29^{a}	9.60 ± 0.62^{b}	6.30 ± 0.92^{bc}	3.30 ± 0.81^{c}
NEUT (%)	50.00 ± 0.00^{a}	47.00 ± 4.00^{ab}	43.00 ± 5.29^{abc}	41.00 ± 7.00^{bc}	37.00 ± 1.73^{c}

LYM (%)	60.00±19.28	55.00±3.60	54.00±4.35	57.00±2.00	47.00±4.58
EOS (%)	3.00±1.00	3.00±1.73	3.00±1.00	2.00±1.00	2.00±0.00
MON (%)	1.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
BAS (%)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

Values on the same row having the same superscript are not significantly different (p>0.05).

PCV- Packed Cell Volume, HB- Haemoglobin, RBC-Red Blood Cell, WBC- White Blood Cell, HET- Heterophyls, LYM- Lymphocytes, EOS- Eosinophil, BAS- Basophil, MON- Monocytes, TRIG- Triglyceride

Intestinal microflora

The rate of occurrence of bacteria in the experimental fish after the feeding trials is presented in Table 4. The highest bacteria load was recorded in fish fed control diet (CTR) and the lowest was recorded in fish fed T5. The total bacteria load in fish decrease across the treatment with the highest (3.70±0.10) recorded in fish fed the control diet (ctr) aand the lowest (1.33±0.15) bacteria load found in fish fed T5.

Table 4: Intestinal Microflora OF *C. gariepinus* fingerlings fed turmeric supplemented diets

	TBC ($x10^6$ CFU/g)		A	B	C	D	E	F
CTR	3.7	3.6 3.7 3.8	+	+	+	-	+	-
T2	2.8	2.8 3.0 2.7	+	+	-	-	-	+
T3	2.3	2.5 2.3 2.2	-	+	+	+	-	-
T4	2.2	2.4 2.0 2.2	-	+	+	-	+	-
T5	1.3	1.5 1.3 1.2	+	-	+	-	+	-

KEY: A = *Escherichia coli;* B = *Aeromonas* species; C = *Pseudomonas fluorescence;* D = *Klebsiella* species E = *Citrobacter* species*;* F = *Serratia* species*;* + = PRESENT*;* - = ABSENT

Table 5: Microbial Count of *C. gariepinus* fingerlings fed turmeric *C. longa* supplemented diets

TOTAL BACTERIA COUNT ($\times 10^6$ CFU/g)					
TREATMENT	CTR	TRT 2	TRT 3	TRT 4	TRT 5
TBC ($\times 10^6$ CFU/g)	3.70 ± 0.10^a	2.83 ± 0.15^b	2.33 ± 0.15^c	2.20 ± 0.20^c	1.33 ± 0.15^d

Fish survival

The survival rate of *C. gariepinus* fed turmeric *C. longa* supplemented diets ranges between 90.00±0.00 and 100±0.00 as shown in Table 2. No significant difference in the survival rate of fish fed experimental diets across the treatment.

Table 6: Whole body chemical composition (% dry matter) of *C. gariepinus* fingerlings fed varying levels of *C. longa* based diets

PARAMETERS	INITIAL	CTR	T2	T3	T4	T5
CRUDE PROTEIN	57.50	47.44	57.98	61.50	42.30	48.57
CRUDE FIBRE	4.49	4.43	1.00	5.99	4.08	5.63
MOISTURE	81.92	80.63	78.83	81.87	77.93	79.00
ASH	6.55	6.38	6.00	5.10	7.03	3.04
FAT EXTRACT	18.50	18.30	21.48	19.10	21.32	20.57
NFE	12.96	21.45	10.49	8.31	25.27	22.19

Table 7: Proximate Composition (% dry matter) of the Experimental Diets containing varying levels of turmeric (*C. longa*) fed to *C. gariepinus* Fingerlings

PROXIMATE COMPOSITION (%)	CTR	T2	T3	T4	T5
CRUDE PROTEIN	40.45	40.14	38.99	40.02	39.06
CRUDE FIBRE	6.38	6.20	4.05	4.20	3.80
MOISTURE	8.80	12.28	12.10	11.99	14.48
ASH	4.50	4.76	5.29	6.20	5.33
FAT EXTRACT	21.50	18.02	17.63	18.80	17.10
NFE	27.17	30.88	34.04	30.96	34.71

Discussion

Growth and nutrient utilization

Diets of *C. gariepinus* did not improve the growth performance and nutrient utilization indices throughout the experiment. The weight gain of experimental fish is observed to decrease with increasing inclusion levels of *C. longa*. Significant differences occurred in the final weight of fish fed control diet (CTR) which has 0% inclusion level of *C. longa* compared to fish fed the highest (3 %) inclusion level of *C. longa*. A completely opposite trend, in terms of growth performance was observed by Adeshina *et al.,* (2017) who fed *C. gariepinus* juveniles with diets fortified with *C. longa* leaf. In the study, growth performance of *C. gariepinus* juveniles increased proportionately with increase in inclusion of level of *C. longa* leaf. Abdel-tawab *et al.,* (2016) also recorded a positive growth trend in common carp *Cyprinus carpio*, after feeding the fish with turmeric powder diets for 70 days.

Blood parameters

Haematological parameters are important health indicators which reveal the health conditions of fish regarding diseases and immune system conditions before and after an experiment (Bello, 2014). RBC and Hb are known to indicate erythrocyte status and oxygen carrying capability in fish (Houston, 1997). Blood parameters of fish in the present study, is observed to decrease across the treatment with increasing supplementation of turmeric powder in the diets of *C. gariepinus* fingerlings. The present study revealed that there were significant differences ($p<0.05$) among treatment groups (Table 3). Highest values for PCV, RBC, HB, WBC, LYM, BAS were seen in fish fed the control (CTR) diet while the lowest values of blood parameters are observed in fish fed diets containing 3% turmeric powder supplementation. The WBC of fish or any animal is a function of the immunity and the animal's resistance to some vulnerable illness or disease (Akinwande *et al.,* 2004). The population of WBC decreased across the diets giving an indication that the fish fed diets containing 0% inclusion level of turmeric developed higher immunity to environmental factors during the experiment. However, contrary to what is obtained in the present study, *Oreochromis niloticus* fed *Aloe vera* supplemented diets (0.5%, 1%, 2% and 4% per kg feed) showed no significant differences in hematological parameters (Gabriel, 2015). However, all the haematological parameters are within the normal range in teleosts (Adedeji and Adegbile, 2011).

Intestinal microflora

Bacteria and other microogranisms are abundant in the environment in which fish live and it is therefore impossible for fish to avoid them being a component of their diet (Strom and Olafsen, 1990). The bacteria entering along with the diet of fish during ingestion may adapt themselves in the gastro intestinal tract and form symbiotic association within the digestive tract of fish in which large numbers of microbes are present which is much higher than in surrounding water indicating that digestive tracts of fish provide favorable ecological niches for these organisms (Jimoh *et al.,* 2014). Representatives of 25 bacteria genera have been reported as pathogen of freshwater or marine fish (Cameron, 2002). In the present study, the microbial load in the gut of *C. gariepinus* fingerlings fed turmeric

C. longa supplemented diets is similar with earlier works by Mondal *et al.*, (2008) and Jimoh *et al.*, (2014). The microflora isolated in the gastrointestinal tract of the experimental fish in the present study were *Escherichia coli, Aeromonas* species, *Pseudomonas fluorescence, Klebsiella* species, *Citribacter* species and *Serratia* species. Haniffa and Abdulkader (2011) reported that bacteria especially motile *Aeromonads* are frequently isolated from both healthy and diseased fish as well as from other aquatic animals.

Conclusion

The results of the present study shows that high inclusion levels of turmeric *C. longa* in the diets of *C. gariepinus* fingerlings does not improve the growth performance and nutrient utilization of the fish. Furthermore, high level blood parameters found in *C. gariepinus* fingerlings fed lower inclusion levels of turmeric *C. longa* supplemented diets is responsible for better innate immune response parameters of the fish. Lower Bacteria count found in fish fed higher inclusion levels of turmeric *C. longa* is attributed to antimicrobial properties of *C. longa* which provide better relative protection against pathogen. *C. longa* contains turmerone, curcuminoids, zingiberene and curcumin which are antimicrobial agents and serve as bactericidal and bacteriostatic agents in the body of *C. gariepinus* fingerlings.

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Nutritional analysis of *Clarias gariepinus* cultured with *Spirulina* supplemented diets

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Abstract
Fish nutrition has been a major cost of fish production in Aquaculture and Fisheries hence it has been very important for fisheries nutritionist to keep on searching for some better alternatives to reduce cost of fish production consequent by fish feed. It was in this regard that a research was conducted to ascertain the Growth indices and Proximate profile of *Clarias gariepinus* cultured with Spirulina supplemented diets at 0% (T1), 10% (T2), 20% (T3) and 30% (T4) treatments respectively. After 60 days feeding trials, samples were randomly collected, oven dry and prepared for Proximate indices. Results followed the following trend: Growth, T4>T2>T3>T1, (P<0.05 between T4 and T1), Length: T4>T2>T3>T1, (P<0.05 between T4 and T1), Survivial: T1>T3>T2>T4, Proximate indice: T1>T3>T4>T2. The supplementation of commercial fish diets with Spirulina powder have a positive impact on the growth indices, haematological indices, fatty and amino acid profile of *Clarias gariepinus.* It is therefore, recommended for utilization in commercial fish production to maximize profit.

Keywords: Nutritional indices, *Clarias gariepinus*, Spirulina, Growth indices and Proximate indices

Introduction

Fisheries and aquaculture make crucial contributions to the world's well-being and prosperity. In the last five decades, world fish food supply has outpaced global population growth, and today fish constitutes an important source of nutritious food and animal protein for much of the world's population (FAO, 2010). In addition, after the pandemic of Covid-19 in 2020, many sectors were affected including the livestock feed industries that provide feed for Aquaculture sector, unfortunately, the sector provides livelihoods and income, both directly and indirectly, for a significant share of the world's population (Mathiesen, 2012). The aquaculture growth has relied heavily on fishmeal and fish oil. Fishmeal is an internationally traded, high protein powder, which results from the industrial processing of small pelagic fish (e.g. anchovy, sardine, capelin, and herring). It is a key component of the aqua feed of salmon, trout, shrimp and other farmed marine species (Naylor *et al.*, 2009), supplying essential amino acids, fatty acids and other micronutrients (Tacon and Metian, 2008). Due to these properties, fishmeal (FM) has become one of the primary components of commercial feed formulations. The demand for FM in aquatic feeds has been estimated to account for 31% to 42.5% of total world FM production (Tacon and Barg, 1998). However, as a result of a decreasing supply of fishery byproducts and concerns over its quality, the aquaculture industry is now actively investigating alternatives nutrient sources (Naylor *et al.,* 2000). In the last two decades, although worldwide FM production remained at a relatively stable level, it still could not match the rapid worldwide development of aquaculture (Goytortua-Bores *et al.,* 2006). The cost of FM increased constantly, which caused the price of commercial feed increase sharply. Thus, there is an urgent need to find alternative protein sources to make up for the shortage of FM and to secure a stable supply for commercial diets (Hardy, 2001). Nowadays, considerable interest and research have been focused on the developing unicellular organisms such as yeast, molds, bacteria, microalgae and fungi as additives to aquaculture feeds.

The microorganism called "*spirulina*" was so named this because of its spiral filament-like appearance under the microscope (and is classified as cyanobacterium). The nutritional composition of spirulina may vary according to the growing conditions. For example, the iodine content will vary as a function when the spirulina is grown in sea water vs. fresh water. It should be noted that the cell wall of spirulina is composed of protein, carbohydrates and fat and not from indigestible cellulose. Bioavailability of nutrients from spirulina is more than that from other food sources, especially plant food sources. Spirulina has an exceptionally high protein content (on the order of 60-70% of its dry weight), of which 90% is digestible. The use of plant products as protein supplements and sources in fish feeds shows considerable application potential for aquaculture worldwide (FAO, 2010). Spirulina is a multicellular and filamentous blue-algae that has gained considerable popularity in the health food industry and increasable as a protein and vitamin supplement to aquaculture diets (Habib *et al.*, 2008).

The biological value of algae protein varies according to the algae species (Becker, 2007). The main objective of the present study was conducted to analyze the nutrient profile such as proximate composition, mineral content and amino acid profile of species of freshwater algae (*Spirulina platensis)* powder for the purpose of using alternative protein source or additives for aquaculture feeds using Catfish (*Clarias gariepinus*).

Materials and Method

Experimental site

The field experiment was conducted at the Benoso farm, Afikpo Experimental Station. Afikpo spans an approximately 164 square kilometers in size. It is located on 6-degree north latitude and 8-degree east longitude.

It occupies an area of about 64 square miles ($164km^2$). Afikpo is a hilly area despite occupying a region low in altitude. It is a transitional area between open grassland and tropical forest and has an average annual rainfall of 1955.8mm (195. 58cm).

Experimental Design

Experiment Fish

150 fingerlings of African cat fish *Clarias gariepinus* was purchased from Benoso farm at Amaobolobo Afikpo in Afikpo North Local Government area of Ebonyi state. The fishes were transported to animal unit of Science laboratory Technology, in Akanu Ibiam Federal Polytechnic, Unwana in 25 litres container with opening in both side to ensure proper natural oxygenation of the water containing the fishes were kept for one week to acclimate to the animal house condition.

Experimental Fish Treatment

The experimental fish was grouped into the following treatment.

DIET 1: The commercial feed containing 0g (0%) of dry Spirulina powder (T_1).

DIET 2: The commercial feed supplemented with 10g (10%) of dry Spirulina powder (T_2).

DIET 3: The commercial feed supplemented with 20g (20%) of dry Spirulina powder (T_3).

DIET 4: The commercial feed supplemented with 30g (30%) of dry Spirulina powder (T_4).

Experimental Diet

Experimental diet was prepared by adding various percentage of spirulina powder to every 100g of used commercial feed with the ingredient well mixed with water to obtain dough. Then the dough was molded into pellet for easy assumption. The pellets were dried at room temperature for a few days and crushed to yield fine particles.

Experimental Design II

Analytical methods

Growth Indices

They following formula were used in the calculation of growth indices;

Total weight gain (TWG) = Final weight gain (g) – initial weight gain of the fish.

Percentage Weight Gain (PWG) = Total Weight Gain (g)/Final Weight x 100/1

Average daily weight gain (ADWG) = PWG/Time (days).

Total length gain (TLG) = Final Length Gain (g) – Initial Length Gain of the fish.

Percentage length gain (% LG) = Total Length Gain/Final Length Gain x 100/1

Average daily length gain (ADLG) = Percentage Length Gain/Time (days).

Survival Rate (SR) = Initial Number – Final Number of Fish

Percentage Survival Rate (PSR) = Initial – final x 100/1

Proximate Indices of Cultured fish

The protein content of freeze-dried duckweeds was calculated via the Kjeldahl procedure using the N factor 6.25. The quantitative determination of AA in duckweed samples was based on the chemical properties of the proteinogenic AA. Majority of the proteinogenic AA was determined after subjecting the samples to acid hydrolysis with phenolic hydrochloric acid. For the Sulphur containing AA, methionine and cysteine, an oxidation was performed before acid hydrolysis. The separation of AA occurred by means of ion exchange chromatography (Biochrom 30, Labor service Onken, Gründau, Germany) and post column derivatization was carried out with ninhydrin according to the method of Klaus-J. *et al.* (2016).

Data Analysis

Data were presented as mean ± SE unless otherwise stated. Data were analyzed using one-way analysis of variance (ANOVA), Duncan's multiple range test and, where appropriate, by Student's t-test (SPSS software 19.0). Statistical significance was accepted at $P < 0.05$ level.

Result

Weight Gain

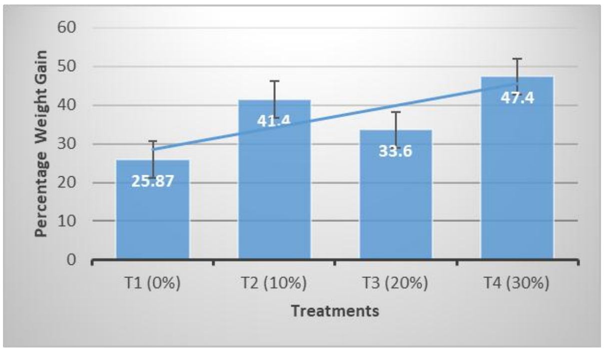


Figure 1: Variations in weight gain in *Clarias gariepinus* treated with various percentages of Spirulina Powder

Length Gain

The results for length rate recorded indicate that there was no significant (p>0.05) between T1 and the rest of the treatments.

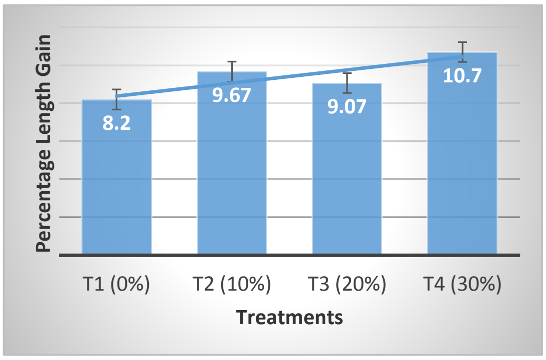


Figure 2: Variations in length gain in *Clarias gariepinus* treated with different percentages of the power

Survival Rate

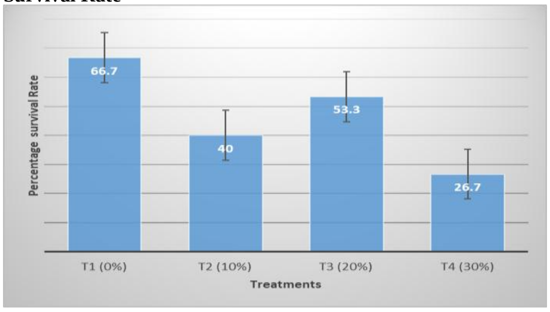


Figure 3: Variations in survival rate among various treatments

Comparing Weight, Length and Survival rates of T1-T4

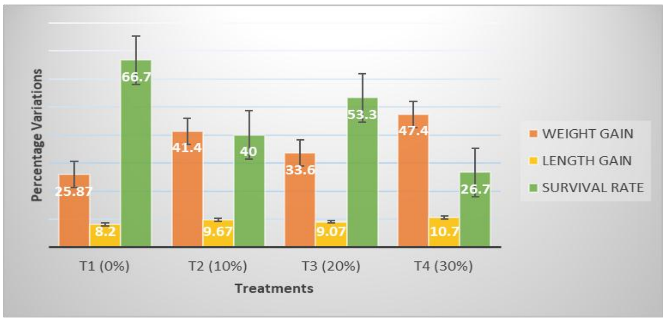
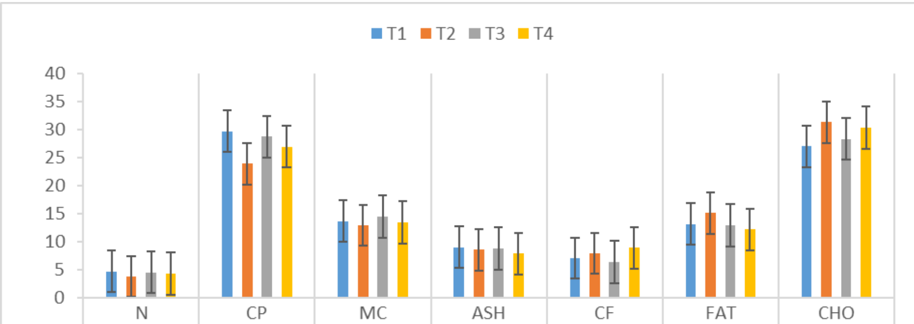


Figure 4: Variations in weight gain, length gain and survival rate among the treatments.



	N	CP	MC	ASH	CF	FAT	CHO
T1	4.76	29.78	13.74	9.06	7.13	13.22	27.06
T2	3.83	23.95	12.96	8.62	7.95	15.14	31.38
T3	4.6	28.77	14.57	8.85	6.44	13	28.37
T4	4.32	27.02	13.5	7.92	8.94	12.2	30.42

Figure 5: Variations in Proximate Analysis of Cultured fishes among Treatments

Discussion, Conclusion and Recommendation

Discussion

In the present study, use of spirulina as supplement in *C. gariepinus* diets at different percentage was evaluated and it was found that increasing level of it in the diet provided better growth comparing to the other commercial feed that are not supplemented and they were consumed fondly. The findings were similar to the work of Seval *et al.* (2010) on the effect of dietary supplementation of different rates of Spirulina (*Spirulina platensis*) on growth and feed conversion in Guppy.

Nandeesha *et al.* (2001) report found that the Rohu fish increased its growth, protein efficiency ratio, digestibility of dry matter, and both protein and lipid content in correlation with the amount of *Spirulina* consumed. They concluded that it was suitable to use *Spirulina* as a protein supplement source for both fish. These results showed that *Spirulina* could improve growth, reduction of mortality; overall elements of fish quality, firmness of flesh, brightness of skin color as well as improving the cost/performance ratio of the fish feed. Similar results were reported by previous researchers (Tongsiri *et al.,* 2010).

James *et al.* (2006) evaluated the effect of dietary spirulina level on growth performance and feed intake in red swordtail (*Xiphophorus helleri*) and they reported that SGR, feed intake and mean body weight increased with increasing level of spirulina. Fish fed with 8% spirulina also performed better than those fed with lower levels, similarly, in this study, fish fed with 30% supplementation of Spirulina had highest growth performance when compared with 20%, 10% and 0%.

Jaime-Ceballos *et al.* (2005) studies the effect of *Spirulina Platensis* meal inclusion in microdiets for white sharmp *Litopenaeus schmitti* larvae. Also the work of Seval *et al.* (2010) shows that those fed with higher percentage of supplementation also have lesser survival rate of 96% for 30% when compared with the control that is 98%. In this study, survival was around also found higher at 30% rate too though much lesser than the result recorded 26% against 66% compared with the control in this study.

Palmegiano *et al*. (2005) reported that sturgeon (*Acipenser baeri*) fed by diets containing spirulina meal had better growth than the control diets and particularly 50% inclusion seemed to result the best performance; a high increase in biomass gain and growth rate, the best FCR and a high protein efficiency rate. Seval *et al.* (2010) also reported that spirulina meal was an excellent substitute for commercial diets in lepistes diet as even at the high substitution level (40%). In a study by Rogatto *et al.* (2004), the influence of spirulina intake on metabolism of exercised rats were determined and reported that this seaweed might be a good alternative of protein.

Shabana and Arabi (2012) reported that fish has 22% protein. Similarly, in this study, it was recorded that studied fishes have between 24% and 29% (fig. 5) which shows that the results were greater when their diets are supplemented with Spirulina.

Conclusion

Fish nutrition has been established to be a major cost of fish production in Aquaculture and Fisheries hence it has been very important for fisheries nutritionist to keep on searching for some better alternatives to reduce cost of fish production consequent by fish feed. It was in this regard that a research was conducted to ascertain the growth indices and proximate profile of *Clarias gariepinus* cultured with Spirulina supplemented diets. The supplemented commercial fish diets with Spirulina powder had a positive impact on the growth indices, haematological indices, fatty and amino acid profile of *Clarias gariepinus.* The present study also showed that the usage of spirulina inclusion up to 30% can be possible in the aquarium fish diet.

Recommendation

Based on the findings from this study, it is therefore recommended that farmers should supplement their feed with *Spirulina platensis* powder and can as well replace fish meal partially as source of protein. However, proper water management is highly recommended as well to ensure increase in survival rate as it was observed from this study that poor water management must have contributed in the lower survival rate recorded in this study.

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Effect of graded level of Ziziphus *mauritania* leaf meal on growth performance and reproductive indices of *Oreochromis niloticus*

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Abstract
This study was carried out to determine the effect of graded level of *Ziziphus mauritania* leaf meal on growth performance and reproductive indices of *Oreochromis niloticus* at different inclusion level. Four different (0, 10, 20 and 30%) inclusions of *Ziziphus Mauritania* leaf meal were incorporated into 25% crude protein diets and fed juveniles of *Oreochromis niloticus* (pooled weight of 55.4g and 14.8cm length). The fish were fed with experimental diet for 56 days, twice a day (morning and evening). The result revealed that fish fed with 30% *Ziziphus mauritania* leaf meal had the highest final weight followed by 20%. The lowest growth was recorded in 10% and the control (0%). The highest protein efficiency ratio and condition factors were achieved in 30% *Ziziphus mauritania* leaf meal inclusion level. High gonadosomatic indices was recorded on fish fed 30% diet, which shows high significance difference (p<0.05). Best result for fecundity was similarly achieved in fish fed 30% *Ziziphus mauritania* leaf meal. These results indicated that *Ziziphus mauritania* leaf meal diet enhanced growth performance, improve gonadosomatic and reproductive indices of female *Oreochromis niloticus*.

Key words: Effect, Fecundity, Growth, Gonadosomatic, Indices, *Ziziphus Mauritania*

Introduction

Ziziphus mauritania called *Jujube*, Ber, Chinese apple, Indian plum and masau is a tropical fruit tree (Michel, 2002; Kebu and Fassil, 2006). According to their morphological changes, this species was named as *Ziziphus mauritania* due to it adaptation to grown in dry places. The species varies widely in height, from a bushy shrub 1.5 to 2m tall, to a tree 10-12m tall with a trunk diameter of about 3.0m (Orwa *et al.,* 2009). Analysis of the chemicals constituents on a dry weight basis indicated that the leaves contained 15.4% crude protein, 15.8% crude fibre, 6.7% total minerals, and 16.8% starch (Akinso *et al.,*2016).

The feedstuff used in fish feed are derived from crop residue, mill by–products, food processing wastes or agro-industries by- products (Eyo, 2001). Feedstuff resources in Nigeria are declining due to stagnant or diminishing output of certain traditional crops (Fasakin *et al.,* 2001). Whereas the high cost and competition of some feed ingredient such as groundnut cake, soya beans, maize, millet, sorghum and sesame seeds which human population also use as food has necessitated the use of unconventional materials for fish feeds, such as *Moringa oleifera* leafmeal, *Carica Papaya* leaf meal, *Hibiscus Sabdarifa, Jatropha kernel* meal maize, rice brand and Ziziphus leaf, meal (Ahmed *et al*., 2012).

Oreochromis niloticus are naturally occurring in African coastal rivers: Nile basin in Uganda, Awash River in Congo Kinshasa, in Ethiopion Lakes, Omo River System Lake Turkana, Suguta River, and Lake Baringo (Trewavas, 1983; Trewavas and Teugels, 1991). In Nigeria, they are found in Lake Chad, river Niger, and Benue, Ero reservoir in Ekiti and Opa reservoir at Ile-Ife (Komolafe and Arawomo, 1998). This study therefore aimed at determining growth performance and estimate reproductive indices of *Oreochromis niloticus* fed with different inclusion levels of *Ziziphus mauritiana* leaf meal.

Materials and Methods

Study Area

The experiment was conducted at the Teaching and Research Fish Farm of Department of Fisheries, University of Maiduguri situated between latitude 11^o 51^1 N and longitude 13^o 05^1 E (Google, 2019).

Collection and preparation of *Ziziphus mauritiana* leaf

Ziziphus mauritiana leaves were collected from the twigs and sundried under the shade to maintain its nutrient. The leaves were milled using a pestle and mortar into powder and kept in an air tight container before the commencement of the experiment.

Preparation of experiment diet

Twenty-five percent (25%) crude protein diet was formulated from some fish feed ingredients using Pearson's square method (Table 1). These ingredients were procured from Maiduguri Monday market. Proximate composition of the experimental diet (Table 1) was carried out according to AOAC, (2000).

Table 1: The feed Composition of the experimental diet of *Ziziphus mauritiana* leaf meal

	Inclusion levels of *Ziziphus mauritania* (%)			
INGREDIENTS	DI(0)	DII(10)	DIII(20)	DIV(30)
Fish meal	14.62	14.62	14.62	14.62
Soya beans meal	14.62	14.62	14.62	14.62
Maize	32.88	32.88	32.88	32.88
Wheat bran	32.88	32.88	32.88	32.88
Methionine	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Binder	1.5	1.5	1.5	1.5
Oils	1	1	1	1
Ziziphus mauritania	0.00	10.0	20.0	30.0
Totals	100	100	100	100
Proximate Composition of the Experimental diet				
Ether extract	16.6	9.9	13.7	16.1
Dry matter	98.99	97.28	99.14	98.37
Moisture content	1.005	2.72	0.86	1.63
Crude protein	25.37	25.14	25.98	25.77
Crude fibre	14.7	16.1	15.3	17
Ash	0.03	0.07	0.05	0.1

Source of fish and Experimental design

Forty-eight (48) juveniles of *Oreochromis niloticus* were obtained from Departmental fish farm and research unit, Department of Fisheries, University of Maiduguri. They were acclimatized for one week prior to the commencement of the experiment. The fish were distributed in a completely randomized design (CRD) into 12 hapas (1m x 1m x1m) suspended in polythene lined pond, with four (4) treatments in three (3) replicates. The fish were fed with various concentrations of 0, 10, 20 and 30% inclusions of *Ziziphus Mauritania* leaf meal-based diet for the period of 60 days.

Growth performance indices

At the end of the rearing period with the *Ziziphus Mauritania* leaf meal, the following data were recorded; final weight (g), final length (mm), survival rate, quantity of feed consumed, Temperature, pH and Dissolved oxygen.

Reproductive indices of *Oreochromis niloticus*

Fecundity was estimated by tsub-sampling dry gravimetric method'' modified after Simpson (1959). This formula was used $F = aX^b$, Where F = fecundity, x= body length (cm) or body weight (g), b = the slope, a= intercept (Ekanem *et al.*, 2013).

Gonadosomatic index (GSI) was determined by using the equation 1 (Ekanem *et al.*, 2013).

GSI= weight of gonad/ Body weight x 100

Water Quality parameters

The water qualities were monitored every day (morning and afternoon) weeks throughout the period of the study. These include: Temperature range, and pH.

Data analysis

All data obtained from the experiment were subjected to one-way analysis of variances (ANOVA). The differences among mean were separated using Tukeys ,least Significant Difference (LSD) at P> 0.05 level of significant differences using statistic 8.0 for windows, Followed by Duncan's multiple range test (Duncan, 1995).

Results

Table 2 shows the effect of *Ziziphus mauritania* leaf meal (ZMLM) at different inclusion levels on growth performance parameters of *Oreochromis niloticus* obtained during the experimental period. The higher (36.98±7.51) weight gain value was obtained in fish fed with treatment DIV (30%) *Ziziphus mauritania* leaf meal (ZMLM) diet at different inclusion levels while the lowest(3.74±2.55g) value was recorded in treatment DII (10%). There was statistical difference ($p<0.05$) among the treatments. Fish fed *Ziziphus mauritania* leaf meal at 30% inclusion level had the highest (0.29±0.12) specific growth rate while the least (0.10 ± 0.02) specific growth rate was recorded in 0%. No significant difference ($p>0.05$) was observed in specific growth rate among the treatments during the study. However, there is in increase in specific growth rate with an increasing level of ZMLM in the experimental diets compared with the control. The higher survival rate (100±0.00) was recorded in all the treatments including the control. The mean final length ranges from 15.77±0.40 to 11.75±0.55. The feed conversion ratio had the highest (0.46±0.23) values in treatment DI (0%) while the lowest was recorded in DIV (30%). The condition factor ranges from 0.41±17.27 to 0.33±0.10. There was no significant difference ($p>0.05$) in FCR and CF among the fish fed with the experimental diet. The protein efficiency ratio was high (1.05±0.30) in fish fed with DIV (30%) ZMLM inclusion level which were statistically different ($p>0.05$) from fish fed with ZMLM at 0, 10 and 20% inclusion levels 0.35±0.20, 0.33±0.10 and 0.92±0.59 respectively.

Table 2: Means ±standard error of growth performance of *Oreochromis niloticus* fed different inclusion levels of *Ziziphus mauritania* leaf meal

	Inclusion levels of *Ziziphus mauritania* (%)			
Parameters	DI(0)	DII(10)	DIII(20)	DIV(30)
INW (g)	$55.93±1.43^{b}$	$55.42±3.92^{b}$	$55.68±10.74^{ab}$	$55.52±14.98^{a}$
FLW(cm)	$59.67±3.79^{c}$	$64.72±5.82^{bc}$	$82.52±11.25^{ab}$	$92.50±9.07^{a}$
WG	$3.74±77.58^{b}$	$9.30±2.55^{b}$	$26.84±1.48^{ab}$	$36.98±7.51^{a}$
SGR	$0.10±0.07^{a}$	$0.12±0.02^{a}$	$0.25±0.04^{a}$	$0.29±0.12^{a}$
SR(%)	$100±0.00^{a}$	$100±0.00^{a}$	$100±0.00^{a}$	$100±0.00^{a}$
FSL(cm)	$11.75±0.55^{b}$	$13.15±0.43^{b}$	$13.90±1.29^{ab}$	$15.77±0.40^{a}$
FCR	$0.46±0.23^{a}$	$0.20±8.14^{a}$	$0.09±5.51^{a}$	$0.09±0.03^{a}$
CF	$0.19±13.29^{a}$	$0.17±0.10^{a}$	$0.33±6.13^{a}$	$1.41±17.27^{a}$
PER	$0.35±0.20^{b}$	$0.33±0.10^{b}$	$0.92±0.59^{ab}$	$1.05±0.30^{a}$

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

Table 3 represents the values (means±standard error) of reproductive indices on *Oreochronis niloticus* fed with *Ziziphus mauritania* leaf meal at different inclusion levels. Fecundity and GSI values were significantly highest in fish fed with 30% *Ziziphus mauritania* leaf meal inclusion level diet. There was significant difference ($p>0.05$) observed in the fecundity and GSI among the entire treatments during the experimental period.

Table 3: Means ±standard error of the reproductive index of *Oreochromis niloticus* fed *Ziziphus Mauritania* leaf meal

	Inclusion levels of *Ziziphus mauritania* (%)			
Parameters	DII(0)	DII(10)	DIII(20)	DIV(30)
Fecundity	$11.67±5.24^{b}$	$25.00±13.05^{b}$	$44.67±16.49^{ab}$	$68.00±11.14^{a}$
GSI	$1.87±0.18^{d}$	$3.03±0.23^{c}$	$3.87±0.23^{b}$	$4.87±0.26^{a}$

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

Table 4 gives the results of water quality parameters obtained during the study period. There was statistical ($p<0.05$) variations observed between the Temperature, Dissolved oxygen and P^{H} from the treatments during the experiment. The highest (25.48±0.01) mean value was obtained in treatment III (20%) while higher $_{P}{}^{H}$ values was recorded in treatment II (0%). The ranges were; water temperature (25.48 – 25.22 °C), dissolved oxygen (4.49 – 9.32 mg/l) and pH (7.22 – 6.98).

Table 4: Means ±standard error of water quality parameters *Oreochromis niloticus* fed Different inclusion levels of *Ziziphus mauritania* leaf meal

	inclusion levels of *Ziziphus mauritania* (%)			
Parameters	DI(0)	DII(10)	DIII(20)	DIV(30)
TEMP	$25.33±8.81^{a}$	$25.22±0.038^{b}$	$25.48±0.015^{bc}$	$25.29±0.023^{c}$

pH	7.22±0.11[a]	7.00±0.05[ab]	6.99±0.52[ab]	6.98±0.039[b]
DO	5.20±053[a]	5.23±0.45[ab]	5.67±0.34[b]	5.29±0.73[c]

Mean with different superscripts of the same row are significantly different (p<0.05)

Discussion

The result of weight gains obtained in the present study was higher than the value obtained by Bello *et al.* (2013) after feeding *Clarias garipienus* with *Moringa olifera* leaf meal. The reason could be due to difference in fish species. Meanwhile, it is also higher than the values reported by Hassan *et al.* (2016) for *Clarias gariepinus* fed with Garlic (*Allium Sativum*). According to the obtained results SGR and FCR were no significant difference (p>0.05) among the fish fed with the experimental diet. The present results were similar with those obtained Sahu *et al.* (2007) and Agbo *et al,* (2011) whose reported that SGR and FCR in fish (*Labeo rohita*) fed with 0.5, 1% garlic powder/kg diet was not significantly different as compared with controls. The 100% survival rate recorded in this study is similar with the Tan *et al.* (2018) who reported 100% survival for *Anguilla marmorata*. However, it was higher than the 86% reported by Chukwu *et al*. (2012) after feeding Oreochromis *niloticus* with Carica *papaya* seed meal.

The final standard length obtained in this study was higher than the one reported by Chukwu *et al.* (2012). The result for protein efficiency ratio observed in this experiment was lower than the value for *Clarias gariepinus* (Abdel-Halim *et al.*, 2009). Protein efficiency ratio and feed efficiency are utilized as quality indicator for fish diet and its amino acid balance (Hassan *et al.*, (2016) and it is used to evaluate protein utilization and turnover (Shalaby *et al.*, 2006). The mean values of condition factor obtained in this work (1.41) was lower than 3.37 obtained by Mohammed (2017). This result it is an indication of wellbeing of the fish fed with graded level of ZMLM during the study.

The temperatures obtained in this study was similar to the one reported by Dada and Adeparusi (2012) which recommend a temperature range of 25.40^{o}c. It is also close to 27.1^{o}c reported by Bhujel (2000). While the pH recorded during the present study is 7.00-7.22 which is similar to the one reported by Dada and Adeparusi, (2012) as 7.20-7.35.

Fecundity is an important aspect of fish culture used to evaluate the average reproductive characteristics of fish (Ekanem *et al.*, 2013). The data obtained for fecundity in the present study of *Oreochromis niloticus* fed ZMLM experimental diet was significantly different (P>0.05). Ekanem *et al.* (2017) reported a significant influence of diet formulated with plant-based ingredients (*G. kola* and *S. jamaicensisi*) on the fecundity of *C. gariepinus.* This finding indicates the quality of experimental feeds used during the experiment. Shim *et al.* (1987) documental that the quantity and composition of dietary protein are known to affect fish fecundity. There was significant difference (p>0.05) observed in the GIS among the entire treatments during the experimental period. There is an increase in mean value of GIS with an increasing level of ZMLM in the experimental diets. These findings agree with the findings of Eyo *et al.* (2014) and Opeh *et al.* (2018) that utilization of good quality feed helps in a better development of gonads in fish.

Conclusion

It is therefore concluded that, the best growth response was achieved with *Ziziphus mauritania* leaf meal diet at 30% inclusion level. Results obtained for fecundity and gonadal development of *Oreochromis niloticus* indicated that *Ziziphus mauritania* leaf meal diet has positives influenced on fecundity and gonado-somatic indices. It is recommended that inclusion of *Z. mauritania* up to 30% will improve the growth performance and reproductive indices of *O. niloticus* juveniles

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Nutritional evaluation of animal by-products meal as partial substitute for fishmeal in the diet of African catfish, *Clarias gariepinus* (BURCHELL, 1822).

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Abstract
The effects of substituting fishmeal with Animal By-products Meal (ABM) in six experimental diets for African catfish fingerlings, *Clarias gariepinus* (mean weight=2.05g$\pm$0.11) with 0%, 20%, 40%, 60%, 80% and 100% substitution were investigated for 70 days. In general, the best growth and feeding performance were obtained with the control diet (D_1) based on fishmeal as the sole protein, but the result was not statistically different ($P>0.05$) from those obtained with 20%, 40%, and 60% ABM inclusion. A significant ($P<0.05$) growth depression was observed with diet treatments containing 80%, and 100% ABM inclusion. Whole body percentages of moisture, lipid, ash, and NFE were not significantly affected by the dietary treatments. Crude protein contents however, were highest for fish fed higher levels of dietary protein. The result of this study suggest that 60% ABM/40% fishmeal can be incorporated in the diet of African catfish without adversely affecting growth or any other aspect of performance, and as well as, improving the economics of feeding in comparison with fishmeal.

Key words: Animal By-Products Meal, *Clarias gariepinus*, Fishmeal.

Introduction

The increasing population of human being necessitates the increase in the production of food especially the refined proteinous food from fishes. According to Audu and Adejor (2003), fish have enormous nutritional and economic values and the current high demand for fish and its products as a healthier source of protein lead to the realization that captured fisheries from the wild alone cannot meet the demand of the human population. The extensive fish culture system is not reliable due to pollution; bioaccumulation of some substances in water organisms and the pressure of fishermen per unit area have led to poor harvest. In view of these practices, fish farmers tend to look toward intensive fish culture system in order to meet the demands for fishes and fishery products. This in turn has generated a need for development of suitable fish diets for economic and practical reasons. There has been an increasing tendency to use alternative plant and animal proteins as a low cost substitute for fishmeal, but in general the nutritional value of these proteins is lower than that of fishmeal, resulting in lower growth rates or a reduction in performance of the cultured animals (Pongmaneerat and Watanabe, 1991; Ofojekwu and Kigbu, 2002; Anderson *et al*., 1993; and Rumsey, 1993).

Individual by-product meals, such as blood meal, hydrolyzed feather meal or meat and bone meal often have deficiencies, or excesses in essential amino acids; nonetheless these meals can be mixed in certain proportions to produce a nutritionally balanced and economic fish diets (Robinson and LI, 1994; Eyo and Olatunde, 1996; Rodrigues *et al*., 1996; Absalom *et al*., 1996).

This study aims to determine the nutritional value of Animal By-products meal, their optimal level of inclusion in *C. gariepinus* diets and to investigate the performance of the experimental fish on the formulated diets.

Materials and Methods

Mixed sex of the same African catfish (*Clarias gariepinus*) fingerlings with average weight of 2.05g$\pm$0.11g were obtained from Rock Water Fish Farm Jos, Nigeria. The fish were transported to the laboratory in plastic bags with well oxygenated water in the early hours of the morning. The fish were acclimated to laboratory conditions for 7 days in circular plastic baths with a capacity of 50 litres prior to feeding trials. The plastic bags contained dechlorinated tap water. During the acclimation period, the fish were fed with commercial feed at 4% of their body weight daily divided into 2 equal feedings. The feeding of the fish was at 09:00 and 16:00 hours. Before each feeding, leftover food and faecal matter were siphoned out to prevent depletion of dissolved oxygen and accumulation of toxic wastes in the water. Temperature of water, pH, free carbon dioxide and dissolved oxygen were determined by method of APHA (1985).

At the end of acclimation period, ten (10) fingerlings were randomly selected to determine their initial carcass proximate composition. Twelve green plastic baths of 40cm diameter, 10cm depth and 16 litre capacity were filled and maintained with dechlorinated municipal water to 10L level and arranged into 6 feeding treatments tagged D_1-D_6. Each treatment was replicated and designated 'a' and 'b' for each diet. Ten fingerlings were weighed before stocking in each of the labeled plastic baths. Each bath was then covered with a square net mounted on a wooden frame to ensure the fingerlings did not jump out of the tanks and at the same time preventing entrance of unwanted materials. The experimental baths were washed fortnightly and treated with 20% $KMnO_4$ solution, after which they were properly rinsed with water. Fish in each treatment tank were fed at 4% body weight daily as recommended by Dupree and Huner (1984). Each diet contained different level of Animal By-product Meal (ABM) and fishmeal. The diets were prepared using methods described by Eyo and Olatunde (1996). Chromic oxide was incorporated into the diets as an inert digestibility marker following the method suggested by Furukawa and Tsukahara (1996). The average body weight was used to adjust the amount of food to be given. Faecal matter and any uneaten food were siphoned out before feeding. Each of the six (6) diets was administered two (2) times daily at 09:00 and 16:00 hours.

All fish in each tank were bulk weighed at the beginning of the experiment and thereafter on a bi-weekly basis. To facilitate weighing, fish were collected with a scoop net and dried by blotting with soft damped tissue paper and weighed in a small plastic container using a Metler P20110 top loading balance. During the weighing, faeces for the protein digestibility analysis were collected by siphoning before the second feeding, drying the faeces at 105^{o}c for 24h and storing them in air-tight vials under refrigeration (4^{o}c) for subsequent chromic oxide and protein analysis. The feeding trials lasted for 70 days.

The six (6) experimental diets were analyzed for moisture content, crude protein, lipid, fibre, ash and carbohydrate using the method of Association of Official Analytical Chemists (AOAC, 1990) (table 2). During the experimental period, the water parameters (pH, dissolved oxygen, free carbon dioxide and alkalinity) of the experimental tanks were determined fortnightly as described by APHA (1985), while temperature (^{o}C) was determined on daily basis throughout the 70 days period.

Growth and feed utilization indices such as percentage live weight gain (LWG %) were determined as described by Cho *et al*., (1983); specific growth rate (SGR) were determined as described by Jauncey and Ross (1982); food conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU) were determined as described by Halver (1989). Apparent Protein Digestibility (APD) was determined as described by Furukawa and Tsukahara (1996).

To test for significant difference between treatments, the one-way Analysis of Variance (ANOVA), single classification was used to test which pairs of means differed significantly from the other.

Result

Result of the proximate composition of the experimental diets (Table 1) showed that all the diets contained between 31-35% crude proteins with exception of diet D_1 which had 36.79% crude protein. Diet D_2 had the highest fibre and ash contents compared to the other diets. The result of growth performance indices and protein digestibility are given in Table 2. Variations in the mean weight of fish in each treatment group at the start of the experiment was not significant ($P>0.05$). However, variations in the cumulative weight gain among the different treatments at the end of the experiment was significant ($P<0.05$). although fish fed the control diets (D_1), weighed more than those fed diets D_2, D_3, and D_4, no significant difference were obtained among the final weight gain of fish in this treatments. The groups fed diets D_5 and D_6 weight significantly less than those of the other treatments.

Other growth and food utilization parameters namely, Mean Growth Rate (MGR), and Specific Growth Rate (SGR) followed the same trend as the final weight gain.

The percentage proximate composition of the fish carcass at the beginning and end of the experiment expressed as percentage wet matter is shown in Table 4. Difference in protein deposition observed between fish fed the control diet, D_1 and diet D_2 and D_3 was not significant (LSD=0.99). Final whole body percentage of moisture, ash, lipid and NFE were not affected by dietary treatment.

Table 1: Percentage Composition of Experimental Diets Fed to *C. gariepinus* for 10 Weeks

	Diets					
Ingredients	D_1	D_2	D_3	D_4	D_5	D_6
Fish meal	54.0	43.2	32.4	21.6	10.8	0.0
ABM[a]	-	10.8	21.6	32.4	43.2	54.0
Cassava flour	18.0	18.0	18.0	18.0	18.0	18.0
Maize flour	18.0	18.0	18.0	18.0	18.0	18.0
Vegetable oil	5.0	5.0	5.0	5.0	5.0	5.0
Premix (vitalyte)	4.5	4.5	4.5	4.5	4.5	4.5
Chromic oxide	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Fish meal Replaced By ABM (%)	0.0	20.0	40.0	60.0	80.0	100.0

a: ABM = Animal By-products Meal: is a mixture of blood meal, poultry offal and shrimp meal.

Table 2: Percentage Proximate Composition of Experimental Diets Fed to *C. gariepinus* Fingerlings for 10 Weeks

	Diets						
Proximate Composition (% Dry Weight)	D_1	D_2	D_3	D_4	D_5	D_6	±SE
Crude Protein	36.79	35.10	34.25	33.75	33.04	31.18	0.77
Lipid	11.86	13.55	13.18	12.98	13.44	13.60	0.27
Fibre	1.01	1.62	O.33	0.22	0.19	0.13	0.25
Ash	4.87	5.53	4.60	4.63	3.53	4.41	0.27
Moisture	7.33	6.02	6.29	6.40	6.85	7.05	0.20
***NFE**	38.14	38.18	41.35	42.02	42.95	43.63	0.97
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	

*NFE (Nitrogen Free Extract) = 100 – (% moisture +% lipid + % ash + % fibre + % crude protein)

Table 3: Table of Means for Food Utilization Indices for *C. gariepinus* Fingerlings Fed Experimental Diets for 10 Weeks.

Exp. Diets	**TOTAL FOOD FED (g)**	**CRUDE PROTEIN FED (g)**	**INITIAL WEIGHT (g)**	**FINAL WEIGHT (g)**	**WEGHT GAIN (g)**	**FCR**	**PER**	**ANPU (%)**	**APD (%)**
D_1	16.60	6.11	3.26^a	13.83^a	10.57^a	0.64^a	1.74^{ab}	86.84^a	71.00^a
± SE	(0.29	(0.11)	(0.02)	(0.09)	(0.28)	(0.00)	(0.01)	(1.49)	(0.05)
D_2	16.41	5.42	3.36^a	13.72^a	10.36^a	0.63^a	1.93^a	75.76^b	69.00^{ab}
± SE	(0.60)	(0.12)	(0.13)	(0.94)	(0.81)	(0.07)	(0.21)	(1.75)	(1.00)
D_3	15.43	5.39	3.41^a	13.41^a	10.00^a	0.65^a	1.90^a	63.20^c	64.00^{bc}
± SE	(0.13)	(0.15)	(0.09)	(0.50)	(0.13)	(0.01)	(0.04)	(0.54)	(1.10)
D_4	14.97	5.06	3.53^a	12.92^a	9.36^a	0.63^a	1.86^a	26.34^e	59.00^c
± SE	(0.61)	(0.21)	(0.10)	(0.99)	(0.89)	(0.03)	(0.10)	(1.68)	(0.10)
D_5	13.51	4.47	3.42^a	9.92^a	6.50^b	0.48^a	1.46^c	40.18^c	58.00^c
± SE	(0.64)	(0.22)	(0.20)	(0.01)	(0.21)	(0.02)	(0.02)	(1.94)	(0.00)
D_6	13.83	4.31	3.30^a	9.97^a	6.67^b	0.48^a	1.55^{bc}	15.78^f	58.30^c
± SE	(0.09)	(0.03)	(0.22)	(0.01)	(0.21)	(0.01)	(0.04)	(0.10)	(0.20)

*values in parenthesis are standard errors of means (±SE).
*Within columns, values with the same superscripts are not significantly different (P>0.05).

Table 4: Percentage Proximate Composition of *Clarias Gariepinus* Carcass Before and After Feeding the Experimental Diets for 10 Weeks

	Diets							
***proximate Composition**	Before Feeding	D_1	D_2	D_3	D_4	D_5	D_6	±SE
Moisture	76.68	71.56^a	72.03^c	74.13^a	76.57^a	76.21^a	77.10^a	0.81
Crude Protein	12.30	17.60^a	16.40^a	15.64^a	13.63^c	14.09^{bc}	12.96^a	0.67
Lipid	3.56	4.15^a	4.75^a	4.01^a	3.89^a	3.75^a	3.62^a	0.14
Ash	4.82	5.44^a	5.38^a	4.36^a	4.23^a	4.19^a	4.13^a	0.19
NFE	2.64	1.25^a	1.26^a	1.86^a	1.68^a	1.76^a	2.19^a	0.17
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

1. Values within the same row with the same superscripts are not significantly different (P>0.05).

- Calculations based on wet weight

Discussion

Protein requirement for optimal growth and feed efficiency of juvenile fish usually ranged from 31-35%. Ayinla and Akande (1988) gave a percentage crude protein requirement of 31-34% for fingerlings and juveniles of *C. gariepinus*. Rumsey (1993) reported that 31% crude protein diet had the highest protein efficiency and highest growth rate in *C. gariepinus* fingerlings, while Faturoti (2003) suggested a percentage crude protein requirement of 35% for fingerlings and juveniles of *C. gariepinus*. In line with this findings, the percentage dietary crude protein (35%) used in this study is in good range that maximize growth of *C. gariepinus*.

The present study shows that 60% ABM can be used with 40% fishmeal in the diet of *C. gariepinus* fingerlings without affecting the overall performance (Table 2). Although final body weight and growth rate were higher in fish fed the control diet, no significant differences (P>0.05) were detected between the control and the treatments with 20-60% ABM inclusion. Significant growth depression was observed when a higher level of ABM was added to the diets. Although diet D_5 with 80% of ABM inclusion resulted in the poorest growth, there was no statistical difference (P>0.05) between growth in diet D_5 and diet D_6 with 100% of ABM inclusion. The low performance obtained from these diets may be due to amino acid imbalances. Audu and Adejor (2003) reported that although optimal dietary crude protein is important in promoting growth, other factors such as lipid and crude fibre are usually very important parameters. The suggestion by Rodriguez *et al.*, (1996) that higher levels of ABM in fish diets be supplemented with oils (e.g. soy bean oil) to enhance its performance, may perhaps be related to a better supply of essential fatty acid. The result for Protein Efficiency Ratio (PER) and Apparent Net Protein Utilization (ANPU), used as an indicator for the protein productive value, were also within a good range. PER values ranged from 1.93 in fish fed diet D_2 to 1.46 in the group fed diet D_5. In all except 2 treatments, the values of ANPU were over 40%, showing good nutritional quality of ABM for catfish feeds. These figures are relatively similar to those reported by Rodriguez *et al*., (1996) using ABM for *Oreochromis niloticus*, but however higher than those reported by Steffens (1994) using poultry by-product meal for rainbow trout, *Onchorynchus mykiss.*

Throughout the study period, there was a relatively narrow fluctuation in temperature. The least mean temperature of 21.50 ± 0.30^oC was recorded in bath D_5, while bath D_6 had the highest mean temperature value of 23.70 ± 1.10^oC. The average temperature was 22.82 ± 0.33^oC. This value is within tolerant range but however falls below the recommended range of 25 to 32^oC for optimum growth of fresh water fishes (Boyd and Tucker, 1998). Average pH was 6.68 ± 0.02. This value is within acceptable limit as FAO (2001) reported that pH values range of 6-9 is best for growth. Dissolved oxygen fluctuated from $2.15 \pm 0.30mgl^{-1}$ to $3.90 \pm 0.20mgl^{-1}$ with an average $3.08 \pm 0.24mgl^{-1}$. This value falls below the optimum dissolved oxygen content for normal growth and reproduction in tropical waters which should be in the range of $5mgl^{-1}$ to saturation level (FAO, 2001). Free carbon dioxide content was in the range of $2.00 \pm 0.40mgl^{-1}$ to $1.7 \pm 0.30mgl^{-1}$ with an average of $1.85 \pm 0.04mgl^{-1}$. This value is well within acceptable limit as FAO (2001) stated that sub lethal effects including respiratory stress and nephrocalcinosis will occur when the free carbon (IV) oxide content is in the range of $12\text{-}50mgl^{-1}$. Total alkalinity ranged from $20.10 \pm 1.82mgl^{-1}$ to $23.60 \pm 1.25mgl^{-1}$ with an average of $21.84 \pm 0.50mgl^{-1}$. These values were within the optimum range, as according to Wurts and Masser, (2004), $20\text{-}300mgl^{-1}$ alkalinity is ideal for warm water fishes.

Conclusion

The result of this experiment showed that it is feasible to use animal by-product meal as a substitute for fishmeal in catfish feeding without adverse effects on growth and at the same time, improving the economics by reducing costs of feeding. In the experiment, good growth performance was obtained in fish fed the 60% ABM/40% fishmeal diet. Increasing dietary ABM above 60% resulted in depressed weight gain and food conversion.

Inclusion of 60% ABM in the diet of African catfish may be a way of reducing the amount of expensive fishmeal in formulated diets without reducing the growth performance of the fish.

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Growth Performance and Feed Utilization Of African Catfish (*Clarias gariepinus*) Juveniles Fed Varying Inclusion Levels Of Butterfly Pea (*Clitoria ternatea*) Seed Meal

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Abstract
High cost of qualitative fish feed is one of problems hampering the development and profitability of fish farming and consequently leads to food insecurity in terms of food availability and accessibility. The study was conducted to determine growth response and feed utilization efficiency of *Clarias gariepinus* juveniles of mean weight 21.74g±0.54g fed at varying levels of dietary inclusion of *Clitoria ternatea* seed meal substituted for soybean meal over a period of eight weeks. Four iso-nitrogenous experimental diets were formulated at 0% (control), 25%, 50% and 100% inclusion levels of *C. ternatea* seed meal. The 8-week feeding experiment was conducted in rectangular plastic tanks, each treatment having three replicates with two feeding regime at 5% body weight and weighed every week. , Comparatively, the growth response; FI, FWG, AWG, %WG and SGR values for diets I and III had no significant difference (p>0.05). The feed utilization efficiency parameters values; FCR (g), PER (%), SR (%) and TFY (kg/m^3) for control diet and diet III were the best with no significant difference (p>0.05). It was established that fish fed 50% inclusion level of *C. ternatea* seed meal had effective comparable biological values with the control diet in terms of growth performance and feed utilization efficiency.

Keywords: Growth performance, Carcass, juveniles, *Clitoria ternatea, Clarias gariepinus,* food security.

Introduction
Fish continues to make substantial contributions to animal protein requirements. There has been a steady increase in aquaculture produce (inland and marine) from about 55.7 million tons in 2009 to 167.2 million tons in 2014 (FAO, 2016). In Africa, it is one of the cheapest and direct sources of protein and micro nutrients for millions of people (Ben and Heck, 2005). Food and feeding habits coupled with other considering factors for culture fish makes *Clarias gariepinus* the most popularly cultured fish in Nigeria (Sogbesan and Ugwumaa, 2008). However, fish feed technology is one of the least developed sectors in aquaculture particularly in Africa and other developing countries of the World (Gabriel *et al*., 2007 and Alegbeleye *et al*., 2001). In Nigeria, feed is one of the major inputs in aquaculture production as its account for over 60% of the total production cost (Alatise *et al.,* 2014). In a bid to reduce the cost of fish production and maximize profit, many researches are being conducted to identify non- conventional feed resources of high nutritive values, less expensive and readily available. Protein requirement is given high priority in any nutritional study because it is the nutrient that is required in the right quantity or proportion for growth and development. Protein based ingredients are also the most expensive ingredients in diet formulation (Solomon *et al*., 2016). Variations may occur in individual feed stuffs as a result of their variety, climatic condition and processing methods. Studies have been conducted on the replacement of the conventional protein based diet such as fishmeal, soybean meal and groundnut cake with unconventional ones for African catfish production (Tiamiyu *et al*., 2013; Alatise *et al.*, 2014).

Clitoria ternatea commonly known as Butterfly pea belonging to the family *Fabaceae*, comprises 60 species distributed mostly within the tropical belt with a few species found in temperate areas and frequently reported species is *Clitoria ternatea* (Gomez *et al*., 2003). *Clitoria ternatea* seeds meal has nutrient density that is comparable to any other plant protein sources. It has a good amino acids profile with its essential amino acids level (except lysine) higher than soybean meal (Kumar *et al*., 2010). *Clitoria ternatea* is a high-quality protein rich legume, which is often referred to as a protein bank that can be grown at low cost (Cook *et al*., 2005). The use of *Clitoria ternatea* seed meal in fish diets is not well documented compared to other forage crops; Kumar *et al*,(2010) used detoxified *Jatropha curcas* meal for carp; Fakunle *et al.*, (2013) and Alatise *et al.,* (2014) also used boiled *Jatropha kernel* meal for *Clarias gariepinus*. Soybean meal is one of the major feed ingredients used in fish feed production. The ever increasing price of this feed resource has necessitated the need for a search of replacement which could be an ideal nutritional source of dietary protein for fish. There is a dearth of knowledge specifically for the replacement of soybean meal with *Clitoria ternatea* in the diet of *Clarias gariepinus*. This study therefore investigated the growth response of *Clarias gariepinus* juveniles fed *Clitoria ternatea* seed meal.

Materials and Methods
Study Location
The experiment was carried out in the Fish Biology Laboratory of Oyo State College of Agriculture and Technology (OYSCATECH) Igboora, Oyo State Nigeria.

Source of Ingredients, Diet formulation and Preparation
Fishmeal, Groundnut Cake, Soybean meal and Maize were obtained from the market while Butterfly pea seed (*Clitoria ternatea* seed) was freshly plucked from the pasture and ranch Department of Animal Health and Production of Oyo State College of Agriculture and Technology, Igboora Oyo State. Nigeria and was identified from a herbarium in the department. The diets used in the experiment were formulated and iso-nitrogenous (40% CP) containing 0%, 25%, 50% and 100% inclusion levels of Butterfly pea seed (*Clitoria ternatea)* meal. The seed was extracted from the cob, processed and was oven dried at 70^0C using electric oven. All ingredients were ground into powdery form using **burr mill** and mixed thoroughly with the use of hand. Warm water was added to the premixed ingredients and homogenized to a dough-like paste. This was then pelletized using a 2mm pellet press. The pelletized feed was later sun-dried for 4 days, stored in airtight containers.

Experimental procedure
The experiment was laid out in a Simple Randomized Design (SRD) which was replicated three times. The total number of 144 *Clarias gariepinus* juveniles with average weight 21.74g±0.54g were randomly distributed across a total of twelve plastics tanks at stocking density of 12 juveniles per tank. The fish were acclimatized for two days before the start of the feeding trials. The feeding trial was conducted in an experimental unit containing a set of 12 rectangular plastic tanks, each with a capacity of 55 L of water. The 35 L of water was maintained in each tank and changed at 3-day intervals at 60: 40 (stale and fresh water ratio). This was done to avoid incessant seemingly environmental shock as a result of the new environment when the whole water is changed. The four treatments (0%, 25%, 50%, and 100% concentration of *Clitoria ternatea* seed meal) were administered to the fish in triplicates. Experimental fishes were fed twice daily at a fixed feeding rate of 5% body weight day^{-1}. Feeding regime was in the mornings at 09.00 and 15.00 h except on sampling day when they were fed after weighing for 8 weeks.

Data collection for growth parameters and feed utilization evaluations
Data on fish growth characteristics were measured weekly and at the end of the experiment. The following parameters were measured;

- Weight gained = final weight- initial weight
- Specific growth rate (SGR) = $\frac{\text{Final Weight – Initial weight}}{\text{Duration of the Experiment (Days)}}$
- Feed conversion ratio (FCR) = $\frac{\text{Feed intake}}{\text{Body weight gain}}$
- Survival rate = $\frac{\text{Total number of dead fish}}{\text{Total number of stocked}} \times 100$
- Protein efficiency ratio = $\frac{\text{Mean weight gain}}{\text{Average crude protein feed}}$
- Percentage weight gain = $\frac{\text{Mean final weight gain – Mean initial weight}}{\text{Mean Initial weight}} \times 100$
- Total fish production (kg/m^3) = $\frac{\text{Final weight X Survival rate}}{\text{1000 (L)}}$

Statistical analysis of data.
All the data obtained were statistically analysed using analysis of variance (ANOVA) for significant differences in the treatment means, and the mean separation was achieved by using Duncan Multiple Range Test using the SAS software.

Results
Growth response and feed utilization efficiency
Table 1 shows the growth performance and feed utilization efficiency of juveniles in each treatment. Diet 1 (27.7±1.11g) and III (27.23±0.94g) recorded the highest weight gain followed by Diet II (25.3±0.71g) while fish fed Diet IV (22.2±1.73g) has the lowest weight gain. Comparatively, the highest final weight gain was recorded in diet III (49.8±2.15 g) followed by control die, diet II and diet IV recorded the least. Diets I, II and III had the same specific growth rate (SGR) values but with varying feed intake values.

The best food conversion ratio was recorded in diets I, II and III. The highest protein efficiency ratio was observed in diet I followed by diet III, II and IV. Diets I and III had highest survival rate (%) (92% each) while diet III recorded highest fish yields of $4.58kg/m^3$.

Table 1: Growth Performance of African Catfish (*Clarias gariepinus*) Juvenile Fed Varying Inclusions of *Clitoria ternatea* Seeds Meal

Parameters	Diet I	Diet II	Diet III	Diet IV
Av. Initial weight (g)	21.90±1.54[a]	21.10±2.08[a]	22.57±1.03[a]	21.40±0.89[a]
Av. Final weight (g)	49.6±2.77[a]	46.4±1.48[b]	49.8±2.15[a]	43.6±1.13[c]
Av. Wt. gain (g)	27.7±1.11[a]	25.3±0.71[b]	27.23±0.94[a]	22.2±1.73[c]
% weight gain (g)	126.5±4.42[a]	120±2.18[b]	120.6±3.73[b]	103.7±2.19[c]
Feed Intake (g)	14.8±1.08[a]	13.7±0.82[b]	14.6±0.91[a]	13.6±0.54[b]
SGR (%)	0.5±0.10[a]	0.5±0.05[a]	0.5±0.08[a]	0.4±0.03[b]
FCR (g)	0.53±0.04[b]	0.54±0.02[b]	0.53±0.02[b]	0.61±0.04[a]
PER (%)	0.70±0.02[a]	0.63±0.05[b]	0.68±0.03[a]	0.55±0.03[c]
Survival rate (%)	92.0±1.33[a]	75.0±0.67[c]	92.0±0.33[a]	90.8±0.50[b]
Total fish production (kg/m^3)	4.56±0.12[a]	3.48±0.32[c]	4.58±0.21[a]	3.92±0.33[b]

* Mean values along the row with different superscripts are significantly different ($p<0.05$)

Discussion

Table 1 shows parameters examined and recorded in the growth performance and nutrient utilization of *C. gariepinus* at inclusion levels of 0%, 25%, 50% and 100% of *Clitoria ternatea* seed meal in the diets. The results of growth response; the mean weight gain (MWG) result showed the weight of the fish increased across the diets after 8 weeks of feeding trials. Also, feed intake across the diets indicated that the diets were accepted and consumed because of their palatability which is a function of handling methods. The processing technique might have ameliorated the effects of embedded anti nutritional factors of Butterfly seed pea. The observation agrees with the reports of (Siddhuraju and Becker, 2003 and Alatise *et al.,* 2014). The authors reported that reduction in anti-nutritional factors by different processing methods resulted in better palatability and growth in fish. The feeding trial shows that the soyabean-based diet (control) and diet III performed best in terms of growth; feed intake, weight gain, percentage weight gain and specific growth rate, finding agrees with the opinion of Fakunle *et al.,* (2013*).* This is an evidence that protein quality of *Clitoria ternatea* was effectively utilized by *Clarias gariepinus* juveniles. Also, result agrees with growth performance of *Clarias gariepinus* as reported by Alatise *et al.,* (2014) who reveals that 30% boiled jatropha kernel meal as a substitute for soya bean meal in diet of African mud fish Catfish fingerlings showed best growth indices. Feed utilization efficiency was comparatively higher in the control diet (Diet 1) and diet III with 50:50% soybean meal and *Clitoria ternatea* seed meal. The analysis of variance showed that the growth response and feed utilization indices for diet I (control) and diet III (50:50% soybean and butterfly pea meal) were not significantly different ($p > 0.05$).

Conclusion:

The results of the experiment indicated that, Diet III with 50% inclusion of *Clitoria ternatea* seeds meal can efficiently replace soybean meal as its showed favourable growth and feed utilization indices comparatively with the control diet.

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Assessment of some fatty acids composition of cultured African mud catfish (*Clarias gariepinus*) in Lagos State

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Abstract
Fish is a source of key nutrients important for growth and development as well as maintenance of good health and wellbeing. The fatty acids profile and the percentage composition of the lipids were determined. The fish samples were collected from the major fish farms within Lagos and its environment and then transported to the laboratory for analysis. The total lipids were 1.97±0.29, 1.43±0.31, 2.63±0.37, 2.81±0.45, 3.21±0.62%, the total fatty acids were 98.87, 99.73, 99.98, 99.82, 99.65% and the saturated fatty acids were 33.53, 39.85, 47.62, 35.04, 30.63% for farms A, B, C, D and E respectively. There was significant difference in the percentage lipid content of the samples.

Introduction
Fisheries are an important part of food security. Food security is "a state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life" (UNEP, 2002).

The fatty acid content of a diet modulates the fatty acid profile of immune cells. This may be an effective way to regulate the functionality of normal cells through nutrition. Fuentes (1998) indicated that diets in which unsaturated fatty acids replaces the saturated ones are associated with low incidence of coronary diseases.

Omega-3 and omega-6 fatty acids are unsaturated "Essential Fatty Acids" (EFAs) that need to be included in the diet because the human metabolism cannot create them from other fatty acids (Saini and Keum, 2018). It has been reported that highly unsaturated n-3 fatty acids, particularly (EPA) and (DHA), are important for human health and early development (Connor, 2000). Dieticians are advising increased consumption of foods that contain these fatty acids (Ruxton *et al.*, 2007).

Environmental factors can affect the makeup of body-oil fatty acids, feed and feeding habits, maturity and sex of fish have influences upon composition as well(Berge and Barnathan, 2005) . There is dearth of accurate basic chemical composition data for fish species particularly from African and Asian sources (Schonfeldt, 2002). In Nigeria, our present knowledge of the fatty acids composition of fish species from Nigerian waters and cultured fish species is very limited. The African catfish, *Clarias gariepinus*, is easily cultured in Nigeria and of great economic interest. It is generally considered to be one of the most important tropical catfish species for aquaculture hence, need for the total lipids and fatty acid report which would enhance their utility in public health and nutrition. The study was designed to determine the total lipids and fatty acids composition of cultured African mud catfish (*Clarias gariepinus*) in Lagos state and its environ

Materials and Methods
Sampling and Sampling Preparation
Table size cultured *Clarias gariepinus* of the same age were collected from Nigerian Institute for Oceanography and Marine Research (NIOMR) and five (5) fish farms in Lagos state. The culture system for the farms were earthen pond, WRS, concrete pond, earthen pond and WRS for ponds A, B, C, D, E respectively. Collected fish samples were transported live to the Fish Technology Department laboratory of NIOMR where the analysis were carried out.

Lipids Determination
Lipid content was determined according to Bligh and Dyer (1959).

Fatty Acids Composition Analysis
Lipid extraction from the samples was carried out according to Bligh and Dyer (1959). The methylation which was carried out to convert the fats to their methyl esters was carried out according to AOCS, (1998) and the fatty acids methyl esters (FAME) were separated by gas chromatography as described by AOAC, (2001).

Statistical Analysis
Data obtained were subjected to descriptive statistics.

Results

The Percentage lipid composition of mud cat fish from 5 major fish farms ranged from 1.97 % to 3.21% and there was significant difference (p>0.05) among the farms. The highest lipid content was obtained on the samples from farm E.

The fatty acid composition as a percentage of eluted methyl esters of the catfish samples were summarized in Table 2 and ranged from 0.06% to 33%. Among those occurring in highest proportions were palmitic acid (C16: 0; 22.2%%-333.11%), elaidic acid (tC18:1 2.54-34.90%), linoleic(cisC18:2 0.63%-30.88%).

FarmC has the highest and monounsaturated fatty acids but least polyunsaturated acids. While farm D has the highest polyunsaturated fatty acids but least omega 3 fatty acids.

Table 1: Percentage lipid composition of mud cat fish from 5 major fish farms in Lagos

Catfish from major farms	% Lipid
Farm A	1.97±0.29[ab]
Farm B	1.43±0.31[a]
Farm C	2.63±0.37[bc]
Farm D	2.81±0.45[bc]
Farm E	3.21±0.62[c]

Notes: Values are mean±standard deviation of triplicate run. Values followed by different letters with in a column indicate significant difference ($p < 0.05$)

Table 2: Fatty acids profile of mud cat fish from 5 major fish farms in Lagos.

Names of FAMEs	Fatty acids profile	Farm A	Farm B	Farm C	Farm D	Farm E
Lauric	C12 : 0		0.097	0.06		0.16
Myristic	C14:0		1.33	1.06		0.868
Myristoleic	C14:1	0.15				
cis-10-Pentadecanoic	C15:1	0.086			0.083	0.14
Pentadecanoic	C15 : 0		0.20	0.86	0.12	
Palmitic	C16 : 0	22.2	26.2	33.11	23.3	20.246
Palmitoleic	C16 : 1	1.63	1.90	3.853	1.63	2.082
Heptadecanoic	C17 : 0	0.24	0.40	0.199	0.10	0.296
Stearic	C18 : 0	8.68	8.70	8.955	7.55	7.127
Oleic	cisC18 : 1	30.9	2.59	3.207	1.88	2.477
Elaidic	tC18 :1	2.54	29.6	34.90	25.2	30.78
Linolelaidic	tC18 : 2	22.5	0.12	0.158	.072	
Linoleic	cisC18 : 2	0.63	18.1	5.438	30.88	24.499
ϒ-Linolenic	C18 : 3n6	2.29	1.15	0.34	0.86	0.769
Linolenic	C18 : 3n3	0.24	1.14	0.495	0.22	4.20
Arachidic	C20 : 0	1.25	0.51	2.51	1.09	0.35
cis-11-Eicosenoic	C20 : 1n9		1.28	0.479	0.16	0.857
cis-11,14-Eicosadienoic	C20 : 2	0.68	0.69	1.20	0.84	0.657
Cis-11,14,17-Eicosatrienoic	C20 : 3n3	1.15			0.15	
cis-8,11,14-Eicosatrienoic	C20: 3n6	0.72	0.75	0.641	0.81	0.58
Heneicosanoic	C21 : 0	0.12	1.31	0.97	1.75	1.051
Behenic	C22 : 0	0.62	0.59	0.568	0.68	
Arachidonic	C20 : 4n6				0.10	
cis-5,8,11,14,17-Eicosapentaenoic	(EPA)C20 :5	0.25	0.21	0.119	0.21	0.259
Tricosanoic	C23 : 0				0.14	
Lignoceric	C24 : 0	0.42	0.51		0.30	0.395
cis-4,7,10,13,16,19-Docosahexaenoic	(DHA)C22:6	1.57	2.35	1.53	1.67	1.857
	Total	98.866	99.727	99.978	99.815	99.65

Table 3: Fatty acids composition (%) of mud cat fish from 5 major fish farms in Lagos.

Fatty acids composition (%)	Farm A	Farm B	Farm C	Farm D	Farm E
Total lipids	**1.97**	**1.43**	**2.63**	**2.81**	**3.21**

Total fatty acids composition	**98.866**	**99.727**	**99.978**	**99.815**	**99.65**
Saturated fatty acids (SFA)	**33.53**	**39.847**	**47.618**	**35.04**	**30.633**
Monounsaturated fatty acids (MUFA)	**35.306**	**35.37**	**42.439**	**28.963**	**36.196**
Polyunsaturated fatty acids (PUFA)	**30.76**	**24.51**	**9.921**	**35.812**	**32.821**
PUFA / SFA	**0.917**	**0.615**	**0.208**	**1.02**	**1.071**
Eicosapentaenoic EPA	**0.28**	**0.21**	**0.12**	**0.21**	**0.259**
Docosahexaenoic DHA	**1.57**	**2.35**	**1.53**	**1.67**	**1.857**
∑ EPA + DHA	**1.85**	**2.56**	**1.65**	**1.88**	**2.116**
Omega-3 fatty acids (n-3)	**1.39**	**1.14**	**0.495**	**0.37**	**4.20**
Omega 6- fatty acids (n -6)	**3.71**	**1.9**	**0.981**	**1.59**	**1.349**
n-6 / n-3	**1:2**	**1:1.7**	**1:1.98**	**1:4**	**1:0.32**

Discussion

The total lipid contents of the fish muscles obtained from five major fish farms within Lagos were 1.97±0.29, 1.43±0.31, 2.63±0.37, 2.81±0.45, 3.21±0.62 for farms A, B, C, D, E respectively. According to Effiong and Fakunle, (2013) lean fish usually contain less than 2% of lipids and this varies among and within species. Lipids contents also depends on some factors like seasonal and biological (season, diet).

Fish muscular lipids are rich in polyunsaturated fatty acids, especially eicosapentaenoic acid (EPA, 20:5n3) and docosahexanoic acid (DHA, 22:6n3) which play an important role in health promotion and disease prevention (Simopoulos *et al*, 1999). The fish samples from each farm were excellent sources of polyunsaturated fatty acids, range from 24.51-35.8% of the fatty acid composition except the sample from farm C. This might be as a result of its diet composition as well as its culture system. The sum of ∑(EPA and DHA) were 1.85, 2.25, 1.65, 1.88, and2.11 for the various farms.

The ratios of omega-6 to omega-3 for the fish samples were 2:1, 1.7:1, 1.98:1, 4:1, 1:3.1 for farms A, B, C, D, and E respectively which fell within the range 2:1 n-6/n-3 recommended by panel of lipid experts. Omega-3 and omega-6 fatty acids are essential PUFAs which cannot be synthesised in the body, therefore must be derived from the diet. A number of studies have indicated an association between depression and increase in the ratio of omega-6 to omega-3 fatty acids (Husted and Bouzin 2016). In addition, an increase in omega-6/omega-3 increase the risk of obesity (Simopoulos, 2016). The recommended ratio of omega-6 to omega-3 fatty acids is 4:1 or less (Simopoulos *et al*, 1999). The ratios of omega-6 to omega-3 for the fish samples fell within the limit, hence they all have good fat.

Conclusion

This study showed that catfish obtained from major fish farms in Lagos contained medium levels of lipid and are good sources of lipids with excellent polyunsaturated fatty acids, especially the omega-3 fatty acids. The study also indicated that the ratios n-6/n-3 of the samples were within the recommended range therefore, it is a healthy food.

Recommendation

There is need to boost the nutritional quality of cultured catfish to enhance n-3 concentration, therefore fish feeds rich in fatty acid composition should be used in fish farming. Earthen pond is highly recommended in fish farming.

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What Fish Can Do To Immune System:A Case Study Of Corona Virus Relief

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Abstract

This study reviewed an investigated on what fish can do to immune system as a corona virus relief. Corona virus (covid-19) is the largest group of viruses belongings to "nidovirales" order which includes corona viridae, arteriviridae, meso viridae and roniviridae family. Corona virus as a respiratory syndrome binded to targeting cells by converting emzymes generated by lungs, intestine, kidney, hearts and blood vessels epithelial cells, thus raised the management of diabetes and hypertension with severe and fatal destructions. Dietary source of fish is responsible for increased immune systems, and cod liver oil has a cumulative therapeutic benefit against bacterial and viral acute respiratory tract infections. High blood pressure, diabetes mellitus with its complications affecting the eyes, nerves, blood vessels, skin and kidney. Neuron disorders like Alzheimer`s, dementia, ischemia's related to neuron death. Findings suggested that no antibiotics removed all virus or bacteria,an antibiotics merely reduces the number of the growing virus or bacteria to low enough level so that the body immune system can hopefully removed or control the rest. It was therefore, concluded that fish dietary hold a promise and deserves more attention in reducing these parameters and normalizes Bp, control diabetes, prevent cognitive decline as well as improved learning and memory retention.

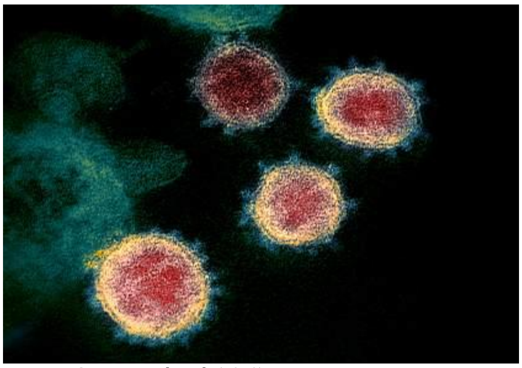
Keywords: Fish, Immune system, Corona virus relief

Introduction

Corona astronomically is a noun, means the cycle of light around the sun or the moon, seem especially clearly during an eclipse (Oxford advanced lear ner`s dictionary, 2004). It is an electrical discharge from the outer atmosphere of the sun.

Corona virus (Covid-19) is the largest group of viruses belonging to "Nidovirales" order which include corona viridae, arteriviridae, mesoniviridae as well as roniviridae families (venkatesh, 2020). Coronavirus virion are circular with a diameter of nearly 125nm under microscopical examinations. The most conspicuous character of the virus is the club-shape spike projection that has originated from the surface. Such spikes are a definite characteristics of the virus that give them a solar corona appearance leading to the name coronavirus (Anthony and Stanley, 2020). Described that corona virus covered a wide spectrum of host and carriers infecting a lot of mammals and avian species (Oz demir, 2020). These hosts and carriers of the virus may affect the upper respiratory, gastro in testinal, hepatics and communicate futher to destroy the central nervous system via number of diseases (Rabban etal,2020).Stated that virologically corona virus came from nidovirales, nidovirales order include those viruses that use a nested set of mRNAs for their replications. Further corona virus sub family has four (4) genera (alpa,beta, gamna, and delta coronaviruses). According to Rismanbaf,(2020) beta (B) corona viruses carry the disease comprises the middle east respiratory corona virus syndrome (MERS-COV), severe acute respiratory corona virus syndrome (SARS-COV).At this point genomic and phylogenic research indicated that COVI D-19 is a beta cov-2 of the cov of the same subgenus as SARS virus but in different class (Lu, *et al*, 2020). Suggested in their studied that COVID-19 and SARS viruses are in mirrow image and the constitution of the receptor binding gene region are very like to that of SARS-COV and the virus had been demonstrated to used the same receptor converting enzyme for entrance into respiratory cells.

Figure 1: Structure of corona virus

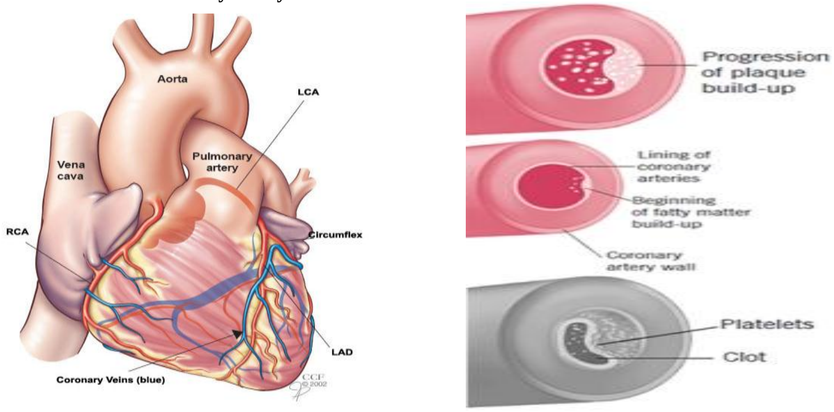


Source: Venkatesh (2020)

Methodology

Coronary Heart Diseases: coronary heart diseases (CHO) or coronary artery disease, developed when the coronary arteries became too narrow. The coronary arteries are the blood vessels that supply oxygen and blood to the heart (Debra, 2019).This tend to develop when cholesterol build up on the artery walls creating a plaques. These plaques cause the arteries, reducing blood flow to the heart. It cause coughing, dizziness, short of breath, panic, sweating, restlessness, body and chest pain and other general discomfort.

Figure 2. Structure of coronary artery diseases



Source: Debra (2019), Cleveland Clinic (2019)

Anti hypertension: High blood pressure associated with corona virus as one of the risk factor for coronary heart infections as per epidemiological studies (Prasam, 2012). Narrated that functional fish diet as food as potential alternative therapies for the reduction of hypertension (Chen, *etal.*2009). Findings indicated that no antibiotics kill all virus or bacteria; an antibiotics merely reduces the number of the growing virus or bacteria to a low enough level so that the body immune system can hope fully removed or control the rest (Garba, 2012,Dini*,et al*,2011). Additionally, it was shown that activation of minerals by fish extract in the kidneys reduces intra cellular concentration and normalizes Bp. Fish dietary modification has conventionally recommended as the first line therapy in the prevention of heart diseases.

Diabetes mellitus: was a common endocrine disorder characterize by hyper gly caemia leading to long term complication affecting the eyes, nerves, blood vessels, skin and kidney(Li,2016).Therefore, suggested that fish deserve more attention because of the ability to reduced these parameters,normalises erythrocytes,and control diabetes status (Rajaram, 2003). Many of these findings have also been evaluated in clinical trials. (Chen, *etal*,2020).Suggested that although, fish appears to hold a promise in reducing parameters associated with diabetes and cardiovascular diseases. Nevertheless, scientist believed that those feed on food dietary including fish live strongly.

Narvous Protection

Alzheimer`s disease of neuron (kwon, *et al* 2003). Alzheimer`s disease of neuron and dementia which causes cognitive decline (Liu, *et al* 2012).Opined that allocated dietary from fish may help prevent cognitive decline by protecting neurons from neurotoxicity. It also prevents ischemia or reper- fusion related to neuron death, thus improves learning and memory retention. Evidence supports the beneficial health effects attributed to fish help to control cerebrovascular diseases.Researches determine that no antibiotics remove all virus or bacteria, an antibiotics merely reduces number of growing virus or bacteria to a low enough level so that the body immune system can hope fully remove or control the rest.

Conclusion

Corona virus as a respiratory syndrome binded to targeting cells by converting (angiotensin) emzyme generated by lungs, intestine, kidney, heart, and blood vessels epithelial cells, thus raised the management of diabetes and hypertension with severe and fatal destructions. Dietary source of fish vitamins,proteins, minerals is responsible for increase immunity acquired and regenerating the endothelial lining, this is beneficial in minimizing the alveolar damage caused. Cod liver oil in fish has cumulative therapeutic benefit against bacterial and viral acute respiratory tract infections and reduces mortality. Findings determine that no antibiotics remove all virus or bacteria, an antibiotics merely reduces number of growing virus or bacteria to a low enough level so that the body immune system can hope fully remove or control the rest.High blood pressure associated with corona virus that resulted to decrease immunity, also functional fish diet as food as potential alternative therapies for the treatment of hypertension. Diabetes mellitus that affects nerves, blood vessels, skin and kidney, fish dietary hold a promise and deserves more attention to reduce these parameters and normalized erythrocytes, control diabetes status. Nervous system disorder or diseases of neurons like alzheimer`s dementia and other cause of cognitive decline, fish help to prevent cognitive decline, prevent ischemia or reper- fusion related to neuron death, thus improve learning and memory retension.

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Nutritional evaluation of animal by-products meal as partial substitute for fishmeal in the diet of African catfish, *Clarias gariepinus* (BURCHELL, 1822).

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Abstract

The effects of substituting fishmeal with Animal By-products Meal (ABM) in six experimental diets for African catfish fingerlings, *Clarias gariepinus* (mean weight=2.05g±0.11) with 0%, 20%, 40%, 60%, 80% and 100% substitution were investigated for 70 days. In general, the best growth and feeding performance were obtained with the control diet (D_1) based on fishmeal as the sole protein, but the result was not statistically different ($P>0.05$) from those obtained with 20%, 40%, and 60% ABM inclusion. A significant ($P<0.05$) growth depression was observed with diet treatments containing 80%, and 100% ABM inclusion. Whole body percentages of moisture, lipid, ash, and NFE were not significantly affected by the dietary treatments. Crude protein contents however, were highest for fish fed higher levels of dietary protein. The result of this study suggest that 60% ABM/40% fishmeal can be incorporated in the diet of African catfish without adversely affecting growth or any other aspect of performance, and as well as, improving the economics of feeding in comparison with fishmeal.

Key words: Animal By-Products Meal, *Clarias gariepinus*, Fishmeal.

Introduction

The increasing population of human being necessitates the increase in the production of food especially the refined proteinous food from fishes. According to Audu and Adejor (2003), fish have enormous nutritional and economic values and the current high demand for fish and its products as a healthier source of protein lead to the realization that captured fisheries from the wild alone cannot meet the demand of the human population. The extensive fish culture system is not reliable due to pollution; bioaccumulation of some substances in water organisms and the pressure of fishermen per unit area have led to poor harvest. In view of these practices, fish farmers tend to look toward intensive fish culture system in order to meet the demands for fishes and fishery products. This in turn has generated a need for development of suitable fish diets for economic and practical reasons. There has been an increasing tendency to use alternative plant and animal proteins as a low cost substitute for fishmeal, but in general the nutritional value of these proteins is lower than that of fishmeal, resulting in lower growth rates or a reduction in performance of the cultured animals (Pongmaneerat and Watanabe, 1991; Ofojekwu and Kigbu, 2002; Anderson *et al*., 1993; and Rumsey, 1993).

Individual by-product meals, such as blood meal, hydrolyzed feather meal or meat and bone meal often have deficiencies, or excesses in essential amino acids; nonetheless these meals can be mixed in certain proportions to produce a nutritionally balanced and economic fish diets (Robinson and LI, 1994; Eyo and Olatunde, 1996; Rodrigues *et al*., 1996; Absalom *et al*., 1996).

This study aims to determine the nutritional value of Animal By-products meal, their optimal level of inclusion in *C. gariepinus* diets and to investigate the performance of the experimental fish on the formulated diets.

Materials and methods

Mixed sex of the same African catfish (*Clarias gariepinus*) fingerlings with average weight of 2.05g±0.11g were obtained from Rock Water Fish Farm Jos, Nigeria. The fish were transported to the laboratory in plastic bags with well oxygenated water in the early hours of the morning. The fish were acclimated to laboratory conditions for 7 days in circular plastic baths with a capacity of 50 litres prior to feeding trials. The plastic bags contained dechlorinated tap water. During the acclimation period, the fish were fed with commercial feed at 4% of their body weight daily divided into 2 equal feedings. The feeding of the fish was at 09:00 and 16:00 hours. Before each feeding, leftover food and faecal matter were siphoned out to prevent depletion of dissolved oxygen and accumulation of toxic wastes in the water. Temperature of water, pH, free carbon dioxide and dissolved oxygen were determined by method of APHA (1985).

At the end of acclimation period, ten (10) fingerlings were randomly selected to determine their initial carcass proximate composition. Twelve green plastic baths of 40cm diameter, 10cm depth and 16 litre capacity were filled and maintained with dechlorinated municipal water to 10L level and arranged into 6 feeding treatments tagged D_1-D_6. Each treatment was replicated and designated 'a' and 'b' for each diet. Ten fingerlings were weighed before stocking in each of the labeled plastic baths. Each bath was then covered with a square net mounted on a wooden frame to ensure the fingerlings did not jump out of the tanks and at the same time preventing entrance of unwanted materials. The experimental baths were washed fortnightly and treated with 20% KMnO4 solution, after which they were properly rinsed with water. Fish in each treatment tank were fed at 4% body weight daily as recommended by Dupree and Huner (1984). Each diet contained different level of Animal By-product Meal (ABM) and fishmeal. The diets were prepared using methods described by Eyo and Olatunde (1996). Chromic oxide was incorporated into the diets as an inert digestibility marker following the method suggested by Furukawa and Tsukahara (1996). The average body weight was used to adjust the amount of food to be given. Faecal matter and any uneaten food were siphoned out before feeding. Each of the six (6) diets was administered two (2) times daily at 09:00 and 16:00 hours.

All fish in each tank were bulk weighed at the beginning of the experiment and thereafter on a bi-weekly basis. To facilitate weighing, fish were collected with a scoop net and dried by blotting with soft damped tissue paper and weighed in a small plastic container using a Metler P20110 top loading balance. During the weighing, faeces for the protein digestibility analysis were collected by siphoning before the second feeding, drying the faeces at 105^{o}c for 24h and storing them in air-tight vials under refrigeration (4^{o}c) for subsequent chromic oxide and protein analysis. The feeding trials lasted for 70 days.

The six (6) experimental diets were analyzed for moisture content, crude protein, lipid, fibre, ash and carbohydrate using the method of Association of Official Analytical Chemists (AOAC, 1990) (Table 2). During the experimental period, the water parameters (pH, dissolved oxygen, free carbon dioxide and alkalinity) of the experimental tanks were determined fortnightly as described by APHA (1985), while temperature (^{o}C) was determined on daily basis throughout the 70 days period.

Growth and feed utilization indices such as percentage live weight gain (LWG %) were determined as described by Cho *et al*., (1983); specific growth rate (SGR) were determined as described by Jauncey and Ross (1982); food conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU) were determined as described by Halver (1989). Apparent Protein Digestibility (APD) was determined as described by Furukawa and Tsukahara (1996).

To test for significant difference between treatments, the one-way Analysis of Variance (ANOVA), single classification was used to test which pairs of means differed significantly from the other.

Result

Result of the proximate composition of the experimental diets (Table 1) showed that all the diets contained between 31-35% crude proteins with exception of diet D_1 which had 36.79% crude protein. Diet D_2 had the highest fibre and ash contents compared to the other diets. The result of growth performance indices and protein digestibility are given in Table 2. Variations in the mean weight of fish in each treatment group at the start of the experiment was not significant ($P>0.05$). However, variations in the cumulative weight gain among the different treatments at the end of the experiment was significant ($P<0.05$). although fish fed the control diets (D_1), weighed more than those fed diets D_2, D_3, and D_4, no significant difference were obtained among the final weight gain of fish in this treatments. The groups fed diets D_5 and D_6 weight significantly less than those of the other treatments.

Other growth and food utilization parameters namely, Mean Growth Rate (MGR), and Specific Growth Rate (SGR) followed the same trend as the final weight gain.

The percentage proximate composition of the fish carcass at the beginning and end of the experiment expressed as percentage wet matter is shown in Table 4. Difference in protein deposition observed between fish fed the control diet, D_1 and diet D_2 and D_3 was not significant (LSD=0.99). Final whole body percentage of moisture, ash, lipid and NFE were not affected by dietary treatment.

Table 1: Percentage Composition of Experimental Diets Fed to *C. gariepinus* for 10 Weeks

	Diets					
Ingredients	D_1	D_2	D_3	D_4	D_5	D_6
Fish meal	54.0	43.2	32.4	21.6	10.8	0.0
ABM[a]	-	10.8	21.6	32.4	43.2	54.0
Cassava flour	18.0	18.0	18.0	18.0	18.0	18.0
Maize flour	18.0	18.0	18.0	18.0	18.0	18.0
Vegetable oil	5.0	5.0	5.0	5.0	5.0	5.0
Premix (vitalyte)	4.5	4.5	4.5	4.5	4.5	4.5
Chromic oxide	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Fish meal Replaced By ABM (%)	0.0	20.0	40.0	60.0	80.0	100.0

a: ABM = Animal By-products Meal: is a mixture of blood meal, poultry offal and shrimp meal.

Table 2: Percentage Proximate Composition of Experimental Diets Fed to *C. gariepinus* Fingerlings for 10 Weeks

	Diets						
Proximate Composition (% Dry Weight)	D_1	D_2	D_3	D_4	D_5	D_6	±SE
Crude Protein	36.79	35.10	34.25	33.75	33.04	31.18	0.77
Lipid	11.86	13.55	13.18	12.98	13.44	13.60	0.27
Fibre	1.01	1.62	O.33	0.22	0.19	0.13	0.25
Ash	4.87	5.53	4.60	4.63	3.53	4.41	0.27
Moisture	7.33	6.02	6.29	6.40	6.85	7.05	0.20
***NFE**	38.14	38.18	41.35	42.02	42.95	43.63	0.97
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	

*NFE (Nitrogen Free Extract) = 100 − (% moisture +% lipid + % ash + % fibre + % crude protein)

Table 3: Table of Means for Food Utilization Indices for *C. gariepinus* Fingerlings Fed Experimental Diets for 10 Weeks.

Exp. Diets	TOTAL FOOD FED (g)	CRUDE PROTEIN FED (g)	INITIAL WEIGHT (g)	FINAL WEIGHT (g)	WEGHT GAIN (g)	FCR	PER	ANPU (%)	APD (%)
D_1	16.60	6.11	3.26^a	13.83^a	10.57^a	0.64^a	1.74^{ab}	86.84^a	71.00^a
± SE	(0.29	(0.11)	(0.02)	(0.09)	(0.28)	(0.00)	(0.01)	(1.49)	(0.05)
D_2	16.41	5.42	3.36^a	13.72^a	10.36^a	0.63^a	1.93^a	75.76^b	69.00^{ab}
± SE	(0.60)	(0.12)	(0.13)	(0.94)	(0.81)	(0.07)	(0.21)	(1.75)	(1.00)
D_3	15.43	5.39	3.41^a	13.41^a	10.00^a	0.65^a	1.90^a	63.20^c	64.00^{bc}
± SE	(0.13)	(0.15)	(0.09)	(0.50)	(0.13)	(0.01)	(0.04)	(0.54)	(1.10)
D_4	14.97	5.06	3.53^a	12.92^a	9.36^a	0.63^a	1.86^a	26.34^e	59.00^c
± SE	(0.61)	(0.21)	(0.10)	(0.99)	(0.89)	(0.03)	(0.10)	(1.68)	(0.10)
D_5	13.51	4.47	3.42^a	9.92^a	6.50^b	0.48^a	1.46^c	40.18^c	58.00^c
± SE	(0.64)	(0.22)	(0.20)	(0.01)	(0.21)	(0.02)	(0.02)	(1.94)	(0.00)
D_6	13.83	4.31	3.30^a	9.97^a	6.67^b	0.48^a	1.55^{bc}	15.78^f	58.30^c
± SE	(0.09)	(0.03)	(0.22)	(0.01)	(0.21)	(0.01)	(0.04)	(0.10)	(0.20)

*values in parenthesis are standard errors of means (±SE).

*Within columns, values with the same superscripts are not significantly different (P>0.05).

Table 4: Percentage Proximate Composition of *Clarias Gariepinus* Carcass Before and After Feeding the Experimental Diets for 10 Weeks

		Diets						
***proximate Composition**	Before Feeding	D_1	D_2	D_3	D_4	D_5	D_6	±SE
Moisture	76.68	71.56^a	72.03^c	74.13^a	76.57^a	76.21^a	77.10^a	0.81
Crude Protein	12.30	17.60^a	16.40^a	15.64^a	13.63^c	14.09^{bc}	12.96^a	0.67
Lipid	3.56	4.15^a	4.75^a	4.01^a	3.89^a	3.75^a	3.62^a	0.14
Ash	4.82	5.44^a	5.38^a	4.36^a	4.23^a	4.19^a	4.13^a	0.19
NFE	2.64	1.25^a	1.26^a	1.86^a	1.68^a	1.76^a	2.19^a	0.17
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

1. Values within the same row with the same superscripts are not significantly different (P>0.05).

- Calculations based on wet weight

Discussion

Protein requirement for optimal growth and feed efficiency of juvenile fish usually ranged from 31-35%. Ayinla and Akande (1988) gave a percentage crude protein requirement of 31-34% for fingerlings and juveniles of *C. gariepinus*. Rumsey (1993) reported that 31% crude protein diet had the highest protein efficiency and highest growth rate in *C. gariepinus* fingerlings, while Faturoti (2003) suggested a percentage crude protein requirement of 35% for fingerlings and juveniles of *C. gariepinus*. In line with this findings, the percentage dietary crude protein (35%) used in this study is in good range that maximize growth of *C. gariepinus*.

The present study shows that 60% ABM can be used with 40% fishmeal in the diet of *C. gariepinus* fingerlings without affecting the overall performance (Table 2). Although final body weight and growth rate were higher in fish fed the control diet, no significant differences (P>0.05) were detected between the control and the treatments with 20-60% ABM inclusion. Significant growth depression was observed when a higher level of ABM was added to the diets. Although diet D_5 with 80% of ABM inclusion resulted in the poorest growth, there was no statistical difference (P>0.05) between growth in diet D_5 and diet D_6 with 100% of ABM inclusion. The low performance obtained from these diets may be due to amino acid imbalances. Audu and Adejor (2003) reported that although optimal dietary crude protein is important in promoting growth, other factors such as lipid and crude fibre are usually very important parameters. The suggestion by Rodriguez *et al.*, (1996) that higher levels of ABM in fish diets be supplemented with oils (e.g. soy bean oil) to enhance its performance, may perhaps be related to a better supply of essential fatty acid. The result for Protein Efficiency Ratio (PER) and Apparent Net Protein Utilization (ANPU), used as an indicator for the protein productive value, were also within a good range. PER values ranged from 1.93 in fish fed diet D_2 to 1.46 in the group fed diet D_5. In all except 2 treatments, the values of ANPU were over 40%, showing good nutritional quality of ABM for catfish feeds. These figures are relatively similar to those reported by Rodriguez *et al*.,(1996) using ABM for *Oreochromis niloticus*, but however higher than those reported by Steffens (1994) using poultry by-product meal for rainbow trout, *Onchorynchus mykiss.*

Throughout the study period, there was a relatively narrow fluctuation in temperature. The least mean temperature of 21.50 ± 0.30^oC was recorded in bath D_5, while bath D_6 had the highest mean temperature value of 23.70 ± 1.10^oC. The average temperature was 22.82 ± 0.33^oC. This value is within tolerant range but however falls below the recommended range of 25 to 32^oC for optimum growth of fresh water fishes (Boyd and Tucker, 1998). Average pH was 6.68 ± 0.02. This value is within acceptable limit as FAO (2001) reported that pH values range of 6-9 is best for growth. Dissolved oxygen fluctuated from $2.15 \pm 0.30mgl^{-1}$ to $3.90 \pm 0.20mgl^{-1}$ with an average $3.08 \pm 0.24mgl^{-1}$. This value falls below the optimum dissolved oxygen content for normal growth and reproduction in tropical waters which should be in the range of $5mgl^{-1}$ to saturation level (FAO, 2001). Free carbon dioxide content was in the range of $2.00 \pm 0.40mgl^{-1}$ to $1.7 \pm 0.30mgl^{-1}$ with an average of $1.85 \pm 0.04mgl^{-1}$. This value is well within acceptable limit as FAO (2001) stated that sub lethal effects including respiratory stress and nephrocalcinosis will occur when the free carbon (IV) oxide content is in the range of $12\text{-}50mgl^{-1}$. Total alkalinity ranged from $20.10 \pm 1.82mgl^{-1}$ to $23.60 \pm 1.25mgl^{-1}$ with an average of $21.84 \pm 0.50mgl^{-1}$. These values were within the optimum range, as according to Wurts and Masser, (2004), $20\text{-}300mgl^{-1}$ alkalinity is ideal for warm water fishes.

Conclusion

The result of this experiment showed that it is feasible to use animal by-product meal as a substitute for fishmeal in catfish feeding without adverse effects on growth and at the same time, improving the economics by reducing costs of feeding. In the experiment, good growth performance was obtained in fish fed the 60% ABM/40% fishmeal diet. Increasing dietary ABM above 60% resulted in depressed weight gain and food conversion. Inclusion of 60% ABM in the diet of African catfish may be a way of reducing the amount of expensive fishmeal in formulated diets without reducing the growth performance of the fish.

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Growth performance and haematology parameters of *Clarias gariepinus* juveniles fed *Moringa Oleifera* leaf meal diet

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Abstract
An eight-weeks feeding trial involving 300 *Clarias gariepinus* juveniles was conducted to assess the growth performance and haematological parameters of C. *gariepinus* juveniles fed *Moringa oleifera* leaf meal diet. *M. oleifera* leaf meal substituted for soya bean meal at 0% (control), 25%, 50%, 75% and 100% in five different feeding diets. The result obtained from the experiment showed that there is a significant difference ($p<0.05$) between the treatments in mean weight gain (MWG) and percentage weight gain (PWG), the highest MWG was recorded in fish fed with the control diet (T1) while the lowest was recorded in fish fed in treatment 5 (T5). There was no significant difference ($p>0.05$) in the specific growth rate (SGR) between the fish fed with the control diet (T1) and the fish fed with 25% (T2) Moringa leaf meal. The treatment with the highest feed conversion ratio (FCR) was T5, T4 and T3 while the lowest was the control diet T1 and T2. The hematological parameters show the value of packed volume cell of the control (0%), T2 (25%) and T5 (100%) with *M. oleifera* leaf meal as 31.67±1.53, 32.67±0.58, 30.33±0.58, with treatment 2 having the highest value. Heamoglobin and red blood cell was high in treatment 2 (25%) but low in treatment 4. The present study reveals that *M. oleifera* has a good potential for use as soya bean meal substitute in *C. gariepinus* diet up to 25% inclusion level without compromising growth.

Keywords: growth performance, haematology, *Clarias gariepinus*, *Moringa oleifera* leaf

Introduction

Feed is one of the major factors influencing high cost of production in fish farming (aquaculture) this is due to high reliance on imported feed from European countries which makes fish farming expensive as fish feed account for at least 60% of the total cost of production. Therefore, local production of fish feed is very crucial to the development and sustainability of aquaculture in Nigeria. For aquaculture to thrive and bridge the gap between demand and supply, the role of locally produced fish feed in reducing the cost of production and making fish farming attractive to commercial and private investor cannot be emphasized. Development and management of fish feed stuff plays an important role in fish farming growth and expansion, it is one of the many factors that determines the profitability of aquaculture venture accounting to at least 60% of total cost of fish production in Africa (Jamu and Ayinla, 2003). Therefore, there is a need to intensify the investigation of other alternative feed ingredients (plant source) in producing fish feed in other to reduce cost of production. Moringa (*M. oleifera*) is a multipurpose tropical tree mainly used for food and has numerous industrial, medicinal and agricultural uses including animal feeding. Rediscovered in 1990, its cultivation has since become increasingly popular in Africa and across Asia also referred to as the “miracle tree” or “tree of life” in popular media (FAQ, 2014; Radovich, 2013; Orwal *et al*, 2019). The aim of this experiment is to establish the effects of *M. oleifera* leaf meal on the growth and haematological parameters of *C. gariepinus*

Materials and Methods

Moringa processing

M. oleifera leaves were collected from a Moringa farm at Alapa community, Ile-Ise Awo in Abeokuta North, Ogun state, Southwest Nigeria. The leaves were air-dried indoors, milled into powdery form using an electric blender and stored into a well-sealed plastic container.

Table 1: Proximate composition of *M. oleifera*

Parameters	Proximate composition (%)
Dry matter	91,32
Crude protein	25.19
Crude lipid	7.41
Crude fiber	10.18
Ash	16.28
Nitrogen free extract	32.26
Gross energy (kJ g^{-1})	348.49

Fish diet formulation and processing

Five different diets were formulated All other ingredients were milled using hammer mill, then the *M. oleifera* leaf was incorporated to each diet at different percentage level to replace Soya Bean Meal (SBM) at (a) 0% replacement in the first diet (T1), (b) 25% in the second diet (T2), (c) 50% replacement in the third diet (T3), (d) 75% replacement in the fourth diet (T4) and (e) 100% replacement in the fifth diet (T5). Each diet was weighed and mixed properly with adequate water to ensure smooth pelletizing using manual pelletizing machine in the Department of Aquaculture and Fisheries Management and thereafter sun dried for three (3) days to remove the moisture (Eyo, 1994). Sample from each treatment was subjected to proximate analysis which followed the procedure of AOAC, (1990).

Table 2: Ingredient composition of experimental feed diet

Ingredients	T1 (control)	T2	T3	T4	T5
Maize	19.59	15.70	11.36	6.51	1.02
Fish Meal	18.29	19.26	20.34	21.56	22.93
Groundnut cake	18.29	19.26	20.35	21.56	22.93
Soybean meal	36.58	28.89	20.35	10.78	-
Moringa Leaf meal	-	9.63	20.35	32.34	45.87
Vit. Premix	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5	0.5
Vegetable oil	6	6	6	6	6
Total	100	100	100	100	100

Experimental design and feeding trails

Three hundred (300) African Catfish Juveniles (*C. gariepinus*) were purchased from a reputable fish hatchery in Abeokuta, Ogun State, Southwest Nigeria. The fish were purchased and transported very early in the morning to avoid mortality as a result of stress and increase in temperature. Fish were immediately transferred to the Student Experimental Unit of the Department of Aquaculture and Fisheries Management and fed with commercial diet, where they were acclimatized for one week.

The experimental design consisted of five (5) treatments replicated thrice at a stocking density of twenty (20) per tank. The design was a complete randomized design having the juveniles randomly distributed into the tanks (15). The fish were initially weighed in batches 20 fish per tank and recorded using a sensitive Mettle top loading balance before transferring them into the tanks.

The experimental fish were starved for 24 hours before the commencement of the experimental diet in order to increase the appetite of the fish as well as to eliminate variation in weight due to residual food in the gut and also to prepare the gastro intestinal tract for the experimental diet. After 24hours all the experimental fish were fed with the prepared diet 3% body weight and twice daily; 9hrs-10hrs and 16hrs-17hrs. Experimental fish in each tank are weighed weekly and recorded using a sensitive Mettle top loading balance for 8 weeks.

Growth parameters

The growth parameters of the experimental fish were assessed taking the following parameters into consideration:

Percentage Weight Gain (%) = (WF (G)/WI) ×100

Protein Efficiency Ratio (PER) = Weight gain (g)/ Protein fed

Protein fed = % Crude protein of the feed x feed intake

Specific Growth Rate (SGR) (%)=((log e WF(g) – log e WI (g)) ×100)/ Time (days)

Haematological experiment
The following parameters were used to determine the effect of the dietary treatment on the hematological profile of *C. gariepinus* at the beginning and the end of the experiment. Blood samples for hematological analysis were collected from the experimental fish with a fine syring into a heparinized bottled. Blood was drawn from the caudal arch of the fish into hematological tube from this sample (Blaxhall and Dalsey 1973).

Analytical procedure
The proximate analysis of the feed ingredient and fish were carried out to determine the crude protein, ash, crude fiber, fat and moisture contents (AOAC, 1990).

Result
Growth performance
The result of the feed utilization and growth parameters are presented in Table 3. Fishes fed the control diet (Trt1) gained 40.22g body weight while the fishes fed with 25% *M. oleifera* leaf meal diet (Trt2) gained 35.17g, fishes fed with 50% (Trt3) gained 19.00g, fishes fed 75% (Trt4) gained 11.36g while 5.93g weight gain was recorded in fishes fed with diet containing 100% *M. oleifera* leaf meal (Trt5), Means of all treatment (1, 2, 3, 4 and 5) were significantly different. There was no significant difference (p>0.05) in the feed conversion ratio (FCR) in fishes fed the control diet and 25% moringa leaf meal diet. The highest value of 1.77 for protein efficiency (PER) was observed in fishes fed control diet (TRT 1) and the lowest value of 0.83 was recorded in fishes fed diet containing 100% (TRT 5) moringa leaf meal diet. The apparent net protein utilization (ANPU) of 78.67 and 74.00 were obtained in fishes fed the control diet and 25% moringa leaf meal based diet respectively. There was no significant difference (p>0.05) between these values but were significantly different (p<0.05) when compared with fishes that were fed with 50%, 75% and 100% moringa leaf meal diet.

Table 3: Growth Performance and Nutrient Utilization of *C. gariepinus* Juveniles fed Moringa leaf meal based diet.

PARAMETERS	TRT1 (0%)	TRT2 (25%)	TRT3 (50%)	TRT4 (75%)	TRT5 (100%)
IMW	10.10±0.05	10.08±0.10	10.12±0.06	10.08±0.15	10.10±0.10
FMW	50.32±0.83^{a}	45.26±4.37^{b}	29.08±3.09^{c}	21.45±0.97^{d}	16.15±1.44^{e}
MWG	40.22±0.8^{a}	35.17±4.3^{b}	19.00±3.1^{c}	11.36±0.8^{d}	5.93±1.44^{e}
PER	3.98±5.81^{a}	3.49±39.0^{b}	1.88±30.20^{c}	1.13±6.55^{d}	58.67±13.^{73e}
FI	56.97±1.1^{a}	52.73±6.07^{a}	32.27±5.0^{b}	25.33±1.8^{b}	17.75±3.72^{c}
FCR	1.42±0.005^{d}	1.50±0.01^{d}	1.70±0.010^{c}	2.23±0.06^{b}	3.00±0.10^{a}
SGR	2.55±0.02^{a}	2.38±0.14^{a}	1.67±0.17^{b}	1.20±0.051^{c}	0.74±0.13^{d}
SR	95.00±0.00	93.33±2.89	95.00±5.00	98.33±2.89	86.67±10.41
PER	1.77±0.01^{a}	1.68±0.01^{b}	1.47±0.010^{c}	1.12±0.03^{d}	0.83±0.030^{e}
ANPU	78.67±1.15^{a}	74.00±1.0^{a}	67.67±4.6^{b}	60.67±1.15^{c}	53.33±2.89^{d}

Means along the same row with different superscript are significantly different (p<0.05); IMW: Initial Mean Weight, FWM: Final Mean Weight, Mean Weight Gain, FI: Feed Intake FCR: Feed Conversion Ratio, SGR: Specific Growth Rate, SR: Survival Rate, PER: Protein Efficiency Ratio, ANPU; Apparent Net Protein Utilization.

Survival rate
The effect of *M. oleifera* leaf meal on the survival of *C. gariepinus* is shown in Table 3. In the course of feeding with the experimental diet, there was a significant difference (p<0.05) in the survival rate of *C. gariepinus* juveniles fed varying inclusion levels of moringa leaf meal diet for the 8weeks. The highest survival was obtained in Treatment 4 (98.33±2.89), followed by Treatment 1(95.00±0.00), Treatment 3(95.00±5.00), Treatment 2(93.33±2.89) and the least in Treatment 5 (86.67±10.41).

Heamatological profile
Table 4 revealed the hematological indices of fishes fed with *M. oleifera* leaf meal based diet during the experiment. The packed cell volume (PCV) result indicates that fishes fed diet 1 with (0%), diet 2 with (25%) and diet 5 (100%) Moringa leaf meal had values of 31.67, 32.67 and 30.33 respectively. These values were not significantly different (p>0.05). The fishes fed with diet containing 50% and 75% *M. oleifera* leaf meal diet showed a decrease PCV. The Red blood cell (RBC) showed that fish fed with diet containing 0%, 25% and 100% *M. oleifera* has the highest value of 2.67, 2.70 and 2.60 respectively with no significant difference (p>0.05), while the fish fed with diet containing 50% and 75% has the lowest values of 1.97 and 1.97 respectively. Hemoglobin decreases in the fish fed diet containing 50%, 75% and 100% *M. oleifera* leaf meal. The fishes fed diet 1(control) and diet 2 (25%) *M .oleifera* meal diet recorded values of 9.00g/100ml and 10.07g/100ml respectively. These

values show significant difference ($p<0.05$) from fishes fed diets containing 50%, 75% and 100% *M. oleifera* leaf meal. Lymphocyte count increases in the fishes fed diet containing 0%, 25%, and 50% *M. oleifera* leaf meal diet, the highest value of 69.33% was recorded in fish fed diet containing 50% *M. oleifera* leaf meal while the least value of 64.33% was recorded in fish feed diet containing 100% *M. oleifera* leaf meal diet.

Table 4: Haematological parameters of *Clarias gariepinus* juveniles fed different levels of *M. oleifera* leaf meal diet.

BLOOD PARAMETERS	TREATMENT 1 0%	TREATMENT 2 25%	TREATMENT 3 50%	TREATMENT 4 75%	TREATMENT 5 100%
PCV	31.67 ± 1.53^{a}	32.67 ± 0.58^{a}	24.33 ± 3.21^{b}	23.67 ± 5.03^{b}	30.33 ± 0.58^{a}
HB	9.00 ± 0.53^{a}	10.07 ± 0.12^{a}	7.17 ± 0.86^{bc}	7.08 ± 1.46^{c}	8.67 ± 0.61^{ab}
RBC	2.67 ± 0.29^{a}	2.70 ± 0.10^{a}	1.97 ± 0.29^{b}	1.97 ± 0.45^{b}	2.60 ± 0.20^{a}
WBC	13.2±1.17	13.03±2.05	13.33±1.22	12.33±0.64	10.60±0.53
HET	30.33±2.25	29.00±2.00	28.33±3.51	32.33±2.08	33.33±2.31
LYM	67.33 ± 2.25^{a}	68.33 ± 1.15^{a}	69.33 ± 1.15^{a}	66.67 ± 1.15^{ab}	64.33 ± 0.58^{b}
EOS	0.67±0.58	0.67±0.58	0.00±0.00	0.67±0.58	0.67±0.58
BAS	0.00±0.00	0.67±0.58	1.00±1.00	0.00±0.00	0.00±0.00
MON	1.33±0.58	1.00±1.00	0.67±1.15	1.00±1.73	0.33±0.58
TRIGLY	96.33±3.51	90.00 ± 4.36^{b}	1.01 ± 2.31^{a}	96.00 ± 2.65^{ab}	93.00 ± 3.61^{b}

Values on the same row having the same superscript are not significantly different ($p>0.05$).
PCV- Packed Cell Volume, HB- Haemoglobin, RBC-Red Blood Cell, WBC- White Blood Cell, HET- Heterophyls, LYM- Lymphocytes, EOS- Eosinophil, BAS-Basophil, MON- Monocytes, TRIG- Triglyceride

Discussion

The final mean weight showed significant difference ($p<0.05$) between the treatments, as increase in weight gain in animal is normally as a result of increase feed intake. In this study, there was decrease in final mean and body weight gain with increased level of moringa. The weight gain value showed significant difference ($p<0.05$) between the treatment. This was in contrast with the findings of Bundit and Masumoto (2012) who reported no significant difference ($p>0.05$) in weight gain. There is a significant difference ($p<0.05$) in the Protein Efficiency Ratio (PER) of all the treatment (1, 2, 3, 4, 5) with (0%, 25%, 50%, 75%, 100%) *M. oleifera* leaf meal. It shows that there is a decrease in the PER as the inclusion of *M .oleifera* increases in the diet and this might have a link with the palatability of the diet which is shown in the feed intake. Feed intake is important in the sense that it is the determinant of its performance. FCR was better in fishes fed diet 1(0%), 2(25%), 3(50%) *M. oleifera* leaf meal diet among all experimental diet in contrast to the finding by Ozovehe (2013) who reported that fishes show better in his control diet, 10% and 20% *M. oleifera* meal based diet. The decrease in the FCR can be attributed to the presence of high fibre content (Dienye and Olumuyi, 2014). The decrease in the growth performance with increase in the *M. oleifera* leaf meal diet can be attributed to the presence of Anti-nutritional factors in leaf of *M. oleifera* as suggested by Dienye and Olumuyi (2014).

The low survival rate in treatment 5 (100%) *M. oleifera* leaf meal based diet might be due to presence of some toxic compound in moringa plant which indicates that excessive use of *M. oleifera* leaf meal can pose a threat on the health of the fish. Although, the survival rate may be due to environmental factors and handling of the fish throughout the experimental period.

Blood analysis is a valuable means of evaluating the physiological condition of cultured fish with respect to determining the effect of diet and other stress factor on fish health. Changes in hematology of fish in response to stressing agent are indicator of the stressful stage of fish producing useful information to curb any unfavorable condition that may affect the fish health, (Bello-Olusoji *et al*., 2006). All hematological parameters measured in this study were within the recommended physiological range for PVC (16 - 37 %), haemoglobin (4.6 - 11.7 g/dl), WBC (9300 - 336200 mm^3), Red Blood Cell, (1.03 - 3.92 x 10^6mm), Lymphocytes (34 - 78 %), MCV (26.50 - 191.20 μ^3), MCH (25.10 - 55.10 pg) and MCHC (26 - 33 %) in teleosts (Adedeji and Adegbile, 2011).. Blaxhall and Diasley (1973) reported the essence of using hematocrit to detect anaemic condition in fishes. The packed cell volume (PCV) range of 24.33% -32.67% observed in this study is within the range of 20-50 reported by Pietse *et al*., (1981) and rarely do values above 50% being reported (Etim *et al*., 1999). There is a reduction in PCV value in fish fed with diet 3 (50%) and diet 4 (75%). Reduction in concentration of PCV in the blood usually suggest the presence of a toxic factor, an example of which is hemaglutin which has adverse effect on blood formation (Oyawoye and Ogunkunle, 1998). The reduction in trend observed in the PCV of this study may be attributed to the presence of some anti –metabolite such as tannin and phenol; in *M. oleifera* leaf meal. The hemoglobin result shows an increase in diet 1(0%), 2(25%) and 5(100%) moringa leaf meal. The hemoglobin range (7.08-10.07g/100ml) recorded were high and fell within the range (5.6-15.8g/100ml) reported by Esox Lucius (Mulcahyl, 1970). It also compares well with 8.70g/100ml for *C. gariepinus* (Sowunmi, 2003). The values were higher than

4.40g/100ml reported for *Heterotis niloticus* (Fagbenro *et al*., 2000). The high range of hemoglobin in those studies can be related to large anaerobic metabolism capacity of *C. gariepinus* and decrease level of hemoglobin in the diet with high level of *M. oleifera* implies that the diets (3, 4, 5) had negative effect on the blood. The lymphocytes result recorded in these study showed an increase as the level of *M. oleifera* increased in the diet. The lymphocytes count shows that the highest value of 69.33 was recorded in fish fed the diet containing 50% *M. oleifera* leaf meal. Lymphocytes and white blood cell are the defense of the body. The increase in WBC and lymphocytes as *M. oleifera* leaf meal increased in the diet could be as a result of feed toxicity. Reduction in Red Blood Cell was recorded from fish fed diet 3(50%) and 4(75%) *M. oleifera* leaf meal which shows a decrease from the diets (1, 2, 5). The range of RBC reported by Bhasker and Rao (1990) is 1.97×10-2.70×10mm. These decrease may be due to higher concentration of anti-metabolites especially tannin in diet containing *M. oleifera* leaf meal.

Conclusion

Soya bean is among the most important fish feed ingredient, ironically it is expensive due to cultivation and availability. Moringa plant is one of the cheapest close substitutes. It has a high nutritional profile and can be made available in quantity that can support aquaculture industry. The result obtained from this study shows that *M .oleifera* could be substituted with soya bean meal up to 25% in C. *gariepinus* diet without any negative effect on growth and feed efficiency. The hematological result also showed that 25% substitution rate of *M. oleifera* meal in *C. gariepinus* diet would not have adverse effect on the blood and serum enzymes. Fish feed can therefore be produced at a relatively cheaper cost and as thus profit of the fish farmer can be increased.

Recommendation

From the result obtained from this experiment, 25% of *M. oleifera* leaf meal can be included in the diet of *C. gariepinus* replacing soya bean meal without any negative effect on the health status of the fish in other to reduce cost of feeding.

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Nutritional Composition of Commercial Fishes from Ikpoba Reservoir and Their Potential Contribution to Recommended Nutrient Intake.

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Abstract
Global concern for good health and well-being of human populations especially in underdeveloped and developing nations has necessitated the need for routine nutritional assessment of their food sources. This study was undertaken to determine the nutrient composition of commonly consumed freshwater fish species in Ikpoba reservoir and to assess the potential contribution of selected key nutrients in the fishes to recommended nutrient intakes (RNI). The fishes were captured over a period of twelve months (February 2018 to January 2019) and three composite samples from each species were analysed using accredited methods. The result of the proximate composition of *Clarias gariepinus* and *Tilapia zilli* showed moisture content of 61.09% and 63.39 %; protein value of 15.15 % and 15.71%; lipid value of 6.03% and 1.48 %; and ash content of 4.58 % and 5.09 % respectively. The mineral content of fish species showed that sodium ranged from 3.32 to 5.64 mg/100g, potassium from 8.14 to 12.64 mg/100g, magnesium from 2.56 to 4.42 mg/100g, calcium from 1.75 to 5.85 mg/100g, iron from 5.47 to 9.35 mg/100g and zinc from 1.40 to 3.66 mg/100g. The potential contribution of each species to recommended nutrient intakes (RNIs) for preschool children and adults; indicated that the fish species contributed ≥25% of RNIs for iron and zinc for preschool children from a standard portion. This work has increased the knowledge on the nutritional value contribution to RNI of fishes in combating nutritional deficiencies and food security in Nigeria.

Keywords: Proximate composition, mineral content, *Clarias gariepinus*, *Tilapia zilli*, Ikpoba Reservoir.

Introduction
Fish is one of the healthiest sources of animal protein and other important nutrients required in human diets. It contributes significantly to food security, provides relief from malnutrition and a relatively cheap and easily available means for nutritional diversification in several underdeveloped and developing countries (FAO, 2018; Oboh *et al.,* 2019). In Nigeria, fish is an irreplaceable animal-source food which accounts for about 40% of the total animal protein consumed by its citizens (FAO, 2018).). Also, population growth and the increasing awareness on the nutritional value of fish has resulted in the increased demand and consumption of fish. Despite the abundance of freshwater bodies containing assortment of fishes; malnutrition chiefly caused by inadequate intake of micronutrients remains prevalent particularly among preschool children in various parts of the country (Olufunke *et al.,* 2016; Olowole and Agboola, 2018).

The nutritional composition of fish is the relative amounts of moisture, fat, protein, ash, carbohydrate and mineral contents (Adewumi *et al.,* 2014). Fishes of various species do not provide the same nutrient profile to their consumers; as values of fish body composition parameters vary considerably within and between species, and influenced by several factors such as age (Anthony *et al.,* 2000), gender (Lawson *et al.,* 1998) and diet (Shulman *et al*., 2005; Moss *et al.,* 2009). The knowledge of the nutrient composition is a good indicator of its physiology which is an invaluable tool needed for routine analysis of fishery resources, the quality and quantity of the nutrients available to the consumer and policy development (Saliu *et al.,* 2007; Oboh *et al.,* 2019).

Reliable and updated scientific documentation of food composition data are of vital importance to diverse nutrition based activities, such as establishing and assessing nutrient requirements, epidemiological research, clinical practice, government policy development and implementation, and for educational purposes (Greenfield and Southgate, 2003). The Ikpoba reservoir serves as a source of commercial important fish species to the artisanal fishing households and surrounding communities. With the global sustainable development goals of zero hunger, good health and wellbeing in purview, it is pertinent to determine the nutritional status of these fish species to ascertain their suitability in meeting human nutritional requirements. Therefore, the aim of this study is to determine the proximate and mineral composition of *Clarias gariepinus* and *Tilapia zilli* from the Ikpoba reservoir, and estimate the potential contribution of selected key nutrients – calcium, iron, zinc to the recommended nutrient intakes (RNI) for preschool children and adults in Nigeria.

Materials and Methods
Study Area: This study was carried out at the Ikpoba reservoir (Latitudes 006˚22'50" N and 006˚22'43" N and Longitudes 05˚38'36" E and 05˚38'46" E) situated in Benin City, Edo State.

Fish Collection and Identification: Fish species (*Clarias gariepinus* and *Tilapia zilli)* selected for sampling were based on the local diet content and commercial importance. The fish specimen were collected fresh from the reservoir over a period of twelve months (February 2018 to January 2019) with the assistance of artisanal fishermen and properly identified using taxonomic guides.

Analytical Methods: Proximate components (moisture content, protein, fat and ash) and mineral contents were determined by the standard analytical methods of the Association of Official Analytical Chemists (AOAC, 1995).

Data management and presentation of data: All statistical analysis were computed using Microsoft® Office Excel 2013 version and Statistical Package for Social Sciences (SPSS) version 21. Variations among means were determined using analysis of variance (ANOVA). The data are presented as means ± SD per 100 g of the three composite specimen of each species of fish and reported to the same units of expression.

Calculation of potential contribution to Recommended Nutrient Intakes (RNI): The potential contribution of each species to daily RNI was calculated in reference to the average RNI values for each nutrient as recommended for adults/ adolescents (8 years and above) and children (1 – 3 years). Percentage contribution to daily RNI It is calculated from an assumed standard portion (36.4g/ day) of each fish species as a percentage of the average RNI. The micronutrients of interest - calcium, iron and zinc were selected based on reported deficiency studies in Nigeria. The per capital consumption of fish as food in Nigeria is 13.3 kg (World Fish Centre, 2015), which is equivalent to 36.4g portion per day.

Results

Proximate composition

The moisture, protein, fat and ash composition of *C. gariepinus* and *T. zilli* are shown in Table 1. For *C. gariepinus*, range of values for moisture content (54.73 – 66.31%), protein (14.32 – 16.5%0, fat (5.63 – 6.70%) and ash (4.13 – 5.13%) were recorded. For *T. zilli*, range of values for moisture content (57.31 – 68.16%), protein (14.55 – 16.44%0, fat (1.22 – 1.96%) and ash (3.16 – 7.24%).

Table 1: Analytical values of the proximate composition of the fish species.

	Moisture (%)	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)
C. gariepinus	61.09 ± 3.73^{a}	15.15 ± 0.39^{a}	6.03 ± 0.25^{b}	4.58 ± 0.28^{a}
T. zilli	63.39 ± 3.20^{b}	15.71 ± 0.49^{b}	1.48 ± 0.19^{a}	5.09 ± 1.16^{b}

Values are presented as means ± standard deviations (SD) of the fish species analysed in triplicates. Dissimilar superscript indicates significant difference ($p < 0.01$).

Mineral composition

The sodium, potassium, magnesium, calcium, iron and zinc composition of *C. gariepinus* and *T. zilli* are shown in Table 2. For mineral content in the fishes, ranges of sodium (4.26 – 5.48 mg/100 g), potassium (8.14 – 9.12 mg/100 g), magnesium (2.63 – 4.42 mg/100 g), calcium (4.43 – 2.17 mg/100 g), iron (5.47 – 8.32 mg/100 g) and zinc (2.67 – 3.65 mg/100 g) were recorded in *Clarias gariepinus*. *Tilapia zilli,* value ranges for sodium (3.32 – 5.64 mg/100 g), potassium (9.22 –12.64 mg/100 g), magnesium (2.56 – 3.34 mg/100 g), calcium (1.75 – 2.53 mg/100 g), iron (7.75 – 9.35 mg/100 g) and zinc (1.40 – 2.74 mg/100 g) were recorded.

Table 2: Analytical values of mineral composition of the fish species.

	Sodium (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
C. gariepinus	4.87 ± 2.76^{b}	8.56 ± 2.78^{a}	3.87 ± 3.87^{b}	5.13 ± 4.06^{b}	7.43 ± 6.59^{a}	3.16 ± 2.95^{b}
T. zilli	4.70 ± 5.69^{a}	10.34 ± 8.95^{b}	2.87 ± 2.16^{a}	2.17 ± 1.87^{a}	8.56 ± 3.85^{b}	2.12 ± 3.22^{a}

Values are presented as means ± standard deviations (SD) of the fish species analysed in triplicates. Dissimilar superscript indicates significant difference ($p < 0.01$).

Discussion

Moisture content varies between 60 and 80%, and influences the taste, texture, weight, appearance and shelf life of fish (Ninan, 2003). The moisture content of fish species which ranged from 54.73% to 68.16% were within acceptable limits. Nutritionally, protein is the most important constituent of fish which determines its wholesomeness and quality (Ninan, 2003). The total protein content in *C. gariepinus* and *T. zilli* ranged from 14.32 to 16.44 g/100g and can be ascertained to be of good dietary quality (WHO, 2007).

Fish lipids are leading sources of polyunsaturated fatty acids predominantly Omega – 3- fatty acids which play an important role in human health (Oboh *et al.*, 2019). According to Ackman (1989) categorization of lipid content in percentage of total body weight; *C. gariepinus* (6.03%) belongs to the medium fat (4 – 8%) category which implies that they are good sources of fish oil, while *T. zilli* (1.48 %) belong to the lean fish category an indication of poor fish oil source for food therapy in humans. The ash content of fish species gives a measure of the total mineral content in the tissue of the fish (Adewumi *et al.*, 2014), The observed mean ash content of 4.55 g/100g and 5.09 g/100g for *C. gariepinus* and *T. zilli* respectively indicate that the fish species are good sources of minerals such as sodium, potassium, magnesium, calcium and iron.

Fishes are sources of essential mineral elements in a readily usable form, with mineral concentrations varying among species (Oboh *et al.*, 2019). The mean content of sodium, potassium, magnesium, calcium, iron and zinc recorded in *C. gariepinus* (4.87 mg/100 g, 8.56 mg/100 g, 3.87 mg/100 g, 5.12 mg/100 g, 7.43 mg/100 g and 3.16 mg/100 g) and *T. zilli* (4.70 mg/100 g, 10.34 mg/100 g, 2.87 mg/100 g, 2.17 mg/100g, 8.55 mg/100g and 2.12 mg/100g) were generally consistent with ranges reported for other fish species and seafood (FAO/ INFOODS, 2013; Oboh *et al.*, 2019).

Pertaining to the fishes' contribution to nutritional intake, none of the fish species meet ≥ 25% of the required nutritional intake (RNI) of calcium for adults and children. Both fish species were identified to meet ≥ 25% of the RNI of iron and zinc for children from a standard portion, while unable to meet the RNI for adults (Table 3). Low dietary calcium intake among children especially from poor households have been linked to reported incidences of rickets in Nigeria (Okonofua *et al.,* 1991). This implies that the reliance of these fish species as source of dietary calcium predisposes both children and adults to calcium deficiency and its attendant negative effects on physical development. With reported studies on the high prevalence of iron and zinc deficiency anemia among preschool children (< 5 years) in various parts of the country (Olufunke *et al.,* 2016; Ibeawuchi *et al.,* 2017; Olowole and Agboola, 2018); the consumption of *C. gariepinus* and *T zilli* obtained from the reservoir will contribute significantly to dietary intakes of iron and zinc in preschool children in communities surrounding the Ikpoba reservoir in Edo State.

Table 3: Potential contribution of fish in a Standard Portion, and to average daily RNI (%). Recommended Nutritional Intake (RNI).

Average daily RNI	Calcium (mg)		Iron (mg)		Zinc (mg)	
	Adults	Children	Adults	Children	Adults	Children
	1000	700	16	7	10	3
C. gariepinus	1.87 (0.20%)	1.87 (0.30%)	2.71 (16.94%)	2.71 (38.71%)	1.15 (11.50%)	1.15 (38.33%)
T. zilli	0.80 (0.08%)	0.80 (0.11%)	3.12 (19.50%)	3.12 (44.57%)	0.77 (7.70%)	0.77 (25.67%)

*Assumed standard portion is equivalent to 36.4g/ day for Nigerians
*Children here refers to toddlers (1 – 3 years). *RNI – Recommended Nutritional Intake

Conclusion and Recommendation

The consumption of fish as a source of animal protein and a readily available substitute for meat especially among poor communities has necessitated their nutritional quality evaluation. Presented data indicate that *C. gariepinus* and *T. zilli* are good sources of animal protein, while *C. gariepinus* was a good source of fish oil. The mineral percentage contribution to required nutritional intake (RNI) of the fishes indicate that they can only be used as food-based strategy to ameliorate reported nutrient deficiencies of iron and zinc in pre-school children in the surrounding communities. The mineral insufficiency of the fishes to meeting the RNI of calcium, iron and zinc in adults from a standard portion, implies that the fishes should not be solely relied upon to meet their dietary needs. It is recommended that other sources of animal protein be included in their diets and the portion of fish consumed be increased. This work has increased the knowledge on the nutritional value contribution to RNI of fishes in combating nutritional deficiencies and food security in Nigeria.

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Survival rate and performance characteristics of African catfish (*Clarias gariepinus*) fed varying inclusion levels of cow rumen epithelial tissue

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Abstract
This study was carried out to assess the survival and performance characteristics of *Clarias gariepinus* juveniles fed varying inclusion of cow epithelial tissue as replacement for fish meal in fish diet. Epithelial tissue was scraped from the cattle rumen and dried to fine powder in an electric oven at 70º C. Five (5) dietary treatments (diet I-V) were formulated with varying replacement levels (0%, 25%, 50%, 75%, and 100%) of fish meal with cow rumen epithelial tissue scrapings. The experiment was carried out in 20litres rectangular plastic tanks. Each treatment tank contained 12 *Clarias gariepinu*s juveniles of average weight 20g±1.14. The treatments were in triplicates and the fish were fed at 5% body weight daily for 12weeks. The weight of the fish was recorded weekly and the blood samples were collected after the experiment for analysis. After 12 weeks (84 days) of intensive feeding, all the fish samples had positive weight gain. *Clarias gariepinus* juveniles fed treatments II recorded the highest weight gain (40.7±1.03g) and specific growth rate (0.7). The feed conversion ratio of the samples was not significantly different ($p>0.05$), with the exception of treatment V (0.56) which was significantly higher. The study concluded that fish meal could be replaced with cow rumen epithelial tissue scrapings to 75% inclusion level for adequate growth performance and good physiological status.

Keywords: Growth performance, Juveniles, cow rumen epithelial tissue scrapings, *Clarias gariepinus*

Introduction

Aquaculture can play a complementary role to terrestrial animal production in ensuring food security to the teeming Nigerian population. This is even more critical at a time such as this when there is a global food crisis. However, fish like other animals require the provision of essential nutrients and energy for their growth, development and physiological processes (Ochang, 2008). In a practical feed, amino acid requirements are best met by feeding a mixture of feed stuff supplemented with amino acid. Traditionally, fish meal (FM) has been the main sources of dietary protein for fish because it offers a balance of indispensable amino acids, essential fatty acids, vitamins, minerals and generally enhances profitability.

Feed cost is known to account for over two third of the variable cost of an intensive aquaculture system (Aderolu and Sogbesan, 2010). The cost of fish feeds can be significantly reduced if some locally available ingredients are incorporated in feed formulation. Recent increases in the price and demand of fish meal, the primary protein source in livestock and fish feed call for a search for alternative protein sources (Duangrat *et al*, 2010). The search for unconventional animal feed protein sources is not a recent issue and many studies have been carried out. These include the use of meat meal, hatchery waste (Sathishkumar and Prabakaran, 2008), earthworm meal, maggot meal (Adeniji, 2007), Shrimp meal (Aktar *et al.*, 2011) and cattle rumen epithelial tissue scrapings (Bawala *et al.*, 2007 and Ogunwole , 2011). The most suitable solution to the problem of high cost of conventional animal protein sources may be the exploitation of vast, cheap and available and underutilized slaughterhouse wastes and animal byproducts which often constitute environmental pollutants (Ogunwole, 2011). However, the use of cattle rumen epithelial tissue scrapings which is a waste from cleaning rumen of cattle for human consumption could reduce cost of production of fish. This study was therefore designed to determine the effect of substituting cattle rumen epithelial tissue scrapings for fish meal a conventional protein source on the survival and performance characteristics of the *Clarias gariepinus* (Juvenile).

Materials and Methods

Experimental site

The experiment was carried out in the Fish Biology Laboratory in the Department of Fisheries Technology in Oyo State College of Agriculture and Technology, Igboora Oyo State.

Experimental diet

Fishmeal, Groundnut cake, Soybean meal, Maize, DCP, Premix, Lysine, Methane, Vitamin C, Salt, were obtained from the market while the Cow rumen epithelial scraping tissue was sourced from the abattoirs at Towobowo market and Igboora market, Ibarapa Central Local Government. The Cow epithelial tissue scrapings were oven dried in an electric oven at 70^{0}C to reduce the moisture content for 48hours. All ingredients were grinded into powdery form using burr mill and were mixed thoroughly with the use of hand. Warm water was added to the premixed ingredients and homogenized to a dough-like paste. The treatments were then pelletized using a 2mm pellet press. The treatments were sun-dried for 4 days and then stored in an airtight container during the experiment.

Experimental fish and acclimatization

Two hundred mixed sexes of African catfish (*Clarias geriepinus*) juvenile of average weight 20g±1.14 were conditioned for two days and randomly allotted at the rate of 12 juveniles per plastic into each of the rectangular experimental plastic tanks. Feed was formulated using cow rumen epithelial tissues scrapings to test their efficiency on the survival and performance.

Diet formulation and Feeding procedure

The experimental diet was formulated consisting of the following replacement of fish meal with cow rumen epithelial tissue scrapings as shown in Table 1. Fish were fed twice daily between 9am and 4pm, for a duration of eight weeks, at 5% body weight, weekly weight gain of the fish was taken and recorded using top loading sensitive scale.

Table 1: Composition of Feed Ingredients in the Test Treatments

Ingredients	**T 1**	**T 2**	**T 3**	**T 4**	**T5**
Replacement level	0%	25%	50%	75%	100%
Maize	25	24	23	22	22
Soya bean meal	30	30	30	30	28
Groundnut cake	20	21	22	23	25
Cow epithelial tissue	0	6.25	12.5	18.75	25
Fish meal	25	18.75	12.5	6.25	0
DCP	1.0	1.0	1.0	1.0	1.0
Premix	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1	0.1
Vitamin C	0.1	0.1	0.1	0.1	0.1
Salt	0.1	0.1	0.1	0.1	0.1
Total	**101.5**	**101.5**	**101.5**	**101.5**	**101.5**

Growth performance parameter of test organism juvenile fed different diets

Fish growth and fed utilization efficiency of the experiment were measure weekly and at the end of the experiment the following parameters were measure:

Weight Gained = Final Weight- Initial Weight

$$\text{Growth Rate} = \frac{\text{Weight Gain}}{\text{Duration of the Experiment}}$$

$$\text{Specific Growth Rate (SGR)} = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Duration of the Experiment (Days)}}$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed Intake}}{\text{Body weight gain}} \times 100$$

$$\text{Survival Rate} = \frac{\text{Total number of dead fish}}{\text{Total number of stocked}} \times 100$$

$$\text{Protein efficiency ratio} = \frac{\text{Mean weight gain}}{\text{Average crude protein feed}} \times 100$$

$$\text{Percentage weight gain} = \frac{\text{Mean final weight - Mean initial weight}}{\text{Mean initial weight}} \times 100$$

Statistical analysis of data

All the data obtained were statistically analysed using Analysis of Variance (ANOVA) at P<0.05. To the means were separated was achieved by using Duncans Multiple Range Test of the SAS software.

Results

Proximate composition of Test ingredient (Cow *epithelial tissue*) fed to *Clarias gariepinus (Burchell 1822)* juvenile

The proximate composition of the test ingredient (cow epithelial tissue) is presented in table 2. The cow epithelial tissue had a crude protein 0f 60.10%, crude fibre of 5.20%, ether extract of 8.10%, ash content of 16.5% and dry matter of 93.11%.

Growth Performance and Nutrient Utilization of *Clarias gariepinus* fed Cow Rumen epithelial tissue scrapings supplemented treatment

The growth performance and nutrient utilization of *Clarias gariepinus* fed cow rumen epithelial tissue scrapings supplemented treatment are shown in table 3. Treatment 2 recorded the highest weight gain (40.7±1.03g), specific growth rate (0.7±0.02), and protein efficiency ratio (0.7±0.01). The lowest weight gain was recorded for Treatment 5 (21.5±1.82g), however the analysis of variance showed that the weight gains of all the treatments varied significantly (P<0.05). However, the value for specific growth rate for Treatment 2 was not significantly different (P > 0.05) from that of the control treatment. Treatment 5 recorded the highest feed conversion ratio (0.6±0.05) followed by treatment 1 (control), treatment 2 and treatment 3 had the least Feed Conversion Ratio (FCR) value of 0.4±0.04. There was no significant difference (P>0.05) in the FCR across the treatments with the exception of Treatment 5 (0.6±0.03g). Treatment 3 had the highest survival rate (92.1±1.05), followed by treatment 1(control) (86.7±1.10%), while the lowest survival rate (79± 0.81%) was recorded for treatment 2.

Table 2: Proximate composition of Test ingredient (Cow *epithelial tissue*) fed to *Clarias gariepinus (Burchell 1822)* juvenile

Crude protein %	Crude fibre %	Ether extract %	Ash content %	Dry matter %
60.10	5.20	8.10	16.5	93.11

Table 3: Growth Performance and Nutrient Utilization of *Clarias gariepinus* fed Cow Rumen epithelial tissue scrapings supplemented treatment

Parameters (g)	T1 (0%)	T2 (25%)	T3(50%)	T4(75%)	T5(100%)
Initial weight	21.6±2.41^{a}	19.1±1.71^{a}	18.6±1.14^{a}	20.3±1.32^{a}	19.3±1.71^{a}
Final weight	55.7±1.01^{a}	59.8±0.81^{a}	47.3±1.48^{b}	47.6±1.12^{b}	40.8±2.15^{c}
Average weight gain	34.1±1.31^{b}	40.7±1.03^{a}	29.9±1.5^{c}	27.3 ±2.01^{c}	21.5±1.82^{d}
Specific growth rate	0.6±0.05^{a}	0.7±0.02^{a}	0.5±0.04^{ab}	0.5±0.02^{ab}	0.4±0.03^{b}
Protein efficiency ratio	0.6±0.02^{a}	0.7±0.01^{a}	0.5±0.02^{b}	0.5±0.01^{b}	0.4±0.09^{b}
Food conversion ratio	0.5±0.01^{b}	0.4±0.04^{b}	0.4±0.04^{b}	0.5±0.01^{b}	0.6±0.03^{a}
Survival rate	86.7±1.10^{b}	79±0.81^{c}	92.1±1.05^{a}	81.8±1.21^{c}	85.8±0.75^{b}
Percentage weight gain	157.9±2.17	213.1±0.72	159.9±1.15	134.5±1.57	111.4±2.17
Feed intake	15.4±1.12^{a}	15.1±0.67^{a}	12.6±0.45^{c}	13.7±0.81^{b}	12.1±0.85^{c}

Discussion

The experimental fish showed positive response in terms of mean weight. Treatment 2 (25%) recorded the highest mean weight gain (40.7±1.03) which is significantly higher than the control treatment (34.1±1.31) The mean weight gain reduced with increasing level of cow rumen epithelial tissue scrapings inclusion. This is similar to the findings Aliu and Dako (2018) who observed reduction in the mean weight gain of *Heteroclarias* fingerlings as the level of replacement of fish meal with blood meal increases. The significantly higher specific growth rate in treatment 2 0.7±0.02 and the low feed conversion ratio of 0.4±0.03 indicate that replacement of fish meal with 25% cow rumen epithelial tissue scrapings in fish feed had the best performance in terms of growth and feed utilization. This result is similar to the observation of Adegoke (2012) on the use of bovine blood and rumen digest in catfish treatment to replace fish meal at varying inclusion levels.

Conclusion

The scope for improving the aquaculture nutritional practices in Nigeria is very wide with new developments of integrated cultures arising and paving way for better aquaculture nutritional practices with a resulting increase in production for food security and income generation for fish farmers. In line with this, cow rumen epithelial tissue has been identified as a possible substitute for the expensive fish meal. However, Treatments 2, 3 and 4 were able to compete favorably with the control diet in term survival and performance characters observed. Based on the findings of this research, fish meal can be replaced with cow rumen epithelial tissue scraping up to 75% level of inclusion.

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Black soldier fly: A perfect replacement of protein source of feed in Nigeria livestock industry (Review)

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Abstract:

Approximated 14% of total fish catch worldwide is used in formulating feed, fishmeal is fast becoming depleted and increasingly scarce with continued rise in demand, small scale livestock farmers are suffering from the increasing cost of feed and desperate for an alternative substitute for fishmeal in animal feeds thereforeBlack soldier fly larvae is considered as a supplemental feed with higher fat and protein levels than other foods. BSF has 60% crude protein, 33% crude fat, 15% ash, 12% crude fibre, 0.56% manganese, 3.07% sodium, 0.57% iron, 2.27% potassium, 0.24 mg/100 g thiamin, 2.2mg/100 g riboflavin and 1.3 mg/100 g vitamin E and several authors have fed BSF larvae to different kinds fish and poultry birds successfully.

Introduction

Livestock industries such as fish and poultry feed is formulated using large amount of fishmeal approximated 14% of total fish catch worldwide is used in the production of fishmeal (FAO, 2012). However, fishmeal is fast becoming depleted and increasingly scarce. It continued to rise in demand, this imbalance between supply and demand has led to fishmeal price increase throughout the world (FAO, 2014). Barrientos and Soria (2013) reported that the price of fish meal doubled during the period 2008-2013. Consequently, small scale poultry and fish farmers are suffering from the increasing cost of feed and desperate for an alternative substitute for fishmeal in animal feeds (Bertrand *etal* 2019). Feed in poultry and fish farming business accounts for nearly 70 to 80% of the total production costs. This situation is affecting meat, egg and fish production in addition to reducing family incomes (World Bank, 2014), and necessitates a search for an alternative protein source (Nyakeri *et al* 2017)

In the developing world, the livestock sector can act as a gateway towards alleviating poverty and enhancing food security (Marwa 2019). In Africa, livestock production currently accounts for about 30% of the gross value of agricultural production. However, production is struggling to keep up with the demands of expanding human populations, the rise in urbanization and the associated shifts in diet habits. High costs of feed prevent the livestock sector from thriving and to meet the rising demand. Insects have been identified as potential alternatives to the conventionally used protein sources in livestock feed due to their rich nutrients content (Marwa 2019).

Black soldier fly

Black soldier flies are small, harmless insects that have the potential to provide promising solutions to agriculture's growing problems: the high cost of animal feed and the disposal of large amounts of animal waste. Many farmers buy animal feed and pay to evacuate waste from farm animals. Recent research has indicated that black soldier fly may be instrumental in closing the loop between animal waste and animal feed (Watson, 2005). Black soldier fly larvae (BSFL) eat nearly any kind of organic waste ranging from animal waste to food scraps. As the BSFL mature, they grow into half inch long grubs, at which point they climb out of their food source and turn into pupae. The pupae can immediately be fed to chickens and are a good source of protein. They can also be dried and processed into feed for use at a later time. Small composting operations also allow them to turn into flies and breed, propagating the population.

The black soldier fly (BSF), *Hermetia illucens* is a common and widespread fly of the family Stratiomyidae. The insect family contains over 2,700 species (Wikipedia) BSF is a fly with unique properties. One of their most interesting properties is it has short life cycle. The adult female lays its eggs not long before dying and the larvae hatches in around 4 days. The larvae will develop into flies they'll lay eggs, starting the process over again. Black soldier flies are considered to be sanitary, as they're designed to break down the bacteria in their food.

Black soldier fly larvae are decomposers; they help in **breaking down organic substrates and returning nutrients to soil with** no trace of bacteria in their waste once they've digested it. (Newton *et al* 2005). Furthermore, they prevent houseflies and other insects from laying eggs in the materials inhabited by BSFL. The adults do not have digestive organs, relying on stores of body fat from the larval stage. Their short life cycle makes them a reliable source of food for fish, chickens and potentially all other farm animals like ducks, pigs, turkeys and even dogs.(causeway 2019) Previous work has also shown that black soldier flies are effective in reducing the mass as well as nutrient and moisture content of various kinds of organic waste.

Nutritional profile of black solder fly

BSF larvae has high protein supplemental food with higher fat levels than other foods (Pairs 2019). BSF larvae are nutritionally very rich, it contained60% crude protein, 33% crude fat, 15% ash, 12% crude fibre, 0.56% manganese, 3.07% sodium, 0.57% iron, 2.27% potassium, 0.24 mg/100 g thiamin, 2.2mg/100 g riboflavin and 1.3 mg/100 g vitamin E (Nyakeri *et al* 2016 and Aloysius 2018).Several authors have successfully fed BSF larvae to different fish like rainbow trout, catfish and tilapia and domestic animals like swine and poultry (St-Hilaire *et al*., 2007a, Bondari and Sheppard, 1987 and Yu and Chen, 2009). BSF larvae contain high level of omega-3 fatty acid fed with fish offal and slaughter-house leftovers (St-Hilaire *et al*., 2007) which can enhance fish health as well as production. Maggots are excellent waste and smell managers (Kelly 2018) thereby helps in saving the ecosystem. The excellent nutritional profile of the BSF larvae shows its potential to serve as a cheap and sustainable substitute protein source for fish and poultry industries.

Types of Maggot

Dyed maggots: White maggots are often dyed to enhance their attractiveness to the fish. However, not all dyes are safe for fish to eat. To be on the safe side, avoid using dyed maggots as aquarium fish food.

Pinkies: Not to be confused with dyed white maggots, pinkies are naturally pink in color. They are the larvae of the green bottle fly and generally about half the size of their white counterparts.

Squats: Squats are the white-colored larvae of the common housefly and are the smallest maggot offered for sale. They are a great size for aquarium fish, but not as often found for sale as the large maggots. (Shirlie 2019)

The role of black soldier fly in waste management

Black soldier fly maggot has high digestible protein capable to substitute other valuable limited protein sources from animal and plant origin and this can be achieved by transforming worthless waste to valuable cool product by using black soldier fly to produce a low-cost, high-quality protein source (Pierre-Olivier 2016). According to World Bank the global livestock feed industry is worth 370 billion dollars. The industry accounts for 70% global feed production cost and in the last 10 years the price of livestock feed has increased by 200% (Sourav Roy 2020).The world population is estimated to reach 10 billion by 2050 (Marwa 2020) and the global food demand is expected to increase by 70%. In order to meet the demands of the people there must be alternative means of feeding our livestock. In the recent past already major shifts in diets have happened, favoring more animal-based foods, in particular milk, meat, fish and eggs, and these preferences are expected to increase with time (Center for Development Research (ZEF).

Conclusion

From all the work cited, it could be concluded that black soldier fly might excellently replace all protein sources for fish and livestock feeds thereby solving the problems of unavailability and competition on convectional protein sources for man and other domestic animals

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The use of non-conventional feed resources for fish nutrition in Nigeria: A review

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Abstract:
This paper reviewed the use of non-conventional feed resources (NCFR) in Nigeria either as replacement or as a supplement in fish nutrition. The cost of feeds is the most expensive operating cost in fish farming accounting for over 50% of total cost of production. This is due to the cost of conventional feed resources such as fishmeal, soyabeans and groundnut. Their use in fish diet may not be sustainable because they are sources of protein for human beings and therefore competes with human food. Subsequently majority of research in the field of fish nutrition tend to look into ways to overcome the high cost of feed. A possible and perhaps the most viable option is the inclusion of non-conventional feed resources in fish feed. Some Non-conventional feed resources (NCFR) are cheap to purchase, they are byproducts or waste products from agriculture as such are able to serve as a form of waste management in enhancing good sanitation. This article highlights some common non-conventional feed resources (NCFR) such as animal based feed ingredients, agro-industrial by products, crop residues, leaf meals, seed meals and probiotics that have been evaluated for fish feed in Nigeria. The advantages and problems associated with the use of non-conventional feed resources (NCFR) were also reviewed with a purpose of giving information on the potentials of abundant non-conventional feed resources (NCFR) for fish feed in Nigeria.

Keywords Nonconventional feed resources, Fish Nutrition, Fish feed

Introduction

As global population continues to grow there is an increased demand for fish and other aquatic products (FAO, 2014). In Nigeria projected fish demand for 2015 was estimated at 2.66 million tonnes while projected domestic supply was 0.66 million tonnes (FDF, 2007). The deficiency of about two million tonnes is usually bridged by importation which was valued at USD 594.4 million (FDF, 2007). The rapid expansion and success of commercial fish culture will depend on the availability of good quality feed which is affordable to the small scale fish farmer (Eyo, 2001; Madu *et al.,* 2003).

Feed is the most expensive operating cost in fish farming accounting for over 50-70% of total cost (Madu *et al.,* 2003). High cost of feed inputs such as fishmeal, soyabeans and groundnut has contributed to make fish feeds unaffordable. Most conventional feed ingredients are expensive and not sustainable because they are good sources of protein for human and therefore compete with human food (Abowei and Ekubo, 2011). Non-conventional feed resources (NCFR) are feeds resources that are not the traditional ingredients used for commercial fish feed production such as agro-industrial by products, crop residues, leaf meals, seed meals (Fagbenro *et al*., 2003).

Advantages of Non-conventional feed resources

Non-conventional feed resources (NCFR) are credited for being non competitive in terms of human consumption, very cheap to purchase, byproducts or waste products from agriculture and are able to serve as a form of waste management in enhancing good sanitation (Abowei and Ekubo, 2011). Non-conventional feed resources (NCFR) can be classified into various groups

Groups of NCFR

Resources of animal origin

Resources of plant origin

Resources of animal origin

Table 1 presents some non-conventional animal-based feed resources tested in fish diets.

Table 1 Non-conventional animal-based feed resources tested in fish diets

Feed ingredient	Fish species	Maximum inclusion level (%)	Utilization	Reference
Bloodmeal	*Nile tilapia*	100	Meal was used to replace fishmeal	Aladetohun and Sogbesan (2013)
Maggot meal	*Clarias gariepinus* *Oreochromis niloticus*	75 50	Maggot meal was used to replace fishmeal, high level of crude protein in maggot meal.	Olaniyi and Salau (2013) Ezewudo et al.(2015)
crab meal	*Heterobranchus longifilis*	30	Used to replace fishmeal, high ash and inadequate levels of some essential amino acid limits utilization	Keremah and Gabriel (2013)
Tadpole meal:	*Clarias gariepinus*	25-50	Meal was used to replace fish meal utilization is better at lower inclusion level	Hindatu and Solomon (2017)

Resources of plant origin

Some non-conventional plant-based feed resources tested in fish diets are presented in Table 2.

Table 2 Non-conventional plant-based feed resources tested in fish diets

Feed ingredient	Fish species	Maximum inclusion level (%)	Utilization	Reference
Moringa seed meal	*Clarias gariepinus*	75	MSM replaced Soybean meal (SBM) high level of antinutritional factors decreased utilization	Bamidele *et al.* (2015)
African yam beans	*Clarias gariepinus*	45	Used to partially replace fishmeal, processing method and antinutrients affected utilization	Ogunji *et al.* (2016)
Sesame seed meal	*Clarias gariepinus*	25-50	The meal replaced soybean meal, high level of antinutritional factors decreased utilization	Falayi *et al.* (2013)
Jackbean meal	*Clarias gariepinus*	30	Used to partially replace soyabean, utilization affected by antinutrients	Anyawu *et al.* (2012)
Pigeon pea meal	*Clarias gariepinus*	25	Used to replace soyabean, quantity of mineral in meal enhanced utilization	Hammed *et al.* (2013)

Constraints to the use of non-conventional feed resources

Although non-conventional feed resources are cheap and available in large quantities they are presently underutilized because some have high fibre content, poor amino acid profile poor palatability, poor digestibility, antinutritional factors (Francis *et al.*, 2001). Some are not readily available in terms of time, location, seasonality and storage.

Probiotics

Probiotics can be defined as a live microbial feed supplement or live feed additives which beneficially affects the host animal by improving its intestinal balance (Makridis et al., 2005). Probiotics are applied with the feed and a binder (egg or cod liver oil) and most commercial preparation contain either Lactobacillus species or Sacharomyces cerevisiae (Abidi, 2003). Probiotics have helped to solve some of the problems faced in the aquaculture industry and the following benefits have been reported (Nwachi, 2010; George *et al.*, 2016; Diyaolu *et al.*, 2018).

Benefits of probiotics

1. Probiotics are environmentally friendly and an alternative to the antibiotics in which disease resistant is becoming a problem. Probiotics help to boost immunity of aquatic organisms.
2. Probiotics assist in promoting growth and enhancing economic yield thereby leading to a reduction in the use of synthetic growth promoters.
3. Probiotics can improve the quality of non-conventional feed ingredients by denaturing their anti-nutritional factors and enhancing bioavailability of essential nutrients thereby making them more digestible.
4. It reduces the cost of aquaculture management by disease prevention and It also improves the quality of pond water.
5. Probiotics enhances in fish larval rearing and development. It assists reproductive performances in parent fish, helps in fish seeds viability and reduces mortality in hatcheries.

Table 3 presents some probiotics tested in fish diets in Nigeria.

Table 3 Some probiotics tested for fish in Nigeria.

Probiotic	**Fish species**	**Effect**	**Reference**
Lactobacillus plantarum	*Clarias gariepinus* fingerlings	Improved growth and increase in intestinal microbial count	Falaye *et al.* (2016)
Lactic acid Bacteria	*Oreochromis niloticus*	Enhanced growth and Immunity	Folorunsho *et al.* (2011)
Lactobacillus plantarum	*Clarias gariepinus* juveniles	Improved growth, nutrient utilization and immunity	George *et al.* (2016)
Lactobacillus acidophilus	*Cyprinos carpio*	Increased immunity against pathogenic bacteria	Adeshina (2018)
Lactobacillus fermentum	*Oreochromis niloticus* juveniles	Improved growth, better immune response and haematology	Nwanna *et al.* (2014)
Shewanella algae	*Clarias gariepinus* fingerlings	Better haematological performance	Ariole and Eddo (2015)
Lactobacillus acidophilus and Bifidobacterium bifidum	*Heteroclarias* fingerlings	Enhanced growth and Immune response	Yisa *et al.* (2015)
Lactobacillus pentosus	*Clarias gariepinus* juveniles	Improved growth and nutrient utilization	Oluyemi (2019)
Lactobacillus and bifidobacterium species	*Clarias gariepinus* juveniles	Enhanced health, survival and growth	Ayoola *et al.* (2013)
Bacillus subtilis	*Clarias gariepinus* juveniles	Improved growth and nutrient absorption	Lawal *et al.* (2019)
Lactobacillus mixtures Saccharomyces cerevisiae	*Clarias gariepinus* larva	Enhanced growth and survival of larva	Enyidi and Onuoha (2016)

Limitations to probiotic usage in Nigeria as observed by Nwogu *et al*. (2011) and Dauda *et al*. (2013) include

1. The development and application of probiotics to aquaculture in Nigeria being recent and novel.
2. Lack of continued research for new probiotic strains from local aquaculture rearing systems to suit the specific requirement in Nigeria.
3. The little information available on probiotics is still experimental and there are limited commercial probiotic products for aquaculture.
4. Advance technology is required to prepare probiotics

Conclusion

To meet the increasing needs of fish feed for the expanding aquaculture industry in Nigeria, Non-conventional feed resources (NCFR) will have to be utilized maximally. However, most research on non-conventional feed resources is limited to laboratory trials (Eyo, 2001). It is recommended there should be increased research into the use of indigenous probiotics, that on farm trials and long term usage of non-conventional feed resources be evaluated. This information will be useful for effective fish feed management in fish farming.

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Potentials of sweet potato *(Ipomoea batatas*) leaf meal as dietary ingredient for *Oreochromis niloticus* fingerlings

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Abstract:
An 8-week feeding trial was conducted to evaluate the potential of sweet potato (Ipomoea batatas) leaf meal (SPLM) as dietary protein source in the diet of *Oreochromis niloticus* fingerlings. Five isonitrogenous diets of 35% crude protein were formulated to contain various inclusion levels of (0, 5, 10,15and 20%) sweet potato leaf meal diets with 0% as the control to partially replace fishmeal ingredients in the tilapia diet. The diet containing 0% leaf meal served as the control. *Oreochromis niloticus* fingerlings were reared in plastic aquarium of 60×30× 30cm. Each dietary treatment was tested in triplicate groups of 10 fingerlings per aquarium. The results of the growth and nutrient utilization responses showed that there were no significant (p>0.05) differences among the fish fed diets 0, 5, 10 and 15% inclusion level of SPLM but were significantly (p>0.05) different in the group diet 5 (20% sweet potato leaf meal). The present findings showed that sweet potato leaf meal has good potential for use as one of the protein sources in *Oreochromis niloticus* diet up to 15% level without compromising growth but better profit than the control diet.

Keywords: Sweet potato leaf meal, plant protein, feed utilization, growth, tilapia

Introduction

One of the problems facing the aquaculture industry today is the high cost of fish feed. Nutritionist all over the world are constantly searching for the dietary protein sources in which fish will maximize growth and increase production within the shortest possible time and at lowest cost. Leaf meals are one of the cheapest sources of proteins that may reduce the high cost of fish feed. Many studies have been conducted using various sources of leaf meal proteins (Ng and Wee 1989 on cassava leaf meal, Reyes and Fermin, 2003 on Carica papaya and other leaf meal, Bairagi *et al*., 2004 on Leucaena leucocephala). The sweet potato *(Ipomoea batatas*) belongs to the morning-glory family Convolvulaceae. It is cultivated in over 100 nations and ranks fifth among the most important food crops in the tropical areas (An, 2004). The leaves of this plant have been used in the tropics as a cheap protein sources in ruminant feeds. Studies have been conducted to determine the nutritive value of sweet potato leaf meal. According to Woolfe Idiroko (1992), Ali *et al*. (1999), Ishida *et al*. (2000), An (2004), the leaf meal has a high protein content of between 26 to 33%. It has good mineral profile and vitamins such as A, B , C and E. Aside from its nutritive values, sweet potato leaves can be harvested many times throughout the year (Hong *et al*., 2003) thereby making the leaf meal to be abundant. One major factor limiting the use of this leaf meal in fish feed is the presence of anti-nutritional factors (Tacon, 1993). The antinutritional substances present in the sweet potato leaves, according to Oyenuga (1968), are the invertase and protease inhibitors. These substances can be inactivated by various processing methods such as oven or sun-drying, boiling or steaming and grinding prior to inclusion in fish feeds. Although, various leaf meals have been tested as potential fish feed ingredient to decrease diet cost, the use of sweet potato leaf meal has not been tested. It is against this background that the present study was designed, to evaluate the potentials of incorporating sweet potato leaf meal into the pelleted feed of *Oreochromis niloticus*, a widely culturable fish species in Africa. The objective of this work, therefore, was to determine the growth performance, feed utilization and carcass composition of *Oreochromis niloticus*, fingerlings fed on graded levels of sweet potato leaf meal.

Materials and Methods

Fresh leaves of sweet potatoes were collected from New Bussa, Niger state, Nigeria. The collected samples were washed thoroughly with tap water to remove dirt and debris, drained properly and later air dried to a constant weight. The dried leaves were milled using a Hammer- mill. Five isonitrogenous and isocaloric diets were formulated to contain 35%crude protein. The sweet potato leaf meal was incorporated into each of these diets at 0, 5, 10, 15 and 20% to replace clupeid fish meal ingredients in the diets. The diet containing 0% leaf meal serves as the control diet. Feed ingredients were weighed according to the gross composition in Table 1. The ingredients were mixed before the addition of micro-ingredients such as vitamin, premix, methionine and so on. The mixed ingredients were pelleted, sun dried and kept in air-tight containers. Fingerling of *Oreochromis niloticus* were purchased from the hatchery of the NIFFR New Bussa, Kainji, Niger state, Nigeria. The fish were allowed to acclimatized for two weeks, during this period, they were fed on commercial diet. Prior to the commencement of the experiment, all fish were starved for 24 hours. This practice was to eliminate variation in weight due to residue food in the gut and also to prepare the gastro intestinal tract for the experimental diets, while at the same time to increase the appetite of the fish. The feeding trial was conducted in plastic aquaria each and 150 fingerlings of initial mean weight of 60.10 ± 0.41g were randomly allotted at the rate of 10 fingerlings per aquarium into five dietary groups designated Diet 1, Diet 2, Diet 3, Diet 4 and Diet 5 and each group was fed on 0, 5, 10, 15 and 20% sweet potato leaf meal respectively. Fish were fed on allotted experimental diets at 3% of their total body weight per day. Feedings were generally done between 0900 - 1800hours. All fish were reweighed every fortnight and feed weight were adjusted accordingly to accommodate for weight changes. For statistical reasons, each of the dietary group was triplicate. The experiment lasted for 56 days.

Statistical analysis of data
All experimental data were subjected to the analysis of variance test (ANOVA) using Microsoft software statistical followed by Duncan's multiple range test (Duncan, 1955).

TABLE 1: PROXIMATE COMPOSITION OF SWEET POTATO (*ipomoea batatas*) LEAF MEAL

Nutrient	**Percentage composition**
Moisture	5.12
Crude protein	30.00
Crude fat	4.27
Crude fiber	9.18
Total Ash	13.21
Nitrogen Free Extract (NFE)	51.43

TABLE 2: PERCENTAGE COMPOSITION OF EXPERIMENTAL DIETS

Ingredients	**Control**	**5%**	**10%**	**15%**	**20%**
Fishmeal	20.00	15.00	10.00	5.00	_
Potato leaf meal	_	5.00	10.00	15.00	20.00
Groundnut cake	19.79	23.79	25.79	28.79	33.79
Soybean	19.00	21.00	26.00	30.00	32.00
Maize bran	10.00	8.00	5.00	4.00	2.00
Wheat bran	25.00	21.00	17.00	11.00	6.00
Salt	0.25	00.25	0.25	0.25	0.25
Starch	2.00	2.00	2.00	2.00	2.00
Methionine	0.200	0.200	0.200	0.20	20.00
Premix	0.50	0.50	0..50	0.50	0.50
Vegetable oil	2.00	2.00	2.00	2.00	2.00
Vitamin c	0.03	0.03	0.03	0.03	0.03
Vitamin B. Complex	0.02	0.02	0.02	0.02	0.02
Bone meal	1.00	1.00	1.00	1.00	1.00
Lysine	0.20	0.20	0.20	0.20	0.20
Enzyme	0.01	0.01	0.01	0.01	0.01

Table 3: GROWTH RESPONSE AND NUTRIENT UTILIZATION OF *Oreochromis niloticus*

Parameters	**DT1**	**DT2**	**DT3**	**DT4**	**DT5**
Mean Initial Weight (g)	60.10 ± 0.41	61.00 ± 0.47	60.73 ± 0.66	62.14 ± 0.13	62.19 ± 0.42
Mean Final Weight (g)	98.67 ± 1.26	98.21 ± 2.16	98.04 ± 6.04	90.85 ± 4.73	88.85 ± 4.52
Weight Gain (g)	38.35 ±0.82	37.48±1.67	37.04±0.84	28.71±1.24	26.66±0.83
% Weight Gain	63.81±2.45	61.72±0.80	60.72±1.65	46.20±3.28	42.87±1.65
Feed Conversion Ratio (FCR	0.02±0.01	0.02±0.01	0.02±0.01	0.02±0.01	0.03±0.01
Specific Growth Rate (SGR%)	0.38±0.02	0.38±0.02	0.36±0.02	0.30±0.02	0.29±0.02
Protein Efficiency Ratio (PER)	1.26±0.22	1.21±0.26	1.19±0.17	1.19±0.17	0.82±0.10
Survival %	100 ± 0.00	100 ± 0.00	97 ± 0.47	97 ± 0.47	93 ± 1.25

TABLE 4: **PROXIMATE ANALYSIS OF FEED SAMPLES**

PARAMETERS	**DT1**	**DT2**	**DT3**	**DT4**	**DT5**
%Moisture	6.80 ± 0.05	8.02 ± 0.01	8.01 ± 0.01	8.00 ± 0.01	8.01 ± 0.01
%Ash	16.01 ± 0.01	16.01 ± 0.01	16.00 ± 0.01	14.56 ± 0.01	18.00 ± 0.01
%Crude fibre	12.00 ± 0.05	12.01 ± 0.01	12.00 ±0.01	12.00 ± 0.01	12.01 ± 0.01
%Crude protein	30.45 ± 0,02	30.63 ± 0.01	31.50 ± 0.04	31.67 ± 0.09	32.38 ± 0.01
%Crude lipid	12.01 ± 0.01	12.20 ± .0.01	12.00 ± 0.01	11.20 ± 0.09	11.50 ± 0.05
%NFE	38.74±0.80	37.14 ± 1.67	36.49 ± 0.83	37.13 ± 0.84	36.10 ± 1.64

TABLE 5: **HAEMATOLOGY OF *Oreochromis niloticus* FED DIETS CONTAINING SESAME SEED CAKE FOR 56 DAYS**

PARAMETERS	**DT1**	**DT2**	**DT3**	**DT4**	**DT5**
WBC(×10^g/L	84.96	68.42	23.55	55.16	143.83
LYM%	94.65	91.11	84.85	97.43	95.20
RBC(×10^/l)	1.54	1.01	0.60	0.86	1.67
HGB(g/dl)	6.3	2.6	3.4	2.2	4.5
MCHC(g/dl)	28.85	22.87	52.89	18.68	23.75
MCH(pg)	40.88	25.70	56.47	25.70	26.94
MCV(fl)	141.68	112.30	106.77	137.57	113.44

The haematological analysis showed significant ($p < 0.05$) difference over the fish fed control diet with respect to haemoglobin concentration (Hb), white blood count (WBC),red blood count (RBC), Lymphocyte (LYM), mean corpuscular haemoglobin (MCH) and mean corpuscular volume(MCV). Whereas WBC and LYM values decreased with increase in the levels of sesame seed meal in the diets, MCH and MCV increased. Hence, the inclusion of potato leaf meal up to 20% is recommended in the diet of *Oreochromis niloticus* fingerlings, since this inclusion level did not exhibit any negative effect on the fish health.

Results

The result of the proximate analysis of the sweet potato leaf meal is presented in Table 2. Sweet potato leaf meal had a crude protein level of 30.00%, crude fat 4.27%, crude fiber 9.18%, total ash, 13.21% and 51.43% for nitrogen free extract. The growth performance and feed utilization efficiencies of *Oreochromis niloticus* fingerlings in terms of Mean initial weight, Mean final weight, weight gain, percentage weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio and survival are presented in Table 3. The mean final weight of the fish increased from the initial value in all the dietary treatments. *Oreochromis niloticus* fingerlings fed on Diet 1 had the highest weight gain while Diet 5 had the poorest weight gain. The general trend was that decreasing growth rate was observed with increasing inclusion level of sweet potato leaf meal in the experimental diets. However, there were no significant differences ($p>0.05$) in the weight gain of fingerlings fed Diet 1 with those fed on Diets 2, 3 and 4. Fingerlings fed on Diet 5 had significantly ($p<0.05$) lower weight gain than the other diets. The FCR was lowest 0.02 in fish fed on Diet 1,2,3,4 and highest 0.03 in fish fed on Diet 5, however, FCR values were not significantly (p>0.05) different in all the diets except Diet 5 which was significantly (p<0.05) different from other diets.The protein efficiency ratio was not significantly (p>0.05) different in Diets 1, 2, 3 and 4 but were all significantly (p<0.05) differences from Diet 5.

Discussion

When alternative sources of feedstuff such as plant protein are used in fish diets, one of the common problems is the acceptability by fish and this has to do with the palatability of the diet (Rodriguez *et al*., 1996). In the present investigation, all the experimental diets were accepted by *Oreochromis niloticus* fingerlings, indicating that the levels of incorporation of sweet potato leaf meal did not affect the palatability of the diets. This might be due to the processing technique employed in this study. The air drying and the grinding techniques might have reduced the anti-nutrient in the sweet potato leaf meal thereby increasing its palatability in *Oreochromis niloticus.* This observation is in support of the work of Francis *et al*. (2001) and Fagbenro (1999). These workers reported that reduction in anti-nutrient by different processing techniques resulted in better palatability and growth in fish. The potentials of a feedstuff such as leaf meal in fish diets can be evaluated on the basis of its proximate chemical composition, which comprises the moisture content, crude protein, crude fibre, crude lipid, total ash and nitrogen-free extract. The proximate composition of sweet potato leaf meal in the present investigation revealed that the crude protein content was 30.00%, crude fibre 9.18% and ash 13.21%. These values were higher than the values reported by Woolfe (1992) and An (2004) for sweet potato leaf meal. These differences might be due to different environmental conditions such as soil type, harvesting time, local varieties and processing methods.

Although the nutritional quality of sweet potato leaf meal as determined by Tilapia body weight gain, specific growth rate, food conversion ratio and protein efficiency ratio were higher in fish fed the control diet (0% leaf meal) no significant (p>0.05) differences were observed in other experimental diets containing leaf meal up to 15% level. In this present investigation, inclusion of sweet potato leaf meal at 20% level reduced the growth rate and feed utilization of *Oreochromis niloticus* fingerlings.

The body moisture and crude protein content were similar in all the experimental groups, but there were reductions in the body lipid of fish fed on sweet potato leaf meal. The reason here might be due to the reduction of the level of fishmeal lipid as the level of sweet potato leaf meal increased in the diets. . This agrees with the results of Siddhuraju and Becker (2001) and Afuang *et al*. (2003) who observed similar reductions in body lipid of fish fed on diets containing plant-based proteins. These various workers have shown that leaf meal protein at low levels of inclusion (less than 50%) in fish diets were able to support growth, therefore, supporting the results of this study.

In conclusion, the results of this study show that sweet potato leaf meal could be included up to 15% level in diets of *Oreochromis niloticus* without any negative effects on the growth and feed efficiency. Furthermore, sweet potato leaves are locally available in the tropics and can be obtained throughout the year.

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Evaluation of commercial and locally made feed in the culture of African catfish (*Clarias gariepinus*) in Nigeria

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Abstract
This study was conducted to determine the growth, feed conversion efficiency and economic effectiveness of *C. gariepinus* juveniles fed five diets, Skretting commercial feed (S), Bluecrown commercial feed (B), Skretting cum local feed (SL), Bluecrown cum local feed (BL) and local feed (L). The growth and survival were observed for 12 weeks in a complete randomized design in triplicate. Fish fed on S diet showed significantly better ($p<0.05$) growth rate and final weight than fish fed the L diet. No significant difference ($p>0.05$) were detected among treatment groups fed B, SL, BL and L diets. The growth reflected the crude protein content in the Skretting feed (37.18%) which was significantly higher ($p<0.05$) than the Bluecrown feed (35%) and local feed (32.55%). The feed conversion ratio was lowest in the group fed the S diet (1.35) significantly lower ($p<0.05$) than the other treatments, followed by treatment B (1.97) and treatment SL (1.97) which were the same but significantly different ($p<0.05$) to treatment BL (2.65) and treatment L (2.81). However, *C. gariepinus* fed diet L indicated better profit index and lower incidence cost over other treatments. The study showed that diets S, B, SL and BL may increase diet cost over diet L by 47%, 43%, 11.9% and 11.6% respectively. Equally, the combined diets indicate a viable result and had a better cost effectiveness on fish growth than the commercial diets solely. This study indicates a potential for growth performance, nutrient utilization, condition factor and profitability in the local diet if well formulated. The present study suggests that the local diet have a potential to be used for catfish culture at reduced cost.

Introduction
Fish has continued to be the source of hope towards solving global problem of protein malnutrition due to its nutritive value above other animal protein. Moreover, about 50% of the world fish harvest is captured by the less developed countries and a large proportion of this catch is consumed internally (Ibiyo *et al.,* 2018b). In Nigerian, animal protein is supplied through fishing (Ibiyo *et al.,* 2018). To increase the availability of fish and fish consumption, aquaculture development has been encouraged in recent times in Nigeria. As aquaculture production becomes more intensive, fish feed is a significant factor in increasing the productivity and profitability of aquaculture (Mogaji & Ibiyo, 2016). For productive and sustainable aquaculture, reliable supply of nutritionally balanced feed containing adequate amounts of all essential nutrients such as protein, fat, carbohydrate, vitamins and minerals is a necessity (Zafar & Khan, 2020). The increasing demand for aquafeed can be met through the availability of local raw materials for indigenous feed production by the fish farmers (Udo & Dickson, 2017). This study is to evaluate the performance of different diets and feed combination on the growth of African catfish in Nigeria aquaculture industry.

Material and Methods
A feeding trial was undertaken at the Department of Aquaculture and fisheries management, University of Ibadan, Nigeria and Matis laboratory, Reykjavik, Iceland. The feed ingredients for the locally made fish feed were compounded according to the formulation of the University of Ibadan fish farm unit. These ingredients were sourced and purchased in consideration of their similarities to the ingredients commonly used as catfish diet in Nigeria. Fish offal was procured from the fish farm unit of the University of Ibadan. The offal was cleaned and cooked gradually to a 100 ºC for 15 minutes before blended with other ingredients. The mixture was further ground with a Unitech hammer mill to homogenous size, mixed in an appropriate ratio, made into dough, pelleted into 2 mm size and sun-dried for 24 hours. The dried feed was packaged in an air-tight polythene bags and stored in a container at room temperature. The commercial 2 mm size feed was purchased at a feed depot in Ibadan. The two commercial diets, Skretting and Bluecrown were used in this experiment. The experiment lasted for 12 weeks. Experimental feeds were nomenclated in alphabetic letters as treatment S, B, SL, BL and L for the five different treatments for the feeding trials respectively. Treatment "S" and "B" were fed commercial feed of Skretting and Bluecrown till the end of the trial; treatment "SL" was fed Skretting for six weeks and locally made feed the latter six weeks; treatment "BL" was fed bluecrown for initial six weeks and locally made feed for the latter six weeks; and treatment "L" was fed locally made diet through all the 12 weeks.

Results
The proximate analysis of the experimental diets (figure 1) showed some difference in chemical composition. The Skretting feed was significantly different ($p<0.05$) and had the highest crude protein level (37.18) compared to the Bluecrown (35.0) and local diets (32.55) respectively.

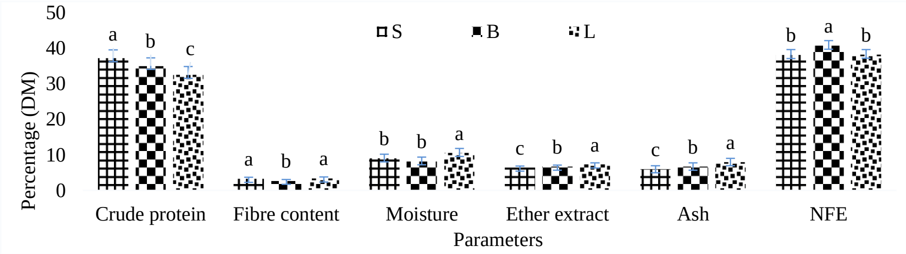

Figure 1: Proximate analysis of experimental diet used for the study

Values are Mean ± S.E of three replicates. Treatments having different letters in a group are significantly different at P<0.05

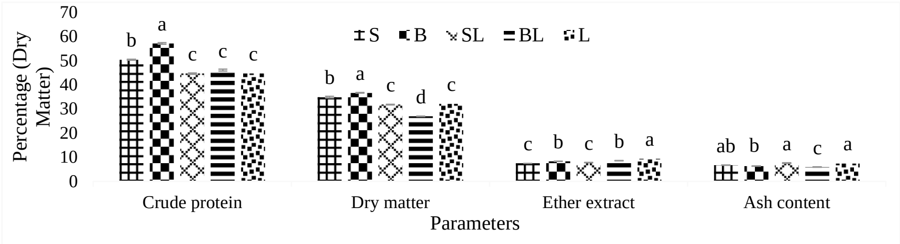

Figure 2: Proximate analysis of whole fish samples after feeding trial

Values are Mean ± S.E of three replicates. Treatments having different letters in a group are significantly different at P<0.05

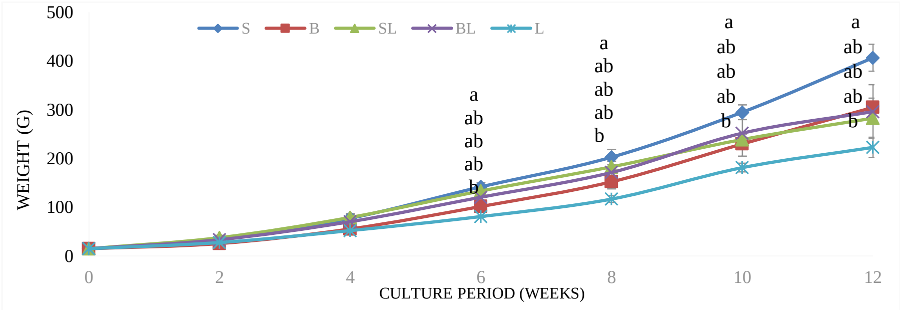

Figure 3: Average body weight of treatments during the culture period

Values are Mean ± S.E of three replicate. Treatments having different letters in a group are significantly different at P<0.05

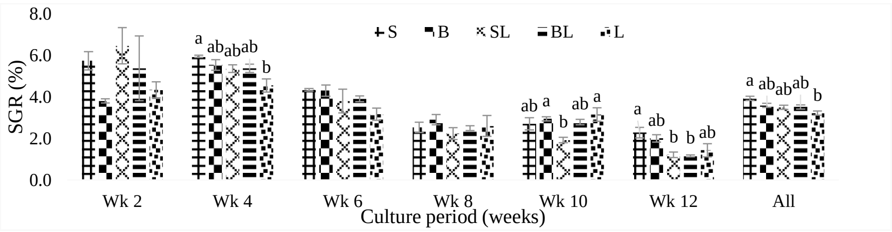

Figure 4: Specific growth rate of fish during the culture period

Values are Mean ± S.E of three replicates. Treatments having different letters in a group are significantly different at P<0.05

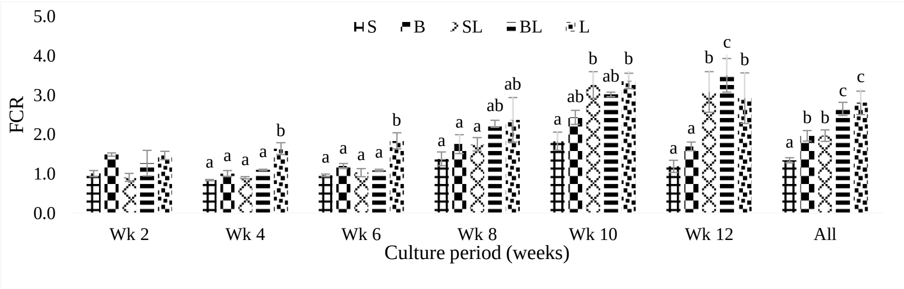

Figure 5: Feed conversion ratio (FCR) for different treatments during the culture period

Values are Mean ± S.E of three replicates. Treatments having different letters in a group are significantly different at P<0.05

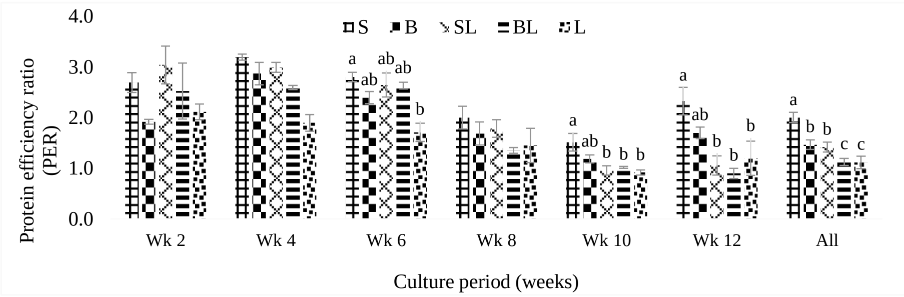

Figure 6: Average protein efficiency ratio (PER) of the treatments during the culture period

Values are Mean ± S.E of three replicates. Treatments having different letters in a group are significantly different at P<0.05

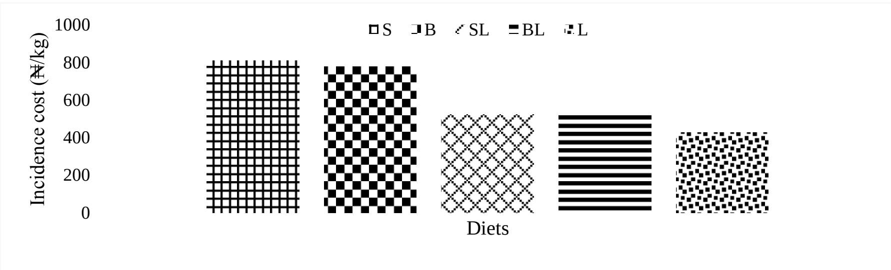

Figure 7: The incidence cost for production of *C. gariepinus* using commercial, combined and local diets during the study.

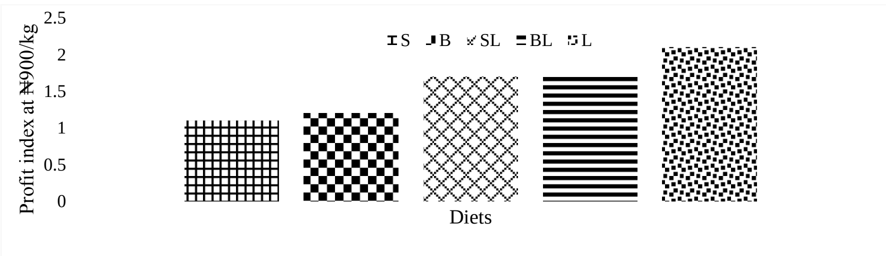

Figure 8: The profit index for production of *C. gariepinus* using commercial, combined and local diets during the study. The product value is set as ₦900/kg

DISCUSSION

The results of the protein composition analysis (figure 1) of the different experimental diets showed that diet S (37.18%), B (35.00%) and L (32.55%) were significantly different at $p<0.05$. The study showed that crude protein content in the diet is one of the important factors and proportionate for the growth of catfish which in turn is inversely proportional to feed cost. This corroborate the study in comparative effect of local and commercial feeds on the growth and survival of *Clarias gariepinus* juveniles (Moshood *et al.,* 2014).

The growth performance of *C. gariepinus* fed different commercial feed, combination of commercial and local feed, showed that fish fed on Skretting feed grew significantly better ($p<0.05$) than treatment L and performed best among other treatments with lesser protein contents respectively. Growth of fish fed B, SL, BL and L were not statistically different ($p>0.05$). Similar result was recorded in the study of Joshua *et al.,* (2019) in substituting higher protein fishmeal diet with sesame seed meal in catfish. Also, the study showed that the growth response fed combined diets SL and BL were not significantly different ($p<0.05$) to the treatments fed the commercial diets (S and B) only. The study of Ibiyo *et al.,* (2018) on the evaluation of different fishmeal-based diets in growth of catfish reported that floating feed has no significant difference over sinking diet in growth provided the crude protein are same.

There was no significant difference in the specific growth rate in all the treatments in the first 6 weeks of the study. Between the introduction of the local diets till the end of the study, treatment fed the Skretting diet performed better than the other treatments. Though, treatment S was only significantly different ($p<0.05$) to treatment L, other treatments (B, SL and BL), showed relativeness to treatment L with no significant difference. This reflect that the fish responded according to the protein compositions of the feeds respectively

The FCR at the end of the first 6 weeks of the study showed that there was no significant difference ($p>0.05$) in treatment fed the commercial diet (S, B) or in the groups SL and BL since they were fed the same types of commercial diets respectively. However, in the same period, there were significant difference ($p<0.05$) in treatment L compared to others. At 12 weeks, treatment S (1.35) performed best and significantly different ($p<0.05$) among all the treatments; followed by treatment B (1.97) and treatment SL (1.97) which were same and significantly different to treatment BL (2.65) and treatment L (2.81). This study reflected the relationship in diet protein content to FCR, which corroborated the study of Heuze *et al.,* (2015) in nutrients for fish growth and optimum performance as protein requirement for varying species of fish; and the report in the principles of protein and fish meal in the fishery industry (Ahmad & Ibrahim, 2016).

The protein efficiency ratio in treatment S was significantly different ($p<0.05$) compared to other treatments except treatment B. However, treatment B, SL, BL and L were not significantly different. This PER of this study indicate that diet S and B had a better quality of protein in the feed, compared to the combined and local diets. This further showed that the protein efficiency most probably correlates to the nutritional composition of diet and the protein quality /digestibility. The study showed that diets S, B, SL and BL may increase cost of diet L by 47%, 43%, 11.9% and 11.6% respectively. This present study corroborates the report in the effect of different diets on growth and cost effectiveness of African catfish, that incidence cost reflects the cost of feed used to produce a kilogram of fish (Limbu, 2015). The incidence cost was between 11.9% to 11.6% higher in the combined diets, and 47% to 43% more in the commercial diets than the local diet. The profit index for *C. gariepinus* on all the diets showed that the cost of feed affects both growth and profitability in catfish culture and is an important factor to consider.

CONCLUSIONS

Economically, there is need to encouraging feed manufacturers and catfish farmers to continue to improve in the formulation of local diet that are mostly produced on farms because of cheaper raw materials, no importation cost and reduced processing cost. This will facilitate a more developed, sustainable and productive aquaculture sector. This study showed that the local diet may have a potential for catfish culture at reduced cost. The study indicates more room for improvement in the development of local feed formulation to the recommended nutritional needs of the African catfish.

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Assessment of Some Fatty Acids Composition of Cultured African Mud Catfish (*Clariasgariepinus*) In Lagos State

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Abstract
Fish is a source of key nutrients important for growth and development as well as maintenance of good health and wellbeing. The fatty acids profile and the percentage composition of the lipids were determined. The fish samples were collected from the major fish farms within Lagos and its environment and then transported to the laboratory for analysis. The total lipids were 1.97±0.29, 1.43±0.31, 2.63±0.37, 2.81±0.45, 3.21±0.62%, the total fatty acids were 98.866, 99.727, 99.978, 99.815, 99.65% and the saturated fatty acids were 33.53, 39.847, 47.618, 35.04, 30.633% for farms A, B, C, D and E respectively. There was significant difference in the percentage lipid content of the samples.

Introduction
Fisheries are an important part of food security. Food security is "a state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life" (UNEP, 2002).

The fatty acid content of a diet modulates the fatty acid profile of immune cells. This may be an effective way to regulate the functionality of normal cells through nutrition. Fuentes (1998) indicated that diets in which unsaturated fatty acids replace the saturated ones are associated with low incidence of coronary diseases.

Omega-3 and omega-6 fatty acids are unsaturated "Essential Fatty Acids" (EFAs) that need to be included in the diet because the human metabolism cannot create them from other fatty acids. It has been reported that highly unsaturated n-3 fatty acids, particularly (EPA) and (DHA), are important for human health and early development, and dieticians are advising increased consumption of foods that contain these fatty acids (Connor, 2000) and (Ruxton *et al.,* 2007).

Environmental factors can affect the makeup of body-oil fatty acids, feed and feeding habits, maturity and sex of fish have influences upon composition as well. There is dearth of accurate basic chemical composition data for fish species particularly from African and Asian sources (Schonfeldt, 2002). In Nigeria, our present knowledge of the fatty acids composition of fish species from Nigerian waters and cultured fish species is very limited. The African catfish, *Clarias gariepinus*, is easily cultured in Nigeria and of great economic interest. It is generally considered to be one of the most important tropical catfish species for aquaculture hence, need for the total lipids and fatty acid report which would enhance their utility in public health and nutrition. The study was designed to determine the total lipids and fatty acids composition of cultured African mud catfish (*Clarias gariepinus*) in Lagos state and its environ

Materials and Methods
Sampling and Sampling Preparation
Table size cultured *Clarias gariepinus* of the same age were collected from Nigerian Institute for Oceanography and Marine Research (NIOMR) and five (5) fish farms in Lagos state. Collected fish samples were transported live to the fish technology department laboratory of NIOMR where the analysis were carried out.

Lipids Determination
Lipid content was determined according to Bligh and Dyer (1959).

Fatty Acids Composition Analysis
Lipid extraction from the samples was carried out according to Bligh and Dyer (1959). The methylation which was carried out to convert the fats to their methyl esters was carried out according to AOCS, 1998 and the fatty acids methyl esters (FAME) were separated by gas chromatography as described by AOAC, (2001).

Statistical Analysis
Data obtained were subjected to descriptive and inferential statistics.

Results
The Percentage lipid composition and fatty acids profile and their % composition of the samples were determined and results presented in tables 1, 2 and 3

Table 1: Percentage lipid composition of mud cat fish from 5 major fish farms in Lagos

Catfish from major farms	% Lipid
Farm A	$1.97{\pm}0.29^{ab}$

Farm B	$1.43{\pm}0.31^{a}$
Farm C	$2.63{\pm}0.37^{bc}$
Farm D	$2.81{\pm}0.45^{bc}$
Farm E	$3.21{\pm}0.62^{c}$

Notes: Values are mean±standard deviation of triplicate run. Values followed by different letters with in a column indicate significant difference ($p < 0.05$)

Table 2: Fatty acids profile of mud cat fish from 5 major fish farms in Lagos.

Fatty acids profile	Farm A	Farm B	Farm C	Farm D	Farm E
C12 : 0		0.097	0.06		0.16
C14:0		1.33	1.06		0.868
C14:1	0.15				
C15:1	0.086			0.083	0.14
C15 : 0		0.20	0.86	0.12	
C16 : 0	22.2	26.2	33.11	23.3	20.246
C16 : 1	1.63	1.90	3.853	1.63	2.082
C17 : 0	0.24	0.40	0.199	0.10	0.296
C18 : 0	8.68	8.70	8.955	7.55	7.127
cisC18 : 1	30.9	2.59	3.207	1.88	2.477
tC18 :1	2.54	29.6	34.90	25.2	30.78
tC18 : 2	22.5	0.12	0.158	.072	
cisC18 : 2	0.63	18.1	5.438	30.88	24.499
C18 : 3n6	2.29	1.15	0.34	0.86	0.769
C18 : 3n3	0.24	1.14	0.495	0.22	4.20
C20 : 0	1.25	0.51	2.51	1.09	0.35
C20 : 1n9		1.28	0.479	0.16	0.857
C20 : 2	0.68	0.69	1.20	0.84	0.657
C20 : 3n3	1.15			0.15	
C20: 3n6	0.72	0.75	0.641	0.81	0.58
C21 : 0	0.12	1.31	0.97	1.75	1.051
C22 : 0	0.62	0.59	0.568	0.68	
C20 : 4n6				0.10	
(EPA)C20 :5	0.25	0.21	0.119	0.21	0.259
C23 : 0				0.14	
C24 : 0	0.42	0.51		0.30	0.395
(DHA)C22:6	1.57	2.35	1.53	1.67	1.857
Total	98.866	99.727	99.978	99.815	99.65

Table 3: Fatty acids composition (%) of mud cat fish from 5 major fish farms in Lagos.

Fatty acids composition (%)	Farm A	Farm B	Farm C	Farm D	Farm E
Total lipids	**1.97**	**1.43**	**2.63**	**2.81**	**3.21**
Total fatty acids composition	**98.866**	**99.727**	**99.978**	**99.815**	**99.65**
Saturated fatty acids (SFA)	**33.53**	**39.847**	**47.618**	**35.04**	**30.633**
Monounsaturated fatty acids (MUFA)	**35.306**	**35.37**	**42.439**	**28.963**	**36.196**
Polyunsaturated fatty acids (PUFA)	**30.76**	**24.51**	**9.921**	**35.812**	**32.821**
PUFA / SFA	**0.917**	**0.615**	**0.208**	**1.02**	**1.071**
Eicosapentaenoic EPA	**0.28**	**0.21**	**0.12**	**0.21**	**0.259**
Docosahexaenoic DHA	**1.57**	**2.35**	**1.53**	**1.67**	**1.857**
∑ EPA + DHA	**1.85**	**2.56**	**1.65**	**1.88**	**2.116**
Omega-3 fatty acids (n-3)	**1.39**	**1.14**	**0.495**	**0.37**	**4.20**
Omega 6- fatty acids (n -6)	**3.71**	**1.9**	**0.981**	**1.59**	**1.349**
n-6 / n-3	**1:2**	**1:1.7**	**1:1.98**	**1:4**	**1:0.32**

Discussion

The total lipid contents of the fish muscles obtained from five major fish farms within Lagos were 1.97±0.29, 1.43±0.31, 2.63±0.37, 2.81±0.45, 3.21±0.62 for farms A, B, C, D, E respectively. According to Effiong B.N. and Fakunle, 2013 lean fish usually contain less than 2% of lipids and this varies among and within species. Lipids contents also depends on some factors like seasonal and biological (season, diet).

Fish muscular lipids are rich in polyunsaturated fatty acids, especially eicosapen**taenoic acid (EPA, 20:5n3) and** docosahexanoic acid (DHA, 22:6n3) which play an important role in health promotion and disease prevention (Simopoulos *et al*, 1999)**. The fish samples from each farm were excellent sources of polyunsaturated fatty acids, range from 24.51-35.8% of the fatty acid composition except the sample from farm C. This might be as a result of its diet composition as well as its culture system. The culture system for the farms were earthen pond, WRS, concrete pond, earthen pond and WRS for ponds A, B, C, D, E respectively. The sum of ∑(EPA and DHA) were 1.85, 2.25, 1.65, 1.88, and2.11 for the various farms.**

The ratios of omega-6 to omega-3 for the fish samples were 2:1, 1.7:1, 1.98:1, 4:1, 1:3.1 **for farms A, B, C, D, and E respectively which fell within the range 2:1 n-6/n-3 recommended by panel of lipid experts. Omega-3 and omega-6 fatty acids are essential PUFAs which cannot be synthesised in the body, therefore must be derived from the diet. A number of studies have indicated an association between depression and increase in the ratio of omega-6 to omega-3 fatty acids (Husted and Bouzin 2016). In addition, an increase in omega-6/omega-3 increase the risk of obesity. The recommended ratio of omega-6 to omega-3 fatty acids is 4:1 or less** (Simopoulos *et al*, 1999)**. The ratios of omega-6 to omega-3 for the fish samples fell within the limit, hence they all have good fat.**

Conclusion

This Study showed that catfish obtained from major fish farms in Lagos contained medium levels of lipid and are good sources of lipids with excellent polyunsaturated fatty acids, especially the omega-3 fatty acids. The study also indicated that the ratios n-6/n-3 of the samples were within the recommended range therefore, it is a healthy food.

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Comparative growth performance and haematological profile of *Clarias gariepinus* (Burchell, 1822) fed dietary inclusions of *Zingiber officinale*, *Allium sativum* and *Azadirachta indica* extracts

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Abstract
Growth performance and haematological profile of *Clarias gariepinus*-fed dietary *Zingiber officinale*, *Allium sativum* and *Azadirachta indica* extracts were compared with controls without herbal inclusions. Fish-fed treatment diets had higher percentage weight gain, FCR and better body condition than control. *C. gariepinus*-fed dietary *A. sativum* inclusion showed higher (P>0.05) weight gain and SGR amongst the treatment groups. Haematologic profile of *C. gariepinus* shows fish-fed *A. indica* dietary inclusion had significantly (P<0.05) higher levels of plasma protein while WBC total counts were higher (P>0.05) in treatment than in control fish. Highest levels of erythrocyte, PCV and Hb were observed in fingerlings-fed dietary *A. sativum*. For the WBC differentials, fish-fed *A. sativum* inclusion had higher (P<0.05) eosinophils and lymphocytes counts than fish in other treatment groups. This study showed that growth performance of *C. gariepinus* is enhanced with 1 % dietary herbal treatments. *A. sativum* inclusion in diet improved fish growth better than did *Z. officinale,* and neem inclusions. Haematologic profile indicates that 1 % dietary inclusions of *Z. officinale,* followed by *A. sativum* in fish feed can boost immune system of *C. gariepinus* better than *Azadirachta indica* dietary inclusions and control.

Keywords: Growth, haematology, *Clarias gariepinus*, plant extracts.

Introduction

Fish disease is a major challenge to fish farmers. The ability of the fish farmer to notice disease of fish when they occur has been difficult because different diseases have different symptoms. Disease outbreaks are increasingly being recognized as a potential constraint on aquaculture production with massive financial loss either through mortality or reduced meat quality resulting in reduced profit margins (Smith *et al.* 2003). The use of antibiotics for prevention and control of fish diseases have been criticized widely for being expensive and having negative impacts like residual drug accumulation in tissues development of the drug resistance, immunosuppression and imbalance of the normal beneficial intestinal flora (Reverter *et al.,* 2014). Nwachi, (2013) observed that the use of medication for every infection in aquaculture can reduce the growth rate and consumer acceptability because of bioaccumulation and magnification. Plant extracts have been effective alternatives to antibiotics and chemicals compounds due to their antibacterial, anti fungal and anti-inflammatory properties Hariskrishan *et al*., 2011). Plant medicinal products have been safely used as feed additives without posing any environmental hazard in intensive fish farming (Pasca *et al.,* 2018). The administration of plant extracts at various concentrations through oral diet or injection route have proven to enhance the innate and adaptive immune response of different freshwater, marine fish and shellfish against bacterial, viral and parasitic diseases (Harikrishnan *et al*. 2010). Catfishes particularly the Clariids are very important to the sustainability of aquaculture industry in Nigeria (Owodeinde and Ndimele, 2011). Even though much work has been done on *Clarias gariepinus*, limited reports are available on the use of plant extracts in fish fish health management. This study therefore compares the growth performance and haematological profile of *Clarias gariepinus*-fed varying dietary inclusions of *Zingiber officinale*, *Allium sativum* and *Azadirachta indica*.

Materials and methods

The study which lasted 24 weeks in 2018 was carried out in the Department of Fisheries, Delta State University, Asaba campus, Asaba, Delta State. *Zingiber officinale* (ginger) and *Allium sativum* (garlic) were purchased from local market in Asaba and *Azadirachta indica* (neem leaves) were harvested from *A. indica* trees in the University compound. Six weeks old *Clarias gariepinus* fingerlings (1.49 ± 0.2 g ; 4.9 ± 0.06) were bought from the Ministry of Agriculture and Natural Resources fish farm in Asaba, Delta State and were acclimated in for 7 days during which fish were fed twice daily at 3% body weight with commercial feed. Plant parts were prepared according to Mikail, (2010) for ginger and garlic extracts and Okwuzu *et al.* (2017) for neem extract. Experimental diets (Table 1) and proximate analyses of experimental feeds done. After acclimation, fish were randomly distributed in four tanks T1 (control), T2 (ginger), T3 (garlic) and T4 (neem). The set up was held in a weekly half renewal triplicate static bioassay. Growth indices such as weight gain, total length gain, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), condition factor (K) were determined thus:

Weight gain = Final weight (g) - Initial weight (g)

Total Length gain = Final length (g) - Initial total length (g)

SGR = 100[(Logn final weight-Logn initial weight)]/Time (days)

FCR = Total feed (g)/Weight gain (g)

PER = Weight gain (g)/Protein intake (g)

K = $100W/L^3$

Blood samples were collected and haematological parameters determined (Dacie and Lewis, 2001, Tomlinson *et al*., 2013). Data obtained was analyzed using Analysis of Variance (ANOVA) at P<0.05 and significant means separated with Dancan Multiple Range Test.

Table 1: Composition of experimental diets

Ingredients	Experimental diets			
	T1(control)	**T2 (1% ginger)**	**T3 (1% garlic)**	**T4 (1% neem)**
Maize	1.5	1.5	1.5	1.5
Fishmeal	45.7	45.7	45.7	45.7
Groundnut Cake	31.7	31.7	31.7	31.7
Palm Kernel Cake	2.6	2.6	2.6	2.6
Wheat meal	2.5	2.5	2.5	2.5
Bone meal	5.0	5.0	5.0	5.0
Starch	5.0	5.0	5.0	5.0
Vitamin	5.0	5.0	5.0	5.0
Palm oil	1.0	1.0	1.0	1.0
Herbal extract	-	1.0	1.0	1.0

Results

Growth performance of *C. gariepinus*-fed different herbal dietary inclusions is presented in Table 2. Fish-fed treatment diets had higher percentage weight gain, FCR and better body condition than control. *C. gariepinus*-fed dietary garlic inclusion showed higher (P>0.05) weight gain and SGR amongst the treatment groups. Percentage length gain was slightly lower in fish fed-ginger inclusion. Haematologic profile of *C. gariepinus* (Table 3) shows fish-fed neem dietary inclusion had significantly (P<0.05) higher levels of plasma protein while WBC total counts were higher (P>0.05) in treatment than in control fish. Highest levels of erythrocyte, PCV and Hb were observed in fingerlings-fed dietary ginger. For the WBC differentials, fish-fed garlic inclusion had higher (P<0.05) eosinophils and lymphocytes counts. Levels of neutrophils and lymphocytes were higher in treatment than in control fish.

Table 2. Growth performance of *C. gariepinus*-fed different herbal dietary inclusions

Growth Parameters	T1(control)	T2 (1% ginger)	T3 (1% garlic)	T4 (1% neem)
Final weight (g)	144.13 ± 17.03a	156.99 ± 30.28b	162.12 ± 13.65c	154.14 ± 31.27b
Initial weight (g)	1.49 ± 0.04a	1.49 ± 0.04a	1.49 ± 0.03a	1.47 ± 0.04a
% Wt gain (x 10^3)	9.57	10.44	10.78	10.39
Final TL (cm)	32.76 ± 0.78b	28.28 ± 1.10a	32.91 ± 0.88b	32.69 ± 0.75b
Initial TL (cm)	4.78 ± 0.01 a	4.80 ± 0.02 a	4.81 ± 0.02 a	4.81 ± 0.01 a
% TL gain (x 10^2)	5.85	4.89	5.84	5.80
SGR (%)	2.54a	2.54a	2.61a	2.59a
FCR (%)	0.92 ± 0.04a	1.04 ± 0.02ab	1.20 ± 0.02b	1.11 ± 0.03ab
PER (%)	2.52a	2.42a	2.52a	2.37a
K	0.99 ± 0.04a	1.13 ± 0.04a	1.12 ± 0.08a	1.68 ± 0.36b

Means with different superscripts on the same row are significantly different at P<0.05

Table 3. Haematological profile and indices of *C. gariepinus*-fed different herbal dietary inclusion.

Haematology	T1(control)	T2 (ginger)	T3 (garlic)	T4 (neem)
PCV	34.3 ± 3.18a	37.7 ± 4.33a	33.0 ± 5.19a	30.0 ± 1.16a
Plasma Protein	5.9 ± 0.59a	6.0 ± 0.50a	6.4 ± 0.81a	23.6 ± 18.20b
Hb	11.4 ± 1.09b	12.7 ± 1.34b	11.0 ± 1.62b	9.9 ± 0.49a
RBC x 10^6	48.33±10.53b	52.0±5.86c	24.33 ± 6.98a	20.33 ±3.93a

WBC Total	4900 ± 493.29a	5700 ± 152.75b	6833.33± 783.86c	5566.67± 883.81b
WBC Differentials				
Neutrophils	50.0 ± 1.16a	47.3 ± 8.353b	41.0 ± 1.0b	45.0 ± 0.58b
Lymphocytes	44.7 ± 1.33a	48.7 ± 8.51b	50.7 ± 2.96b	49.3 ± 0.67b
Eosinophils	4.0 ± 0.0b	2.7 ± 0.67a	5.3 ± 1.76c	4.3 ± 0.33b
Monocytes	2.0 ± 0.0a	2.0 ± 0.0a	2.6 ± 0.67a	1.7 ± 0.33a
Basophils	0	0	1	1
Indices				
MCV(fl)	5.93×10^{-6}	6.09×10^{-6}	1.7×10^{-6}	1.68×10^{-6}
MCH(pg)	1.95×10^{-6}	1.95×10^{-6}	5.7×10^{-6}	3.76×10^{-6}
MCHC(g/dl)	33.0	33.98	33.74	33.13

Means with different superscripts on the same row are significantly different at P<0.05

Discussions

C. gariepinus exhibited higher growth with herbal dietary inclusions than with control diet. Fish-fed garlic and ginger inclusions had higher weight gain and body condition than other treatment diets. Garlic inclusion in diet has been reported to stimulate growth, improve anti- oxidant status, and enhance immunological, hematological and serum biochemical parameters (Sahu *et al*., 2007; Talpur and Ikhwanuddin, 2012). Kanani *et al.* (2014) observed significant increase in specific growth rate, body weight gain and condition factor in fish-fed ginger treatment.

Ginger inclusion in diet elicited higher levels of RBC, PCV and Hb. Herbal diet have been reported to improve some growth and physiological parameters. Haghighi and Rohani (2013) reported that dietary powdered ginger stimulates increase in PCV, WBC and RBC values. De Pedro *et al.* (2005) indicated that total and differential leukocyte counts (WBC) are important indices of non-specific defense activities in fish. Irkin *et al.* (2014) reported lower (P<0.05) levels of RBC, Hb and PCV in fish-fed garlic inclusion in treatment diets than control and that increase in garlic concentration resulted in decreased growth of fish. Irklin *et al*. (2014) also observed that MCV and MCHC levels were lower (P<0.05) in treatment groups than in control. This finding is contrary to results obtained in this study. MCHC levels were similar for both treatment and control fish while MCV was higher in only fish-fed ginger in diet.

Conclusion

This study showed that growth performance of *C. gariepinus* is enhanced with 1 % dietary herbal treatments. *A. sativum* inclusion in diet improved fish growth better than did *Z. officinale* and *A. indica* inclusions. Haematologic profile indicates that 1 % dietary inclusions of *Z. officinale* and *A. sativum* in fish feed can boost immune system of *C. gariepinus*.

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Substitution of soyabean with *Moringa oleifera* on the growth performance of *Clarias gariepinus*.

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Abstract
The work investigated on the growth performance of *Clarias gariepinus* when fed with diet containing various substitution of soyabean meal with *Moringa oleifera* leaf meal. The experiment was carried out at the Department of Fisheries and Aquatic Resources Management, Michael Okpara university of Agriculture, Umudike. One hundred and twenty African catfish fingerlings of mean weight 10.5±0.5g were used. Ten fish were placed in each of the experimental units of 70 litre containers which were twelve in number. Four treatments were assigned as follows in a completely randomized design and were replicated thrice. Treatment 1 contains no *M. oleifera* leaf meal, and served as the control, treatment 2 was 5% replacement of soyabean with *M. oleifera* leaf meal, treatment 3 was 10% replacement of soyabean with *M.oleifera* leaf meal and treatment 4 was 15% replacement of soyabean with *M. oleifera* leaf meal. Sampling was done every two week and data collected was used to calculate the specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), percentage weight gain and percentage survival. Result show treatment 2 had a mean weight gain which was not significantly different ($P>0.05$) from treatment 3, but was significantly different ($P<0.05$) from treatment 1, also there were no significant difference ($P>0.05$) in the feed conversion ratio (FCR), specific growth rate and protein efficiency ratio between treatments 1 and 2, but they were significantly different ($P<0.05$) from treatments 3 and 4. The work demonstrated that *M. oleifera* leaf meal can successfully supplement soyabean meal at 5% level and can however be extended up to 10% supplementation.

Introduction
Increased vegetable utilization and consumption are necessary to improve upon and alleviate world-wide incidence of nutritional deficiencies (Nwanna *et al.*, 2005). Protein supplementation is often important to improve livestock performance, and this needs to be done with respect to the requirements of the animal in addition to the balance of other nutrients available (Hasanat *et al.,* 2006).The prices of protein sources have been escalating continuously in recent times, whilst availability is often erratic. The problem has been worsened due to the increasing competition between humans and livestock for these protein ingredients as food (Nuhu, 2010). According to Odunsi (2003), the rapid growth of human and livestock population, which is creating increasing needs for food and feed in the less developed countries, demand that alternative feed resources must be identified and evaluated.

There is the need, therefore, to explore the use of non-conventional feed sources that have the capacity to yield the same output as conventional feeds, and perhaps at cheaper cost. This strategy could help reduce the cost of production, and ensure cheaper fish production thereby making available the major crops for human consumption.

One possible source of cheap protein is the leaf meals of some tropical legume browse plants. Leaf meals do not only provide protein source but also some essential vitamins such as vitamins A and C, minerals and oxycarotenoids. (Foidl *et al*., 2001).The constraints to enhanced utilization of leaf meals reside chiefly on factors such as fibre content, the presence of anti-nutritive compounds and deficiencies of certain amino acids.

M. oleifera can contribute to increased intake of some essential nutrients and health-promoting phytochemicals (Rajangam *et al.,* 2001). Phytochemicals are present in virtually all of the fruits, vegetables, legumes (beans and peas), and grains we eat, so it is quite easy for most people to include them in their diet. *M. oleifera* leaf meal is considered a good protein source that can be used to supplement other protein sources to boost aquaculture production. It has high protein content and relatively good in terms of anti-nutritional factors unlike the other plant legumes. Hence an investigative work is necessitated to see its effect on growth performance and nutrient utilization of *Clarias gariepinus* when soyabean is substituted with *M. oleifera.*

Materials and methods.
The experiment was carried out at the Department of Fisheries and Aquatic Resources Management, Michael Okpara university of Agriculture, Umudike. *C. gariepinus* fingerlings were collected from the Department fish farm. The fish were allowed to acclimate for 7 days (Okoye and Sule, 2001) and was fed a commercial feed, prior to the commencement of the experiment. All the fish were starved for 24 hours before the commencement of the experiment. This practice is to eliminate variation in weight due to food residue in the gut and also to prepare the gastrointestinal tract for the experimental diets.

One hundred and twenty African catfish fingerlings (*C. gariepinus*) were used. Ten (10) fish were placed in each of the experimental units (70 litre containers) at 40 litres volume of water. The experimental units were twelve

(12) in number. There were 4 treatments in all and each treatment was replicated thrice in a completely randomized design. The experiment lasted for 3 months. Treatments were assigned as follows: Treatment 1 contains no *M. oleifera* leaf meal, and served as the control, treatment 2 was 5% replacement of soyabean with *M. oleifera* leaf meal, treatment 3 was 10% replacement of soyabean with *M.oleifera* leaf meal and treatment 4 was 15% replacement of soyabean with *M. oleifera* leaf meal. The feed ingredients as well as the experimental feed were subjected to Proximate Composition Analysis according to AOAC (2000)(Table 2). The experimental fish was fed thrice a day at five percent (5%) body weight per day. Sampling was done every two (2) week and data collected was used to calculate the growth performance. The physico-chemical parameters of the water as well as mortality were monitored.

M. oleifera leaves were obtained at the University farm. They were dried at room temperature to ensure that they retained their greenish colouration. The dried leaves were milled using manual grinder to reduce the particle size to obtain a product herein referred to as *moringa* leaf meal (MOLM) after which the leaves were analyzed for proximate composition according to AOAC (2000) (Table 1). The *M. oliefera* leaf meal was stored in bottles. Feed ingredients were purchased from a reputable aqua-feed store here in Umuahia, Abia state, Nigeria. The feed ingredients used for feed formulation were; maize, wheat offal, soya bean meal, fish meal, bone meal, vitamin/mineral premix, oil and salt. The experimental diets were formulated using Pearson's square method. The pellets were oven dried to prevent deterioration and the feed was stored in an air tight container.

The following growth and nutrient utilization parameters were calculated: specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), percentage weight gain, (Ridha and Cruz, 2001) and percentage survival.

All data collected on performance were subjected to Analysis of Variance (ANOVA) and significant in means were separated using Duncan's Multiple Range Test (Steel and Torrie, 1990).

Results and discusion

Table 3 show data on growth performance of the various treatments fed the experimental diets. Treatment 2 had a mean weight gain of 158.67g, which was not significantly different (P>0.05) from treatment 3, but was significantly different (P<0.05) from treatment 1 which had the highest mean weight gain of 181.0g and also from treatment 4 which had the lowest mean weight gain of 123.0g. There were no significant difference (P>0.05) in the feed conversion ratio (FCR), specific growth rate and protein efficiency ratio between treatments 1 and 2, but they were significantly different (P<0.05) from treatments 3 and 4. There are no significant difference (P>0.05) between treatments 2 and 3 for mean weight gain, percentage weight gain and final weight. The experiment had one hundred percent survival.

The growth response and nutrient utilization by fish decreased as *M. Oleifera* leaf meal increased in the diets. This observation supports the findings of previous studies. Richter *et al*. (2003) showed that higher substitution of *M. oleifera* leaf meal had an impact on lowering the growth performance because of the presence of anti-nutrients such as phenol, tannins, phytates and saponins etc.

Specific growth rate decreased in the values and this could be due to difference in the *M. oleifera* leaf meal levels, which decreased at increasing level of *M .oleifera* leaf meal in the diet.

It was observed from the result that treatments 1, 2 and 3 showed better FCR. However, there was a decrease across the treatments and the reason for this present observation might be due to high fibre content in *M. olifera* leaf meal.

Conclusion

This work demonstrated that *M. oleifera* leaf meal possess good dietary protein quality for optimal growth in fish, however the 100 per cent survival rate shows that *M. oleifera* leaf meal can successfully supplement soyabean meal up to 10% level of supplementation as shown in the result although 5 % supplementation did the best and hence should be recommended. Further, more work should be done on *Moringa oleifera* to ensure that some factors such as phenol, tannins, phylates and saponins etc. are properly removed without denaturing or affecting the nutritional quality of *Moringa oleifera* leaf meal, as well as ways to improve the palatability, acceptability and digestibility of *M. oleifera.*

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Table 1:Proximate Composition of *Moringa oleifera* Leaf

Nutrient	Percentage composition (%)
Moisture content	8.19
Crude lipid	28.03
Crude protein	35.25
Crude fiber	18.87
Total ash	6.81
NFE	35.85

Table2: Proximate composition of the experimental diets

Variables	treatment 1	treatment 2	treatment 3	treatment 4
Moisture (%)	7.37	7.38	6.87	8.88
Crude lipid (%)	6.98	6.97	6.00	7.62
Crude protein(%)	42.31	42.10	42.41	42.05
Crude fiber (%)	3.96	4.90	3.94	10.73
Total ash (%)	10.89	11.11	11.04	11.11
NFE (%)	28.49	27.54	29.74	19.61

Table 3 Growth performance for the various treatments during the culture period.

Paremeters	**treatments**			
	1	2	3	4
Initial mean weight (g)	111.67 ± 5.89^{a}	108.67 ± 6.44^{a}	101.33 ± 4.91^{a}	108.67 ± 10.17^{a}
Final mean weight (g)	292.67 ± 28.96^{a}	267.33 ± 8.21^{ab}	242.0 ± 10.4^{ab}	231.67 ± 1.5^{b}
Mean weight gain (g)	181.0 ± 23.8^{a}	158.67 ± 1.86^{ab}	140.67 ± 8.84^{ab}	123.0 ± 11.06^{b}
% mean weight gain (g)	161.06 ± 14.45^{a}	146.89 ± 7.46^{ab}	139.45 ± 11.20^{ab}	113.28 ± 1.6^{b}
Specific Growth Rate (%)	$1.70\pm.09^{a}$	1.61 ± 0.06^{a}	1.56 ± 02^{ab}	1.35 ± 0.08^{b}
Feed conversion ratio	$2.45.0\pm0.13^{a}$	$2.58.0\pm0.1^{a}$	2.78 ± 0.17^{ab}	3.16 ± 0.15^{b}
Protein efficiency ratio	0.96 ± 0.06^{a}	$0.92\pm.034^{a}$	0.86 ± 0.06^{ab}	0.75 ± 0.02^{b}
Percentage Survival	100	100	100	100

*Mean values within row with same superscript are not significantly different (P > 0.05)

*Values are mean of the triplicate of each treatment ± standard error of mean for all the parameters.

Effects of dietary lipid on the growth performance and serum biochemistry in carp (*Barbonymus schwanenfeldii* BLEEKER 1853) fingering in an aquaponics system.

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Abstract
Four isoproteic diets were designated to investigate the effects of dietary lipid levels from 0% to 12% on the growth performance, nutrition utilization and serum biochemistry of carp tin foil barb initially weighing, 2.99 ± 0.05 g per fish. Each diet was fed to triplicate tanks of 20 fish per tank for 60 days. Although the survival was unaffected by the lipid inclusion level, the specific growth rate and weight gain significantly increased as dietary lipid level increased from 0% to 8% ($P < 0.05$). However, serum glucose and triglyceride increased from 0% to 8% while, aspartate aminotransferase and alanine aminotransferase showed opposite trend. Based on the Third order polynomial regression analysis of weight gain, this study suggested that tinfoil barb optimally utilized 7.15% dietary lipid level for best the growth performance and nutrition utilization.

Keywords: Lipid level, Growth performance, Serum biochemistry, Carp, Nutrition.

Introduction
Dietary lipids are considered as an important source of energy and essential fatty acids (EFA) for the fish, which are also act as carriers of nutrients such as the fat-soluble vitamins A, D and K (Kamarudin et al., 2012). Especially for carnivorous and marine fish, dietary lipids are major provider of energy, because of their ability to utilize carbohydrate for energy is generally limited (Bami et al., 2017). Fish also utilized protein preferentially to lipid or carbohydrate as an energy source (Ding et al., 2010), and it is important to improve protein utilization for tissue synthesis rather than energy source (Mohanta et al., 2008). Therefore, it was also pointed out that dietary lipid had a protein sparing effect, which was benefit for growth performance and maximized the nitrogen retention (Du et al., 2005). However, excessive lipid in diets might also lead to decrease feed consumption and reduce growth (Pei et al., 2004). Meanwhile, high level of dietary lipids could also cause an increase of fat deposition and affect carcass composition in fish (Chatzifotis et al., 2010; Ding et al., 2010; Luo et al., 2005; Mohanta et al., 2008), which would reduce its commercial value (Martino et al., 2002). In conclusion, an appropriate dietary lipid level should be carefully evaluated and determined for fish growth and product quality (Wang et al., 2005). A feeding trail was conducted to evaluate the effects of different lipid level on growth performance, biochemistry and nutrition utilization of this carp**.**

Methodology
A 60-day feeding trial was conducted to determine the optimum dietary lipid inclusion level for tinfoil barb. Four test diets containing increasing amounts of crude palm oil (0,4,8 and 12 % diet) were used (**Table 1**). Triplicate groups of fish (2.99 ± 0.05 g) were fed twice daily to satiation.

Table 1: Ingredient and proximate composition (% as fed basis) of the experimental diets

Ingredient	Dietary Lipid Level (%)			
	0	**4**	**8**	**12**
Fishmeal [1]	40.13	40.13	40.13	40.13
Soya meal	36.33	36.33	36.33	36.33
Crude palm oil	0.00	4.00	8.00	12.00
Corn starch	20.00	15.00	10.00	5.00
α-cellulose [2]	1.54	2.54	3.54	4.54
Vitamin premix [3]	1.00	1.00	1.00	1.00
Mineral premix [4]	1.00	1.00	1.00	1.00
Proximate composition				
Moisture	7.8 ± 0.13	7.6 ±0.16	7.5 ±0.10	7.2±0.22
Crude protein	45.09 ±0.25	45.11 ± 0.07	45.08 ± 0.28	45.10 ± 0.17
Crude lipid	0.49± 0.12	4.48 ± 0.17	8.46± 0.10	12.45± 0.21
Crude ash	9.32 ± 0.16	10.51 ± 0.17	9.61 ± 0.18	10.95 ± 0.13
Crude fiber	1.63±0.09	2.69±0.16	3.72±0.18	4.66±0.15

Nitrogen free extract[8]	35.67±0.16	29.61±0.21	25.63±0.11	19.64±0.09
Gross energy (kJ g^{-1})	17.02±0.11	17.68± 0.13	18.34± 0.09	18.76± 0.12

[1] Fishmeal (local mixed species) with a crude lipid, crude protein, and dry matter at 5.5, 69.1, and 92.4respectively on a as is basis.
[2] α-cellulose was purchased from Sigma (C8002)
[3] Vitamin premix (g kg^{-1} premix): ascorbic acid, 45; thiamin mononitrate, 0.9; niacin, 4.5; riboflavin, 1; pyridoxine, 1; retinyl acetate, 0.6; cholecalciferol, 0.08; choline chloride, 75; Ca-pantothenate, 3; myo-inositol, 5; vitamin K menadione, 1.7; biotin, 0.02; α-tocopheryl acetate (500 IU g^{-1}), 8; vitamin B_{12}, 0.001; folic acid, 0.1
[4] Mineral premix (g kg^{-1} premix): NaCl, 40; $CuSO_4.5H_2O$, 3; KI, 0.04; $MnSO_4.H_2O$, 3; $ZnSO_4.7H_2O$, 4; $CaCO_3$, 215;
KCl, 90; $CoSO_4$, 0.02; $FeSO_47H_2O$, 20; $Ca(H_2PO_4).H2O$,500; MgOH, 124; Na_2SeO_3, 0.03; NaF, 1.
[5] nitrogen-free-extract; NFE = 100 – (moisture + lipid + protein + fibre + ash)

Results

Although the survival was unaffected by the lipid inclusion level, the specific growth rate and weight gain significantly increased (*$P < 0.05$*) as dietary lipid level increased from 0% to 8% (**Table 2**). However, serum glucose and triglyceride increased from 0% to 8% while, AST and ALT shows opposite trend. (**Table 3**).

Table 2: Growth performance and feed utilisation of tinfoil barb fed diets with increasing lipid level after 60 days

Parameter	Dietary Lipid Level (%)			
	0	4	8	12
Survival (%)	100	100	100	100
Initial body weight (g)	2.99±0.10[a]	2.99±0.15[a]	2.99±0.12[a]	2.99±0.11[a]
Final body weight (g)	09.10±0.14[d]	12.10±0.13[b]	12.98±0.18[a]	09.97±0.11[c]
Body weight gain (g)	6.11±0.12[d]	9.11±0.11[b]	9.99±0.08[a]	6.98±0.11[c]
Body weight gain (%)	204.35±0.11[d]	304.68±0.21[b]	334.11±0.15[a]	233.44±0.08[c]
SGR (% d^{-1})	2.32±0.13[b]	2.72±0.21[a]	2.81±0.13[a]	2.45±0.11[b]
FCR	1.64±0.11[a]	1.09±0.15[a]	1.00±0.07[a]	1.43±0.12[a]

Values are means ± SE of three replicates. Different superscripted letters in the same row indicate significant differences (P < 0.05).
SGR=specific growth rate; FCR=feed conversion ratio.

Table 3: Serum biochemistry of tinfoil barb fed diets with increasing lipid level after 60 days

Parameter	Dietary Lipid Level (%)			
	0	4	8	12
Glucose (mmol/L)	2.5±0.11[c]	2.9±0.08[b]	3.4±0.12[a]	3.0±0.19[b]
Total Protein (g/L)	40.8±0.10[b]	43.3±0.15[a]	43.4±0.12[a]	40.8±0.11[b]
AST (U/L)	518±0.14[a]	505±0.13[b]	400±0.18[c]	506±0.11[b]
ALT (U/L)	13.0±0.12[d]	9.0±0.11[b]	10.0±0.08[a]	8.0±0.11[c]
Triglyceride (mmol/L)	2.55±0.11[c]	3.65±0.21[b]	3.84±0.15[a]	3.71±0.08[a]
Cholesterol (mmol/L)	11.70±0.12[a]	13.60±0.05[a]	13.60±0.04[a]	12.70±0.09[a]

Values are means ± SE of three replicates. Different superscripted letters in the same row indicate significant differences (P < 0.05).

Discussion

The specific growth rate and weight gain significantly increased as dietary lipid increased which is in agreement with Bami et al. (2017) earlier reported that increasing dietary lipid levels are likely to improve the growth performance of many marine carnivorous species such as white seabass *Atractoscion nobilis* and Atlantic halibut *Hippoglossus hippoglossus*. However, a high dietary lipid level can inhibit the growth of some freshwater species such as hybrid tilapia *Oreochromis niloticus* × *Oreochromis aureus*, silver barb *Puntius gonionotus*, and grass carp *Ctenopharyngodon idella* (Du et al. 2005; Mohanta et al. 2008).

Conclusion

In conclusion, the results of the present study indicate that, tinfoil barb optimally utilized 7.15% dietary lipid level for best the growth performance and nutrition utilization.

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Growth performance of maggot meal as a Substitute for Imported Fishmeal in the Culture of *Clarias gariepinus* Juveniles.

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Abstract
Evaluation of growth performance of *Clarias gariepinus* juveniles fed with maggot meal as a substitute for imported fishmeal was carried out. Three hundred juveniles (7.01±0.02) were stocked in 15 experimental plastic tanks (80x60x60cm) at the rate of 20 juveniles per tank and fed thrice daily at 3% body weight for 10 weeks. Five experimental diets were formulated with varying levels (25%MGM, 50%MGM, 75%MGM and 100%MGM) of maggot meal to fishmeal and a control diet containing 100% fish meal. All the diets were iso-nitrogenous (35% crude protein level). Final body weight, Mean weight gain specific growth rate and Relative growth rate were measured lower in 100%MGM. Higher mean survival rates were recorded in all the treatment with highest value of 93.33 ±3.33% in the fish fed with 100%MGM. The maggot meal-based diets compared favorably at all inclusion levels significantly ($P < 0.05$) with best results at 75%MGM. Thus, fish meal can, to a very large extent be replaced by maggot meal, as this will reduce cost and still adequately meet the nutritional requirements of the fish.

Key words: maggot meal, *C. gariepinus*, juveniles, specific growth rate, survival rate,

Introduction
The high cost and scarcity of feedstuffs particularly the protein sources such as fishmeal, soybean cake and groundnut cake are the major factors militating against commercial fish production (Adeniji, 2007). In Nigeria, there is high demand for low cost fish feed as a result of increase and limited supply of commercial feeds which necessitate the search for alternate protein sources of feed ingredients as a partial or complete substitute to fish meal Presently, the demand for feed grade fish and fish meal far exceeds availability. As a result, Gabriel *et al.* (2007) opined that locally produced feed using locally available ingredients will reduce the cost of production. Maggot meal has been reported to be a possible alternative (Teguia *et al*. 2002; Ogunji *et al.* 2006). It has good nutritional value, cheaper and less tedious to produce than other animal protein sources. It is also produced from wastes, which otherwise would constitute environmental nuisance. Maggot meal is also rich in phosphorus, trace elements and B complex, vitamins (Teotis and Milles, 1973).Therefore, this work endeavours to draw attention to the nutritional value of insects' larvae as constituents of fish diets in smallholder fish production.

Methodology
Study site and maggot production
This research was conducted at Bodore Station of Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria. Maggots used for this experiment were cultured from poultry droppings purchased from Obasakeru fish farm, Lekki axis using perforated plastic bowls. The collection was done as described by Adejinmi (2000) and Sogbesan *et al.* 2006 using screens. Maggots collected were blanched in hot water, weighed and dried using Uniscope SM9053 Laboratory Oven at 50°C for 24hrs to prevent the protein being denatured. The dried maggots were grounded into powdery form, packed in air tight container and stored at room temperature shortly before the commencement of the feed formulation.

Feed ingredients
Feed ingredients were purchased from Nigerian Institute for Oceanography and Marine Research feed mill factory, Badore Station. The ingredients for the formulation included: fish meal, cassava, soybean, vitamins/mineral premix, anti mould and groundnut oil.

Diets formulation
Five isonitrogenous diets of 35% crude protein were formulated. The compounded ration in percentage of fish meal (FM) and maggot meal (MGM) in the five experimental diets I, II, III, IV and V were 100%:0%, 75%:25%, 50%:50%, 25%:75% and 0%:100% respectively, while I contained 100% of fish meal as control. The experiment was carried out in triplicates and diets were fed to *Clarias gariepinus* fingerlings for a period of 70 days.

Experimental fish

The experimental fish *C. gariepinus* juveniles total 300 were randomly sorted, weighed, stocked at 20 fingerlings per each plastic bow before the commencement of the feeding trial. The fish *C. gariepinus* fingerling were fed at 5% body weight, thrice daily between 8 am and 4 pm. Dead fish were removed, counted and recorded for determination of survival rate (Table 1).

Evaluation of growth performance indices

The growth performance of *Clarias gariepinus* was studied and compared with the group fed with imported fishmeal based diet. The data collected were subjected to analysis of variance (ANOVA) using completely randomized design (CRD). Performance characteristics were evaluated according to the method of Olvera- Novoa et al. (1990) as follows:

Parameters including Percentage weight gain (PWG), Specific growth rate (SGR), were measured and calculated. Chemical analysis was carried out on the maggot and catfish products.

Statistical analysis of data: -

All experimental data were subjected to analysis of variance test (ANOVA) as mean separation was carried out using Duncan's multiple range test (Duncan, 1955).

Results

The weekly changes in weight of all the experimental fish for the experimental period are shown in figure 1. There were progressive increase in weight of the fish sample throughout the experimental period with highest mean final body weight (MFBW) of 38.33g was recorded for fish fed FMG1 (25% fishmeal and 75% maggot meal) supplemented diet followed by 37.82g for fish fed FMG3 (75% fishmeal and 25% maggot meal) supplemented diet while the least value of 30.06g was recorded for fish fed FMG4 (100% maggot meal) supplemented diet. High survival rates were recorded throughout the experimental period with the highest mean value of 93.33±3.33% recorded in fish fed 100% maggot meal (100%MGM) followed by mean value of 86.67±1.66 for fish fed 50% maggot meal (50%MGM) while least value of 81.67±3.33 was recorded for both

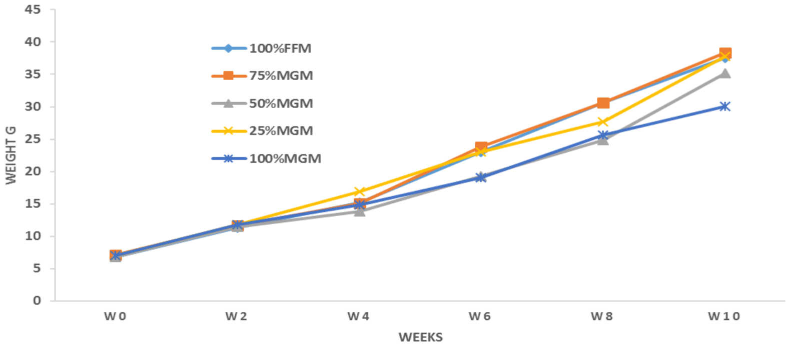

Figure 1: Mean weekly weight increase of *C. gariepinus* fed with experimental diets

Keys: FFM - Fish fed with 100% fishmeal supplemented diet
FMG1 -Fish fed with 25% fishmeal and 75% maggot meal supplemented diet
FMG2 -Fish fed with 50% fishmeal and 50% maggot meal supplemented diet
FMG3 - Fish fed with 75% fishmeal and 25% maggot meal supplemented diet
FMG4- Fish fed with 100 maggot meal supplemented diet

Table 1: Growth performance of *C. gariepinus* fed the experimental diets

	Experimental Diets				
Parameters	I (100%FFM	II (25%MGM)	I II(50% MGM)	IV (75% MGM)	V(100%MGM)
No. of fish	60	60	60	60	60
MSR (%)	81.67±7.26^a	81.67±3.33^a	86.67±1.66^a	85.00±2.88^a	93.33±3.33^a
MIBW (g)	6.78±0.07 ^{a}	7.11±0.02^a	6..84±0.26^b	7.06±0.02^a	7.05±0.01^a
MFBW (g)	37.54±2.18^a	38.33±3.74^a	35.13±2.24 ^{a}	37.82±0.82^a	30.06±2.56^b
MWG(g)	30.67±2.15^a	31.22±3.04^a	28.29±2.16 ^{a}	30.76±0.82^a	23.01±2.56^b
SGR (%)	2.45±0.13^a	2.41±0.23^a	2.34±0.20^b	2.40±0.07^a	2.07±0.33^c
RGR (%)	433.69±18.01^a	439.10±32.01^a	413.30±17.98^b	435.69±6.83^a	326.4±21.79^c

Table 2: Gross composition of experimental diets

Ingredients	Experimental	Diets			
	I (100%FM)	II (25%MGM)	III (50% MGM)	IV (75% MGM)	V (100%MGM)
Fish meal	20	15	10	5	-
Maggot meal	-	5	10	15	20
Soybean meal	40.77	44.55	48.36	52.17	55.89
Cassava meal	38.23	34.45	30.64	26.83	23.11
Fish premix	0.50	0.50	0.50	0.50	0.50
Vitamin C	0.10	0.10	0.10	0.10	0.10
Anti-mould	0.40	0.40	0.40	0.40	0.40
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
ME (kcal/kg)	3,343.39	2,868.87	2,858.87	2,801.47	2,936.27
Crude protein	35	35	35	35	35

Discussions

The improving growth response observed with increasing levels of maggot as the diets compared favorably at all inclusion levels may be caused by the high level of crude protein in maggot meal. Thus, fish meal can, to a very large extent be replaced by maggot meal. In this study maggot meal can replace fish meal up to 75% inclusion without any adverse effect on the growth. This has been attributed to its nutritive quality, acceptance and digestibility (Alegbeleye *et al.*, 1991; and Aniebo *et al*., 2009). which is supported by Adewolu et al 2010 and Michael and Sogbesan, 2015, who reported that maggot meal could replace 50%, 75% fishmeal respectively in the diet of *C. gariepinus* fed with maggot and fish meal supplemented diets without adverse effect on the weight gain, specific growth rate, feed efficiency ratio and conversion ratio. The effect of the experimental diets on the nutritional composition of the fish at the end of this study is very similar to what was obtained by Ajonina and Nyambi (2013) who also recorded best carcass composition at 100% and 75% maggot inclusion. Ajani *et al.* (2004) also concluded that maggot meal can replace up to 100% of fish meal in the diets of Nile tilapia (*O. niloticus*) as its nutritive value compared favorably with that of fish meal. Fish fed 100% maggot meal inclusion level (100%MGM) recorded the least FCR (2.40) is an indication that it has lower feed to flesh conversion.

The control diet would have been expected to show the best growth performance especially in terms of weight gain since it contains fish which has high level of protein that has been known as the best feed ingredient for fish (Steffens, 1989, Michael and Sogbesan, 2015) but this was not so. However, Lovell 1994 reported that the biological value of protein source does not only depend on its amino acid profile but also on its digestibility energy which increased with maggot meal inclusion. Fibre content has been documented by Newton *et al.*, 2005 to enhance growth performance in fish. The high growth performance of juvenile fed maggot supplemented diet in this experiment have formed a better balance diet for the juvenile catfish. Maggot meal has a great benefit as a potential protein source in fish feed production.

Conclusion and recommendation

Based on these results, the use of maggot to substitute the costly fish meal to about 75% inclusion level is recommended to fish farmers and feed industry though there is a need to appraise large scale production of maggots so as to offer solution to the high cost of protein source in fish feed production.

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Effects of replacement of fish meal with pig blood meal in catfish feeds on their growth, survival and heamotology

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Abstract
Aquaculture activities in Nigeria started about 50 years ago, yet Nigeria has not been able to meet domestic production demand for the populace. Seventy two African catfish (ACF) *Clarias gariepinus* juveniles were fed with different inclusion levels of Pig Blood Meal (PBM) at 10% ,25%, 50% and 0% control. The samples were fed with commercial feed during seven days of acclimatization and were randomly allotted into three experimental groups (0%, 10%, 25% and 50%) in triplicate and were maintained in 12 plastic tanks each containing six (6) catfish; fed once daily for 70 days. African catfish in group feed with 50 % PBM showed an increase in average weight gain at the end of the experiment (P<0.05). Proximate analysis result (among the three experimental groups) showed the highest moisture, protein and ash contents in group fed with 50% PBM i.e. (61.43±0.153,17.94±0.013 and 1.33± 0.004) (P<0.05). However, group fed with 10% PBM recorded the highest fat and fiber content (2.64±0.018 and 0.20±0.12) and carbohydrate content was highest in the group fed with 25% PBM (P < 0.05). The hematological test also implicated groups fed with 10% PBM to have the highest Packed Cell Volume (PCV) and Hemoglobin (HB) (44 ±1.73 and 9.81±0.79), Red Blood Count(RBC) and White Blood Count (WBC) in group fed with 50% PBM(8600±529.15 and 8.2±0.36) and platelets showed highest value in group fed with 25% (P<0.05) when compared to other groups. The body weight gain showed that Fish group fed 50% had higher weight gain. The head length(HL) and body length(BL) showed the highest value in group fed with 50% PBM. The findings of this study conclude therefore, that fish meal can be substituted with PBM up to 50% in the diets of *C. gariepinus* without adverse effect on the growth and nutrient utilization.

Keywords: *Clarias gariepinus,* fish feed, Blood meal, Growth rate, Hematology.

Introduction

Fish is one of the numerous food substances available for man.It has crucial nutrients of high proteins values (Onyia *et al.,* 2010).The need for availability of fish is raising because of the continued raising of the global human number, the high style of living among people and general nutritional contents of fish that attract its consumers (Cahu *et al*., 2004; Oshozekhai and Ngueku, 2014). Fish farming is a popular agricultural sector that is rapidly growing and represents a highly valued protein source (Agbebi *et al*., 2009). Fish feed has been reported by Agbebi (2009) and Brink (2001) to represent up to Forty to fifty percent of general cost of production in commercial fish farming system with protein playing the major role in the cost as the most eexpensive of all the fish feed ingredients in the compounded fish feed. ACF is of the family Clariidae. It is common in the African continent and has found its way to other countries in Europe and Asia where they have been farmed commercially.ACF is good for fish farming because of their rapid growth, their ability to consume many waste products from agriculture, their ability to live in water with a high level of ammonia and low oxygen levels (Njieassam, 2016).ACF has many groups and is known for being ray-finned with whiskers like that of a cat (Synodontis batensoda and Njieassam, 2016).Fish feed is importantly made up of the Fish Meal (FM) which, however, is not common and very expensive(Agbebi *et al*., 2009). FM is known for its high valued protein make-up which is seen in its balanced amino acids that can digest at ease (Dawczynski *et al*., 2007). It is of great importance to have option for the expensive FM ingredient, most importantly, now that there is global hike in its cost in the recent times (Agbebi *et al*., 2009).According to FAO (2017) and UN (2014) in no distant time, the global populace will be living in urban areas and consequential result of the above reports is the increase in the global need for food sources like fish that will match the population that is not yet met. Fish farming, by the year 2002, contributed 29.9 percent of the total quantity of fish needed globally (FAO, 2004). The implication of this is that if sixteen thousand tons of fish farm products are produced annually, it will meet up with the raising need (Brink, 2001).Different scientific reports have shown that blood meal can take the place of FM and will not affect the fish weight gain as well as the feeding (Agbebi *et al*., 2009). The findings from this study will add to the wealth of aquaculture information. The aim of this study was to evaluate the effect replacement of FM with PBM in African Catfish on their growth, survival, and hematology.

Fish require ccording to Fagbenro (1999), to reduce the price of a complete feed, locally available feed stuff should be included in the feed, especially Blood meal which is an animal waste product and readily available in abattoirs is an a(Olukayode and Emmanuel, 2012)

METHODS

Study Area

The research was carried out in the Department of Biotechnology Laboratory, Ebonyi State University, Abakaliki.

Ebonyi State is located approximately within latitude 6°20'N and longitude 8°06'E in the derived savannah of south-Eastern part of Nigeria at an elevation of 117m. The rainfall pattern is bimodal (April-July and September-November) with a short spell in August referred to as August break and annual rainfall of about 1,800-2,000mm. The average temperature is between 25°C in January, 34°C in June and 30°C in November (Ude, 2011).

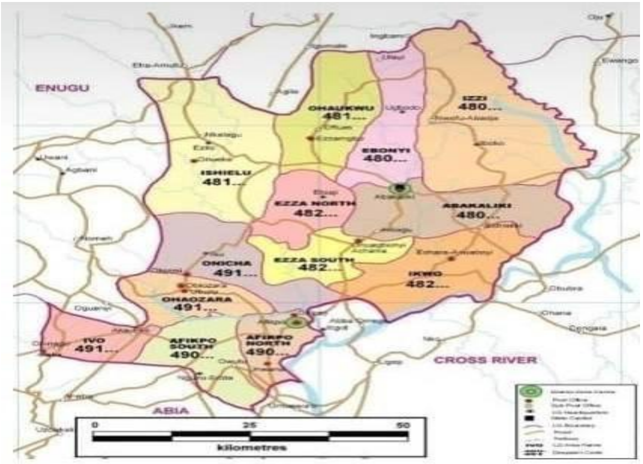

Fig. 1 Map of Ebonyi State showing Abakaliki.

***Clarias gariepinus* juveniles used:**
A total of seventy two (72) African catfish (C. gariepinus) juveniles of average weight of 5g were used and procured from secretary to state government fish farm located at Presco Campus, Ebonyi State University, Abakaliki. The fish were acclimatized for seven (7) days and were fed with commercial feed (1.5mm of top feed) prior to the commencement of the experiment.

Water Quality Analysis (Water Parameters)
Physicochemical analysis of water was measured once a week during the duration of the study. The following parameters were tested; water temperature, hydrogen ion concentration (pH), and total dissolved solids (Turbidity) while dissolved oxygen (DO) was tested using dissolved oxygen test kit following the manufacturer's instructions.

Preparation of PBM
A fresh blood of pig was purchased at abattoir in boundary market in Aluu, Port Harcourt, Rivers State with a sterile container.It was parboiled and sun-dried and grinded using hand grinder prior to the catfish juveniles feed formulation using modified method according to Bekibele **(2012).**

Experimental diets formulation and compounding
The ingredients used for compounding of the four different diets containing (50%, 25%, 10% and 0%) different inclusion levels of PBM used in the study were sourced from feed mill and nutrition section of African Regional Aquaculture Center(ARAC), Aluu, Port Harcourt, Rivers State of Nigerian Institute for Oceanography and Marine Research. All the ingredients are mixed together (each ingredient in different quantity following peerson's method) with water and then pelleted , after which the feeds were sun dried and bagged for use using modified method according to Bekibele **(2012).**

Experimental design
The experiment was carried out in twelve (12) plastic tanks $1m^2$ each with a stocking density of six (6) fish per square meter. The experiment lasted for seventy seven (77) days. Six (6) catfish juveniles in three replicates were stocked into the tanks (1mx1mx1m) in a completely randomized design (CRD). Each diet was fed to the catfish daily (4.00pm) at 3% of body weight for 77 days. Fish mortality was monitored daily; sampling was also done at the interval of one week to determine the new weight in order to adjust the rate of feeding accordingly.

G**rowth response**

To determine the growth response, parameter like mean weight gain in grams (MWG) was calculated according to the method described by Ogunji, (2004):

Mean Weight Gain (g) (MWG)

$MWG = WT_2 - WT_1$……………………………………………1

Where WT_1 = initial mean weight of fish at time T_1

WT_2 = final mean weight of fish at time T_2

Proximate and Hematological analysis

The experiment ended after 77 days and catfish samples from the three experimental and control groups were sent to chemistry laboratory at University of Nigeria Nsukka for proximate and hematological analyses.

Statistical Analysis

Data collected from the experiment were subjected to Analysis of Variance (ANOVA) using SPSS package version 20 and the differences among treatments were separated using Duncan multiple range test (Duncan, 1955).

RESULTS

African catfish in group feed with 50 % PBM showed the highest increase in average weight gain at the end of the experiment which was determined using equation above.

Table1: Proximate Analysis of ACF Fed With PBM

	0 %	**10%**	**25%**	**50%**
Moisture	66.50 ± 0.22^a	59.20 ± 0.240^b	58.73 ± 0.196^c	61.43 ± 0.153^d
Ash	1.53 ± 0.009^a	1.19 ± 0.090^b	1.30 ± 0.018^b	1.33 ± 0.004^c
Fats	2.80 ± 0.100^a	2.64 ± 0.018^b	2.255 ± 0.090^a	2.44 ± 0.013^a
Protein	18.85 ± 0.055^a	17.86 ± 0.024^b	17.38 ± 0.05^c	17.94 ± 0.013^d
Fiber	0.13 ± 0.003^a	0.20 ± 0.012^b	0.015 ± 0.010^c	0.177 ± 0.014^d
Carbohydrate	10.19 ± 0.292^a	18.91 ± 0.216^b	20.17 ± 0.117^c	16.68 ± 0.144^d

Note: values in rows with different letters are significantly different ($p<0.05$)

Table 2: Hematological analysis of ACF Fed With PBM

	0%	**10%**	**25%**	**50%**
PCV (%)	47.67 ± 1.53^a	44 ± 1.73^b	42 ± 1.00^b	42.67 ± 0.58^b
WBC (X1O*9)	5533.33 ± 305.51^a	6166.67 ± 57.74^b	8266.667 ± 416.33^c	8600 ± 529.15^c
RBC(X10*12)	8.6 ± 0.2^a	7.87 ± 0.95^a	7.67 ± 0.15^a	8.2 ± 0.36^a
Hb (g/dl)	10.57 ± 0.2^a	9.81 ± 0.79^a	8.47 ± 0.36^b	8.53 ± 0.015^b
Platelets (X10*9)	250.333 ± 9.71^a	351 ± 4.58^b	362 ± 13.08^b	295.33 ± 6.03^c

Note: values in rows **with different letters are significantly different ($p<0.05$)**

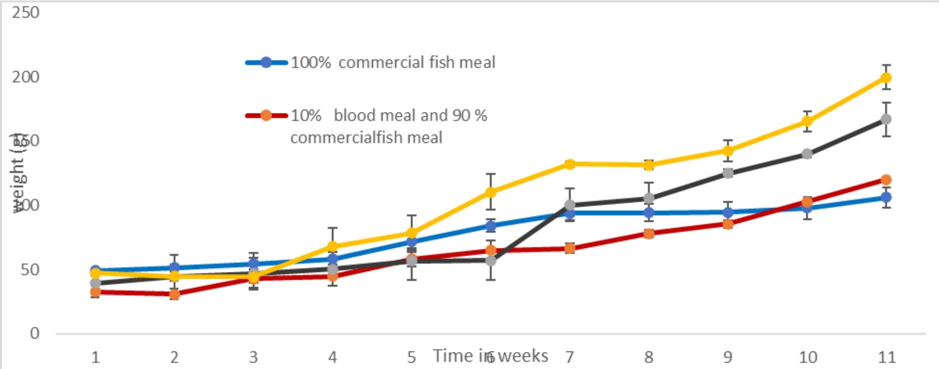

Figure 2: Weight Gain of ACF Fed With PBM

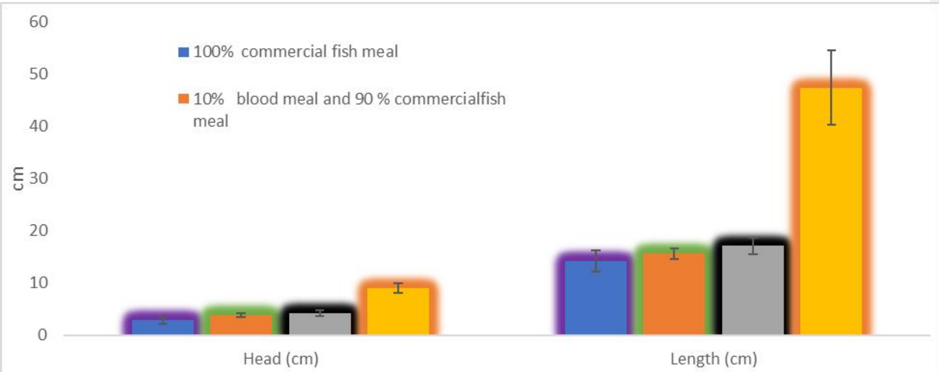

Figure 3: Body length and Head Measurement of Catfish fed with Pig Blood Meal

DISCUSSION

Percentage it is included in a fish feed is crucial and most importantly should tend to reduce the high cost of FM ingredient of fish feed. The result of this study revealed a consistent increase in the average feed given to the African Catfish on a weekly basis and the increase in the feed been given to the fish may be due to increase in growth of the African Catfish, which indicates that more food led to more gained in body weight as expressed in figure 2 which revealed that the African catfish by week 10 had the highest body weight this observation is similar to the findings of Ogunkunle (2002) who reported that at 10% inclusion level of blood meal catfish juvenile showed the greatest feed utilization as seen in their feed conversation ratio.

African catfish in group feed with 50 % PBM showed an increase in average weight gain at the end of the experiment which implies that PBM can replace up to 50% of FM in a fish diet without adverse effect on the weight gain, however, this observation is different from the report of (Njieassam, 2016) who said recorded highest weight gain at 10% inclusion level of blood meal.In addition, the report of Ogunkunle, (2002) recorded highest weight gain of fish at more than 10% inclusion level of blood meal therefore showed similarity with the findings in this study which ,however, is not significantly different($P>0.05$) when compared with other experimental groups.

Proximate analysis result showed the highest moisture, protein and ash contents in group fed with 50% PBM. However, group fed with 10% PBM recorded the highest fat and fiber content and carbohydrate content was highest in the group fed with 25% PBM (P < 0.05).These observations are similar to the report of Ogunkunle (2002) who concluded that blood meal can replace more than 10% of fish meal protein. However, the observations are not very similar to that of Njieassam, (2016) who also recorded a slight different result for proximate analysis.

The hematological test also implicated groups fed with 10% PBM to have the highest Packed Cell Volume (PCV) and Hemoglobin (HB) Red Blood Count(RBC) and White Blood Count (WBC) in group fed with 50% PBM and platelets showed highest value in group fed with 25% ($P<0.05$) when compared to other groups. But, the WBC result recorded the highest value in the control group fed with 0% PBM than the groups fed with different inclusion levels of PBM. This observation could mean well being of the ACF indicating stree-free condition which can induce high production of the WBC when in disease condition, an observation similar to that of (Ogunkunle,1998) who concluded that WBC become increased during infection and disease condition.

The findings of this study conclude, therefore, that fish meal can be substituted with PBM up to 50% in the diets of *C. gariepinus* without adverse effect on the growth and nutrient utilization.

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FISHERIES ECONOMICS

Cultural practices adopted by farmers in Lafia Local Government Area, Nasarawa State for sustainable aquaculture

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Abstract
Aquaculture is one of the fastest growing food producing sectors in the world. It plays significant role in Nigeria's economy in terms of Gross Domestic Production (GDP), job creation and production of cheap and readily available protein. However the sustainability of the production system is a cause of worry. This study therefore examine the socio-economic characteristics and ascertaining the management option adopted by the respondents in the study area. Structured questionnaires was administered in five (5) communities which were purposively selected by random sampling techniques in which forty (40) respondents were selected. Analysis revealed that there were more males than females who were involved in fish farming. The active age of the fish farmers ranged from 36-45 years. Likewise 87.5 percent of the respondents were married while 62.5 percent of the respondents had tertiary education. Furthermore, 42,5 percent had 4-6 ponds, 65.0 percent used concrete pond type and 87.5 percent used intensive production system.

Keywords: Cultural practices, Sustainable, Aquaculture

Introduction

Fish production is a major subsector of agriculture which occupies an important position in Nigeria's economy where the population is increasing rapidly. In terms of Gross Domestic Production (GDP) in Nigeria. It is seen as the fastest growing their nutritive quality and importance in improving human health (CBN Report, 2005). Fish plays a vital role in feeding the world's population and contributing significantly in the dietary protein consumptions of billions of the populace (Amao *et al.*, 2006). Almost 16 percent of total average intake of animal protein was attributable to fish globally (FAO, 1990). FAO had recommended that an individual takes at least 27kg of animal protein per day for sustainable growth and development. The problem of supply of fish food has been on the decline, traced to consistent decreases in the country's major source of food fish. (Ugwumba and Chukwuji, 2010). Interest in fish farming in recent times in Nigeria was due to in adequate protein intake which needs to be addressed by ensuring increase production of fish (Igwe et al., 2011).Aquaculture activities in Nigeria started about 50 years ago yet Nigeria has not been able to domestic production demand for populace (Olagunju *et al*, 2007). According to (FAO, 2012) report, Egypt is the highest producer of aquaculture in 2010 with 919,585 tonnes of total Africa production followed by Nigeria with 200,535 tones. A fish pond is a controlled pond, artificial lake or reservoir that is stocked with fish and is used for aquaculture for fish farming. Mostly earthen ponds are used for culture of camps, tilapia, cat fish and sea bas (FAO, 2009). Other forms of culture system and technique includes flow through system, fish cage culture, fish farms ,Reticulating Aquaculture Systems .Most culture system recommended at least 5% to 10% water exchange rate per day depending on stocking and feeding rates (FAO, 2015).

Materials And Methods

Study Area

The study was conducted in Lafia Local Government Area of Nasarawa State, Nigeria. The population of the study area is 330,712 people (NPC, 2006). Lafia is located between latitude 08° 29' 30'' N and longitude 08°31'0'' E with altitude of 18.5m above sea level.

Sampling techniques

The sampling frame for this study comprised of pond fish farmers in Lafia Local Government Area of Nasarawa State. Five (5) communities were purposively selected from the study area. The selection of fish farms was done by simple random sampling technique in which forty (40) fish farms were selected and data collected from them through the use of structured questionnaires.

Data collection

The data was generated from primary sources which forty (40) respondents with the aid of well-structured questionnaires and interviews scheduled.

Data analysis

The data collected were analyzed with the descriptive statistics such as frequency counts, percentage, mean and bar

Results and Discussion

The socio-economic characteristics of the respondents examined were basically those of sex, age, marital status and level of education. These variables are presented in Table I below and which shows that 75% of fish farmers in the study area were male and 25% were females. For age, 32.5% of fish farmers in the study area are between the age of 46 – 55. The cumulative of the bracket shows that 93% of the fish farmers in the Lafia Local Government Area were at most 55 years old. This gives an insight into prospect that are in fish farming. Since the fish farmers are permanently youths and are in their productive age and no doubt of youthful vigor to ensure maximum production (Kebede, 2001) reported that age is an important factor in determining the productivity and adoption of innovative farmers. This findings also agrees with Eze (2002) who reported that active age of farmers is a positive factor for decision making. Nwaru (2004) also opined that the ability of the farmers to bear risk, do manual work and be innovative decreases with increase in age.The marital status from the table depicts that 12.5% of the respondents were single, 87.5% of the respondents were married. This insists that most of the respondents in the study area were married and it implies that the expected supports from the spouse(s) and children of these farmers with a view of improving and increasing fish production and managements of fish farm could be better achieved. It could mean that unmarried people rarely engaged in farming as they may not have domestic responsibilities to shoulder (Nwosu *et al*, 2012).2.5 % had first school leaving certificate (primary), 30% had secondary school leaving certificate 5% with adult education and 62.5% had tertiary institution certificate. This shows that fish farmers in the study area are well educated. Formal education is widely considered to be the most important form of human capital (Becker, 1994) in a dynamic political and economic environment where new technology and information are regularly developed (Gardner and Rausser, 2001).

Result and Distribution

Table 1: Socio-economic Characteristics of The Pond Fish Farmers in Lafia Local Government Area.

		Frequencies	**Percentage**
I	**Sex**		
	Male	30	75.0
	Female	10	25.0
	Total	**40**	**100**
II	**Age**		
	25 - 35	13	32.5
	36 - 45	18	45.0
	46 - 55	6	15.0
	56 - above	3	7.5
	Total	**40**	**100.0**
III	**Marital Status**		
	Single	5	12.5
	Married	35	87.5
	Divorced	0	0.0
	Total	**40**	**100.0**
IV	**Level of education**		
	No formal	0	0.0
	Primary	1	2.5
	Secondary	12	30.0
	Tertiary	25	32.5
	Adult education	2	5.0
	Total	**40**	**100**

Source: Field Survey 2016

The farm management options adopted by responds were according to number of ponds, pond types and production adopted. For distribution of respondents according to number of pond depicts that majority of pond fish farmers had about 4-6 ponds and very few had less or more of these. To attain the full potential of pond fish production, the operator should have more than 3 ponds that are being managed. Likewise, there was distribution of respondents according to pond type. This shows that most of the pond fish farmers (65%) use concrete tanks. This might be due to its convenience, ease in cleansing and management of pond and in particular, ease of harvesting and draining. Simplicity and inexpensiveness in its construction were basic for preference and earthen pond to concrete pond by the few users (35%). This agrees with OAE (2009) which report that the concrete ponds has many advantages over earthen pond. The distribution of respondents according to production system adopted shows that 12.5% of the respondents adopt semi-intensive system of production, 87.5% adopted intensive system of production while none of the respondents adopt extensive system of production. Thus, it could be said that pond fish farmers in the study area adopt mainly intensive system.

Table 2: Farm Management Option Adopted By Pond Fish Farmers in Lafia Local Government Area.

	Frequency	Percent
Number of ponds		
1 – 3	10	25.0
4 – 6	19	40.5
7 – 9	7	17.5
10 – 12	4	10.0
Total	**40**	**100**
Pond Type		
Concrete	26	65.0
Earthen	14	35.0
Total	**40**	**100**
Production System		
Extensive	0	0.0
Semi-Intensive	5	12.5
Intensive	35	87.5
Total	**40**	**100.0**

Source: Field Survey 2016

Conclusion and Recommendation

Fish farming is being practiced in Lafia mostly by youths and married individuals and the cultural practice adopted by the pond fish farmers is mostly intensive system of production. Fish production could be a major strategy to reduce poverty, generate employment to the teeming unemployed and meet the nutritional needs of Nigerians. Thus this study showed that pond fish farming is a certain phenomena attracting younger and well educated farmers.

Recommendation

Government and co-operate bodies should assist fish farmers in providing educational programs via training.

Farmers are encouraged to form and join co-operative societies as this will help the fish farmers get resources to overcome myriad problems.

Governments should provide more fisheries extension agents to assist in intensive educational program for farmers especially at the gram root.

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Production Constraints Effects On Small Scale Aquaculture In Oyo State

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Abstract
Aquaculture is the farming of aquatic organisms and plants in fresh, brackish or salt water. Unlike capture fisheries, aquaculture requires deliberate human intervention in the organisms' productivity which results in yields that exceed those from the natural environment alone. This study aimed at providing information on the constraints of small-scale aquaculture and their effect on small scale aquaculture in Oyo State. Purposive sampling of 100 small-scale fish farmers across the four ADP zones in Oyo State was carried out to determine the constraints on fish production activities in the study area and assess the effects of each of the constraints on fish production activities in the study area. The study with the aid of a well structured questionnaire highlights relevant information from respondents. Data were analyzed and tested with descriptive statistics (frequency and percentage), and inferential statistics (chi square and t-test).

Findings from this study reveal that fish farmers in the study area experience production and marketing constraints which include lack of capital, high cost of fish feed, inadequate modern technologies, poaching/predators as well as non-availability/high cost of quality fish seed/fry etc, all of which affect aquaculture development. It is therefore recommended that, credit facilities, adequate modern technologies and quality fish seed be made available to fish farmers, this would not only enhance aquaculture development, but also ensure food security and poverty reduction.

Keywords: Constraints, aquaculture, production, marketing, small scale.

Introduction

Aquaculture development is driven by social and economic objectives in Nigeria; such objectives include nutrition improvement in rural areas, generation of supplementary income, diversification of income activities, and creation of employment (Chilaka *et al.,* 2014). Aquaculture continues to rise as the levels of wild fish capture depreciates since 1980s to around 90-93 million tons per year (Agbeja and Obosi, 2015). Small scale aquaculture play important role in aquaculture in many countries, sometimes livelihood which integrate aquaculture, livestock, crops, and through increasing more specialization in household managed enterprise.

However, the global population is increasing and, in order to maintain at least the current level of per-capita consumption of aquatic foods (19.7 kg in 2013, FAO, 2016), the world will require an additional 23 million tonnes thereof by 2020. This additional supply will have to come from aquaculture. Meeting the future demand for food from aquaculture will largely depend on the availability of quality feeds at affordable prices, quality fish seed, good water supply, and in the requisite quantities.

Small-scale producers characterized by a low-asset base and low productivity, dominate the agriculture landscape throughout the developing world , and similarly play an important part in aquaculture in many countries, sometimes through livelihoods which integrate aquaculture, livestock, farm crops and other on- or off-farm activities, and sometimes through increasingly more specialization in aquaculture as a household managed enterprise. Small farms are characterized as largely owned and operated by households with limited access to assets such as land, water, finance and material inputs(seed, feed, *etc.*) and consequently, farm production volumes tend to be low. Small-scale producers face varying degrees of financial, knowledge, market access and other constraints, and therefore commonly face difficulties in raising productivity and incomes. Therefore this research focuses to study the effect of production constraints on small scale aquaculture in Oyo state.

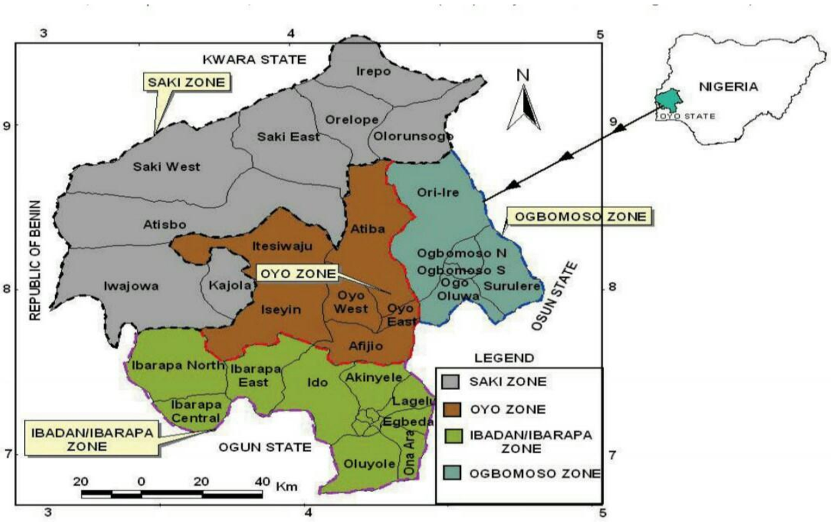
Materials and Methods

Study Area

The study was conducted in Oyo State, Nigeria. Oyo State was chosen because of the abundance of fish farming enterprises and endowment of the region with water bodies which facilitated the operational existence of fish farms in this region. It is also very familiar to the researcher as it increased the ease of data collection. The State is located in the rainforest vegetation belt of Nigeria within longitude of 2038.66^{1}N and 4038.25^{1}N and latitude 908.74^{1}E and 701.68^{1}E. It is bounded in the south by Ogun State and in the north by Kwara State, in the west by the Republic of Benin while in the east it is bounded by Osun State, with a population of over 5,591,589 million people (Olagunju *et al.*, 2007).

Experimental Design, Sampling and Analytical technique

The selection of small-scale catfish farmers were done according to Shaib *et al.* (1997), The list of small-scale fish farmers in the four Agricultural Development Project (ADP) operational zones in Oyo State (Ibadan/Ibarapa, Ogbomoso, Oyo and Saki) were gotten from the Oyo State Ministry of Agriculture and Natural Resources (Fishery Department) register and a purposive sampling was used to select 100 small-scale fish farmers. Primary data were collected using a well structured questionnaire; secondary data were obtained from library, internet, journals, text books etc. Both numerical and statistical analyses of data were employed, such as mean, frequency distribution and percentages. The use of likert scale, Pearson Product Moment Correlation (PPMC) and chi square were also applied.



Formula for statistical tools used

Formula for mean

$$\bar{x} = \left(\sum x_i\right)/n$$

Where x_i is all of the x values

n is the number of items in the sample

Formula for Pearson Product Moment Correlation (PPMC)

$$r = \frac{\frac{\sum xy - (\bar{x})(\bar{y})n}{n-1}}{(s_x)(s_y)}$$

Where x and y are deviation scores

S_x and S_y are sample stand deviations

Formula for chi-square

$$x_c^2 = \sum \frac{(0_i - E_i)^2}{E_i}$$

Where O is observed value

E is expected value

i is the "ith" position in the contingency table

Results and Discussions

Constraints affecting Aquaculture production and marketing

The production constraints identified in the study area are listed in Table 1 below.

Table1 shows that lack of finance (capital and credit) with the highest mean of 5.42 and ranked 1st is the major constraints faced by the respondents. The scores were ranked and the constraint with the highest total score was regarded as the most severe. This is followed by inadequate modern technology with mean of 5.29 and ranked 2nd and high cost of fish feed with mean of 5.25 and ranked 3rd. However, lack of technical know-how has the lowest mean of 4.34 and ranked 20th is the least constraints faced by the respondents.

Table 1: Distribution of constraints affecting aquaculture production and marketing

Constraints	High	Moderate	Low	Mean	Rank
Production constraints					
Land acquisition	62 (62.0)	12 (12.0)	26 (26.0)	4.42	17th
Insufficient labour	51 (51.0)	20 (20.0)	29 (29.0)	3.90	18th
Distance of the extension staffs' office to village/farm	72 (72.0)	16(16.0)	12(12.0)	4.70	11th
Poor preservation/processing/storage facilities	66 (66.0)	17 (17.0)	17 (17.0)	4.60	12th
Inadequate modern technologies	86 (86.0)	9 (9.0)	5 (5.0)	5.29	3rd
Lack of finance (capital and credit)	93 (93.0)	2 (2.0)	5 (5.0)	5.42	1st
Non-availability/high cost of quality fish seed/fry	79 (79.0)	15 (15.0)	6 (6.0)	5.08	5th
Poaching/predators	85 (85.0)	9 (9.0)	6 (6.0)	5.18	4th
High cost/lack of construction equipment	81 (81.0)	13 (13.0)	6 (6.0)	5.06	6th
Market price fluctuation	59 (59.0)	34 (34.0)	7 (7.0)	4.71	10th
High cost of fish feed	89 (89.0)	6 (6.0)	5 (5.0)	5.25	2nd
Water shortage during dry season	46 (46.0)	29 (29.0)	25 (25.0)	3.85	19th
Lack of technical know-how	43 (43.0)	50 (50.0)	7 (7.0)	4.34	20th
Disease and pest infestation	64 (64.0)	26 (26.0)	10 (10.0)	4.72	9th

Effect of constraints on aquaculture production

Increase in cost of production with the highest mean of 5.33, ranked 1stas the major production constraints faced by the respondents. This shows that production cost of culturing fish is high and most of the respondents might be constrained by inadequate finance to produce on a large scale. However, high mortality rate with the lowest mean of 4.54, ranked 4th as the least constraint faced by the respondents. This means that most of the respondents put good management practice in place especially water quality maintenance.

Table 2: Distribution of effect of constraints on aquaculture production and marketing

Production constraints	High	Moderate	Low	Mean	Rank
Reduction in quality of fish produced	87 (87.0)	9 (9.0)	4 (4.0)	5.10	3rd
Increase in cost of production	88 (88.0)	8 (8.0)	4 (4.0)	5.33	1st
High mortality rate	61 (61.0)	26 (26.0)	13 (13.0)	4.54	4th
Reduction in profit	84 (84.0)	11 (11.0)	5 (5.0)	5.15	2nd

Source: Field survey, 2018

Conclusion

It is important to note that all of the respondents had constraints affecting effective fish production and marketing. Prominent among the identified constraints affecting fish production and marketing in the study area were; lack of finance (capital and credit), high cost of fish feed, inadequate modern technologies, poaching/predators as well as non-availability/high cost of quality fish seed/fry. These constraints were reported to have led to increase in cost of production, reduction in profit, reduction in quality of fish produced and high mortality rate.

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Adaptation Of Fish Farmers To Covid-19 Pandemic In Epe Local Government Area Of Lagos State, Nigeria.

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Abstract
Adapting to various measure due to COVID-19 pandemic is very essential which is critical for fish farmers in order to aid their production during the lock down. The research investigate adaptation of fish farmers to COVID-19 pandemic in Epe Local Government Area of Lagos State, Nigeria. This was achieved through random selection of 30 respondents. Descriptive analysis was used to describe the socio-economic characteristics of fish farmers and chi-square was applied to examine how often the measure on COVID-19 has being used. Majority of fish farmers were male with a percentage 76.7 and female 23.3. Majority of the fish farmers were single with a percentage of 56.7 and married were 40.0%. Ethnicity revealed the Yorubas were showing heavy presence in the study area with a percentage of 46.7.For level of education, secondary school had 3.3% and tertiary education had 96.7%. Purpose of fish farming reveals that it was basically for income and then others followed. The fish farming system used predominantly is intensive system with a percentage of 53.3. the level of severity was highly severe among fish farmers with a percentage of 40%.Hence the use of ICTs reveals that fish farmers that adopted online mareting had a mean rank of 5.7 and a chi square value of 66.56.

Keywords: Adaptation, Fish farmers, COVID-19 Pandemic.

Introduction

The nature and dynamic of the pandemic are manifold. Efforts to contain it, relieve it immediate impacts and cope with and mitigates its growing number of effects have been fraught with uncertainties. (FAO 2020). Fish and fish products are the key component to a healthy diet and are safe to eat. Misleading perception in some countries has lead to decrease in consumption of their products. Yet aquatic animals (fin, fish, reptiles, amphibians and invertebrates such as crustaceans and mousses) do not play an epidemiological role in spreading COVID-19 and who are not following good hygiene practices. Hence it is important to supplement robust hygiene practices which is to protect fisheries and aquaculture workers and fish products from contamination. (Bondad-Reantaso, *et al.,* 2020). Due to COVID-19 pandemic, decrease in fish supplies will be evident which also mean that upstream and downstream sources of employment will be lost or reduced (World Fish, 2020). Considering the requirements, aquaculture production have increased up to 50-60 percent from the present level by 2030as production from capture fisheries remain static (Rafiquizzaman, S.M. (2020).

The COVID-19 outbreak has created and will continue to create many challenges for fish farmers in the area and the country at large. The effort is to make the fish farmers seek to understand the adaptation of fish farmers to COVID-19 pandemic has had in aquaculture productivity in Epe Local Government Area of Lagos State.

Materials and Methods

Study Area

The study area is situated at longitude 6.58° North, Latitude 3.98° East. Epe lies about 86Kms North-East of the city of Lagos. Epe Local Government Area consists of many divisions and four district or areas. The divisions include the Eko Aworis, Akodo, Awoyaya, Ibeju-Lekki, Iberekedo, Idaso, Iwerekin, Igbonwon, Igbesibi, Igbolomi, Mogbo-Alade, Ode- Ifa, Olomowewe, Olorukoya, Ojita, Oriba, Orimedu, Orulu, and others, while the districts or areas are Agbowa, Ejinrin, Epe and Erodo). Major occupation of the inhabitants of the study area is fishing and farming.

Epe is a Yoruba speaking town with 294 rural and 24 semi-urban communities. According to 2006 census, the population of Epe was 181,409.

Source of data

Three (3) districts in Epe were selected (Agbowa, Epe and Ejinrin).

Simple random sampling technique was employed using structured questionnaires administered to ten (10) participants in each district, making a total of 30 participants.

Data Analysis

Both descriptive (Frequencies and Percentage) and inferential statistics Chi square(X^2) were used in analyzing the data.

Results and Discussion

Out of the population, 76.7% were while 23.3% were female. This shows that men are more involved in fish farming while women are into post farming like marketing and processing into consumable products. The marital status of the population are 66.7%, 40.0% and 3.3% respectively for single, married and divorce. Most of the respondents were single and divorce is minimal. Out of the 30 respondents, the Yorubas had the highest percentage which buttress the fact based on history that Yoruba are the most prominent people in Epe Local Government Area. Out of the 100%, secondary schooled had 3.3% and tertiary had 96.7%, this implies that education plays a significant role in skill acquisition and knowledge transfer, this result confirmed to Kareem *et al*, 2008. Which ascertain that educated fisher folks have greater likelihood to understand than illiterate class of fish folks. From the outcome from the fish folks, it shows that 30% of the fish folks were practicing fish farming in the study area basically because of income while others were relatively below 30%. The type of fish farming system practiced most by fish folks was intensive system which had 53.3%, followed by extensive which had 30% and semi-intensive (16.7%). This is so because the highest form of control is given or provided for an extensive system of fish farming.

Table 1: Socio-economic Characteristics of Fish Farmers In Epe Local Government Area

	Frequency	Percent	Percent	Cumulative Percent
Sex				
Male	23	76.7	76.7	23.3
Female	7	23.3	23.3	100.0
Total	**30**	**100.0**	**100.0**	
Marital Status				
Single	17	56.7	56.7	96.7
Married	12	40.0	40.0	3.3
Divorced	1	3.3	3.3	100.0
Total	30	**100.0**	**100.0**	
Ethnicity				
Eggan	1	3.3	3.3	20.0
Egun	1	3.3	3.3	23.3
Eggun	1	3.3	3.3	26.7
Idoma	1	3.3	3.3	30.0
Igale	1	3.3	3.3	33.3
Igbo	3	10.0	10.0	43.3
Ogun	1	3.3	3.3	46.7
Okpe	2	6.7	6.7	53.3
Yoruba	14	46.7	46.7	100.0
Total	30	**100.0**	**100.0**	
Educational Status				
Secondary	1	3.3	3.3	3.3
Tertiary	29	96.7	96.7	100.0
Total	30	**100.0**	**100.0**	
Purpose Of Fish Farming				
Household consumption	2	6.7	6.7	6.7
Household consumption; Culture	1	3.3	3.3	10.0
Income Generation	9	30.0	30.0	40.0
Income Generation; Culture	1	3.3	3.3	43.3
Income Generation; Culture; Festivities/Celebration.	1	3.3	3.3	46.7
Income Generation; Household consumption	2	6.7	6.7	53.3
Income Generation; Household consumption; Culture	1	3.3	3.3	56.7

Income Generation; Household consumption; Festivities/Ceremonies	3	10.0	10.0	76.7
Income Generation; Household consumption/Recreation	1	3.3	3.3	80.0
Types of Fish Farming System				
Extensive	9	30.0	30.0	30.0
Semi-Intensive	5	16.7	16.7	70.0
Intensive	16	53.3	53.3	100.0
Total	**30**	**100.0**	**100.0**	

From table 2 below, it depicts that the level of effect of COVID-19 on the fish farms varied from highly severe to not severe. With highly severe having the highest percentage of 40% and some were not applicable. Also the table depicts how often COVID-19 measures being used by fish farmers. This shows that the use of ICTs in harvesting had a mean of 2.08 and the highest mean rank. While adaptation of farmers to use of ICTs in marketing also had a mean of 2.08 and mean rank of 5.73. This implies that ICTs were measures that fish farmers adopted during COVID-19 pandemic. This will enable people to get or buy fish without close contact.

Table 2.0: Impact of COVID-19 On Fish Production Among Farmers

	Frequency	Percent	Percent	Cumulative Percent
Highly Severe	12	40.0	42.9	75.0
Severe	9	30.0	32.1	32.1
Not Severe	7	23.3	25.0	100.0
Total	**28**	**93.3**	**100.0**	
Not Applicable	2	6.7		
Total	**30**	**100.0**		

Table 2.1: Descriptive Analysis Showing Means, Standard Deviation, Percentile and Mean Rank

	N	Mean	Std. Deviation	Minimum	Maximum	25th	Percentile 50th (Median)	Mean Rank
HowoftenwerethisCOVID19 measures being used on your farm_G	24	1.3333	.48154	1.00	2.00	1.0000	1.0	3.33
HowoftenwerethisCOVID19 measures being used on your farm_F	24	1.667	.38069	1.00	2.00	1.0000	1.0	2.58
HowoftenwerethisCOVID19 measures being used on your farm_E	24	1.5417	.58823	1.00	3.00	1.0000	1.5	3.85
HowoftenwerethisCOVID19 measures being used on your farm_D	24	1.8750	.67967	1.00	3.00	1.0000	2.0	5.02
HowoftenwerethisCOVID19 measures being used on your farm_C	24	2.0833	.58359	1.00	3.00	2.0000	2.0	5.73
HowoftenwerethisCOVID19 measures being used on your farm_B	24	2.0417	.62409	1.00	3.00	2.0000	2.0	5.63
HowoftenwerethisCOVID19 measures being used on your farm_A	24	1.5833	.58359	1.00	3.00	1.0000	2.0	4.10
HowoftenwerethisCOVID19 measures being used on your farm	24	2.0833	.58359	1.00	3.00	2.0000	2.0	5.75

Kendall's Coefficient Of Concordance

This reveals the chi-square (X^2) value of 66.562 with a degree of freedom of 7 and asymp. Sig. of 0.000 shows that there is no significant relationship between how often COVID-19 measures were being used and adaptation of the fish farmers to COVID-19 Pandemic.

Table 2.2: Test Statistics On Measures Being Used During COVID-19 Pandemic

N	24
Kendall's W[a]	.396
Chi-Square	66.562
df	7
Asymp. Sig.	.000

a. Kendall's Coefficient Of Concordance.

From table 3 below,. It depicts that the rate of adaptation level was neither low nor high had the highest percentage with a frequency of 40.0% and followed by somewhat high which had a frequency of 8 and percentage of 26.7%. This implies that fish folks were neutral when it comes to adaptation level. However, adaptation measure put inplace depicts that "yes" had a frequency of 24 and percentage of 80% while "no" had a percentage of 20%. This implies that most fish folks had adaptation measures on ground perfectly.

Table 3.0: Rate of Adaptation Level And Adaptation Measures

	Frequency	Percent	Valid Percent	Cumulative Percent
Rate Of Adaptation Level				
High	**4**	**13.3**	**13.3**	**13.3**
Low	**1**	**3.3**	**3.3**	**16.7**
Neither Low Nor High	**12**	**40.0**	**40.0**	**56.7**
Somewhat High	**8**	**26.7**	**26.7**	**100.0**
Somewhat Low	**5**	**16.7**	**16.7**	**100.0**
Total	**30**	**100.0**	**100.0**	

Acknowledgement

Were Adaptation Measures Put In Place?				
No	**6**	**20.0**	**20.0**	**20.0**
Yes	**24**	**80.0**	**80.0**	**100.0**
Total	**30**	**100.0**	**100.0**	

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COVID-19: The Role of Aquaculture in Employment Generation in Nigeria

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Abstract
COVID-19 pandemic, a sudden and strange human disease which started in China in December 2019 began to ravage the whole world and because there was and still no cure or effective immunization till date, huge casualties is being recorded. The pandemic brusquely caused global total lockdown and Nigeria was economically destabilized, resulting in the loss of sources of fishers' livelihoods. Over 6.5 million fishers along Nigeria's Atlantic Coast of about 853km stretch lost their jobs in the first two months of the pandemic. The study established that aquaculture fishery is practiced under safe environment in the COVID era (relative to capture fisheries) and is capable of providing fish as well as generate employment for Nigeria's vast populations throughout the sector's value chain (production to consumption). About 0.35 million producer households would adopt improved breeds, aqua-feeds, fish health and aquaculture and fisheries management practices. It is also proposed that 0.19 million people of which 50% would be women will be exited from poverty through improvements in aquaculture livelihood programmes.

Keywords: Nigerian economy, COVID-19 pandemic, Aquaculture, Employment generation, Value chain.

Introduction
Since the beginning of the Corona Virus Disease (COVID-19) in December 2019 till the period of this paper, 29th of October 2020, 45.3 million people have been infected and about 1.1 million people have died of the infection and 30.3 million recovered globally. In Nigeria, out of the 62,156 confirmed cases, 57,916 recovered while 1,135 people have died (NCDC, 2020). As the pandemic continues to devastate the Nigerian economy, employers in large and small businesses are faced with a dreadful conundrum on whether to let their staff go, cut their hours, or declare them redundant. The impact of COVID-19 on fishermen and livelihoods could be devastating when one considers the ravaging effects of the disease on human, financial, social and economic resources of the nation. Apart from COVID-19 pandemic, the Blue Growth Initiative (Blue Economy) which emphasizes economic, environmental and social sustainability has fisheries (aquaculture in particular) as one of the major means of achieving Sustainable Development Goals (SDGs). However, depending on the particular situation of fish stocks and ecosystems, and the magnitude of reductions in fishing, the crisis could result in positive impacts on the health of some fish stocks, as well as on biodiversity more generally.

More data need to be collected to understand the impacts of the COVID-19 pandemic on fishing effort; moreover, the relationship between fishing effort and stock health is sometimes hard to predict. The possible impact of the crisis on commercially important fish stocks thus remains largely unknown. However, the plight of fishermen was generally expressed by Makoko fishers in Lagos mainland, where it was estimated that about 6.5 million fishers along the coastal communities of the 850 km Atlantic coast line had been impoverished by the impact of the COVID-19 pandemic (FishNet Alliance, 2020).

Generally, government is charged with the responsibility of ensuring good standard of living through gainful employment and social responsibility for the citizens. In an event where this is not visible, government encourages its citizenry to engage in different entrepreneurship activities through the establishment of ventures unveiling several programmes including aquaculture as well as ensuring their success.

Effect of COVID-19 on Employment
Employment generation is a natural process of social development. Human beings bring with them into the world an array of needs that present employment opportunities for others to meet. Were it not so, the world could not have sustained a more than tripling of population over the past century. Employment generation can be achieved through diversification of agriculture, cheap credit, provision of basic facilities, promotion of local industries, improvement in education and health, tourism or regional craft industry, or new services like IT which require proper planning and support from the government. Unemployment and underemployment in Nigeria are caused by more basic structural factors such as lack of capital, use of capital-intensive technologies, lack of access to land for agricultural household, lack of infrastructure, rapid growth of population resulting in large annual increments in labour force year after year and recently, by the effect of the COVID-19 pandemic

Nigerians are losing their jobs as both individuals and firms face undaunted challenges due to the snowballing effects of the COVID-19 pandemic currently ravaging the economy. According to the National Bureau of Statistics (NBS, 2020) maiden report, the impact of COVID-19 pandemic on employment and income of Nigerians have been widespread. A high rate of households reported income loss since mid-March 2020 as 79% of household reported that their total income decreased. The rates of losses of income were 85% for non-farm families, 58% for wage-based employment and 75% for farming households in livestock and fishing.

Nigeria's Fisheries

Despite Nigeria's oil resources, agriculture remains the base of the country's economy, providing the main source of livelihood for most Nigerians. Like many coastal developing countries, fish is an important source of food for the population, which is currently estimated at 186 million people (World Bank, 2016). Fisheries is a major economic sector, estimated to employ over 8.6 million people directly and a further 19.6 million indirectly, 70 percent of whom are women. Currently, Nigeria produces just over 1 million metric tons of fish annually, leaving a deficit of over 2 million metric tons, which is usually made up from imports. Recognizing the importance of fish within the agriculture sector for its potential contribution towards alleviating poverty, improving food and nutrition security, reducing youth unemployment and building profitable business ventures, both capture fisheries and aquaculture are gaining increased attention of both the public and private sectors. **However, it is ironic that Nigeria still depends on fish importation to meet most of her fish demands despite its associated long coastline bordering the Atlantic Ocean as well as vast fresh and mangrove swamps, creeks, coastal rivers, estuaries, bays, and near and offshore waters. Eight out of the 36 Nigerian states with 25% of Nigeria's total population, share the Atlantic Ocean coastline – a major fishing resource. Yet, national production cannot meet national demand. With the emerging problems in fish captures from the wild, aquaculture began to gain popularity and support through policies, trainings, inputs and finance. Its provision of employment and food fish has been on the increase and in 2015, fisheries' contribution to agricultural GDP rose to 0.88% (FDF, 2018).**

In 2013, per caput consumption of fish was estimated at about 13.3 kg which represents an important dietary element and a major source of animal protein available to majority of Nigerians (FAO, 2014). And while marine fish catches contributed 36 percent, inland waters contributed 33 percent and aquaculture 31 percent to the total national production of 1.027million metric tons in 2015.

Owing to recent significant investments of private capital and a renewed political will to empower the private sector in the area of aquaculture development, Nigeria became the largest aquaculture producer in Sub-Saharan Africa and this importance is steadily increasing. Over the past 35 years, aquaculture production in Nigeria has grown 12 percent a year (compared to the world average of 8 percent), from 21,700 tons in 1999, aquaculture production has grown steadily to 316,700 tons in 2015. Catfish, typically grown in ponds and tanks, is the most farmed species in Nigeria, constituting over half of the total aquaculture production by volume (Amosu et al, 2017). Nigeria's aquaculture focuses mainly on freshwater fish, with catfish species accounting for 64 percent of aquaculture production. In 2012, 13,627 people were reported as employed in aquaculture and 2% of this was women (FAO, 2016).

Aquaculture is the fastest growing food-producing sector in the world, contributing one-third of global food fish production. The nutritional benefits of fish consumption have a positive link to increased food security and decreased poverty rates in developing states (FAO, 2014). Catfish and Tilapia species are the common cultivable fishes in Nigeria and though, the population of fishermen engaged in fishing from the wild had increased (though with depleting output) over the years before the COVID-19 pandemic, it was estimated that aquaculture provided direct and indirect employment to over six (6) million people in Nigeria (FAO 2018). Despite this assertion, there have been controversies about the exact population of people involved in aquaculture production and its value chain as well as production figures. According to WorldFish Nigeria Strategy (2018), about 0.35 million producer households would adopt improved breeds, aquafeeds, fish health and aquaculture and fisheries management practices by 2022. It also proposed that 0.19 million people of which 50% would be women will be exited from poverty through improvements in fisheries and aquaculture livelihood programmes. However, it was estimated that over 60% of fish farmers have retired because of high cost of fish feed which takes off the profit they would have made in rearing fish to table size (FAO, 2020). It is estimated that feeds constitutes about 70 - 80% of total cost of inputs in fish rearing.

Materials and Methods

Materials for the study were extracts of secondary data from existing literatures. The Holt Double Exponential Smoothing method was adopted to extrapolate fish production figure for 2016 to 2019 using 2015 as base. The results of the study are analyzed and presented using descriptive, simple statistics. The HDES method has two characteristics as follows:

1. Holt double exponential smoothing method hast two parameters
   - the weighting parameters (the new value is greater than previous observations) and
   - weighted to estimate the trend of data.

2. It has two estimates
   - permanent component (ℓ_{T-1}) estimate of the level of the time series constructed in time period T–1 and
   - trend component (b_{T-1})
     estimate of the growth rate of the time series constructed in time period T–1

3. There are three equations
   - Smoothing

$$\ell_T = \alpha y_T + (1-\alpha)(\ell_{T-1} + b_{T-1}) \qquad \text{...1}$$

- Trend estimate

$$b_T = \gamma(\ell_T - \ell_{T-1}) + (1-\gamma)b_{T-1} \qquad \text{...2}$$

where α = smoothing constant for the level (0 ≤ α ≤ 1) γ = smoothing constant for the trend (0 ≤ γ ≤ 1)

- Point forecast made at time T for y_{T+p}

$$\hat{y}_{T+p}(T) = \ell_T + pb_T \qquad (p = 1, 2, 3, \ldots) \qquad \text{...3}$$

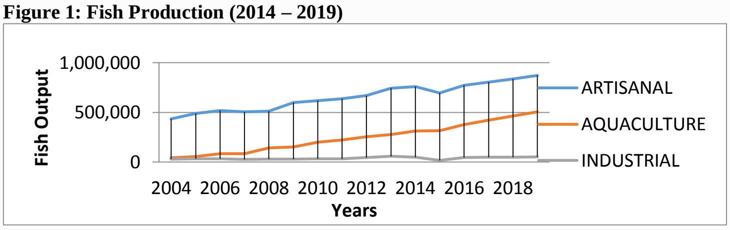
Results and Discussions

Table 1: Estimated Fish Production (metric tons) 2004 - 2019

Year	Artisanal	Industrial	Aquaculture	Total	Aqua/Total (%)
2004	434830	30421	43950	509201	8.63
2005	490594	32595	56355	579544	9.72
2006	518537	33778	84533	636848	13.27
2007	504227	26193	85087	615507	13.82
2008	511382	29986	143207	684575	20.92
2009	598211	29698	152796	780705	19.57
2010	616981	31510	200535	849026	23.61
2011	638486	33485	221128	893099	24.76
2012	668754	45631	253898	968283	26.22
2013	744930	59871	278706	1083507	25.72
2014	759828	49952	313231	843011	37.17
2015	694867	15464	316727	1027058	30.84
2016	772102	46674	378174	1196950	31.59
2017	805201	48467	421113	1274781	33.03
2018	838300	50260	464052	1352612	34.31
2019	871399	52053	506991	1430443	35.44

The percentage share of aquaculture output to total fish production increased steadily as depicted in table 1, from 8.63% in 2004 to 35.44% in 2019 (over 300% increase). These increases resulted from sustained campai gn and assistance to fish farmers through credits and improved fish seeds.

Figure 1: Fish Production (2014 – 2019)



Generally, fishery is considered to be one of the most lucrative economic sectors especially in the coastal communities where the majority of the populations are engaged in fishing and fishing related businesses (Abohweyere et al, 2004). However, the sub-sector is currently being challenged by high cost of inputs, insecurity in Nigeria's coastal environment and lack of credit and infrastructure facilities. Consequently, aquaculture development has been on steady increase (figure 1) as it is considered to be most reliable and safe in fish production. The steady state is associated with the precarious conditions characterizing capture fisheries as well as the effectiveness of government support in the sub-sector, in recent times. The growing prospect in aquaculture to potentially provide employment and stable income encourages investment and reinvestment in the sub-sector.

Conclusion and Recommendations

Unemployment has been of concern to the Nigerian government over the years and this is further exacerbated by the COVID-19 pandemic which resulted in the closure of several manufacturing and service industries locally and globally. There are still many uncertainties ahead, particularly with regard to the duration and severity of the pandemic, but a prolonged downturn is likely to introduce long-term transformations to the sectors as some businesses still remain closed despite lockdown eases. It is recognized that the aquaculture fisheries sector is crucial to people's livelihoods programmes and the national economy, embracing impacts on food and employment. Generally, it contributes to the national goals of environmental protection, conservation of biodiversity, socioeconomic development, good governance and poverty alleviation which translate into employment opportunities. The reduction in fish output due to COVID-19 reduced the amount of fish available for processing and trade.

This particularly impacted on producers, women and transporters, who are mostly in charge of the activities. Globally, before the pandemic, fish consumption was projected to increase by 30 million tons by 2030 as a result of population increases and improved living standards. Therefore, it is essential that this demand be met through the sustainable growth of aquaculture, which will contribute to the attainment of the United Nations' Sustainable Development Goals (SDGs) targets, such as zero hunger, poverty alleviation and conservation and sustainable utilization of natural resources. Therefore, the potentials to sustain increased aquaculture fish production can be rejuvenated and sustained if the enthusiasm exhibited in the 2005 "Fish for all Summit" which grew Nigeria's aquaculture (cat fish production) between 2005 and 2007 can be simulated. From the foregoing, it is suggested that measures should be put in place to sustain aquaculture. However, cataloguing and inventory study of the sub-sector has become necessary for adequate policy formulation.

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Post covid-19 economic recovery: importance of aquaculture fish supply to economic recovery plan.

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Abstract
Fish production options through aquaculture fish production provides rural income, jobs and livelihoods for million in the riparian areas. A simple ordinary least square regression using E-view statistical package to analyze secondary data contribution of aquaculture fish supply to fish production in Nigeria between 1995-2016. Additional data collection is needed to improve stationarity result at I(2) which shows R^2 at 0.96 (96%) positive relationship between total fish production and aquaculture fish production. This activity can contribute positively to post Covid-19 Nigerian economic recovery plan, diversify economy and encourage inclusive economic growth activities which could help to fight against the gloomy post pandemic negative growth and recession. Improved aquaculture fish production will help to grow other resilient export portfolios and strengthen informal agricultural sub-sector.

Keyword: Aquaculture, post covid-19, economic recovery.

Introduction
Covid-19 pandemic effect on the world economic and financial system predictions shows a gloomy and imminent global economic depreciation from year 2020 going forward for many developed, developing and Sub-Sahara Africa countries, Nigeria inclusive, (Global Outlook, 2020; Mahler, *et.al.*, 2020). Sub Sahara African Gross Domestic Product (GDP) is predicted to contract by about 2.4% to a record low of between -2.1 to -5.1% in 2020 owing to export contractions and export price dip primarily due to Covid -19 pandemic (Zeng, 2020).

Nigeria depends largely on foreign trade revenue to fund more than 80% of her annual budget, Covid -19 effect has made Nigeria enters her second recession in 4years (Oyekanmi, 2020). In-order to bring Nigeria out of recession caused by the pandemic (Worldbank 2020; Olurunbi, 2020) new strategic decisions of diversifying the economy away from crude oil export needs to be developed to diversify income earnings which would provide a more pragmatic approach towards economic recovery.

Nigeria is believed to have many of her population about 60% in the rural area (NBS 2018) an indication that economic recovery need to engage the rural dwellers and the informal sector like aquaculture more in economic recovery plan (Fasanya, 2012; Yelwa, *et.al*., 2017).

Methodology

The study used a simple linear regression model to show informal sub-sector contribution of aquaculture production to fish production. To measure contribution to economic recovery, total fish supply (TFS) proxy for GDP as dependent variable and aquaculture fish supply (Afs) is the explanatory variable.

Theoretical Framework
Cobb–Douglas production function modified by Obasa (1998) and Olajide*, et al.,* (2012) is used to embody connection between two or more inputs.

Model Specification
The functional form of the model is thus specified as $Tfs_t = f(Afs_t)$ ………equation 1

Linearize equation (1) is written as $Tfs = \beta_o + \beta_1 Afp_t + \varepsilon$ ..……. equation 2

Where: Tfs =total fish supply in Nigeria, Afp = aquaculture fish supply, t = time period,

β_o = Intercept, β_1 = estimation coefficient, ε = error term

Method of Data Analysis
Time series data covers a period of 22 years (1995-2016). Data analysis uses E-view package while Augmented Dickey-Fuller (ADF) Unit Root test is deployed for stationarity.

Presentation and interpretation of result.

Table 1: REGRESSION RESULT

Dependent Variable: TFS
Method: Least Squares
Date: 08/17/20 Time: 20:08
Sample: 1995 2016
Included observations: 22

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	411388.1	14380.94	28.60648	0.0000
AFP	2.178385	0.087635	24.85746	0.0000

R-squared	0.968647	Mean dependent var	675953.9
Adjusted R-squared	0.967079	S.D. dependent var	250008.1
S.E. of regression	45361.74	Akaike info criterion	24.36923
Sum squared resid	4.12E+10	Schwarz criterion	24.46842
Log likelihood	-266.0616	Hannan-Quinn criter.	24.39260
F-statistic	617.8933	Durbin-Watson stat	0.989959
Prob(F-statistic)	0.000000		

Table 2: Augmented Dickey Fuller Test for Unit Root

Variables	ADF Stat	Critical value 1%	Critical value 5%	Critical value 10%	Order of Integration
ΔAFP	-11.808	-3.831511	-3.02997	-2.655194	I (2)
ΔTFS	-7.8898	-3.857386	-3.040391	-2.660551	I (2)

Definition of variable: ADF= Augumented Dickey Fuller, Tfs =total fish supply, Afp= aquaculture fish supply and Δ = change.

Table 1 shows regression result while table 2 shows result of ADF test, trend and intercept. The variable is only stationary at I(2) is an indicative of no correlation between the value. Therefore, H_0 is accepted which is aquaculture fish production has no significant contribution to economic recovery plan in Nigeria. All though Aquaculture supply has been on the rise in Nigeria, from severall academic studies, acceptance of H_0 is a clear indication of the dearth of relevant, good and adequate data to statistically shows the relevant contributions of Aquaculture fish supply to total fish supply in Nigeria. However, unavailable. Statistically there is no relationship at all between TFS and AFS. However, with good data and adequate statistical data which is needed for a strong causative relationship, with I(2) probability at zero and R^2 at 0.96 (96%) from regression analysis holding other variables constant, the informal sector driven

Conclusion and recommendation

Aquaculture can provide one of the strategic part ways to economic recovery in Nigeria. Covid-19 will inevitably hurt Nigeria's participation in foreign trade, especially crude oil, which will no doubt reduce foreign income inflows (Zeng, 2020).

From the study, adequate statistical data on aquaculture is needed to show statistical correlation between Afs and Tfs in Nigeria. Away from statistical interpretation, aquaculture fish supply can positively contributes to fishery production, creates employment, income and help can help to reduce the effect of post Covid-19 effect on the riparian communities in Nigeria.

The pandemic is an opportunity to diversify economy, develop all inclusive economic growth, build other resilient export portfolios, strengthen informal sector, like aquaculture. It is recommended that provision of single digit loans, targeted empowerment programs, increase extension workers and provision of improved aquaculture digital technology system be considered.

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Appendix 1: Fish Production Supply (Metric Tons) in Nigeria from 1995 - 2016

YEAR	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
AFP	16,619	19,490	25,265	20,458	21,738	25,720	24,398	30,664	30,677	43,950	56,355
TFS	371,053	355,934	413,187	483,483	479,613	467,098	486,313	511,720	510,762	509,201	579,544

YEAR	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
AFP	84,533	85,087	143,207	152,796	200,535	221,128	253,898	278,706	313,231	316,727	306,727
TFS	636,848	615,507	684,575	780,705	849,026	893,099	968,283	1,083,507	1,123,011	1,027,058	1,041,458

Source: FDF 2018 (Definition of variable: TFS =total fish supply, AFP= aquaculture fish supply)

Economic analysis of fresh fish marketing in Kede-Tifin district of Mokwa local government area, Niger state, Nigeria.

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Abstract

The study examined the economic analysis of fresh fish marketing in Kede-Tifin District of Mokwa Local Government Area of Niger State, Nigeria. Multi-stage sampling technique was used to draw up 200 respondents for the survey and questionnaire were used to collect information from the respondents, however only 120 questionnaires were found usable at the end of the survey and were used for the data analysis. Data were analyzed using descriptive statistics, farm budgeting analysis, Gini coefficient, marketing margin analysis etc. The result of the analysis revealed that most players in the industry (91.67%) were males who were mostly married (69.17%) and had modern education. The result of the Gini-coefficient (0.870) shows that the market structure of fresh fish is inefficient, though the venture is highly profitable. The marketers also face a lot of constraints in their activities, but it was recommended that marketers be provided with credit facilities, infrastructures, storage and processing facilities.

Keywords: Economic Analysis, Fresh Fish, Marketing and Kede-Tifin

Introduction

Fish is one of the most important and cheapest sources of animal protein (Flake and Nzeka, 2007), and only egg protein can “rival” fish protein (Ndanitsa, 1994).Fish represent a significant proportion of animal protein in the diets of many, in developing countries, including Nigeria. Globally, fish production has grown steadily in the last five (5) decades with food fish supply increasing at an average annual rate of 3.2 percent (FAO, 2014). According to FAO (2012), fish in the world provides about 3.0 billion people with almost 20 percent of their intake of animal protein and 4.3 billion people with about 15 per cent of such protein.

Fish marketing improves the rural economy through provision of additional source of income, offering employment opportunities, development of infrastructural facilities and improving the nutritional and standard of living of both urban and rural people. Against the backdrop of the critical roles of the fish sub-sector, play and its potentials in resolving the imminent food crisis, this study was designed to focus on the marketing of fresh fish products, to to identify the socioeconomic characteristics of the marketers, determine the costs and returns as well as their profitability in Kede Tifin district of Mokwa Local Government Area (LGA) of Niger State, Nigeria. .

Methodology

Study Area:

This study was conducted in Mokwa LGA of Niger State. The LGA has a population figure of 242,858 people (N.P.C, 2006).

Sampling Technique and Method of Data Collection:

Multi-stage sampling procedure was used for this study. The first stage involves the purposive sampling of Kede-Tifin district of the state, as fishing is the principal occupation of more than 90 percent of the inhabitants of the area. The second stage involves the selection of 5 fishing communities, followed by the selection of 4 fishing locations, and finally the selection of 10 fresh fish marketers from the area, to give a sample size of 200 respondents, from whom relevant information were elicited. However, only 120 questionnaire were returned and found suitable for consideration in the analysis.

Method of Data Analysis:

The descriptive analytical tools such as percentages, tabulations, frequency distribution, means/averages, cross tabulations etc. were employed to describe the socio-economic characteristics of the respondents involved in fresh fish marketing, describe the consumer preference and to identify the constraints associated with fresh fish marketing. Gini coefficient was used to examine the market structure in the area. It is a measure of statistical dispersion most prominently used as a measure of inequality of wealth or product distribution among the key players in the industry (Ndanitsa, 1994 Ndanitsa *et al* and Wikipedia, 2013). The model specification as adopted by Iheanacho (2005),Shuaibu (2015), is expressed as follows:

$$GC = 1 - \sum X_{ab} Y_{ab} \qquad (1)$$

Where: GC = Gini Coefficient; X = Proportion of Sellers; Y = Cumulative Proportion of Sales; $\sum$ = Summation sign and; 1= Constant or Unity. The Gini Coefficient varies from 0 to 1. If the coefficient is equal to Zero (0), it implies perfect equality in the distribution, while if the value is one (1), it corresponds to perfect inequality. According to Ojo (2012), the closer the Gini coefficient is to zero, the greater the degree of equality, the lower the level of concentration and the more competitive the markets are. Further, as the Gini coefficient approaches unity, the degree of inequality increases. Ojo (2012) also submitted that, the higher the level of concentration, the more imperfect the markets are, and the lower the efficiency of such markets. Net Farm Income (NFI) model or sometimes known as Costs and Returns Analysis is one of the Farm Budgeting tools that were employed to measure the level of inputs realized. The tool was used to ascertain the profitability of fresh fish marketing in the study area. In analysis, when the gross income realized from the sale of fresh fish is greater than the cost, profit is made whereas, loss is made when it is the opposite. Net income is the difference between gross income realized and total costs of marketing.

Marketing Margin (MM) Analysis:
This is a measure of market performance. MM is the difference between the price paid by the consumer and that received by the producers (Ali, *et al*, 2008). Gross marketing margin of Fish Marketers is determined by the difference between the cost price of fish and the selling price (Anuebunwa, 2006). This is expressed as:

Marketing Margin = $\frac{Selling\ price - Purchase\ Price}{Selling\ Price}\ x\ 100$ .... (4)

According to Olukosi *et al* (2004), a larger variation between the marketing margins of participants indicates a wide variation along the chain while a participant with higher marketing margin, is said to have a larger share of the marketing benefits. In addition to Marketing Margin Computation, Marketing Efficiency was used to determine the performance of fresh fish marketers in the study area. It is the maximization of the ratio of output to input. The marketing inputs are those costs incurred during the marketing of fresh fish, such as transport costs, commission, taxes, labour used, packaging, processing and storage financing. On the other hand, output is the value added to the commodity as it passes through the marketing system: Accordingly, ME of fresh fish marketing adopted from Inuwa *et al* (2011) is = $\frac{Value\ added\ by\ marketing}{Cost\ of\ Marketing\ Services}\ x\ 100$ .... (5)

Value added by marketing (VA) = C_{PT} - C_{PU} .... (6)

Where: V_A = Value added; C_{PF} = Cost of Purchasing Fresh Fish plus storage cost/commission charges; C_{PU} = Cost of Purchasing Fresh Fish.

Results and Discussion

Socio-economic characteristics of fresh fish markers:
Table 1 shows that, although both men and women were actively involved in fresh fish marketing in the study area, but men were more dominant in numbers (91.67%). This is an indication that fresh fish marketing in the study area was purely men's business, and it is an indication of serious gender inequality in the business, which might be due to some socio-cultural values of inhabitants. A number socio-cultural factors restricted women to access to water resources; low technical know-how and lack of credit facilities (especially Marketing loans) limit full participation of women in the small-scale fisheries sector (Williams, 2002).

Table 1 also shows the age distribution of fresh fish marketers in the study area; majority (66.67%), of the respondents were of middle age and above. The mean age was 33.25 years. This findings agrees with Yisa *et al* (2012), Ndanitsa *et al* (2013) and Shuaibu (2015) who in their separate studies on fish marketing revealed that the mean average of the marketers were 34.3 years, 37.53 years and 34.22 years respectively. The implication of this finding however, is that, the marketers were within their economically active, productive and energetic age which could translate their abundant stamina to withstand pressure and ability to accept innovations.

Table 1: Socio-Economic Characteristics of Fresh Fish Marketers (N=120)

Variable	Frequency (N=120)	Percentage	Minimum	Maximum	Mean	S.D
Age (Years)						
≤ 20	13	10.83				
21 – 40	80	66.67	17.00	60.00	33.25	10.79
41 – 60	27	22.5				
Total	120	100.00				
Gender:						
Male	110	91.67				
Female	10	8.33	0.00	1.00	0.91	0.23
Total	120	100.00				
Marital Status						
Single	37	30.83				
Married	83	69.17	1.00	2.00	1.73	0.44
Total	120	100.00				
Educational Status						
No formal Education	38	31.67				
Primary Education	26	21.67	0.00	14.00	3.88	2.16
Secondary Education	49	40.83				
Tertiary Education	7	5.83				
Total	120	100.00				
Household Size						
No Household Size	35	29.17				
1 – 10	62	51.67				
11 – 20	20	16.66				
21 – 30	2	1.66	0.00	32.00	5.88	6.75
> 30	1	0.83				
Total	120	100.00				
Marketing Experiences (years)						
1 – 20	77	64.17				
21 – 40	35	29.17				
41 – 60	8	6.66				
Total	120	100.00	1.00	48.00	16.82	11.15
Cooperative Membership Cooperativeness (Years)						
Not Belong to Any	24	20.00				
Belong	96	80.00	0.00	1.00	0.86	0.34
Total	120	100.00				

Source: Field Survey Data, 2019 Note: SD = Standard Deviation

Majority of the fish marketers in the study area were married (69.17%), as revealed in Table 1. The result of the finding is an indication that there will be high sense of responsibility on the part of the marketers, and is in line with the findings of Kainga and Adeyamo (2012) on the socio-economic characteristics of Fish marketers in Yenagoa LGA of Bayelsa State, Nigeria, where the author revealed that majority of the respondents (68.9%) were married.

Consumer preferences of fresh fish in the study area

Consumers in the study area usually buy fresh fish at the fishermen landing sites or at fresh fish markets. Table 2 shows the distribution of consumers of fresh fish products in the study area based on their preferences.

Table 2: Consumer Choice of Fresh Fish in the study area markets

Fish type	WuyaKede	Ketso	Kpambo	Kpachita	Total %
Cultured Fish	00(0)	02(10)	19(47.5)	22(55)	43(35.83)

Artisanal	20(100)	18(90)	21(52.5)	15(37.5)	74(61.67)
No Comment	00(0)	00(0)	00(0)	03(7.5)	03(2.50)
Total	20(100)	20(100)	40(100)	40(100)	120(100)

Source: Field survey data, 2019. Figures in parenthesis represents percentages of respondents for individual markets.

Determinants of choices made by the consumers of fresh fish in all the markets surveyed depends on the availability of the fish in the market, the purpose/place of usage and ease of access to the fish market. Table 2 revealed that all the consumers in Wuya Kede Market preferred artisanal fish to cultured fish (100%). This was due to the availability of the fish in the market, acceptability and ease of access to the market, as well as the socio-cultural activities in the study area. It must be noted that Wuya Kede is located along Bida – Ilorin road at the bank of river Kaduna. However, the implication of this finding is that, the effort of government and non-governmental organizations to encourage aquaculture farming to boost fresh fish production in the study area and the entire country is defeated.

Table 3: Consumers' reasons for choice of fish in the study area.

Reasons for Preference	**Frequency**	**Percentage**
Taste	71	59.17
Freshness	33	27.50
Meat quality	8	6.67
Medicinal benefit	5	4.16
Body size	3	2.50
Total	120	100.00

Source: Field survey data, 2019

Table 3 revealed that most of the respondents (59.17%) preferred artisanal fish to cultured fish, and reason advanced for this preference was that the former taste better than the later.

Market structure of fish marketers:

Table 4 reveals the measure of statistical dispersion. The computed Gini coefficient was 0.87. These results indicated a high level of concentration and consequently high inefficiency in the market structure for fresh fish in the study area.

Table 4: Market Structure: Gini-coefficient for fresh fish marketers in the study area.

Income from Sales (₦)	**Number of sellers frequency**	**Proportion of sellers (X)**	**Cumulative proportion of sellers**	**Total sales (₦)**	**Proportion of sales**	**Cumulative proportion of sales (Y)**	$\sum$ **XY**
1 – 400,000	89	0.742	0.742	114511	0.022	0.022	0.016
400,001-800,000	11	0.092	0.834	612690	0.117	0.139	0.013
800,001-1,200,000	8	0.067	0.901	1096250	0.209	0.348	0.023
1,200,001-1,600,000	7	0.058	0.959	1464000	0.280	0.628	0.036
1,600,001-2,000,000	5	0.042	1.000	1950000	0.372	1.000	0.041
Total	120			5237451			

Source: Field survey Data, 2019 Gini – coefficient = 1 - $\sum ZY = 1 - 0.130$ = 0.870.

Performance of fish marketing in the study area
The cost and returns and the Marketing Margin for all the sampled markets were computed, and the results revealed in Table 5. The results revealed that marketing tax and marketing margin wereanalyzed using the marketing margin (MM) equation; (4). The marketing margin for all the sampled markets were calculated as follows:

Marketing margin $= \frac{25455000 - 10{,}031{,}750}{25455000}\ x\ 100$ Marketing margin = 39.4097

Producer Marketing share = 60.5903

Marketing Efficiency:
The efficiency of fresh fish marketing was analyzed using the marketing efficiency computation. The result of the computation is presented in Table 6.

Table 6: Efficiency of fresh fish marketing

Sample	Value Added (₦)	Cost of Marketing (₦)	Marketing Efficiency
Kede – Tifin			
Sampled Markets	631,900	10,642,069	5.94

Source: Field Survey Data, 2019

The result in Table 6 revealed that ₦691,900 values was added to the marketing activities with the marketing efficiency of 5.94%. This value is an indication that fresh fish marketing in the study area was highly efficient. The finding is in line with the report of Obasi *et al* (2012) on the analysis of dried maize marketing in Aba South LGA of Abia State, Nigeria (17.31%).

Constraints to fresh fish marketing:
Results in Table 7 revealed that price instability ranked 1st among the myriad of factors and in decreasing magnitude of importance, as an overwhelming majority, 107 (89.16%) encountered this problem in fish marketing activities in the study area. The implication of this finding is that the price instability could erode the profit margin of the players in the industry, as lower price could constrain the realization of the goal of profit maximization. This is in line with the study of Nwabueze and Nwabueze (2010), who submitted that, instability in the price of product is one of the problems militating against the fresh fish marketing in Oshimili South LGA of Delta State, Nigeria. Inadequate capital and Lack of credit facilities (especially marketing loans) ranked 2nd on the severity of the problems confronted by the fresh fish marketers in the study area, whereby a large majority, 94(78.33%) were confronted with this problem. The implication is that, capital being the bedrock of any meaningful business, marketers with large capital have the propensity to expand their business and consequently make a large returns, whilst those with small capital make lower returns and constrained with little or no future investment/expansion.

Table 7: Constraints to Fresh fish marketing in the study area.

Constraints	*Frequency	Percentage	Ranking
Price instability	107	89.16	1st
Inadequate Capital and Lack of credit facilities	94	78.33	2nd
High cost of transportation	78	65.00	3rd
Seasonality of fish product	76	63.33	4th
Storage problems	67	55.83	5th
Inconsistency in government policy	56	46.67	6th
Inadequate power supply	50	41.67	7th
Low patronage	46	38.33	8th
Total	*574	100.00	

Source: Field Survey, 2019 (*Multiple responses)

Conclusion and Recommendations
The study had examined the Economic Analysis of fresh fish marketing in Kede Tifin district of Mokwa Local Government Area of Niger State, Nigeria, and revealed that the market is not competitive, even though the enterprise is profitable. However, it was evident that the marketers are constrained with a number of factors towards the realization of their goal of profit maximization. The need for the provision of credit facilities, has become imminent in increasing the marketer's activities. This will involve the establishment of sustainable micro-credit schemes. Fishermen in the area should be encouraged to go into fish farming ventures in order to ensure

constant supply of product to the marketers, Feeder roads linking the landing sites and major marketing centres should be constructed and storage facilities should be provided, among others. This would translate to increased capacity utilization, increased marketing activities, increased income and poverty reduction in the study area.

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Fish Farmers Socio-economic characteristics predicting the challenges faced during COVID-19: A case of Akinyele Local Government, Nigeria

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Abstract
Coronavirus disease 2019 is considered a global health pandemic, which has led to a major fall in the 2020 output of the aquaculture sector. The ripple effect has equally been felt in other sectors of the Nigerian economy. However, the challenges posed by COVID-19 to Oyo state (Akinyele Local Government) fish farmers were increasing cost of raw materials and inputs, reduced sales and market inaccessibility. This research seeks to find out the role socio-economic characteristics of fish farmers played in predicting the challenges faced during the COVID-19 period. The research used a cross sectional survey with a bootstrapped sample size of 150 fish farmers from Akinyele Local Government, Oyo state, Nigeria and found out that sex, number of nursery tanks, number of smoking Kilns and location of the farm were significant predictors of the challenges faced by fish farmers during the COVID-19 period.

Introduction
The COVID -19 pandemic has caused serious havoc in economies globally. The agricultural sector has been one crucial sector affected by the pandemic. Especially, in the aquaculture subsector, the pandemic has distorted operations in both small and large scale farm enterprises. The pandemic has been a shock to the industry and has affected output and production drastically (Kabir, 2020). According to Akinsorotan et al. (2019), Nigeria demand for aquaculture product is not met despite the country producing 800,000 metric tonnes annually. This leaves a deficit of 1.3 million metric tonnes from the total demand of 2.1 million metric tonnes. However, COVID-19 has reduced the country's GDP for the Agri-food system by 11%, this was attributed to restriction on food services (Andam et al., 2020). A study by Kabir (2020), further pointed out that, sales of fresh fish were slashed down to less than 50 % as in the case of India. The story is not different from that of Oyo State, Nigeria. During the peak of the COVID-19 pandemic, the outbreak curtailed many social programs in Nigeria, Ghana and West African countries who usually demand fresh fish for such programs. The restriction on social gathering has reduced the purchase of fish within the period. Among the challenges faced by fish farmers include; high feed cost, unsold stock of fish, and disturbance of the supply chain among others. According to Kabir (2020), the pandemic led to the closure of most hatcheries and has as well prevented the import of inputs such as feed. The COVID -19 pandemic has negatively impacted the industry and businesses in the aquaculture subsector. This affected many actors in the fish value chain. While other fish farmers are running at a loss in Oyo state, others have ceased the opportunity to expand. This study, therefore, seeks to find out fish Farmers Socio-economic characteristics predicting their challenges faced during COVID-19. Furthermore, the study addressed the hypothesis; Ho: Socio-economic characteristics do not influence challenges faced by fish farmers in Oyo State and the alternative hypothesis Hi: Socio-economic characteristics influence challenges faced by fish farmers in Oyo State. The result of the study will provide relevant information to formulate policies that put into consideration, the socio-economic characteristics of fish farmers in Oyo State Nigeria. In addressing challenges faced by fish farmers, stakeholders must pay particular attention to the socio-economic characteristics of farmers.

Materials and Methods
Study Area
Akinyele Local Government covers 464.892sq.km with its headquarters being Moniya. Akinyele Local Government area was created in 1976 and it shares boundaries with Afijio local government area (North), Lagelu local government area (East), Ido local government area (West) and Ibadan North local government area (South). The 2010 estimated population for the local government was 239,745. The climate is that of the equatorial with dry (November to March) and wet seasons (April to October). The temperature in the area ranges from 25°C to 35°C yearly with high relatively humidity. Topography and climate favours the development of fish farming and fishing activities.

Procedure
The study adopted the cross sectional survey design to help measure the interrelationship that exist been the socio-economic characteristics of fish farmers and challenges faced during COVID-19. The research used a convenient

sampling procedure to select fish farmers in the area. 11 fish farmers were used for the study with the low number attributed to the COVID lockdown measure, which prevented the tracking of fish farms. The small number led to the test for normality using Kolmogorov and shaper-Wilk test. The result revealed that the variables of the study were significant, hence the researcher conducted a bootstrap of the 11 sample size to 150. Due to the lockdown, the researcher used primary data obtained from the use of google form. The form asked questions like age, sex, education, number of ponds, nursery tanks and smoking kilns and if affected by COVID-19 as the socioeconomic characteristics, while, farmers were made to list their challenges during the COVID-19 period.

Data Analysis

The data were analysed with the help of SPSS 25.0 and the statistical tools used were the descriptive statistics (frequency, percentages, mean and standard deviation) for the socio-economic characteristics and Ordinary Least Square (OLS) regression for socio-economic characteristics on challenges faced during COVID-19. Mathematically;

$Y = X_i \beta + \varepsilon$, where Y= Challenges faced during COVID-19, X_i = Socio-economic characteristics ε- Error term

Results

Socio-Economic Characteristics of fish farmers

From Table 1, it was revealed that the mean age lies between 25-35 years. This shows that fish farmers in Akinyele Local Government were relatively younger. On Sex, it was revealed that females (72.7%) were more engaged in fish farming than males. This could be attributed to fish farms in Akinyele Local Government, Oyo state being within the household setting with females more likely to be at home than males. Table 1 also revealed that the majority of fish farmers had formal education (91.9%). The average farm size was 1.45 acres which lied between 0.5-5.6acres. This shows that fish farmers are small in size and this could be attributed to land scarcity in Oyo state. The small farm size is evident in the few ponds (1-15 (81.8%)) and the number of nursery tanks (0-10(90.9%)). Furthermore, fish farmers had an average of 0-5 smoking kilns. Lastly, the majority of fish farmers in Akinyele Local Government said “yes” (90.9%) they had been affected by COVID-19.

Table 1: Socio-Economic characteristics of fish farmers

Variables	Frequency	Percent	Mean± SD
Age			**1.09±.302**
25-35	136	90.7	
36-46	14	9.3	
Sex			
Male	41	27.3	
Female	109	72.7	
Education			
No Formal	14	9.3	
Formal	136	90.7	
Farm size			**1.45±.688**
0.5-5.6	136	90.7	0.5-5.6
6.7-10.7	14	9.3	
Number of ponds			**1.18±.405**
1-15	123	82.0	
16-30	27	18.0	
Number of Nursery Tanks			**1.09±.302**
0-10	136	90.7	
11-21	14	9.3	
Number of smoking kilns			**1.18±.405**
0-5	123	82.0	
6-11	27	18.0	
COVID-19 effect			
Yes	136	90.7	
No	0	0.0	
Not yet	14	9.3	

n= 150, ***Significant at 5%

Socio-economic characteristics predicting fish farmer’s challenges

From Table 2, it was revealed that the socio-economic characteristics that predicted fish farmers’ challenges in Akinyele Local Government were not limited to variables of the model as these other variables cause changes faced by fish farmers during COVID-19 to increase by 8.254. Sex caused the challenges faced by fish farmers to fall by 3.043. This could be attributed to lockdown measures put in place, as fish farmers (male and female) had more time to address challenges associated with their activities. As the number of nursery tanks owned by fish farmers increase, challenges faced by fish farmers during COVID by fell by 4.738. This could imply that fish farmers although could sell off matured fish stocks, they could still produce fingerlings and juvenile in anticipation of post-COVID. However, the number of smoking kilns and place of farm increased the challenges of fish farmers during the COVID-19 period by 2.520 and 1.223.

Table 2: Socio-economic characteristics that influence fish farmer's challenges during COVID-19

Variables	β	Std. Error	t	Sig.
Constant	8.254**	1.247	6.620	.022
Sex	-3.043**	.586	-5.197	.035
Education	-.520	.296	-1.754	.221
Farm size	-.836	.871	-.960	.439
Number of ponds	1.871	.798	2.346	.144
Number of Nursery Tanks	-4.738*	1.601	-2.960	.098
Number of smoking kilns	2.520*	.837	3.011	.095
Place of farm	1.223 **	.222	5.499	.032
COVID-19 effect	.648	.811	.800	.508
R square	**.982**			
Adj. R square	**.908**			

n= 150, ** significant at 5% * significant at 10%

H_0: Socio-economic characteristics do not predict the challenges faced by fish farmers during the COVID19 period

H_1: Socio-economic characteristics predict e the challenges faced by fish farmers during the COVID-19 period

Table 3 revealed that the regression of socio-economic characteristics on challenges faced by fish farmers during COVID-19 shows that socio-economic characteristics of fish farmers predicted the challenges of fish farmers. Therefore, the null hypothesis that "Socio-economic characteristics do not predict the challenges faced by fish farmers during the COVID-19 period" was rejected.

Table 3: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	43.365	8	5.421	13.279	.072
Residual	.816	2	.408		
Total	44.182	10			

*** Significant at 10%**

Discussion

Results from Table 1 on the age of fish farmers was consistent with findings of Pandey and Upadhayay (2012), Ike and Roseline (2007) and Faruk *et al.* (2004) who found out that younger and middle-aged people are more likely to engage in fish farming than older people. While results on the sex of fish farmers were inconsistent with Ifejika *et al.* (2018), Olaoye *et al.* (2016) who found out that males were more likely to engage in fish farming than females. Furthermore, findings of Abraham, Sil and Vineetha (2010) on the number of ponds and nursery ponds were consistent with the results of this research which found out that fish farmers had few ponds (nursery and out grower out ponds) for their operations. Olaoye *et al.* (2016) and Faruk *et al.* (2004) result on the education of fish farmers was consistent with the findings of this research as it was revealed that the majority of fish farmers had some level of formal education. Pandey and Upadhayay (2012) found out that fish farmers had small size fish ponds. This agrees with the study of Senten *et al.* (2020) in the US, which revealed that 90% of 537 fish farmers accepted that Covid-19 has affected their farm activities. Olaoye *et al.* (2016) result on the number of smoking kilns was consistent with the results of this research as fish farmers had few smoking kilns and mostly these smoking kilns are shared.

On socio-economic characteristics predicting the challenges faced by fish farmers, the results of the research on sex being significant were consistent with Ifejika *et al.* (2018). Duc (2008) also found out that the number of ponds for fish farming was significant to predicting challenges faced by fish farmers. The findings of this research were not consistent with the findings of Olaoye *et al.* (2016) on education as they found education not to be significant to predicting challenges faced by fish farmers, but their findings on farm size were consistent with this research finding of farm size not being significant.

Conclusion

The havoc caused by COVID-19 has been felt by all economies in various sectors. African countries including Nigeria have not been spared the harsh reality of the pandemic as the aquaculture sector tipped by many experts to see marginal growth have seen its output fall drastically. In Nigeria, fish farmers have to battle with issues of increasing the cost of raw materials and inputs, reduce sales and market inaccessibility. The study concludes that, in ascertaining the socio-economic characteristics on challenges faced by fish farmers during COVID-19, the sex of respondents, number of nursery tanks used by farmers, number of smoking kilns and the place where the fish farm is situated predicts the challenges encountered by fish farmers in Oyo State. Hence, to address the challenges faced by farmers during the Covid-19 pandemic, particular attention must be given to the above socio-economic factors.

Acknowledge
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Effect Of Income, Socio-Economic Factors On Consumers' Preferences And Quantity Of Fish Consumed By Staff In Different Campuses Of Lagos State. Polytechnic (Laspotech) Nigeria,

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Abstract
Effect of income, socio-economic factors on consumers' preferences and quantity of fish consumed by staff (academic nom academic) in different campuses (Ikorodu, Isolo and Surulere) of Lagos State. Polytechnic (LASPOTECH) Nigeria was investigated. Multi-stage stratified random sampling technique was used and respondents were stratified into cells of high, medium and low income earners. Level 3-7 and level 8-9 officers were selected for the low income earners, Level 10-13 represented the medium income earners while 14-15 level were selected for high income earners in random sampling procedure with structured questionnaires. The instrument for the measurement was validated for face, content, and purposefulness by the judgment of experts in the related fields. Reliability test was done through the test-retest method. Data obtained were analyzed by descriptive statistics, one-way of Analysis of variance and significant mean was separated at 0.05 level of significant. Results show that species, taste of fish, distance of purchase, unavailability of fish are important factors affecting preference for fish by respondents. Respondents preferred open market, weekly purchases, boiled or smoke fish and average of 1 to 5kg fish purchasing capacity. The results of this study permit the conclusion that preference is a powerful force that pulls a fish consumer towards favourable buying decision for certain fish species more than the others. Effort should be made by encouraging the local fish farmers to produce more African Catfish and improve on selling outlets, Private individuals and corporate bodies should be encouraged to invest in mass production of African Catfish, *Clariae gariepinus*

Keywords Respondents, African Catfish, Consumers' preference, Structured questionnaires

Introduction

General food consumption behaviour is considered to be influenced preference as major factor (Myriand *et al*., 2000). Pieniak *et al*.(2008) reported that fish consumption is mostly affected by tradition, habit, the level of consumption and nutritional awareness. Consumers' choice is a theory of micro-economic that relates preferences for consumption of goods and services to consumption expenditure and ultimately it is the most closely studied relations in consumer economics. Fish is eaten fresh or processed forms is a cherished delicacy that cut across socio-economic, ages, religious and educational barriers (Adebayo-Tayo *et al*., 2008). Socio-demographic information from respondents such as age, gender, marital status, family size, income levels and household size are explanatory variables in previous fish preferences and market research. Studies have further shown that attitude affects the choice of a given product in quantity and quality (Al- Mazrooei *et al.,* 2003). Recent studies have further brought in other attributes influencing consumer purchasing decisions for fish and fishery value added products such as form of the product, package size, method of cooking, price, smell, appearance, taste, size, quality, color, nutritional value, availability and the source of fish (Githukia *et al.,* 2014).

Fish is a very important agricultural product in the country as it occupies a prime place in the economy of the country. Nigerians are large consumers of fish with demand estimate at 1.4 million metric tons. However, a demand supply gap of at least 0.7 million metric tons exists nationally with import making up the short fall at a cost of almost 0.5 billion US dollars per year. There is hardly any religious taboo and any known cultural limitations affecting the consumption of fish unlike pork and beef meat (Eyo, 2001). Apart from its nutritional importance and medicinal values., fish also add varieties and taste to diets as well as improved palatability of food. Fish is the most important animal protein food available in the tropics, and this could account for its large consumption in the country. In Nigeria, fish constitutes 40% of protein intake (FDF, 2000), while, according to Adekoya and Miller (2004), fish and fish products contribute more than 60% of total protein intake in adults especially in rural areas. Relatively, few studies have focused on consumers' fish quality perception and public opinion towards the consumption of farmed fish is poorly understood (Pohar, 2011). This study focus on the effect of income, socio-economic factors on consumers' preferences and quantity of fish consumed by staff in different campuses of Lagos State. Polytechnic (LASPOTECH) Nigeria as the forms of fish products are accepted by consumers varies with fish species, locality and sometimes, time of the year (Abolagba and Nunfah, 2011).

Methology

Study Area

The study was carried out in Lagos State Polytechnic Ikorodu, Isolo and Surulere campuses in Lagos State. Lagos State Polytechnic (LASPOTECH) is a government owned tertiary institution located in Ikorodu, Isolo and Surulere. Geographically, Lagos State Polytechnic Ikorodu is located at GPS coordinates of 6.6463^0 N, 3.5179^{0}E. while the latitude of Oshodi-Isolo, Nigeria is 6.514193^{0}N and 3.308678^{0}E. Lagos Stat Polytechnic, Surulere has GPS coordinates of 6.5050^{0}N, 3.3611.

Sampling Procedure and Data Collection

The target population for this study was the staffs of Lagos State Polytechnic that consumes fish. This study focused on senior and junior staff to determine how income and other socio-economic factors influenced their fish consumption, as well as gather information on consumers' preferences and quantity of fish consumed. Multi-stage stratified random sampling technique was used in selecting the sample needed for analysis. The first step in the sampling procedure was to stratify the respondents into cells of high, medium and low income earners. This was to ensure that each income group was adequately represented in the sample. Level 3-7 and level 8-9 officers were selected for the low Income earners. Level 10-13 represented the medium income earners while for the high income earners, level 14-15 were selected. The second step involved the selection of respondents by random sampling procedure. A total of 250 staff from all levels were randomly selected with sample size distributed proportionate to size. Out of which 211 questionnaires were returned from the respondents The data used for this study consisted of primary and secondary data. For the primary data, structured questionnaires were used to generate the data needed for the study. and the secondary data, relevant publication on the issues under study was extensively reviewed to derive the needed information. Cross-sectional data relating to income distribution, fish consumption pattern and other socio-economic characteristics of the staffs, such as age, sex, job description, and family size were obtained from the selected staffs. Information on consumer’s knowledge about the fish species were also obtained as this could be directly linked to their fish consumption behaviour.

Validity Instrument and Reliability Test

The instrument for the measurement was validated for face, content as well as for clarity and purposefulness by the judgment of the supervisor and other experts in the related fields. Reliability (dependability, stability and consistency) test was done through the test-retest method in which the research instruments were administered to some selected respondents within the spate of two weeks in order to ascertain the consistency of results obtainable from several administered instruments The retest method scores (r=0.75) are reliable and acceptable (Olaoye, 2010).

Data Analysis

Data obtained were analyzed by descriptive statistics, one-way of Analysis of variance (ANOVA) using analyzed statistical package for social sciences (SPSS) version 21.0.and significant mean was separated at 0.05 probability level

Results

Socio-Economic Factors (age, sex, marital status, family size. job description and salary status)

The results show that socio-economic factors (age, sex, marital status, family size. job description and salary status) of respondents on fish consumption were significantly ($p > 0.05$) spread. Figure 1 shows that out of 211 respondents that were interviewed in study area, 65.9% were male and 34.1% were females. In Figure 2, out of 211 respondents, (81) fell within the age group of 31-40 years which represent 38.4% of the sample size. This was followed by respondents within age groups 41-50 years, 51 years and above and below 30 years representing 34.1%, 16.6%, and 10.9% of the total sample respectively. Figure 3 shows that out of 211 respondents, (176) which is 83.4% were married and (35), 16.6% were single. Family size is another important variable affecting the consumption pattern of the respondents. Table 1 gives the distribution of respondents according to their family size. It was observed from table 1, that large proportion of respondents fall on family size of 4 persons, accounting for 26.1% of the total number of sampled. This was followed by family size with 5 persons representing 19.9%, followed by family size of 6 persons, 3 persons, 1 person, 2 persons, 7 persons, 10 persons, 8 persons, and 9 persons accounting for 14.7%, 13.7%, 9.5%, 8.5%, 3.8%, 1.9%, 1.4%, and 0.5% respectively. Figure 4 shows that respondents who are non-academic staffs have the highest percentage distribution of 52.6%, and this was followed by the academic staffs which accounted for 47.4% of the total number sampled. Figure 5 shows that large proportion of the respondents are level 8-9 officers, accounting for 37.9% of the total number of sample. This was followed by level 3-7 officers representing 31.8% of sampled respondents, followed by level 10-13 officers, and level 14-15 officers accounting for 19.0% and 11.4% respectively

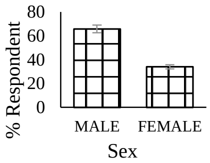


Figure1: Sex Distribution of Respondents

Figure 2 Age Distribution of Respondents

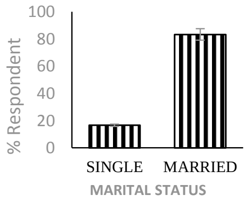


Figure3 Marital Status Distribution respondents

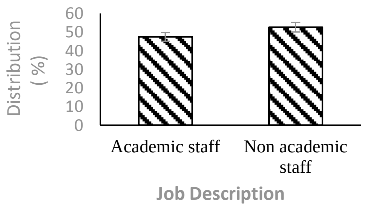


Figure 4: Respondents Job Description

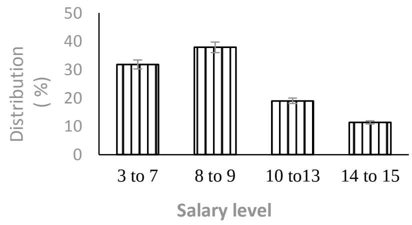


Figure 5: Distribution of Respondents by Salary Level

TABLE 1: Distribution of Respondents by Family Size

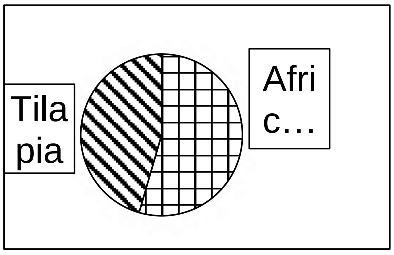
Family Size	Frequency	Percent
1.00	20	9.5
2.00	18	8.5
3.00	29	13.7
4.00	55	26.1
5.00	42	19.9
6.00	31	14.7
7.00	8	3.8
8.00	3	1.4
9.00	1	0.5
10.00	4	1.9
Total	211	100.0

Source: field survey (2018).

Factors Affecting Preference of Fish

Figure 6: shows that 115 respondents preferred African Catfish to Tilapia. This accounted for 54.5% for African Catfish and 46% for tilapia. Table 2 shows that taste affect 156 of the respondent which accounted for 73.9% of the total number of sample, followed by diet restriction (11) respondents accounting for 5.2%. This is followed by taste and availability having (8) respondents, taste and diet restriction (6) respondents, taste and price (6) respondents, availability (6) respondents, taste and smell (4) respondents, taste, price and availability (4) respondents, taste, price, availability and smell (3) respondents, taste, diet restriction and availability (2) respondents, price (2) respondents, smell (1) respondent, cultural belief (1) respondent, taste, diet restriction, availability and smell (1) respondent accounting for 3.8%, 2.8%, 2.8%, 2.8%, 1.9%, 1.9%, 1.4%, 0.9%, 0.9%, 0.5%, 0.5%, and 0.5% respectively. From Table 9, 42.2% of respondents preferred boiled fish, 40.8% preferred smoked fish, and 10.4% preferred fried fish. 3.3% of respondents indicated their preference for both smoked and boiled fish, 1.4% preferred fried and boiled fish, 0.5% preferred smoked, fried and boiled fish, and 0.5% had preference for smoked, fried and canned fish. Figure 7 shows that large numbers of respondents' purchase fish weekly, accounting for 53.1% of the total number of sample. This is followed by monthly purchase representing 23.7% of the sampled respondents, followed by daily, yearly and respondents that purchased once in a while accounting for 19%, 3.3% and 0.9% respectively. Table 4 shows that 74.9% of respondents purchase preferred fish from open market, followed by fish farm, landing site, accounting for 21.8% and 1.9% respectively. 0.9% of

respondents indicated purchasing fish from both super market and fish farm, while 0.5% purchases fish from open market and fish farm.



Source: field survey (2018).

Figure 6: Most Preferred Type of Fish by Respondents

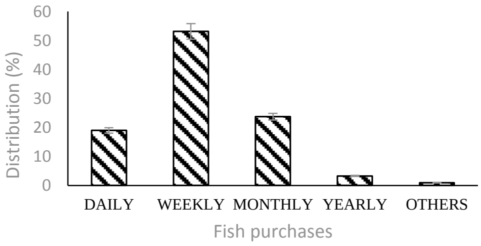


Figure 7: Respondents' frequency of Fish Purchases

Table 2: Factors Affecting Preference of Fish by Respondents

	Frequency	Percent
Taste	156	73.9
Price	2	0.9
Diet restriction	11	5.2
Availability	6	2.8
Smell	1	0.5
Cultural belief	1	0.5
Taste and price	6	2.8
Taste and diet restriction	6	2.8
Taste and availability	8	3.8
Taste and smell	4	1.9
Taste, price and availability	4	1.9
Taste, diet restriction and availability	2	0.9
Taste, price, availability and smell	3	1.4
Taste, diet restriction, availability and smell	1	0.5
Total	211	100.0

Source: field survey (2018)

TABLE 3: Respondent's Preference for Different Forms of Fish Processing

	Frequency	Percent
Smoked	86	40.8
Fried	22	10.4
Boiled	89	42.2
Smoked and fried	2	0.9
Smoked and boiled	7	3.3
Fried and boiled	3	1.4
Smoked, fried and boiled	1	0.5
Smoked, fried and canned	1	0.5
Total	211	100.0

Source: field survey (2018).

TABLE 4: Respondent's Source of Purchase

	Frequency	Percent
Open market	158	74.9
Fish farm	46	21.8
Landing site	4	1.9
Super market and fish farm	1	0.5
Open market and fish farm	2	0.9
Total	211	100.0

Source: field survey (2018)

Respondent's Quantity Purchasing Capacity/ Month and Kind of Problem in Purchasing of Preferred Fish.
Figure 8 shows that 83.9% of the respondents buy between 1-5kg, while 6-10kg representing 16.1%. Results shows in Figure 9 that 18.5% of respondents has no problem in purchasing preferred fish while 81.5% of respondents indicated having problems in purchasing fish. Figure 10 shows the kind of problems associated with purchases of preferred fish. 52% of the respondents attributed it to distance to place of purchase while unavailability 23% and financial capability was 13%. Others accounted for 10%.

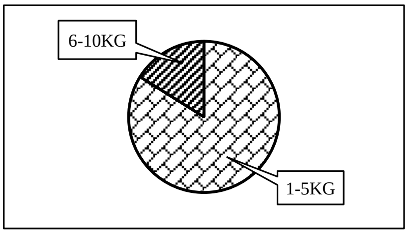


Figure 8: Respondents' Quantity Purchasing Capacity/ Month

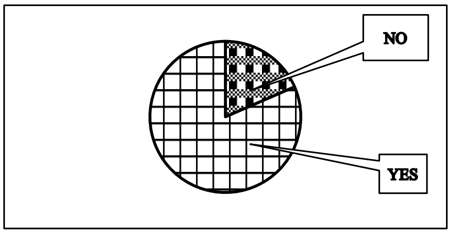
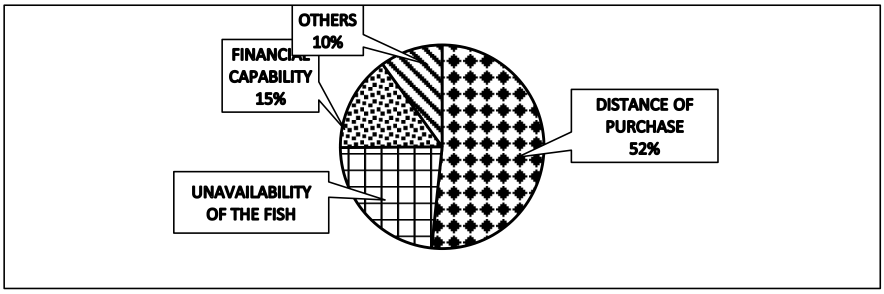


Figure 9: Problems in Purchasing of Preferred Fish



Source: field survey (2018).

Figure 10: Kind of Problem in Purchasing of Preferred Fish

DISCUSSION

Socio-economic characteristics such as family size, income level, age distribution and sex are important factors to be considered in the study of preference for species of fish as good representation of respondents, Analysis of consumers' preference for fish is important and useful for fish production planning, taste and distribution. Respondents' preference to catfish could be due to its convenience for various processing methods, size and good taste. This result agreed with (Githukia *et al.*, 2014) and the variation could be due to other factors such as price, diet restriction, taste, availability and cultural belief. Some respondents' preference for tilapia might be due to their cultural background and change from eating usual fish. The high weekly purchase of the respondents' might be due to spoilage of fish, their purchasing power and lack of preservation facilities and irregular availability of electricity. In Nigeria, certain people prefer fish by taste, the taste of fish are influenced by the method of preservation, so the believe that easiest way of assessing fish quality is by taste. The highest form of processing of the chosen by respondents' is smoking or boiling which were not significantly difference from each other. It is likely that many people process fish by smoking to minimize spoilage and prolong storage time and Clarias is highly acceptable as good fish pepper soup. Canning which happen to be the lowest form of processing by the respondents might be due to the fact that they are not use to canned fish, canned fish are expensive to buy and the technicality involved in canning of fish. Respondents' preference for open market might be based on their life style, free bargain and direct contact which is a common practice in the region. The prevailing economic situation in the country and the fact that fish easily spoil without proper preservation, hence, respondents buying 1-5kg at a prevailing time. Problem in purchasing a preferred fish is high and the highest factor affecting purchase of preferred fish is the distance to the market where purchases can be done. Most consumers prefer short distance fish sales outlet due to rapid spoilage of fish and lack of postharvest storage facilities of the buyers. Consumers' preference study provides better relationship with actual purchase or consumption (Hankenen *et al*., 2004). Pieniak *et al*. (2008) reported that fish consumption is mostly affected by tradition and habit; the level of consumption is also enhanced by nutritional awareness. According to (Polanco and Luna, 2010), food purchasing decisions are directed by cultural, psychological, lifestyles, culinary trends and diet restrictions.

Conclusion And Recommendations

The most important factor affecting preference for fish appeared to be Taste of fish and their high nutritional value. other factors that affect preference of fish are distance of purchase, unavailability of fish and bad smell during cooking. It was observed that the high income respondents preferred open market and fish farm for buying fish. The results of this study permit the conclusion that preference is a powerful force that pulls a fish consumer towards favourable buying decision for certain fish species more than the others. Staff in LASPOTECH preferred African Catfish to Tilapia at a very close percentage of 54.5% and 45.5% respectively. Since many people in the study area preferred Clarias to Tilapia, effort should be made by encouraging the local fish farmers to produce more African Catfish and the awareness of Tilapia value should be made to consumers. Grants, loans and subsidies should be given to fish farmers and marketers to enable them purchase modern equipment in order to increase supply of African Catfish and private individuals and corporate bodies should be encouraged to invest in mass production of African Catfish, *Clariae gariepinus*

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Blue economy as antedote for crude oil market recession, social insecurity and sustainable development in post COVID' 19 pandemic in Nigeria: Extentionist perspective.

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Abstract
Nigeria could see its economy collapse, while all offshore production would be loss making, if oil prices remain suppressed into the teens over long term. Nigeria foreign exchange reserves decline from US$45billion in June, 2019 to US$36.2 billion in March, 2020. The diversification of Nigeria's economy is believed to be the only viable way to survive the current global economic uncertainty. This study examined blue economy as antidote for crude oil market recession, social insecurity and sustainable development in Post COVID'19 Pandemic in Nigeria. The objective was to present opportunity for most competitive and strategic option for Nigeria in the light of current developmental challenges. A descriptive research method was adopted. Data were generated from secondary source; literature, journal, minutes, text book, internet. The strength of the study was anchored on conceptual clarification and theoretical framework. The study concluded that for Nigeria to rise above her economic quagmire and the negative impact of COVID '19 Pandemic, the next level agenda should focus on blue economy with particular attention to aquaculture which offers a suite of opportunities for sustainable, clean, equitable blue growth in both traditional and emerging sectors.

Keywords: Blue Economy, Social Insecurity, Sustainable Development, Insecurity, COVID'19 Pandemic.

Introduction

In recent times, there has been sharp decline in crude oil prices in the global market. This has in turn lowered expected open market price of imported petrol below the official pump price of #145 per litre as at March, 2020. Similarly, the outbreak of Corona virus popularly described as COVID-19 Pandemic and its spread across the world has forced the international oil price to further crash from around US$60 per barrel to about US$29 per barrel. The drastic fall in the price of oil had reduced the expected pump price of petrol in Nigeria. In the light of the aforementioned, Nigeria economy is seriously threatened and on the verge of collapsing. The offshore crude products production is not spared in loss making too. As it were, Nigeria foreign exchange reserves are on the decline from US$45 billion recorded in 2019 to US$36.2 billion in March, 2020 (National Office of Statistic, 2020). The decline in oil price also corresponds to a decline also in the Nation's foreign reserves which is Nigeria main source of earnings. Moreover, there was a high importation capital flight and weak capital importation resulting to inflation rate rising to 12.13% in January 2020 thereby eroding consumer spending, retail sales and house hold income with a high unemployment rate of 23.1% or 20.9 million unemployed people. With the foreign reserves fast declining, credit agencies downgrading the nation's credit rating and global growth projected to slow down in 2020, hence the need to diversify the economy and the choice of blue economy might not be out of place. On the international seen, crude oil average closing price has being undulating on yearly basis with 2020 worst hit (Table1) and this has taken its toll on foreign reserves and in particular on the level of social insecurity in Nigeria.

Table 1: Historical Annual Data on Crude oil prices per barrel in United States Dollar.

Year	Average Closing Price	Year Open	Year High	Year Low	Year Close	Average % Change
2011	$94.88	$91.59	$113.39	$75.40	$98.83	8.15%
2012	$94.05	$102.96	$109.39	$77.72	$91.83	-7.08%
2013	$97.98	$95.14	$110.62	$86.65	$98.17	6.90%
2014	$93.17	$95.14	$107.95	$53.45	$53.45	-45.55%
2015	$48.66	$52.72	$61.36	$34.55	$37.13	-30.53%
2016	$43.29	$36.81	$54.01	$26.19	$53.75	44.76%
2017	$50.80	$52.36	$60.46	$42.48	$60.46	12.48%
2018	$65.23	$60.37	$77.41	$44.48	$45.15	-25.32%
2019	$56.99	$46.31	$66.24	$46.31	$61.14	35.42%
2020	$37.79	$61.17	$63.27	$11.26	$41.93	-31.42%

Source: International Chart of West Texas, New York Habor, 2020

Table 1 indicated the annual crude oil price variation in decade (2011-2020) with the least average closing price of $37.79 per barrel in 2020 as compared to the highest price of $97.05 in 2013.

Furthermore, the present level of social insecurity in Nigeria is alarming and this cannot be divulge from socio-economic challenges defined by poverty, unemployment etc. Similarly, high importation capital flight and weak capital importation resulted to inflation rate rising to 12.13% in January,2020, eroding consumer spending, retail sales and house hold income with a high unemployment rate of 23.1% or 20.9 million unemployed (ILO,2019).

- It has also undermined the economic, social, cultural and environmental rights of many Nigerians.
- Investigations revealed that incidences of restiveness among youths could be traceable to multifarious factors, including incidence of unemployment etc.

In Nigeria for instance, the most prominent ones include;

- Boko Haram, a northern-based socio-religious organization.

Nigeria is currently ravaged with social unrest. To begin with is the case of Boko Haram insurgency in the Northern part of Nigeria. Social dysfunctional elements being perpetrated by herdsmen attack, militancy, banditry, etc. Unfortunately, Nigeria is ranked 149th out of 163 countries on the Global Peace Index in 2017 (Olaniran et.al, 2019). In a related development, the impacts of insecurity on the economy are broad; vis-a-vis agricultural production has been devastated, public infrastructure such as schools, hospitals, and bridges have suffered significant damage and the loss of life including mass displacement of people all remain unbelievable. Take for instance agricultural production which has been devastated, public infrastructure such as schools, hospitals, and bridges have suffered significant damages and the loss of life including mass displacement of people are astounding due to problems of insecurity in Nigeria. Also, in 2018, a huge sum of $1.58 billion budget was allotted to security matters in Nigeria. Nonetheless, the rate of insecurity remains on the high side. Incidentally, 15 states out of Nigeria's 36 states are experiencing one form of violence and upheaval and another. For reference purpose, both the Niger Delta region where crude oil exploration and exploitation is much carried out and the North East region where agricultural food and raw materials are produced are not spared of insecurity and economic disruptions. Quite significant was the emergence of COVID'19 pandemic in Nigeria on 27 February, 2020. This global viral disease led to the shutdown of all human established institutions due to lock down of the country and other nation across the globe. The negative impact on the socio-economic livelihood of the people of Nigeria is unprecedented while most countries including Nigeria are yet to recover from the impact. This has threatened several aspect of human social space including among others, death, job loss, banditry, rape, suicide etc. COVID-19 Pandemic threat to economy could lead to total economic collapse if urgent measure to restore such is not addressed headlong. Consequently, the diversification of Nigeria economy is believed to be the only viable option to mitigate the current concern. It is against this backdrop the present study, explored literature on blue economy as antidote for crude oil market recession, social insecurity and sustainable development in Post COVID'19 Pandemic in Nigeria.

Objective of study

The main aim of the study was to explore relevant literature on how blue economy presents an opportunity for the most competitive and strategic option for Nigeria in light of current economic and developmental challenges due to COVID'19 Pandemic.

Conceptual Clarification

Blue Economy

Blue economy is recent and it originated from the United Nation's Conference on Sustainable Development held in Rio de Janeiro, Brazil in 2012 (UNCSD,2012). Australian Government (2012) posits that, blue economy is a marine based economic development that leads to improved human wellbeing and social equity while significantly reducing environmental risks and ecological scarcities. Blue economy is a part of Green Economy (UNEP et.al. 2012). Similarly, the USSD (2012) opines that blue economy is a sustainable marine economy. In this context, the study opines that blue economy is a macro-economy concept, involves every aspect of national and global governance, economic development, environmental protection, sustainability and international communication.

Social Insecurity

According to Fontana *et.al* (1986), social insecurity is a psychological orientation that has been found to be associated significantly with both coronary atherosclerosis and psychological distress. Urban Dictionary put it as the real and inescapable fear that most of us will never get to collect a dime out of a system we spent a lifetime paying into.

Insecurity

According to the Cambridge Dictionary, insecurity is a feeling of lacking confidence and not being sure of your own abilities or whether people like you. Insecurity is also defined as the quality of not being safe or strong (Olaniran *et.al,* 2019). The Longman Dictionary of Contemporary English sees insecurity as not feeling at all confident about one, your abilities or your relationships with people.

Sustainable Development

Sustainable development was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Also the concept of sustainable development was seen as a practice of maintaining processes of productivity indefinitely, national or human made, by replacing resources used with resources of equal or greater value without degrading or endangering natural biotic system (Olaniran, *et.al*,. 2017). As the global challenges face from advancing gender equality to eliminating poverty, it is crucial to recognize that these issues related to health and security are exacerbated by climate change. Therefore, by looking at these challenges holistically, the better chance at making progress on a range of issues, including improving access to food and clean water. That is where the Sustainable Development Goals (SDG) come in, a framework designed by United Nations for peace and prosperity for both people and the planet. Blue economy will address SDGs 1 to 17 (United Nation report, 2019). The United Nations created a set of 17 distinct but interrelated goals to guide global development between, 2015-2030. Here, poverty reduction is most critical.

Theoretical Framework

This study was anchored on sustainable development theory. The theory was postulated by, Lele (1991), Mebratu (1998) and Zhang (2018). The theory focused on sustainability, that sustainability is something that people can still rely on when everything else is unsustainable. The theory asserted that the early thought of sustainable development mainly reflected in the sustainable use of natural resource, in this context the advocacy for blue economy as best alternative and project to serve as antidote for crude oil market recession, economic quagmire as a result of COVID'19 Pandemic.

Methodology

This study adopted a descriptive research design. Data were generated from secondary source; literature, journal, text book, internet, minutes and reports. Oral interview using unstructured items were conducted on purposely selected staffs of agency whose working mandate is related to Ocean; the Navy, Nigeria Maritime Shipping Agency (NIMASA) and Nigerian Institute for Oceanography and Marine Research (NIOMR) using unstructured interview schedule.

COVID'19 Pandemic: The Concern

Corona Virus Disease (COVID'19) originated from Wuhan, China in December, 2019 (WHO, 2020). The pandemic is the defining global health crisis of our time and the greatest challenge facing the world since World War Two. Incidentally, the pandemic is not just a health crisis but also created unprecedented socio-economic crisis. The socio-economic crisis has the potential to create devastating social crises and fatality. COVID pandemic has led to loss of jobs, increase rape cases, high level suicide, broken homes, creates new normal in religious activities, and above all mar agricultural and crude oil production. Nigeria is a member of Organization of Petroleum Exporting Country (OPEC), a body that fixed the benchmark for price of petroleum products. The OPEC crude oil price is defined by the so called OPEC basket. This basket is an average of prices of the various petroleum blends that are produced by the OPEC members. Incidentally, the price of oil keeps nose-diving in the last decades (Table 2) with the worst experience in price (US$39.7) recorded in 2020. This by implication meant less foreign earnings for Nigeria whose economy is largely dependent on oil. The World Bank projects that a US$110 billion decline in remittance in 2020 was anticipated, which could mean 800 million people will not be able to meet their basic needs. Hence the need for blue economy as alternative source of economy in Post COVID'19 pandemic in Nigeria. The participants interviewed were unequivocally of the opinion that blue economy if adopted by policy maker will solve most teething issues facing the economy of Nigeria.

Table 2: Average annual OPEC crude oil price (2011-2020) in United State Dollar

Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
US$	107.46	109.45	105.87	96.29	49.49	40.76	52.51	69.78	64.05	**39.07**

Source: Sonnichsen, 2020

Blue Economy and Sustainable Development in Post COVID'19 in Nigeria: Extensionists Perspective
Blue economic approach was founded upon the assessment and incorporation of the real value of the natural capital into all aspects of economic activity anchored on conceptualization, planning, infrastructure development, trade, travel, renewable resources exploitation and energy production. This also took cognizance where sustainable the sourcing and usage of local raw materials. Blue economy offers a suite of opportunities, topmost are;

1. **Fisheries:** On a global perspective, 350 million jobs are linked to marine fisheries with 90% of fishers living in developing countries (FAO, 2010).
2. **Shipping and Port facilities:** 80 percent of global trade by volume, over 70percent by volume is carried by sea and handled by ports world-wide. So maritime trade is set fair for growth and economic benefits whilst reducing impacts, offering expanding blue employment opportunities for the foreseeable future.
3. **Tourism:** In 2012, tourism supported 9 percent of global jobs and generate US$1.3 trillion or 6 percent of the World's export earnings. Tourism in blue economy approach provides a prospect where ecosystem services are properly valued and incorporated into development planning (UNWTO, 2013; UNWTO, 2013a).
4. **Energy:** Nigerians have suffered dramatically in the aspect of socioeconomic livelihood due to epileptic or zero level energy/power supply. However, the blue economy offers enormous potential for generation of renewable energy from wind, wave, tidal, biomass, and thermal convention and salinity gradients. The global installed capacity was estimated over 6 GW in 2012 but nonetheless has projected to grow to 175 GW by 2035 if well harnessed (IEA, 2012).
5. **Biotechnology:** In the area biotechnology, Marine biotechnology has the potential to address a suite of global challenges particularly in sustainable food supplies, human health, energy security and environmental remediation. Study revealed that the current global market for marine biotechnology products and processes is estimated at US$2.8 billion and projected to grow to around US$4.6 billion by 2017.
6. **Aquaculture:** FAO (2010) report indicated that fish used for human consumption grew by more than 90 million tons in the period 1960 – 2009, from 27 to 118 million tons. The viability is anchored on aquaculture as to replacing Industrial fish.

Blue Alternative: The Role of Aquaculture in Fisheries
Aquaculture notably affects people and societies far beyond obvious contributions to food security or any positive or negative environmental impact. Globally, 18.7 million people currently work as fish farmers and as with fisheries, this figure increase by three to fourfold if secondary and postharvest employment is included (FAO, 2016). The income earned by each of these employed individuals supports up to four dependants. Increased training of women and greater participation in the workforce has followed. Macroeconomic benefits derived from export earnings are also self-evident (Smith et.al. 2010). Aquaculture jobs offer a certainty of location which allow fish farmers to make choices about family position and housing that improve household stability. This brings many advantages over fishing in terms of access to education, health provision, and appropriately housing (Fatunla, 1996). While fisheries may offer higher returns at times of plenty, aquaculture returns are generally more predictable in both time and value.

Conclusion and Recommendation
Nigeria is presently in a state of deep and threatening socio-economic crisis not only due to insecurity, but largely due to current COVID'19 Pandemic. The country is faced with Boko Haram Insurgent in the North East, Niger Delta Militants in the South, Movement for the Actualization of the Sovereign state of BIAFRA (MASOB) in the south east, as well as the Odua People's Congress (OPC) in the south west. Unfortunately, in February 2020, COVID'19 Pandemic ravaged the health system including stagnating already devastated economy. These problems have taken its toll on the nation human and economic resources. For instance there is deep poverty in the land, unemployment, loss of jobs, insecurity, hunger, increase cases of rape and suicide, viz a viz economic recession. Over decades, Nigeria economy largely dependent on oil, a mono-economic nation whilst the agricultural sector remains largely on peasant status with insignificant economic impact on the foreign earnings for the nation. Consequently, it is important for policy makers and stakeholders to understand that for Nigeria to rise above her economic quagmire and the negative impact of COVID '19 Pandemic, the next level agenda should focus on blue economy with particular attention to aquaculture which offers a suite of opportunities for sustainable, clean, equitable blue growth in both traditional and emerging sectors. This paper recommended that the government should constitute economic recovery and sustainable approach team to draw a blue print on blue economy and action plan toward achieving the United Nations 17 sustainable development goals.

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Factors influencing market price of fish in some coastal communities of Rivers State, Nigeria

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Abstract

This study assessed some factors influencing the market price of fish in some coastal communities of Rivers State, Nigeria. Six coastal communities namely: Abalama, and Buguma (Asari Toru Local Government Area); Obuama and Degema in (Degema Local Government Area) and Obonnoma and Abonnema (Akuku Toru Local Government Area) all in Rivers State, Nigeria were chosen for the study. The respondents of the study were: fishermen, middlemen, fish vendors and consumers. A total of 120 researcher–made questionnaires (20 questionnaires in each of the community) were used in the study. Descriptive statistics were used to quantify and analyzed the gathered data. Based on the findings of the study, among the six identified factors affecting the market price of fish, fish quality (45.00%) was found to greatly affect the market price of fish while water pollution (9.00%) was considered as the lowest factor affecting the market price of fish in the study area. Furthermore, it was found that all the six identified factors cited in the study had significant contributions on the formulation of the market price of fish in some of the markets in the study area.

Keywords: Price demand, Market price, Fish quality Coastal areas

Introduction

Fish production in Nigeria comes from three sources; artisanal (inland rivers, lakes, costal and brackish water), aquaculture (fish farm) and industrial fishing (Adekoya and Miller, 2004). However, majority of the fish supply in coastal areas comes from the artisanal sub-sector. Fish production and supply in Nigeria has not been consistent in all the identified sources (artisanal, aquaculture and industrial fishing) of fish production. Total domestic fish production in Nigeria ranges between 242,525 and 615,507 metric tones from 1981-2007 and has not been consistent (Ali *et al*., 2008). Nigeria, like many other countries in sub Saharan Africa is endowed with substantial marine and inland fisheries resources upon which the fisheries sector is based. Nigeria has a land area of 923,768 km^2 with a continental shelf area of 47,934 km^2 and a length of coast line of 853 km. It also has a vast network of inland waters like rivers, flood plains, natural and manmade lakes and reservoirs (Gaya *et al*., 2005; Alam *et al.*, 2010).

Moreover, Abila *et al*. (1997), noted that few of the major factors identified to influence the price demand of fish in the market include environmental change, quality of fish, water pollution, location and the price demand of some customers . Knowing the factors that affect the market value of fish can help the producer and consumers create and establish the buying and selling strategies. Also, Gobillon *et al.* (2010) reported that fish prices may vary considerably by different factors. However, the more educated producers and consumers are about the process, the better their chances to address the problems of both the fisherman and consumers and make a good profit. In fish marketing, wholesale trade between fishermen and fish merchants are marketed in different categories. Fish trade is a global system that links fishing communities with markets (FAO, 2005). In microeconomics, supply and demand is an economic model of price determination in a market. It concludes that in a competitive market, the unit price for a particular good or other trade item such as labor or liquid financial assets will vary until it settles at a point where the quantity demanded (at the current price) will equal the quantity supplied (at the current price) resulting in an economic equilibrium for price and quantity transacted (Bergman, 2012).

Conversely, Aguero (2004) claimed that there are a number of varying factors affecting the market price of fish. Few of these dealt on freshness and quality measurement, domestic price differentials, storable and non-storable products and production-retail price differentials. It is important, therefore, to close examine the formulation of the market price of fish based on the varying factors. The realities of fish and seafood production and the resulting threat to wild stocks of fish and seafood species will require careful management to assure both a sustainable supply of wild catch and sustainable growth in aquaculture to meet demand of the populace (Bailey, 2009). It can be difficult in some way to predict the prices of fish, because they constantly vary based on differing factors (Alam *et al*., 2010). In the coastal area of Rivers State, the usual practice in buying and selling fish is done directly from the fishing boat to the consumers. This is similar to what local fishermen and farmers have done in several places, whereby fish and agricultural products are directly sold from the harvest area to consumers. In this context, fish selling and buying guide and regulation strategies are being compromised, leading to poor economic competition among the fisher folks. In view of this situation, this study assessed the factors affecting the market price of fish in some coastal areas of Rivers State.

Materials and Methods

Study Area

The study was conducted in five coastal communities namely Buguma, Abalama, and Ilelema (Asari Toru Local Government Area), Obuama (Degema Local Government Area); Abonnema (Akuku-Toru Local Government Area) all in Rivers State, Nigeria. These areas are surrounded by large water bodies and the vegetation in this area varies from mangrove to evergreen swamp forest. The prevailing climatic condition thus favours thriving fishery activities.

Data collection and Analysis

The study made use of the descriptive - survey method using researcher-made questionnaire as main instrument to gather data. The researcher-made questionnaire was composed of questions categorized into four (4), one for each of the intended respondents: fishermen, middlemen, fish vendors and consumers. Informal interviews and observation were made to verify data and ascertain the validity of the respondents' answers. Stratified Random Sampling Technique was used to identify the respondents. Primary data were collected through structured questionnaires answered by 120 randomly selected individual that have different socio-economic backgrounds from six communities namely: Abalama, and Buguma in Asari Toru Local Government Area; Obuama and Degema in Degema Local Government Area and Obonnoma and Abonnema in Akuku Toru Local Government Area all in Rivers State, Nigeria. The data was collated and analyzed using descriptive statistics involving the use of measures of central tendency such as frequency and percentages.

Results

The socio-economic characteristics of the respondent in the study area are presented in Table 1. Most of the respondents (42.50%) were within the age group of 36 – 50, which was followed by 15 – 25 (23.34%) and 26 – 35 (20.00%) while the least (14.16%) was recorded in the age group of 50 and above. Also, in respect of respondent's sex, 65.0% of them were females, while 35.00% were males. The household size which refers to the number of people living under one roof at a time, ranges between 1 – 10, with the highest of 6 – 10 persons in the present study. The marital status of the respondents indicated that most (80.00%) of them are married. Also, the results from the study revealed that the respondents were educated, with majority (50.83%) of them having primary school certificate. The factors affecting the market price of fish are presented in Table 2. From the respondents, fishermen, fish vendor and consumers, the quality of fish account for the highest (45.00%) factor affecting fish price, while water pollution recorded the lowest (9.00%). The challenges to stability of fish price in the study area are presented in Table 3. Consumer's choice account for the highest percentage (42.50%), while activities of government recorded the lowest value of 4.17%.

Table 1: Socio-economic Variable of the Respondents (n = 120)

Parameters	Frequency	Percentage
Age (Years)		
15 – 25	28	23.34
26 – 35	24	21.00
36 – 50	51	42.50
50 and above	17	14.16
Total	**120**	**100**
Sex		
Male	42	35.00
Female	78	65.00
Total	**120**	**100**
Marital Status		
Married	96	80.00
Single	19	15.83
Divorced	5	4.17
Total	**120**	**100**
Household Size		
1-5	30	25.00
6-10	65	54.17
>10	25	20.83
Total	**120**	**100**
Educational Qualification		
Primary	30	25.00
Secondary	61	50.83
Tertiary	23	19.17
Experience (Years)		
1 – 5	25	20.83
6 – 10	34	28.33
11 – 15	51	42.50
15 and above	10	8.33

Total	**120**	**100**

Table 2: Factors Affecting the Market Price of Fish (n = 120)

Respondents	Variables					
	Fish Availability	**Market Location**	**Water Pollution**	**Weather Condition**	**Processing**	**Fish Quality (Size/ Clean)**
Fishermen	2.0	2.0	5.0	10.0	1.0	18.0
Middlemen	8.0	9.0	1.0	1.0	1.0	10
Fish Vendors	7.0	6.0	1.0	1.0	8.0	7
Consumers	7.0	1.0	2.0	1.0	9.0	10
Total	**24.0**	**18.0**	**9.0**	**13.0**	**19.0**	**45.0**
Mean Total	**6.0**	**4.5**	**2.25**	**3.25**	**4.75**	**11.25**

Table 3: Challenges to Fish Price Stability (n = 120)

Challenges	Frequency	Percentage (%)
Consumers choice	**51**	**42.50**
Lack of good storage facilities	**31**	**25.83**
Activities of Government Agents	**5**	**4.17**
Union Activities	**15**	**12.5**
Social vices	**18**	**15.0**
Total	**120**	**100**

Discussion

The socio economic characteristics of the respondents indicated that fishery activities are predominant among younger people than the older ones. This agrees with the report of Akinrotimi and Edun (2011) who reported the same trend of 43.5% of young people within the age bracket of 36-50 among fisher folks in some coastal communities of Rivers State. The reason may be due to the fact that fishery activities is highly demanding and need energetic individual for its various activities. Also, the study revealed that females are more than their male counterparts in fishery business. This result agrees with the submission of Cliffe *et al.* (2011) who reported that women (66.5%) are more than men (33.5%) in marketing of fishery products in some communities of Rivers State, Nigeria.The house hold size recorded in this study area is very large. This is consistent with the works of Cliffe and Akinrotimi (2015), who reported that families with large number of persons (10-14) usually engaged in fisheries activities in the coastal communities of Niger Delta. The respondents were literates and have a lot of marketing experience; this assertion is in line with the opinion of Anyanwu *et al*. (2007) in some communities of Niger Delta.

The factor, size of fish, and processing was found to greatly affect the price of fish. Most of the consumers preferred to purchase high quality and fresh fish to ensure their health safety and satisfaction. The location and weather conditions are two of the factors that also contribute to the market price of fish. Fish are less likely to come up during bad weather because fish from the wild are sensitive to the weather changes. On the other hand, fishermen are reluctant to venture into far places with unpredictable weather condition, for it creates a risky situation and uncertainty of catch. With that condition, fish vendors and consumers are the end receivers, which for them, location and weather conditions are two important factors to look into before going to fishing. The result is further supported by the study of Gordon and Hussain (2015). They opined that the quantity of fish brought to market is determined by many factors, but the weather is an important determinant of supply since strong winds and high waves make it difficult to catch fish. Conversely, Abila (2015) observed that weather and market location are two of the factors that affect the market price of fish as observed in this study. According to Bruton,(1990), fish is perishable and if it is to be sold in good condition, it must be taken to the market within the shortest time period or it must be preserved. Since preservation adds costs, it was considered that traders should instantly sell their fish at the nearest market to avoid deterioration of quality, which would influence price of fish.

From the six identified factors, the water pollution is reflected to be the least factor affecting the market price of fish with a mean of 2.25. This means that the freshness and fish species have significant influence on the price of fish. The lowest factor affecting the market price of fish in the study area is the water pollution because fishermen prefer to avoid areas where water is polluted; instead, they travel beyond to other location where the water is clean. Compared to clean water, where there are lots of fish that are of quality and different species, polluted water may have little number of fish which are unsafe and unhealthy to consume. The result agreed with the study of Israel (2004), that low income of fishermen can be attributed to declining fish catch due to poor access to clean water and environment which greatly affects the production of different fish species. In assessing the challenges to fish price stability. Consumer choice was found to have the most effect and influence of government agencies the least. The result was in agreement with that of Abila (2015), who reported the same trend in Lake Victoria.

Conclusions

Based on the findings, the following conclusions were made: The quality of fish greatly affects the market price of fish, since most of the consumers preferred to purchase high quality and fresh fish for health and safety reasons. Fishermen prefer to avoid areas which are polluted; instead, they travel to other location where abundant fish can be found. Furthermore, it was found that all the six factors cited in the study have significant contributions on the formulation of the market price of fish in the study area.

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Factors Affecting Adoption of Innovative Fish Farming Technologies in the Niger Delta

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Abstract
Agricultural technologies developed and tested under farmers' conditions and proven to be remunerative are not enough to encourage mass adoption and uptake for improved productivity. This suggests that a comprehensive explanation of attitudes towards innovations is needed in fish farming as they impinge directly or indirectly on decisionmaking. Applying a four point Likert scale where: very serious =1, serious = 2, moderately serious = 3, less serious = 4 in a structured questionnaire, this study investigated constraints influencing adoption of fish farming innovations in the Niger Delta. The cutoff point was 2.50 and responses with mean scores of >2.50 were regarded as less/not serious problems while responses with mean scores ≤2.5 were considered very serious problems affecting the adoption of fish farming technologies. Also, grand mean scores were used to determine severity of identified constraints. Fish farmers are facing severe challenges in the Niger Delta and it calls for appropriate interventions for the purposes of food security, employment generation and sustenance of fish farming and aquaculture development in the region.

Introduction
The failure of farmers to adopt agricultural innovations is a serious challenge to research scientists and agricultural extension workers. Even when practices have been tested under the farmers' condition and proved to be remunerative it appears that the profit motive alone is not enough to encourage adoption and uptake of agricultural innovations. This implies that a comprehensive explanation of attitudes towards innovations is needed especially in fish farming where situational factors impinge directly on enterprises. Empirical studies on crop farming agree that both antecedent and situational factors directly affect the adoption of recommended agricultural innovations and farmers' perception of recommended innovation and their locations also affect adoption behaviour (Adams, 1982 and Vabi, 1988).

In Nigeria, research findings including Osuji, (1983), Onyenweaku & Mbuba, (1991) Tiamiyu, Idowu & Misari (2001), Sule, Ogunwale & Atala (2002), Nlerum (2005) and Jatto, Alkali, Aladima, Gunu & Miikasuwa (2013) have investigated factors related to the adoption of improved farming practices. From these studies, it is clear that no consensus exists among researchers about the wide applicability of factors that affect the adoption of tested and proven agricultural innovations. Against this backdrop, this study investigated constraints affecting the adoption of fish farming technologies (innovations) in the Niger Delta.

Methodology
The Niger Delta is sitting directly on the Gulf of Guinea on the Atlantic Ocean in Nigeria. It is typically considered to be located within nine coastal southern Nigerian states, which include: Akwa Ibom, Rivers, Edo, Cross River, Delta, Bayelsa, Ondo Abia and Imo States. Using a multistage sampling procedure, the study randomly selected Bayelsa and Imo States. It further adopted the ADP administrative structure for sample size. In Bayelsa, there were 468 registered fish farmers and 292 in Imo. In Imo State, 45, 28 and 102 fish farmers were randomly selected from Orlu, Okigwe and Owerri Zones respectively, making a total of 175 fish farmers while in Bayelsa State, 125, 53 and 106 farmers were selected from Yenagoa, Sagbama and Brass Zones respectively making a total of 284 fish farmers. Therefore, a total of 459 fish farmers constituted the sample size.

Data Analysis
Mean and grand mean scores were computed to measure variability to respondents scores on the severity of problems militating against the adoption of innovative fish farming technologies in both Bayelsa and Imo States. Applying the Likert scale where: very serious =1, serious = 2, moderately serious = 3, less serious = 4. The cutoff point was 2.50. Responses with mean scores of >2.50 were regarded as less/not serious problems while responses with mean scores ≤2.5 were considered very serious problems affecting the adoption of fish farming technologies. Grand mean scores were used to categorise and determine the severity of identified constraints.

Results and Discussion

Table 1: Constraints affecting adoption of innovative fish farming technologies in the Niger Delta

	State	**Bayelsa State**		**Imo State**	
S/N	**Constraints**	**Mean score**	**Grand Mean**	**Mean score**	**Grand mean**
A	**Land-related constraints**				
1	Suitable land acquisition in the area	2.49		2.21	
2	Stony, laterite soil in the area	2.22		2.90	
3	Cost of land acquisition in the area	1.91	**2.20**	1.63	**2.25**
B	**Inputs-related constraints**				
4	Cost of fingerlings	1.80		1.54	
5	High price of dragnets, spare parts	2.18		2.33	
6	High prices of input (lime, fuel, fertilizer, etc.)	1.99		1.89	
7	High cost of fish feed	1.70		1.43	
8	Insufficient skilled labour	2.33	**2**	2.22	**1.88**
C	**Credit and Policy implementation constraints**				
9	Inadequate finance	2.10		1.45	
10	Low farm-gate prices	2.30		2.01	
11	Unavailability of credit	1.92		1.43	
12	Poor government policy implementation	1.98	**2.08**	1.43	**1.58**
D	**Management-related constraints**				
13	Poor road maintenance ability	1.94		1.60	
14	Incidence of disease and pest	2.77		2.44	
25	Poaching activities in the area	2.78	**2.50**	2.46	**2.17**
E	**Institutional constraints**				
16	Inadequate follow-up extension advice after trial stage	2.45		2.18	
17	Distance of extension staff office to the farm location	2.23		2.03	
18	Insufficient extension officers in their office	2.04		1.52	
19	Irregular electricity supply	1.84		1.32	
20	Unavailability of incubators and hatchery facilities	1.92	**2.10**	1.85	**1.78**
F	**Technological constraints**				
21	Technology not adequate to fish farming system	2.42		2.66	
22	Difficulties in recalling main features of technologies	2.48		2.38	
23	Cost of technological packages	2.09		1.88	
24	Lateness in supply of technological packages	2.00		1.88	
25	Poor knowledge of processing and storage techniques	2.15		2.07	
26	Absence of modern processing and storage facilities	2.22	**2.23**	2.04	**2.15**
G	**Socio-psychological constraints**				
27	Difficult to recall main features of innovation	2.65		2.38	
28	Fish farmers managerial ability of the innovation	2.81		2.46	
29	Social participation in the innovation programme	2.70		2.36	
30	Not participating in innovation programmes	2.13	**2.57**	2.93	**2.53**

Source: Opara and Ani 2020 Note: <2.50 = serious ≥ 2.50 = Not serious
1 = very serious, 2 = Serious, 3 = Moderately serious, 4 = Less serious

Results from Table 1 reveals the extent (severity) of constraints fish farmers faced/encountered in fish farming and management in the Niger Delta. Generally, most of the variables discriminated as significant constraints impinging on the adoption of innovative technologies by fish farmers. It suggests/casts a shadow of negligence, abandonment and gloom perhaps due to the influence of oil and gas exploration in the Niger Delta and disproportionate inclination for white-collar jobs. In the same vein, institutional constraints bordering for instance on availability and accessibility of extension agents in the study area significantly limit/constrain fish farmers from taking up available innovations.

However, socio-psychological constraints were not significant constraints except non-participation (2.13) in the development of innovative programmes. This is a deviation from findings of Singh and Singh (1970) cited in Okwundu (2000) which a total of eighteen independent variables out of twenty-four variables categorized into situational, socio-psychological and communication variables were related to the adoption behaviour of farmers.

Notwithstanding, studies on factors influencing adoption technology have economic and social underpinnings (Sevilleja, 2000).

From the grand mean scores, inputs related constraints (2.0) are about the severest problems facing fish farmers in the region. When further disaggregated, it exposed/highlighted high cost of feed as the major constraint militating against fish farmers in the Niger Delta. Incontestably, the devastating impact of COVID-19 on the economy imposed or triggered rising production costs of goods and services and fish farmers are not exempted. This poses a serious challenge because modern inputs are known to guarantee a successful and bright future for small farmers (fish farmers) and when available modern inputs are innovative packages for an increase in productivity (Falusi and Olayide, 1980). However, in agreement with our findings, inadequate access to input is a major problem fish farmers face in the Niger Delta Region as reported by Anene, Eze & Oputa (2010) and Ogbonna, Onwubuya & Akinnagbe (2014).

Conclusion

This study reveals that inputs-related challenges and institutional constraints, combined with other significantly debilitating variables (Table 1) forecast the state/condition of fish farmers in the Niger Delta. It is a discrepancy and it calls for deliberate interventions or investments on fish farming and aquaculture development in the region. As a petro-dollar state, the implications of these constraints on fish farming and aquaculture development cannot be overemphasized. One of such implications is food insecurity and unemployment. This calls for a policy dialogue with fish farmers in the region with a view to removing or minimixing prohibitive constraints they face with a sense of urgency.

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FISHERIES

Some aspects of the biology of the silver catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) from great Kwa river, Nigeria

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Abstract

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

Keywords: Length-weight relationship; Growth pattern; Silver Catfish; *Chrysichthys nigrodigitatus* Great kwa River

Introduction

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

Materials and Methods

Study Area

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

Sampling Regime

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

Measurements of Biometric Indices

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

Length-Weight Relationship

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

Pauly (1983) equation as follows:

$W = aL^b$

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

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

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

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

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

Results and Discussion
The length-weight relationship and correlation coefficient (r) for male, female and pooled sex of *C. nigrodigitatus* from the Great Kwa River were logarithmically transformed as depicted in Figs. 3-5. The value of 'b' for the male was 1.6067 while that of the female was1.6791, for combined sexes the value was 1.7371. The correlation coefficients (r) were 0.9651, 0.9517 and 0.9329 for male, female and combined sexes respectively.

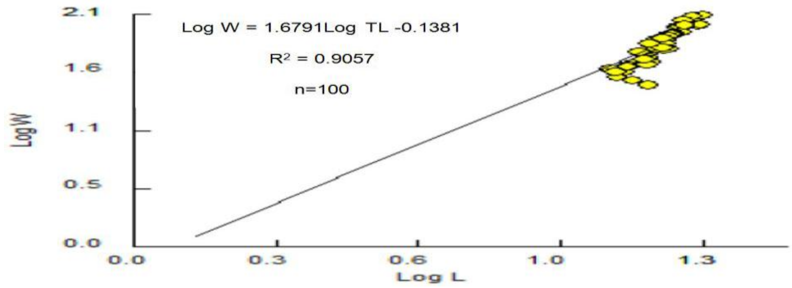

Fig. 1: Length-weight relationship of male *C. nigrodigitatus* obtained from Great Kwa River

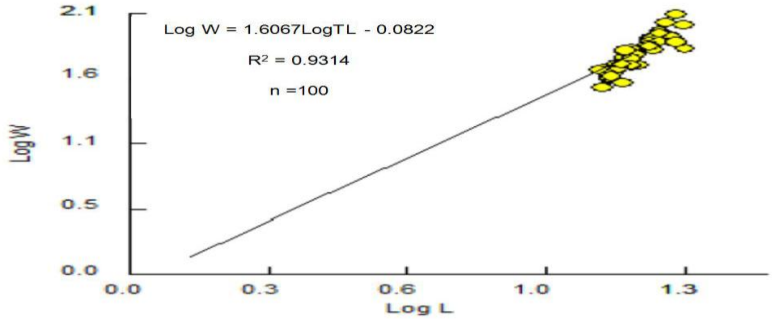

Fig. 4. Length-weight relationship of Female *C. nigrodigitatus* obtained from Great Kwa River

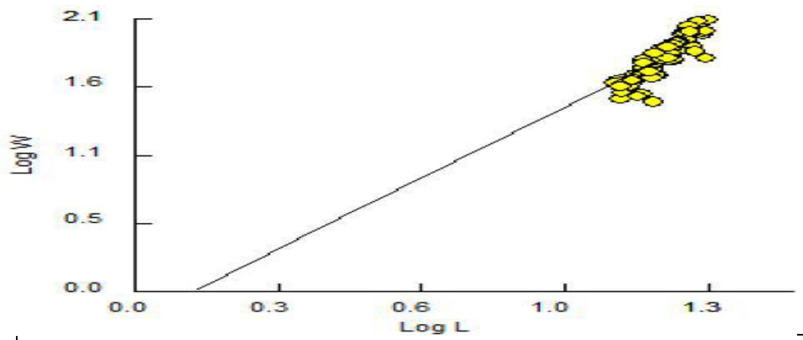

Fig. 5. Length-weight relationship of combined sexes *C. nigrodigitatus* obtained from Great Kwa River

Table 1. The monthly mean condition factor of *C. nigrodigitatus* from the Great Kwa River

MONTH	MALE	FEMALE	POOL SEX
July	2.10 ± 0.06^{a}	2.11 ± 0.05^{a}	2.09 ± 0.03^{a}
August	1.21 ± 0.07^{a}	1.87 ± 0.06^{b}	1.81 ± 0.05^{c}
September	1.78 ± 0.06^{a}	1.81 ± 0.09^{b}	1.97 ± 0.04^{c}

Fulton's condition factor (K) determined for one hundred (100) specimens of *C. nigrodigitatus* (Table 1) showed that mean condition factor of male and female *C. nigrodigitatus* in July was 2.10 ± 0.06 and 2.11 ± 0.05; August was 1.21±0.07 and 1.87 ± 0.06 while September was 1.78± 0.06 and 1.81 ± 0.09 respectively. For pooled sex of *C. nigrodigitatus,* condition factor was 2.09±0.03 (July), 1.81±0.05 (August) and 1.95±0.04 (September). The 'b' value obtained in this study is similar to results obtained from *Ogamba* et al. 2014 who reported a negative allometric growth pattern (b = 0.0536) for *C. nigrodigitatus* collected from Odi River, Niger Delta, Nigeria. Also, a similar finding was reported by Uneke (2013) from Ebonyi River, South Eastern Nigeria. According to Eyo et al.,(2015), fish exhibiting a negative allometric growth pattern tends to become thinner as they increase in length. Findings of this study agrees with findings of Edem et al., (2018) who reported a negative allometric growth pattern function from lower River Benue. According to Lagler et al. *(*1997), such variations in growth parameters documented for different fish species could be attributed to sex, maturity, developmental stage, season and harsh environmental conditions. Froese (2006) opined that length-weight parameters of fish are influenced by both intrinsic and extrinsic factors such as diet, season, stomach fullness, health, preservation techniques, habitat, sex, gonad maturity and annual variation in environmental conditions. Also, "b" value in fish can be affected by sample size, habitat suitability, fishing activities, individual metabolism, age and maturity (Hossain, 2010). In this study, a positive significant (P<0.05) correlation coefficient (r) obtained for *C. nigrodigitatus* (0.965, 0.952 and0.933) indicates a strong association between the total length and total weight of the fish (Andem et al., 2011). Condition factor is an important index used in fisheries science to ascertain the relative wellbeing of fish species. Condition factor which could be used to reflect the health status of water bodies is influenced by factors such as age, sex, food availability, and environmental conditions. Low condition factor in fish may be attributed to poor environmental conditions and reduced availability of food and prey items Abowei and Hart 2009) and Edem et al., (2018). Findings of this study shows that *C. nigrodigitatus* in the Great Kwa River was in a better condition which could be attributed to availability of food.

Conclusion

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

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Relationship between fish species abundance and physico-chemical parameters of Tagwai Lake, Minna, Nigeria.

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Abstract

The study was carried out to investigate the temporal variations, in terms of physico-chemical parameters as well as the fish species abundance in Tagwai Lake, Minna, Nigeria and establish a relationship between both parameters using Canonical correspondence analysis ,from January 2013 to December, 2014. The results of the physico-chemical parameters investigated revealed that the Dissolved Oxygen (DO) ranged from 6.60±0.75 (mg/l) to 12.7±0.66 (mg/l), in 2013 and 6.00±0.31 (mg/l) to 11.20±1.35 (mg/l) in 2014. The BOD ranged from 2.40±0.24 (mg/l) to 7.00±1.52 (mg/l) in 2013; and from 3.28±0.41 (mg/l) to 5.60±1.02 (mg/l) in 2014. The DO values in the rainy season months were significantly different ($p > 0.05$) from those of the dry season months. A total of ten (10) species of fishes belonging to seven families were identified namely, Clariidae (*Clarias gariepinus*), Claroteidae (*Chrysicthys auratus),* Bagridae (*Auchenoglanis occidentalis),* Characidae (*Alestes dentex),* Mormyridae *(Mormyrus hasselquistii)* and Cichlidae (*Sarotherodon galiliaeus, Tilipia zillii and Tilapia aurea, Hemichromis fasciatus, and* Clupeidae (*Odaxothrissa mento*). Correlation between fish species and physico-chemical parameters revealed strong correlation of *Tilapia galileae* and *Mormyrus hasselquistii* with phosphate. *Hemichromis fasciatus* correlated strongly with nitrate, BOD and DO. *Auchenoglanis occidentalis* and *Clarias gariepinus* weakly correlated with pH. This indicate the influence of physico-chemical parameter on the domestication and productivity of the lake

Keywords: Fish species, Physico–chemical parameters, Tagwai Lake

Introduction

Tagwai Lake Minna is the major source of water supply in Minna metropolis. The Lake serves as a primary reservoir for the city of Minna, the largest metropolis in Niger State NSWB (1991). The reservoir has a capacity of 28.3 million cubic meters, thus increasing the flow of river Chanchaga and the supply to the existing water treatment plant of the Niger state water board (Alkali, 1994). Also, the lake serves as sources of primary occupation to the people of the area, trough fishing and farming. However, the significance of fishing activities are often under estimated especially in Nigeria. In many parts of Nigeria, Niger State inclusive, demand for fish has continuously out-weighed supply. Fishing activities in Tagwai lake is all –year- round, with fishermen landing different species of fish (Chukwuemeka, *et al*., 2014). However, due to the recent explosion in human population, environmental degradation and habitat destruction, the supply of fishery resources from the wild have diminished greatly with tremendous impact on human health. This development, expectedly led to the productivity of wild fishery and ultimately the domestication of certain fish species for intensive culture in captivity. Unfortunately, the few fish species successfully domesticated have not been able to meet the increasing human demand for fishery resources. For sustainability of these resources, an adequate knowledge of species composition, diversity and relative abundance of her water bodies must be properly understood and vigorously pursued (Lawson and Olusanya, 2010). Very importantly, the success of any aquaculture is based on a sound knowledge of the biology, ecology and habitat of targeted species. Experts have alluded to the strong positive relationships that exist between the biology, ecology and environmental requirement of fish species and productivity performance in captivity. Understanding these aspects of fish requirements for successful domestication will enhance the cost effective management protocol for the targeted fish species thus increasing productivity, commercial domestication and improved nutrition status of the populace. Thus, there is an urgent need for domestication and intensive culturing of more fish species with great potentials. On these premises the fish species diversity and pysico-chemical parameters of Tagwai Lake, Minna, Nigeria was carried out to determine correlation between both factors in relation to domestication and productivity of the fishes.

Materials and Methods

Study area

The study was carried out in Tagwai Lake (longitude 6°39' E and longitude 91°41'E and latitude 9°34' N and latitude 9°37' N) Minna, Niger State, covering a land area of 88km^2 with an estimated human population of 1.2 million. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30°C, 61.00% and 1334.00mm, respectively (Alkali,1994)

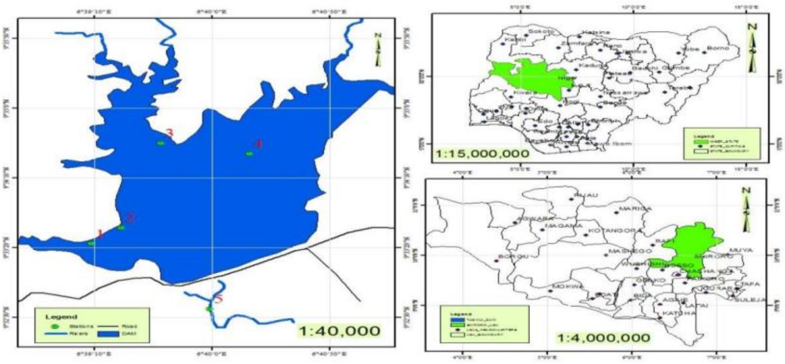

Figure 1. Map of Niger State indicating Tagwai Lake in Bosso Local Government
Sources: Centre for Remote Sensing, Department of Geography, FUT, Minna (2018).

Sample Collection (Physico-Chemical Parameter)

The water samples were collected in 50 cl plastic containers at 10 cm depth from five different stations on the lake (station I, station II, station III, station IV and station V). These stations were selected based on the accessibility of the major tributaries into the lake. Samples were collected bi-weekly and taken to Water Resources Aquaculture and Fisheries Technology laboratory of Federal University of Technology Minna to test for physico-chemical parameter.

Physico-Chemical Parameters

Physic-chemical analysis of the water samples were carried using standard procedures of American Public Health Association (APHA, 2009). Parameters such as Dissolved Oxygen, Hardness, BOD, Nitrate and Phosphate were analysed for and dissolved Oxygen was determined using the modified Winkler - Azide method (APHA, 2009)

Fish Sampling and Identification of Fish Species

Routine sampling of fish in the Lake was conducted bi-weekly for two years (January 2013-December 2014). Sampling was done in the early hours of the day with the assistance of the local fisher folks in the area. Identification and listing of all fish species landed was done using the monographs, standard identification keys and field guide in accordance with Reed *et al* (1967) and Idodo-Umeh (2003). Identification was done from family to species level for different fishes caught.

Statistical Analysis

Data collected for physico-chemical parameters of the surface water and monthly data on species composition were all subjected to analysis of variance (ANOVA) using Statistical Packages of Social Science (SPSS).Canonical Correspondence Analysis (CCA),was used to ascertain the relationship between Physico-chemical parameters and Fish species abundance of Tagwai Lake. All analysis were considered at 0.05 level of significance.

Results

Physico-Chemical Parameter in Tagwai Lake, Minna

The monthly analysis of water quality parameters of Tagwai Lake, Minna during the sample period (2013 - 204) are presented below in Table.1 and 2. The results of monthly dynamic physico-chemical parameters revealed significant variation were in all the parameters from January to December for both years with higher values recorded in 2014. The Dissolved Oxygen (DO) ranged from 6.60±0.75 (mg/l) to 12.7±0.66 (mg/l) in 2013 and 6.00±0.31 (mg/l) to 11.20±1.35 (mg/l) in 2014. The DO values in the rainy season months were significantly different from those of the dry season months. The highest and the lowest BOD was obtained in 2013 with the value of 7.00±1.52 mg/l and 2.40±0.24 mg/l, respectively. The BOD obtained in 2014 fell within the range of the values obtained for 2013 (3.28±0.41 mg/l to 5.60±1.02 mg/l). Significant variation in alkalinity level were recorded in both years with the highest and the lowest alkalinity been 42.20± 0.66mg/l and 10.00 ± 0.37 mg/l, respectively. There was also variation in the hardness values from January to December in both year with values ranged from 29.60 ± 1.33 (mg/l) to 65.20 ± 2.40 (mg/l).The chloride values in September, October, November, December and January were significantly different from those of February, March, April, May, June, July and August. The temperature values ranged from 26.00 ± 0.32ºC to 32.60 ± 2.68 ºC. Between January and April, there was no significant difference in temperature. This result is in conformity with that of Kolo *et al*,(2009),who reported that all the physico-chemical parameters fell within permissible limit set by WHO in Dam Zaria.Karanth 1987 reported that almost all the physical chemical parameters assessed were high and this made the water of that Lake not favourable for Aquatic use.

Relative Abundance of Ichthyofaina of Tagwai Lake Minna

The species composition and relative abundance of fishes showed that Tilapia *galileae* has the highest number abundance of 2474 equivalent to 31.92%. This was followed by O*daxothrissa mento* which was 1701 in number and 21.95% and *Tilipia zillii* with 1250 individuals and 16.13 in percentage. The least abundance of the fish species encountered was *Heamichromis fasciatus* which was about 0.12%.This result also conformed with the findings of Adeyemi *et al (2010),*Ojutiku et al (2008) and Chukwuemeka (2014) who reported that Tilapia species always dominated most water bodies.

Table 3: Species Composition and Relative Abundance of the Ichthyofauna in Tagwai Lake

SPECIES	FAMILY	NO.OF SPECIES	%
Tilapia galileae	Cichlidae	2474	31.92
Tilapia zillii	Cichlidae	1250	16.13
Tilapia aurea	Cichlidae	274	3.53
Hemichromis fasciatus	Cichlidae	9	0.12
Clarias gariepinus	Clariidae	111	1.43
A*uchenoglanis occidentalis*	Bagridae	346	4.46
Chrysicthys auratus	Claroteidae	554	7.15
Mormyrus hasselquistii	Mormyridae	26	0.34
Alestes dentex	Alestidae	1107	14.28
Odaxothrissa mento	Clupeidae	1701	21.95
TOTAL NUMBER		7750	100%

Table 1: Physico-chemical parameters of Surface Water of Tagwai Lake during sampling period 2013

Sample	DO (mg/l)	BOD (mg/l)	Conductivity (μΩ/cm)	pH	Alkalinity (mg/l)	Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Temperature (˚C)	Depth (m)
January	7.10±0.24^{b}	4.10±0.24^{c}	175.80±5.77^{e}	7.46±0.02^{b}	38.20±3.67^{g}	64.40±1.60^{e}	10.78±1.16^{b}	2.76±0.66^{e}	2.30±0.19^{d}	26.60±0.68^{a}	8.64±0.59^{a}
February	8.80±1.02^{b}	7.00±1.52^{d}	160.60±5.11^{e}	7.50±0.14^{b}	32.60±1.08^{f}	65.20±2.40^{e}	12.24±0.60^{c}	0.50±0.12^{b}	2.54±0.09^{d}	26.30±0.37^{a}	8.76±0.62^{a}
March	7.20±0.64^{b}	2.92±0.22^{a}	162.60±2.33^{e}	7.76±0.04^{b}	37.40±1.17^{g}	29.60±1.33^{a}	9.20±0.68^{b}	0.38±0.09^{a}	1.88±0.26^{c}	26.00±0.32^{a}	9.00±0.71^{a}
April	6.60±0.75^{b}	3.00±0.32^{b}	149.00±2.50^{d}	6.08±0.05^{b}	19.20±1.07^{d}	51.60±4.17^{d}	13.92±2.32^{c}	0.58±0.09^{b}	1.40±0.22^{c}	26.60±0.51^{a}	8.60±0.87^{a}
May	7.30±0.20^{b}	2.80±0.25^{a}	160.60±1.46^{e}	6.90±0.05^{b}	20.00±1.26^{d}	52.40±4.31^{d}	14.52±2.43^{c}	0.36±0.04^{a}	0.78±0.06^{b}	25.44±1.53^{b}	8.60±0.71^{a}
June	6.80±0.37^{b}	2.60±0.19^{a}	117.50±0.74^{c}	5.74±0.13^{a}	25.40±1.21^{e}	47.70±1.04^{d}	7.68±1.25^{ab}	0.26±0.04^{a}	0.46±0.05^{a}	32.60±2.68^{b}	8.50±0.71^{a}
July	8.00±0.71^{b}	3.46±0.28^{b}	169.00±2.17^{e}	7.90±0.07^{b}	38.40±0.87^{g}	42.30±0.80^{c}	6.24±0.22^{a}	0.24±0.02^{a}	0.44±0.05^{a}	29.80±0.58^{b}	7.64±0.73^{a}
August	6.90±0.33^{b}	3.50±0.61^{b}	80.00±2.76^{a}	6.92±0.04^{b}	13.40±0.94^{b}	48.20±3.02^{d}	5.98±0.29^{a}	2.06±0.16^{d}	0.20±0.05^{a}	27.32±0.99^{a}	11.60±0.96^{b}
September	4.80±0.58^{a}	2.40±0.24^{a}	63.80±1.88^{a}	6.70±0.15^{b}	10.06±0.37^{a}	33.60±0.68^{b}	8.64±0.78^{b}	2.42±0.12^{d}	0.78±0.08^{b}	31.40±2.18^{b}	13.36±1.04^{c}
October	9.60±0.73^{c}	4.40±0.43^{c}	\84.32±7.17^{b}	8.14±0.04^{b}	11.10±0.62^{a}	41.70±1.58^{c}	11.16±0.51^{b}	1.76±0.12^{c}	0.38±0.12^{a}	30.40±2.73^{b}	13.72±0.99^{c}
November	12.70±0.66^{d}	6.06±0.48^{d}	64.90±0.91^{a}	7.30±0.11^{b}	11.70±0.54^{a}	36.20±1.10^{b}	8.86±0.35^{b}	2.10±0.13^{d}	0.64±0.05^{b}	30.50±1.88^{b}	11.96±0.85^{b}
December	11.60±1.33^{d}	5.60±0.51^{c}	80.64±0.52^{b}	7.14±0.09^{b}	16.00±0.89^{c}	47.60±2.48^{d}	8.44±0.88^{b}	2.12±0.50^{d}	0.72±0.05^{b}	29.40±0.19^{b}	11.68±0.59^{b}

Table 2: Physico-chemical parameters of Surface Water of Tagwai Lake during sampling period 2014

Sample	DO (mg/l)	BOD (mg/l)	Conductivity (μΩ/cm)	pH	Alkalinity (mg/l)	Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Temperature (˚C)	Depth (m)
January	8.80±2.20^{b}	5.10±0.48^{b}	159.3±9.74^{f}	7.22±0.07^{a}	29.00±2.42^{b}	46.80±1.30^{a}	13.4±0.33^{c}	0.40±0.07^{b}	0.44±0.09^{c}	29.20±2.59^{a}	9.96±1.44^{a}
February	7.80±1.04^{b}	3.50±0.35^{a}	204.50±5.27^{g}	6.50±0.07^{a}	25.40±0.87^{a}	49.40±2.38^{b}	12.08±0.22^{c}	0.46±0.12^{b}	0.10±0.00^{b}	30.27±2.08^{a}	8.64±0.73^{a}
March	6.00±0.31^{a}	3.28±0.41^{a}	149.40±1.72^{e}	6.22±0.02^{a}	31.20±3.20^{b}	52.80±3.82^{b}	10.00±0.33^{b}	0.32±0.10^{b}	0.10±0.00^{b}	29.40±1.28^{a}	8.76±1.37^{a}
April	11.20±1.35^{c}	5.60±1.02^{b}	588.20±4.04^{h}	6.10±0.03^{a}	24.80±1.62^{a}	54.00±2.00^{b}	14.56±0.39^{c}	0.48±0.12^{b}	0.10±0.00^{b}	25.80±1.98^{a}	6.02±0.31^{a}
May	11.20±0.58^{c}	5.60±0.48^{b}	132.90±6.98^{d}	7.48±0.11^{a}	32.00±0.83^{b}	58.40±2.11^{c}	16.56±0.28^{d}	0.24±0.02^{a}	0.10±0.00^{b}	26.40±1.51^{a}	6.58±0.56^{a}
June	8.70±1.03^{b}	3.90±0.33^{a}	58.50±1.20^{a}	7.52±0.08^{a}	29.80±1.35^{b}	62.40±4.91^{c}	14.66±.26^{c}	0.16±0.02^{a}	0.10±0.00^{b}	27.40±1.90^{a}	7.72±0.53^{a}
July	10.60±0.67^{c}	5.50±0.59^{b}	54.00±0.47^{a}	7.46±0.05^{a}	42.20±0.66^{c}	80.00±0.54^{d}	14.16±0.10^{c}	0.18±0.02^{a}	0.10±0.00^{b}	28.10±1.23^{a}	8.00±0.41a
August	10.60±0.67^{c}	4.96±0.34^{a}	61.70±2.10^{b}	7.50±0.03^{a}	22.70±2.23^{a}	58.46±5.40^{c}	10.94±0.18^{b}	0.10±0.00^{a}	0.08±0.01a	29.40±2.14^{b}	8.72±0.49^{a}
September	8.40±0.60^{b}	4.30±0.33^{a}	72.40±6.51^{b}	7.22±0.02^{a}	25.40±0.87^{a}	59.80±1.90^{c}	0.14±0.12^{a}	0.10±0.00^{a}	0.10±0.00b	31.00±1.07^{a}	10.24±0.75^{a}
October	7.20±0.37^{b}	4.10±0.18^{a}	97.50±3.94^{c}	6.82±0.03^{a}	25.90±1.96^{a}	64.00±3.61^{c}	9.12±0.19^{b}	0.10±0.00^{a}	0.10±0.00b	30.90±1.48^{a}	11.44±1.25^{a}
November	8.00±0.65^{b}	4.60±0.48^{a}	64.90±2.21^{b}	6.92±0.03^{a}	24.20±1.52^{a}	56.70±1.85^{b}	8.82±0.12^{b}	0.10±0.00^{a}	0.10±0.00b	30.60±1.26^{a}	11.32±1.38^{a}
December	8.10±1.14^{b}	4.00±0.00^{a}	58.80±2.15^{a}	6.68±0.02^{a}	22.10±2.87^{a}	53.80±3.18^{b}	8.46±0.08^{b}	0.10±0.00^{a}	0.10±0.00b	30.40±1.38^{a}	10.26±0.94^{a}

Values followed by the same superscript alphabet(s) on the same column are not significantly different at $p>0.05$ from Duncan Multiple Range Test. Values are means ± standard Error of mean of two determinations.

Relationship between Physico-Chemical Parameters and Fish Species Abundance of Tagwai Lake Minna

A cross correlation between fish species abundance and physico-chemical parameters revealed that in 2013, *Tilapia galilaea* and *Mormyrus hasselquistii* correlated strongly with Phosphate. *Hemichromis faciatus* correlated strongly with Nitrate, BOD, and DO. *Auchenoglanis occidentalis* and *Clarias gariepinus* correlated with pH. *Chrysichthys auratus* correlated with Depth and Temperature (Figure 1). Interestingly, similar trend of correlation was obtained in 2014. However, *Alestes dentex* and *Chrysichthys auratus* correlated with Alkalinity, Conductivity and Temperature (Figure 2). *Odaxotrissa mento* and *Tilapia zilli* did not correlate with any of the physico-chemical parameters. Nitrate did not also correlate with any of the fish species.

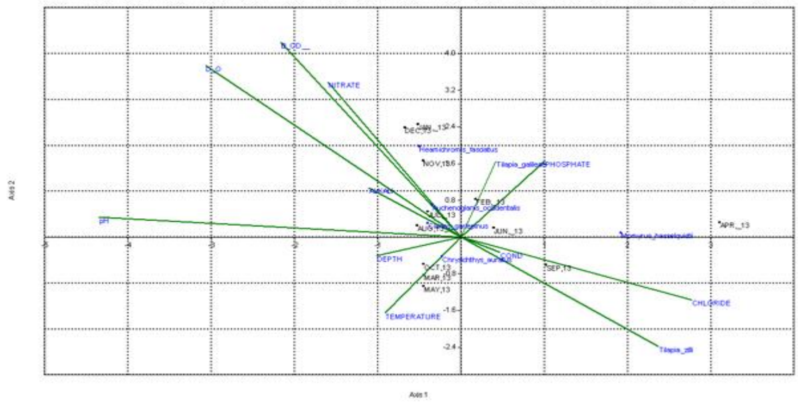

Figure 1: Canonical Correspondence Analysis showing the relationship between Physico-Chemical Parameters and Fish Species Abundance of Tagwai Lake Minna, 2013

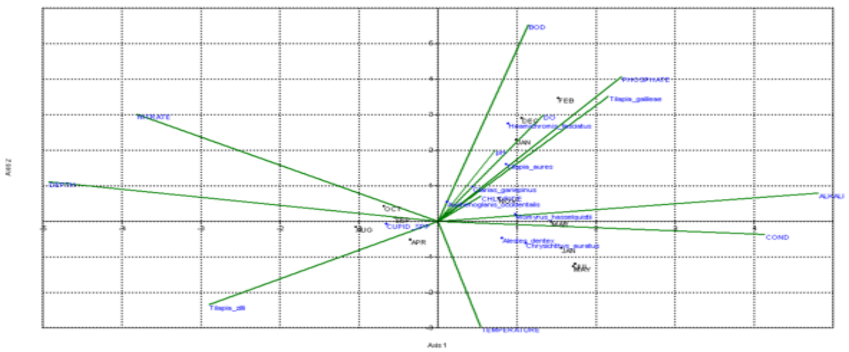

Figure 2: Canonical Correspondence Analysis of the relationship between Physico Chemical Parameters and Fish Species Diversity of Tagwai Lake Minna, 2014

When the physico-chemical parameters were correlated with the fish species abundance in Tagwai Lake.In 2013, *Tilapia galilaea* and *Mormyrus hasselquistii* were seen to correlate strongly with Phosphate; implies that increase in Phosphate in the water could bring about a corresponding increase in the production of T. *galilaea* and M. *hasselquistii* .BOD, DO and Nitrate in a water body could be manipulated to bring about increased production of *Hemichromis faciatus* since they correlated strongly with it. Other fish species such as *Auchenoglanis occidentalis* and *Clarias gariepinus* require just the normal amount of pH to survive as they were seen to cluster around the middle of the quadrant. *Chrysichthys auratus* which correlated with Depth and Temperature will just do well within the normal depth and temperature.The trend was the same in 2014 for *Tilapia galileae*, which correlated strongly with Phosphate; therefore Phosphate could be altered to increase its production. *Tilapia galileae* would do well just within the tolerable limits of BOD, DO and pH could be manipulated to increase the production of *Hemichromis faciatus* since they strongly correlate with it. *H.faciatus* would require just the normal range of Alkalinity and Chloride to survive. *Tilapia aurea, Auchenoglanis occidentalis, Clarias gariepinus* just require the normal amount of chloride to survive as they are also seen to cluster around the middle of the quadrant. These three species just require the normal amount of Phosphate, pH, and BOD to survive*; Alestesdentex* and *C.auratus* require just the normal amount of Alkalinity, Conductivity and Temperature to survive. *Tilapia zilli* did not correlate with any physico-chemical parameter.

Conclusion

In conclusion, findings from this study revealed that most of the physico-chemical parameters of Tagwai Lake were within permissible limits set by WHO 2004. This implies that the water of this Lake can be considered fit to support the survival, growth and development of various Fish species. The study also revealed that 10 fish species, belonging to seven fish families were present in the lake. The correlation between fish species and physico-chemical parameters, revealed that most of the physico-chemical parameters correlated with all the fish species throughout the research period except Nitrate.

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Length–Weight Relationship and Condition Factor of Fresh Water Turtle (*Pelusios castaneus*) Dry Season 1 Study.

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Abstract
This study aimed to determine the length weight relationship of fresh water turtle *Pelusios castaneus* from a natural wetland habitat in Sagamu, Ogun State, Nigeria. Turtle samples were collected from the study area using two-way valve cane trap. Standard techniques of length-weight and length weight relationship were used to analyze data obtained with graphical presentation. Samples of six (n=6) turtle with carapace length range 16.5-24.0cm and weight 430.0-1333.0g was collected. Length weight relationship indicated allometric growth (TW:CL; TW:PL; TW:CW) (2.41; r^2 0.93); (2.11; r^2 0.95) (2.14: r^2 0.93) with isometric growth for TW;PW (3.19; r^2 0.87) with condition factor (8.27) indicating stable well-being of turtle in the study area.

Keywords: Anthropogenic, Freshwater, Rainy season, Turtle, Wetland.

Introduction

Turtle inhabits the marine and freshwater habitat of the world. The freshwater habitat is known to be rich in biodiversity of Fauna and flora of which water turtle is recognized. The habitat of fresh water turtle are marshes, ponds, lakes, rivers and estuaries (Meyers-Schone and Walton 1994; Bandas and Higgins 2004). The fresh water habitat of West Africa has been found to be dominated by *Pelusios niger* and *Pelusios castaneus* (Luiselli and Akani 2002; Segniagbeto *et al.,* 2015). Shi *et al.,* (2013) described the species as of lower risk and of least concern on the red list conservation status of IUCN and not listed by CITES but now listed as near threatened by Luiselli *et al.,* (2018). Turtle abundance and distribution in Nigeria has been reported, while Ohiamani *et al.,* (2014) described that turtle and tortoise exploitation is unsustainable in Nigeria.

Research have documented the haematology (Omonona *et al.,* 2011), Olukole *et al.,* (2014a) skeletal system, Olukole *et al.,* (2014b) anatomy, Olukole *et al.,* (2014c) spermatogenesis and sales of fresh water turtle (Ohimain *et al.,* 2014; Odiko and Akpotebu 2017), Olayinka-Adefemi *et al.,* (2017) transit time in digestion of diet of the fresh water turtle in Nigeria. LuisellI, *et al.,* (2003) studied the hinge-back tortoises (genus *Kinixys*). Anthropogenic activities especially from exploration for mineral resources have led to decline in stocks in the Niger delta region of Nigeria (Luiselli and Akani 2002, Luiselli *et al.,* 2018). Luiselli *et al.,* (2000) reported scientific data on Chelonian population in Nigeria to be scarce, lack of knowledge on species diversity with few data on distribution. Exploitation of wildlife through biodiversity management will shift human concept of indiscriminate hunting and free gift of nature of wildlife for trade (Sotolu, 2017). Turtle has been reported to survive in urban freshwater (Spinks, *et al*., 2003) with report of *P. niger* in savanna dry land (Umar *et al.,* 2020) makes this species to be of special interest in our study. This research aimed at determining the length-weight relationship and condition factor *Pelusios castaneus* caught in a freshwater habitat in South west Nigeria.

Materials and methods

The study site was in Sagamu Local Government area of Ogun State, and collection point given by 6°49'18.46"N 3°38'27.47"E elevation 22m eye alt. 821m goggle earth map (26th September 2019). The collection of samples was achieved by dividing the year into two; January-June (early season) and July-December (late season). These seasons depict the rainfall and dry season in the study area with taint of both wet and dry condition within season. This study covered the dry season. Turtle samples (n=6) were collected from the study area during the dry season from 10-26 September 2019 using a two-way valve local cane fish trap. Samples were transported to the laboratory of Department of Fisheries Management College of Agricultural Sciences, Olabisi Onabanjo University for further investigation. The laboratory technique of measuring board was used in length measurements (cm). The carapace length and width as well as plastron length and width were measured from the tip of the shell head on both sides to the tip of the tail and weight was taken, using an electronic weighing balance (g). Length and weight data generated was subjected to relationship: $W= aL^b$ (Pauly, 1984) and logarithmic transformation values of constants "a" and "b" was estimated: $\text{Log } W = \log a + b \log L$ (Pauly, 1984) using linear regression analysis. While Fulton's Condition Factor $(K) = 100W/ L^3$ (Ikomi and Odun, 1998) used to assess the state of wellbeing of the species. The data from length-weight and condition factor was analysed statistically using descriptive statistics and level of association with respect to length–weight was subjected to correlation and regression analysis with Microsoft Excel package.

Results

Length-weight measurement

The total number of (n=6) *Pelusios castaneus* was collected from study site (Table 1) during the dry season 1 collection period and ranges of length and weight described below.

Length-weight relationship

Table 2 shows the values of the regression constant of the length-weight relationship of *P. castaneus***.** The values of a were significantly lower ($p<0.05$) than 3 in Total Weight:Carapace Length (TW:CL); Total Weight:Plastron Length (TW:PL); Total Weight:Carapace Width (TW:CW); TW:PW= Total Weight:Plastron Width.

Table 1: Ranges and mean values of length and weight of *P. castaneus*.

Parameters	Range, ±SE
Carapace Length Range (cm)	16.50 -24.00
Mean Carapace Length (cm)	19.92 ±1.31
Total Weight Range (g)	430.00-1333.00
Mean Total Weight (g)	813.17±132.09
Plastron Length Range (cm)	14.00-22.00
Mean Plastron Length (cm)	17.83 ±1.33
Carapace Width Range (cm)	14.00-22.00
Mean Carapace Width (cm)	17.07 ±1.29
Plastron Width Range (cm)	11.30-15.00
Mean Plastron Width (cm)	12.83±0.63
K factor	8.27-12.42
Mean K factor	10.04 ±0.61

Table 2: Length-weight relationship coefficient of *P. castaneus*.

Logarithm	Regression Coefficient		Regression Summary		Correlation Coefficient
	a SE	b SE	R^2	R	
TW:CL	2.41±0.34	-0.24±0.44	0.93	0.92	0.96
TW:PL	2.11±0.25	0.25±0.32	0.95	0.93	0.97
TW:CW	2.15±0.29	0.25±0.35	0.93	0.92	0.97
TW:PW	3.19±0.61	-0.65±0.68	0.87	0.84	0.93

TW:CL= total weight:carapace length; TW:PL= total weight:plastron length; TW:CW= total weight:carapace width; TW:PW= total weight:plastron width.

Discussion

The existence of same species has been reported by Odiko and Akpotebu (2017), Ohiamani *et al.,* (2014) Omonona *et al.,* (2011) and Olukole *et al.,* (2014a) in South-East and South-West Nigeria. Luiselli *et al.,* (2018) reported that *P. castaneus* had been confused with *P. niger* and *P. subniger.* (Shi *et al.,* 2013). Ohiamani *et al.,* (2014) reported 98% turtle abundance and <2% tortoise in their study. Luiselli *et al.,* (2000), Segniagbeto *et al.,* (2015) study sites were similar to this study as it lies in the same vegetation zone (rain forest) with the same duration of rain and dry season. The study area was surrounded by human habitation, with the survival of the turtle in the environment due to environmental pressures of urban communities not impacting on species biodiversity. Size distribution of captured turtle corroborates that different stage of growth within the population (De-Lathouder *et al.,* 2009) in the wild. Traps used in our study to catch turtle was different from the ones reported by Ohiamani *et al.,* (2014) who used baited hook traps, basking traps and sliding traps. Small sample size collection had earlier been reported for similar studies on fresh water turtle; Olukole *et al.,* (2014c) (10 adult male) and Olayinka-Adefemi *et al.,* (2017) sampled n=8 *P. castatenus*.

Dunson (1967) calculation and estimation based on carapace length to weight of turtles corresponds with the data of this study. Jones *et al.,* (2008) also estimated growth of *D. coriacea* (Leather back sea turtles) hatchlings in captivity to extrapolate for growth in the wild. Omonona *et al.,* (2011) average weight 0.31kg-1.8kg, CL 18-22cm for adult and 10-12cm juvenile. CL within range of 20cm reported for *P. subniger* (Shi *et al.,* 2013), Olukole *et al.,* (2014a) 0.75kg, CL23.4cm, PL 16.3cm. Olukole *et al.,* (2014b) 0.72kg, CL24.4cm PL 15.7cm, Olukole *et al.,*(2014c) 0.58kg-1.20kg, CL 20.3-28.5cm, PL 17.8-21.2cm. Ohiamani *et al.,* (2014) CL, CW and weight of *Pelusios spp.* were greater than our study. The CL in this study was higher than the value reported for *Pelomedusa* but falls within the range of *Pelusios spp*. Based on the classification of Segniagbeto *et al.,* (2015) of CL into life stages all the samples in this study were within the range of 15-20cm which made the samples adult while no juvenile or hatchlings were observed. Yazarloo *et al.,* (2017) weight range for Caspian pond turtle 23.93-1856g. Luiselli *et* *al.,* (2018) observed CL 35.5cm. *G. nigrinoda* ranged from 145 to 177 mm in plastron length and the *G. pulchra* ranged from 185 to 207 mm in plastron length (Iverson *et al.,* 2019).

The values of a were significantly lower ($p<0.05$) than 3 in TW:CL; TW:PL; TW:CW and allometric growth noticed. Positive correlation between TW:PW of sampled turtles indicated by high values of regression coefficient showed weight and length increase which was in line with the finding of Segniagbeto *et al.,* (2017) that observed five sea turtle species in Togo all species were positively correlated with high r value. The b values in TW:CL; TW:PW (-0.24; -0.65) recorded for *P. castaneus* showed that proportionate rate of increase in TW:CL; TW:PW was not the same to body weight increment and Sule *et al.,* (2020) reported similar result for *C. gariepinus.* While isometric growth was observed in TW:PW. Spinks *et al.,* (2003) r^2=0.924 for carapace length vs. weight of *E. marmorata* corroborates this study with similar value. The domination of adult species in our study was similar to Spinks *et al.,* (2003). Wabnitz and Pauly (2008) r^2 0.992 reported for *C. mydas* similar to that of this study but differs from other sea turtles reviewed.

Conclusion
A positive correlation between length and the weight and condition factor of *Pelusios castaneus* revealed that turtle in the study area are in a state of well-being.

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Stomach content analysis of mangrove oyster crassostrea gasar from Badagry Creek, Lagos Nigeria

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Abstract
Mangrove oyster, *Crassostrea gasar* is a very important marine shellfish resource in West African coast; it belongs to the lamellibranchs class, in the order Dysonta and Family Ostreidae. To investigate the stomach content composition of *C.gasar*; representative samples of the species were used. The samples were preserved immediately after collection in 90% ethanol for preservation of the flesh and gut contents. The valves of oysters were separated and the gut and stomach were dissected. The volumetric, numeric and percentage occurrence data of the food content were calculated and recorded. A total of 650 stomachs were analyzed. Dominant food items identified in the stomach were phytoplankton, substrate particles and detritus. The phytoplankton comprised of 38 genus which belongs to 10 families and they include; Diatomophyceae (Diatoms) (36.8%), Bacillariophyceae (Diatoms) 0.7%, Cyanophyceae) 19.6%, Chlorophyceae (10.2%) amongst others. In conclusion, *C.gasar* diet analysis revealed that they are filter-feeders foraging mainly on phytoplankton.

Keywords: Bivalves, Oyster, filter feeders, Plankton**.**

Introduction

The Mangrove oyster, *Crassostrea gasar* is a very important marine shellfish resource in West African coast; it belongs to the lamellibranchs class, in the order Dysonta and Family Ostreidae. It is widely spread along the west coast of Africa from Senegal to Angola (Lapague *et al*., 2002, Ansa and Bashir, 2007). *C.gasar* inhabits the estuarine/ coastal mangrove swampland along Niger delta and Lagos Coast, they can be found attached permanently to mangrove trees and any other hard substrate in water. They are usually in clusters attached to the prop roots of the mangrove; they thrive in intertidal brackish water with wide salinity and temperature tolerance range. *C. gasar* is massively harvested by grassroots artisanal and commercial fisher folks for food. Compared to finfishes, they exhibit an efficient conversion rate of primary production as well as relatively low cost of rearing (Abiogba and Henadou, 2006; Adite *et al.*, 2013). Also with regards to its ecological importance, *Crassostrea gasar* stands out as an indicator of environmental quality and it is used to measure the degree of contamination of aquatic ecosystem, since it accumulates pollutants that could even lead to chromosomal changes and mutations Adite *et al.*, 2013).

Materials and methods

The creek lies within longitude 2° 42'E to 3°24'E and stretches between 6°22'N to 6°42'N sharing boundary with republic of Benin. It is equidistant from the entrance of Lagos and Cotonou harbor and is influenced by tides and floods from the Lagos and Cotonou Harbor through Lake Novo and Porto- Novo.

Stomach content Analysis

To investigate the food and feeding ecology of *C.gasar*; representative samples of the species were used. The representative samples were preserved immediately after collection in 90% ethanol to allow better entrance of the alcohol and better preservation of the flesh and gut contents. The valves of oysters were separated and the gut and stomach were dissected. The content from the gut and stomach were emptied into a glass slide for examination under a binocular microscope to identify the contents. The preys were identified to the lowest possible taxonomic level using identification guides of Needham (1962), Newell and Newell (1966), Compere (1977), Botes (2003). After identification, each food item of sub sample was separated; counted and volumetric percentage of each prey was estimated.

The volumetric, numeric and percentage occurrence data of the food content were calculated and recorded using the formula.

Volumetric Analysis; Percentage volume of food item = $\frac{\text{Volume of the particular food item}}{\text{Total number of all food items}}\ x\ 100$

Numeric analysis: the number of individual of each food type in each stomach is counted and expressed as a percentage of the total number of food items in the sample studied as described by Hyslop, (1980) in Adite *et al*, 2013. The numeric analysis of each food item ingested by *C.gasar* was computed as follows;

Percent number of a food item = $\frac{\text{total number of a particular food item}}{\text{total number of all food items}}\ x\ 100$

Frequency of occurrence method

The stomach contents of *C.gasar* are examined and the individual food organisms sorted and identified. The number of stomachs in which each item occurs is recorded and expressed as a percentage of the total number of stomachs examined, empty stomach are excluded.

$$\text{Frequency of Occurrence} = \frac{\text{total number of stomachs with the particular food item}}{\text{Total number of stomachs with food}} \, x\,100$$

Index of Relative Importance (IRI)

Index of Relative Importance according to Leo Pinkas., 1971, is an integration of the measurement of number, frequency of occurrence and volume or weight) It determines on the most important and most preferred food of fishes.

Index of Relative Importance = (% N_i + %V_i) % O_i

Where; N_i, V_i and $O_{i,}$ represent percentages of number, volume and frequency of occurrence of Prey i respectively.

Results

A total of 650 stomachs were analyzed. Dominant food items identified in the stomach containing food were phytoplankton, substrate particles and detritus. The phytoplankton comprised of 38 genus which belongs to 10 families and they include; Diatomophyceae (Diatoms) (36.8%), the most common species encountered in this family were; *Melosira*, *Nitzchia*, *Closterium*, *Synedra*, *Pleurosigma*, *Gomphonema*, *Gyrosigma*, *Cyclotella*, and *Stephanodiscus*.

The family Bacillariophyceae (Diatoms) 0.7% also comprised of 4 species namely; *Coscinodiscus*, *Coconeis*, *Diatoma* and *Surirella*. Chlorophyceae (10.2%) the green algae, was represented by the following genus; *Chlorella*, *Pediastrum*, *Tetraspora*, *Microspora*, *Protococus*, *Ulothrix*, *Cladophora*, *Chaetophora*, *Cosmarium* and *Ankistrodesmus*.

The blue-green algae (Cyanophyceae) with 19.6% volumetric proportion had 5 representative genuses which are; *Oscillatoria*, *Gleocapsia*, *Microcystis*, *Anacystis*, *Trichodesmium*.

Zygnemataceae had just one representative *Zygnema*, likewise the family Ceratiaceae a dinoflagellate represented by the genus *Ceratium*.

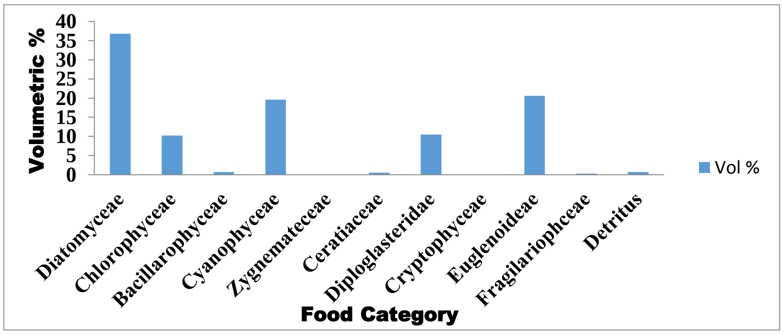

Fig.1. Volumetric percentage (%) of food ingested by *Crassostrea gasar* from Badagry Creek

Numerically, the Diatomophyceae dominated the diet composition of the oysters, with 47.9%. This was closely followed by the Blue-green algae (Cyanophyceae) with 26.94%. The Chlorophyceae (green algae) had a numeric proportion of 15.06%. The Nematode *Diplogateroides* were also high in number 6.8%. Detritus and substrates (1.38%) were the next with high number.

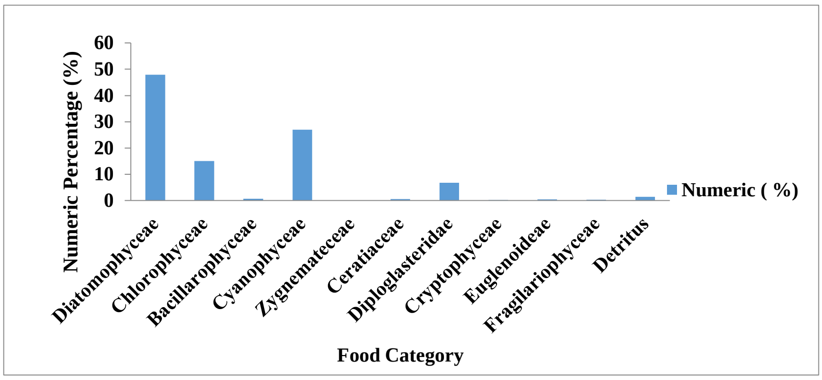

Fig.2. Numeric percentage (%) of food ingested by *Crassostrea gasar* from Badagry creek

Percentage Occurrence

The most occurred prey in the stomach of the oysters were *Oscillatoria* (14.49%) found in 87 stomachs, *Microspora* (11.66%), found in 70 stomachs, the Nematode (*Diplogasteroides*) were next with 10.32% and they were found in 62 stomachs, *Navicula* (9.99%) were found in 60 stomachs, *Phacus* (9.16%) were found in 55 stomachs. *Nitzchia* were also high in occurrence with 7.83% and they occurred in 47 stomachs, following closely was *Melosira* (7.16%) were found in 43 stomach. *Ankistrodesmus* (4.33%) occurred in 26 stomachs, *Gleocapsia* (3.66%) were recorded in 22 stomachs and *Chlorella* (2.16%) was recorded in 13 stomachs. The lowest percentage of occurrence were 0.16% which occurred in 1 stomach each were *Fragillaria*, *Tabellaria*, *Zygnema* and 0.17% were *Cryptomonas*,*Trichodesmium*, *Coconeis* and *Stephanodiscus* respectively.

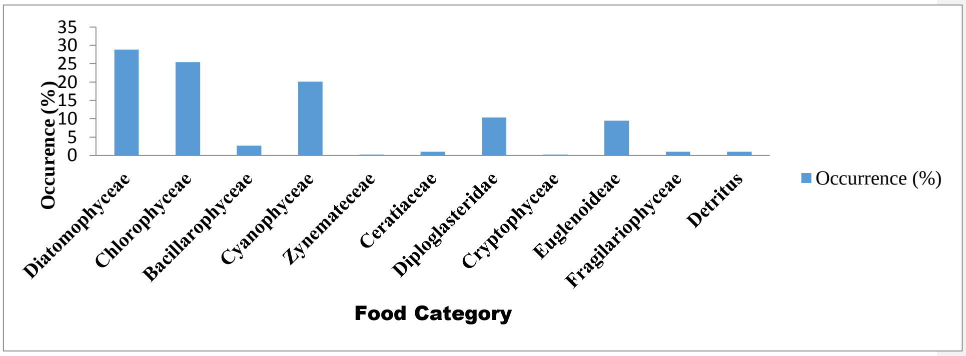

Fig.3. Percentage (%) occurrence of food ingested by *Crassostrea gasar* from Badagry creek

Index of Relative Importance (IRI) of the food items

The % IRI value showed the order of relative importance from the various food items ingested by the Oyster. *Oscillatoria* dominates the food category with 25.38% followed by the green algae *Phacus* with 17.55%. The Nematode (*Diplogasteroides*) was 16.29% followed by *Niztchia* (13.96%), *Melosira* (6.81%) *Ankistrodesmus* (6.15%), *Navicula* 5.67%), Detritus (2.04%), *Cyclotella* (1.54%), *Gleocapsia* (1.53%) and *Synedra* (1.31%) the remaining food items fell below the 1%.

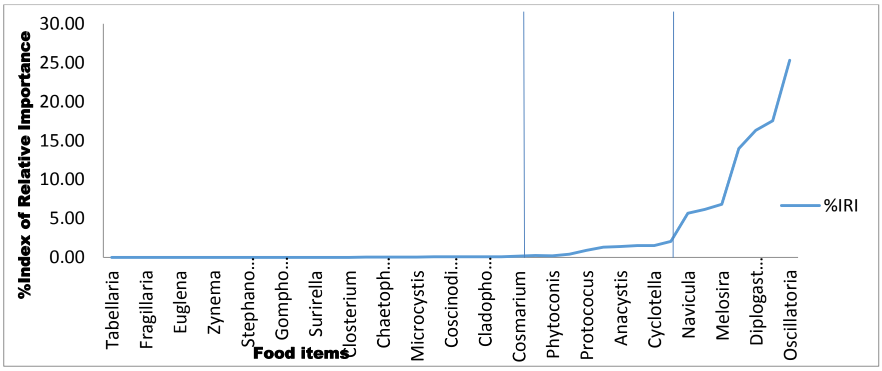

Fig.4. Diet Preference of *Crassostrea gasar* from Badagry creek

Discussion

Information on the feeding ecology of *C.gasar* is important for proper fisheries management and aquacultural purposes. The stomach content analysis of *C.gasar* from the Badagry creek constituted mainly Phytoplankton, Zooplankton, Sand grains, and detritus, this is consistent with the report of Kouakou *et al* (2019), Akinjogula (2014), Sylvio (2008) who worked on the Stomach content analysis of *Crassostrea* sp from the Ebrie Lagoon in Ivory Coast and Lagos Lagoon, from the result of this study, none of the stomach analyzed was empty throughout the stations and during the period of study, the Vacuity index was 0%. This was consistent with the report of Kouakou *et al* (2019). Ishmael (2015) also reported that Oysters can filter between 5 to 16 Liters of water in I hour under optimum condition and it takes 80 to 150mins for the food to complete digestive process within the Oyster system. Therefore, he concluded that this makes the oyster stomach to always have food item. This was contrary to the observations of Adite *et al* (2013) who recorded vacuity index (stomach emptiness) of 20.16% and 20.5%. They attributed the stomach emptiness to the possibility of the oyster collection time. Suggesting that at high tides the water flow is highly disturbed thereby affecting the oysters, causing them to close their valves to resist external pressure from the flow velocity, hence affecting the food intake.

There was no difference in the stomach content of the male and female *C.gasar*, they both constituted of phytoplankton, zooplankton, detritus and sand grain. This was also in consistence with reports from Rizkalla and Fatlas (1997), Ishmail (2015) and Kouakou (2019). In terms of size classes, the stomach content was similar, there was no Ontogenetic shift in the diet of the small sized and adult oysters. This result was consistent with Kouakou *et al* (2019). Bernard (2010) also reported similar observation from his study on *C.gigas*. Rico-Villa *et al* (2010) also reported that *C.gasar* pick up the attitude of being Planktonophagous from their Veliger stages and grow up to adult remaining filter feeding planktonophagous bivalves. Although this report is contrary to the report of Adite *et al* (2013) who recorded that *C.gasar* undergoes ontogenetic diet shift. He stated that the smaller oyster consumes more of *Polycystis* (Chlorophycae) whereas the larger individual consumed more of *Crucigenia* sp. However, he stated that the diatoms (*Melosira*) and substrates particles occurred most frequently in all the size classes and hence were not associated with size class.

Analysis of the index of relative importance of the food items from the stomach of *C.gasar* identified the *Oscillatoria* (25.30) as the most preferred food item, followed by the *Phacus* (17.55). Nematode; Diplogasteroides (16.29). The phytoplankton *Melosira* (6.8) was next and *Navicula* (5.67). They all were greater (> 3), according to Pinkas *et al (*1971) % IRI > 3 are the primary food item consumed by an organism. %IRI of >0.1 to <3 are secondary food items. % IRI < 0.1 are considered incidental food item.

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Length-weight relationship and condition factor (K) of *Clarias gariepinus* (Burchell, 1822) from Kwaru Lake, Tuarare, Dutsin-ma Local Government Area, Katsina State, Nigeria.

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Abstract
Clarias gariepinus (African catfish) is an important fish species in both capture and culture fisheries. Study on length-weight relationship and condition factor of *Clarias gariepinus* from Kwaru was conducted from February, 2019 to January, 2020 to determine the growth pattern and the state of well-being of the species in Kwaru Lake. Specimens were obtained on weekly basis from the fishers' catches at the landing site of the Lake, during the period of the study. A total of 310 fish samples comprising 140 females and 170 males were analysed. The results showed that the fish species exhibited negative allometric growth pattern with regression exponent b values of 2.76 and correlation coefficient (r) values was 0.914 (females), 0.953 (males), and 0.950 combined sexes, these revealed strong positive correlations between the fish weight and length. The average condition factor for combined sexes recorded is 0.85 which is an indication that the species is not in optimal in the lake.

Key words: African catfish, Length-weight, Condition factor, Growth, Kwaru, and Lake

Introduction
According to Dan-kishiya *et al.*, (2018), growth is an irreversible increase in length and weight of living material and an essential attribute of all living organisms. Growth can be measured at various stages of life or developmental levels of living things at the level of the organism there are a variety of parameters which may be measured including length, surface area, volume and mass. There is strong relationship between the fish body weight and length (Abowei, 2009). Length-weight data is used to estimate the wellbeing of the fish (Saila and reedle, 1980; Pauly, 1980 and 1984; Costa and Braga, 2004; Dan-kishiya, 2009).

Condition factor is an index to compare quantitatively the condition of individual fish within a given population, individual fish from different populations, and two (2) or more population from different localities (Yusuf and Abdulkarim, 2015). Similarly it may be used as index of productivity of water (Abdul and Omoniyi, 2007). It is an index to shows the wellbeing of the fish which is the function of weight and length.

There are more than one hundred and fifty (150) different freshwater fish species that are native to Nigeria, where more than half are of commercial important (Reed *et al.*, 1967The length-weight relationship and condition factor of various fresh water fishes of different water bodies has been well studied and documented (Egesi, 2016; Dan-kishiya , 2013 and 2019; Onome *et al.*, 2013; Demirel and Dakara, 2012; Obasohan *et al*., 2012; Alhassan and Ansu-darko 2011; Ude *et al*., 2011, Win *et al.*, 2011; and Imam *et al*., 2010). There is no published study that has been carried out on this commercially important species from Kwaru Lake and this this work will provide preliminary data for further research in fisheries biology and management.

Materials and Methods
Study Area
Kwaru Lake is located in Turare Village of Dutsin-ma Local Government Area, Katsina State. The Dugout Lake with an elevation of 10 m and a total crest length of 550 m^2, it was coordinated between latitude 12.32669N to 7.45876E (Plate 1 and 2). Kwaru Lake came to being due to anthropogenic activity (rocks mining) in 1980 for the construction of Zobe reservoir in the area. It has a dyke of 13m, an average water depth of 7m, and it is isolated water body recharged by rainfall and ground water only. The Lake is a major source of drinking water for the inhabitants of the catchment. Besides, there are multiple fish species present in the water which attracts fishing activities in the Lake.

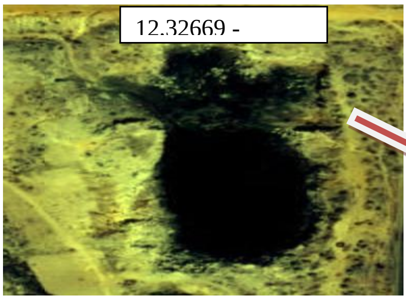


Plate 1. Satellite view of the study area.

Plate 2. Kwaru Lake.

Specimen Collection, Identification, and Measurements

Fish were sampled weekly from the fishers fishing in the Kwaru Lake who employed the use of different fishing gears ranging from traps, long line, and nets of different mesh sizes at the fish landing sites from February to September 2019 as in (Dan-Kishiya, 2018 and Nababa, 2019). Fish samples were transported to the laboratory for further Morphometric (Weight and Length) measurements. A total of three hundred and ten (310) fish were examined Specimens were identified using identification guide by Olaosebikan and Raji (2004), and Reed *et al.*, (1967). The Weight of each specimen was measured using weighing balance (Model: ADAM. CQT 2000), while the length was measured using a customized measuring board calibrated in centimeter grades.

Length–Weight Relationship

Length-weight relationship was meant to establish linear relationships between the fish body weight and length to enable inter-conversion of length to weight and vice versa. The relationship between total weight (W) and total length (L) of the fish were estimated using the equation described by Pauly (1980) in Dan-kishiya *et al*., (2018) as follows:

$W = aL^b$ 1

The above equation was firstly transformed to logarithmic equation giving rise to equation 2 below:

$Log\ W = Log\ a + b\ Log\ L$.............. 2

Where 'a' is a constant and 'b' is a regression coefficient relating weight (in grams) and length (in cm), as estimated by ordinary least square regression. Condition factor (K) of the fish population was calculated using the formula:

$K = W100/ L^3$ ………………….3

Where K= condition factor, W= fish weight in grams, L= total length of fish in centimetre (cm).

Results

The length-weight relationship and correlation coefficient for both sexes were determined separately and combined for both male and female *C. gariepinus.* The growth exponents (b) were determined as 2.708, 2.770, and 2.756 for female, male and combined sexes respectively. The growth exponent (b) values obtained from the present study were less than 3 which was an indication of negative allometric growth pattern. There was strong correlation between the fish's length and weight Table 1. However, the sex ratio of the sample fish for the said period of the study was; male (54.84%) and females (45.16%) table 1

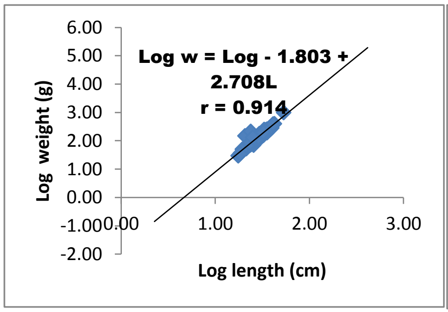
Table 1: Length-weight Relationships Parameters and condition factor values of *Clarias gariepinus* from Kwaru Lake, Dutsin-ma Local Government Area of Katsina State.

Sex	Regression coefficient		Correlation coefficient (r)	Average Condition factor (k)	N	Growth pattern
	A	B				
FEMALE	-1.803	2.708	0.914	0.890	140(45.16%)	-A
MALE	-1.918	2.770	0.953	0.820	170 (54.84%)	-A
COMBINED	-1.885	2.756	0.950	0.850	310	-A

N=number of Specimen used, **-A=** negative allometry

The values of the condition factor recorded in the present study were 0.89 (Females), 0.82 (Males) and (0.85) for the combined sexes Table 1.

The length-weight relationship for female, male and combined was graphically represented by the following figures 1, 2, and 3 respectively. Similarly, condition factor (Average, Minimum and Maximum) values for female, male, as well as for the combined sexes were represented in figure 4 below.



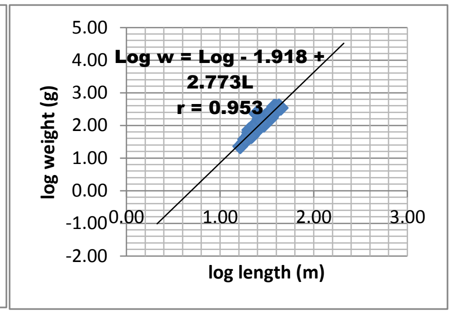
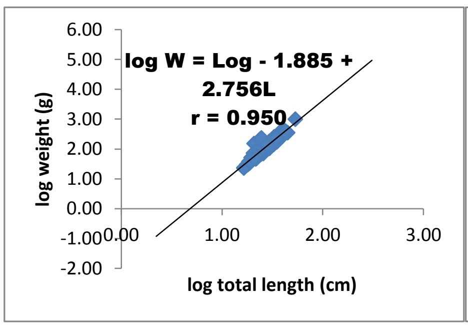


Fig.1: Female LWR (log-log) of *Clarias gariepinus*   **Fig.2: Male LWR (log-log) of *Clarias gariepinus***



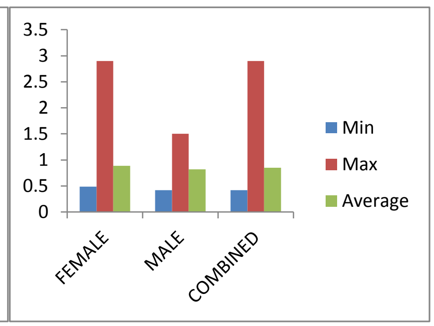


Fig. 3: Combined LWR (log-log) of *C. gariepinus*   **Fig. 4: Range of the Condition factors *C. gariepinus*.**

Discussion

The result of length-weight regression analysis showed that males and females *Clarias gariepinus* from Kwaru lake exhibited negative allometric growth (-A) for the period of this studies (Table 1). The values of "b" obtained shows that the increase in length is not equal in proportion to the increase in fish's body weight under constant specific gravity which implies that the fishes are thinner with increase in length. This might be as a result of lesser natural productivity and other human activities around the Lake and this is in corroboration with the works of Olurin and Aderibigbe (2006) who stated that differences might exist in length-weight relationship due to food availability, food conversion ratio of the fish, sex difference, maturity stage, season of the year, and environmental conditions such as pollution. However, the Correlation coefficient (r), is justifying that there is strong positive association between the Length and weight of the fish (fig. 1, 2, & 3); similar finding was reported by Onome *et al*. (2013) and Anyanwu *et al*. (2007)

Condition factor is a vital index for monitoring of feeding intensity, age and growth rates of fish (Froese, 2006 and Ndimele *et al*., 2010).The average condition factor of *C. gariepinus* recorded from this study ranges from 0.82 to 0.89 (figure 4.) which is lesser than 1. All the values of the condition factor recorded were less than 1 and this implied that Clarias species from the lake is not in good physiological state of well-being. This results is contrasting (Imam *et al*., 2010) from Wasai Reservoir in Kano, Nigeria.

Conclusion and Recommendations

The result of the present study had shown that *C. gariepinus* in Kwaru Lake in Dutsin-ma Local Government Area of Katsina State, Nigeria exhibited negative allometric growth pattern with a strong positive correlation between the total length and weight of the species. It can now be concluded that the species are not in good physiological state of well-being with less than 1 condition factor.

Finally, further studies covering the aspects of water quality, food abundance, and stock assessment are recommended to be carried out in Kwaru Lake so as to provide other important scientific information.

Acknowledgement
Gratitude goes to Professor Sogbesan O. Amos, Professor Armaya'u H. Bichi, and Dr. Ahmed S. Dan-Kishiya, for their timely and scholarly guidance, contribution and support offered whenever the need arise.

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Aspect of the biology of *Hepsetus odoe* in Ebonyi River, Southeast, Nigeria

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Abstract
Aspect of the biology of Hepsetus odoe in Ebonyi River, Southeast, Nigeria was investigated to document the feeding habit and sex ratio of the species as preliminary index for stock improvement and species development to lower cost of commercial fish meal. The information will be useful in enhancing management practices that will improve the stock health and species abundance geared towards production of less competitive fish to serve the fish meal industry in reducing cost of feed production. A total of 201 Fish samples were collected weekly from Ebonyi River using gill nets and baited long line over a period of 5 months. Specimens were measured using graduated measuring board (in cm) for Length and electronic weighing balance (in g) for weight, respectively. The Stomachs were opened for Gonad examination and food content analysis. The total length ranged from 20.3-31.9 cm (males), 21.8-35.8 cm (females), while the body weight range was 46.1-207 (males) and 81.0g-260g (females). The species exhibited 1: 2 (♂:♀) sex ratio. The assessed stomach content of the 201 specimens showed that 46% had empty stomachs while 54 % contained different food materials ranging from copepods (7%), Daphnia (6.4%), Cyclops (1.0%), Chydorus (1.5%), insects (4.5%) and Alestes (32.6%). This study gives relevant clues on reproductive biology and feeding habits required for artificial propagation of H. odoe.

Keywords: Biology of *Hepsetus odoe*, Ebonyi River

Introduction

Hepsetus odoe is a predatory freshwater fish belonging to the family Hepsetidae. It is an elongated fish with a pike-like body. This species can reach up to about 28 cm (11 in) in length. Ude (2011) recorded 5.59 index of preponderance for the species in Ebonyi River, depicting it as one of the most dominant fish species and viable stock in the river. It was formerly believed that only one species and genus existed in sub-Saharan Africa, but studies in 2011-2013 have found that there are several species, and the true *H. odoe* is restricted to West and Central Africa from the Sassandra River, Ivory Coast, to the Kienké River, Cameroon (species elsewhere are now recognized as separate; *H. cuvieri*, *H. kingsleyae*, *H. lineata* and *H. occidentalis*). (Decru *et al* 2013., Zengeya *et al* 2011).

Species diversity within a natural community is in part a reflection of the diversity in the abiotic environment. Some species are known from only a single location, whereas others occur high to low, east to west, temperate to tropics, with far reaching ecological and evolutionary distributions implications. Smith (1966) stated that the greater the variation in the physical environment the more numerous are the species since there exist numerous microhabitats available and more niches to fill.

Changes in most ecosystems are as a result of anthropogenic causes such as pollution, habitat degradation, introduced species and overfishing. Unplanned Fisheries exploitation is a major tool responsible for alterations in the diversities of aquatic resources within communities.

An evaluation of *Hepsetus odoe* stock in Ebonyi river is considered necessary and the knowledge of their biology and species composition is required as preliminary index for stock improvement and species development to lower cost of commercial fish meal, which constitute the major financial impediment to the development of Aquaculture industry. The favourable index of preponderance recorded by Ude (2011) for the species makes it a candidate for exploitation if adequate stock integrity is maintained. The information from this work will be useful in enhancing management practices that will improve the stock health and species abundance geared towards production of less competitive fish to serve the fish meal industry in reducing cost of feed production, as very sparse information exists on the ecology and economic exploitation of the fish stock in Ebonyi river.

This study aims at providing baseline information on its fish fauna for use in appraising the fisheries potential in the area and similar ecosystems subjected to similar ecological pressure; and specifically, to determine the sex ratio, food and feeding habit of Hepsetidae in Ebonyi river

Materials and Methods

The area of study is Ebonyi River (Figure 1) which is a freshwater system that has its source from lower Benue River and opens into Cross River, but transverses the old Abakaliki Zone of Ebonyi State, Nigeria. Abakaliki is situated at 06^0 19.370` North latitudes and $008^0$ 07.692` East longitudes (Ude, 2011)

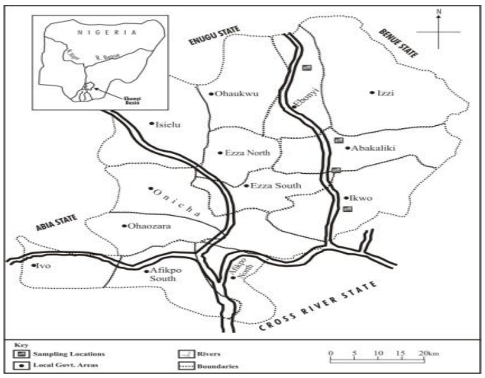

Fig. 1: Map of Ebonyi Basin showing Sampling Locations

Fish Sampling Samples of Hepsetus odoe for the study was collected twice monthly for the period of 2 months from catches landed by artisanal fishers who use gill nets, traps and other gears of varying mesh sizes for their operations.

The specimens were preserved in 10% formaldehyde to stop further food digestion in the gut of fish during transit to Fisheries laboratory of Ebonyi State University, where gut content identification was carried out. Fish specimens were identified with the aid of identification guide according to Ude (2012) after which the meristic and morphological parameters were measured. Total length and body weight measurement was recorded to the nearest ± 0.01 mm and ± 0.1 g using a measuring board and a triple beam balance (Model OHAUS 2010), respectively.

After identification of Fish samples, they were preserved in deep freezers at -10ºC. The fish were dissected later for subsequent gut analysis. The gut content was put into petri-dish and the food items observed with binocular microscope and identified to the lowest taxonomic level. The entire gut content was analyzed using frequency of occurrence methods and percentage composition by number method (Ricker, 1975).

The data collected were subjected to Analysis of variance and standard deviation, whereas treatment differences among means were detected using Duncan multiple test range.

Results

Sex Ratio Preponderance of *Hepsetus Odoe* in Ebonyi River during the investigation period in which 201 individuals were examined is presented in Table 1. The total length ranged from 20.3-31.9 cm (males), 21.8-35.8 cm (females), while the body weight range was 46.1-207 (males) and 81.0g-260g (females). The species exhibited 1: 2 (♂:♀) sex ratio. The assessed stomach content of the 201 specimens showed that 46% had empty stomachs while 54 % contained different food materials ranging from copepods (7%), Daphnia (6.4%), Cyclops (1.0%), Chydorus (1.5%), insects (4.5) and Alestes (32.6%). The results of stomach content analysis using percentage numerical abundance method are shown in Table 2. Observations of stomach content of *H. odoe* were in 7 prey categories.

Table 1: Length, and body weight distribution observed in *Hepsetus odoe* in Ebonyi River

Parameter	Sex	Number	Range	Mean ± SD
Total length	Male	67	20.3-31.9	22.3± 2.14
	Female	134	21.8-35.8	24.6 ± 1.30
Standard length	Male	67	16.6-26.2	19.7 ± 1.43
	Female	134	17.8-30.5	23.2 ± 2.64
Body weight	Male	67	46.1-207.0	109.5 ± 4.13
	Female	134	81.0-260.0	127.4 ± 4.30

Table 2: Food Items identified in the gut of sampled *Hepsetus odoe* in Ebonyi River

Diet components	Numerical abundance	Relative abundance (%)
Alestes	65	32.60
Insect (nymph, larva, adult)	9	4.50
Copepods	14	7.00
Daphnia	13	6.40
Chydorus	3	1.50
Cyclops	2	1.00
Fish eggs and scales	2	1.00

Discussion

The body length and weights of female *H. odoe* were longer and heavier than male specimen. The sex ratio of sampled *H. Odoe* showed a preponderance of females over males and significantly differed (P<0.05). According to Fagade *et al.,* (1984) and King (1991), the wide disparities in sex ratio could be adjudged as a mechanism for population regulation. This result also agrees with the work of Oso *et al*., (2011) who observed preponderance of females over males in a reservoir in Southwest, Nigeria. The dietary composition of the specimens implicated *H. odoe* as piscivorus and this classification agrees with several authors including (Reed *et al*. (1967), Akintunde (1986), Winemiller (1993). Alestes, Copepods, Daphnia, and Insects were the major food items found in the gut. This is not surprising since Alestes are among the most abundant fish in Ebonyi River which made them available food for *H. odoe.*

This result differs from Akintunde (1986), who reported that cichlids were the major fish prey of the species in Volta Lake, upper Ogun River and Lekki Lagoon respectively. This also is at variance with the study on River Zambezi, that *H. odoe* consumed primarily cichlids and momyrids while insects, copepods, higher plants, gastropods, prawns, crustaceans, etc are their supplementary or minor food especially when the tilapia are in short supply due to high level of predation or competition with other piscivorous fishes such as *Gymnarchus niloticus*, *Parachana obscura*, etc.

The percentage of empty stomach shows a high limitation in the feeding habit of *H. odoe*. Aramowo (1976) reported that the occurrence of high percentages of specimens with empty stomachs could be due to the reduction in the number of preys as a result of high predation and competition by different species inhabiting the water body. Accordingto Lagler *et al*., (1977), there exists a strong correlation among the types of dentition, feeding habits and food of fish. The teeth of *Hepsetus odoe* are sharp, numerous and pointed which make it very effective for seizing prey.

Conclusion

This study gives information on sex ratio, diet composition and fecundity of African pike, *Hepsetus odoe* in Ebonyi river, Nigeria. The abundance of *H. odoe* and preponderance of females over males, coupled with limited consumption preference of the species makes it a promising candidate for use in production of fish meal by Aquafeed industries with the potential of reducing cost of production and encouraging aquaculture production and increased fish consumption. The knowledge of the fecundity of *H. odoe* can be utilized to ascertain the time and number of recruitments and population dynamics. Further research and studies on the species should be encouraged to facilitate fish self sufficiency quests geared towards producing less competitive cheaper fish to lower the cost of fish meal and consequently fish feed for profitable Aquaculture practice especially in developing countries.

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Gonadosomatic index, fecundity and sex ratio of *Alestes baremose* (JOANISS, 1835) in Zobe reservoir, Dutsinma, Katsina State

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Abstract
Alestes baremose was collected from Zobe reservoir Dutsinma, Katsina between April-November, 2018 and its Gonadosomatic index, Fecundity and Sex ratio was studied. A total of 193 fish samples were collected from local fishermen. Fish samples collected were measured, length (cm), weighed (g), dissected and sex determined by visual observation of the gonads. Ovaries of the mature female were preserved for fecundity studies. Fecundity was determined using the gravimetric method. Fifteen (15) gravid females were used in fecundity studies where the egg count range of 888-67,909 was recorded with an average of 18,969 eggs. Gonadosomatic index (GSI) recorded in males (0.71±0.69) and females (1.99±0.69) was in May indicating the peak of the spawning season. The lowest GSI was recorded in August and November with 0.17±0.33 and 0.25±0.26 respectively**.** A decline in August and November indicated spawning ends. This indicated that *A. baremose* is a low fecund fish. The sex ratio of 1:1 was also recorded which is in line with the 1:1 distribution.

Keywords: Gonadosomatic index, fecundity, sex ratio, *Alestes baremose*

Introduction

Silverside (*Alestes baremose*) is found in freshwater systems in Africa, thriving well in both riverine and stagnant conditions. It belongs to the order Characiformes, family Alestidae, and genus *Alestes*. Gonadosomatic index which is an index of gonad size relative to fish size is a good indicator of gonadal development in fish (Dadzie and Wangila, 1980). The percentage of body weight of fish that is used for production of eggs is determined by the gonadosomatic index (Adebiyi *et al*, 2013)

Fecundity which gives information on the number of eggs in the ovary before the next spawning season (Bagenal, 1978, Adebiyi *et al*, 2013). Studies on fecundity of fish species are pertinent and useful for systematics in racial studies related to total population estimation and productivity.

Sex ratio studies provide information on the representation of male and female fish present in a population. It states the proportion of male to female fish in a population and indicates the dominance of sex of fish species in a given population. Sex ratio also constitutes basic information necessary for the assessment of the potential of fish reproduction and stock size estimation in fish population (Vicentini and Araujo, 2003, Adebiyi *et al*, 2013). In estimating the reproductive potential of fish, information on sex ratio of fish can be included to determine female spawning biomass. The addition of sex ratio to estimates of reproductive potential can produce some differences in understanding the status of fish stock in relation to a selected point of biological reference (Morgan, 2008, Adebiyi *et al*, 2013).

Alestes baremose is one of the most desirable fish species for food and commercial purposes by majority fishermen. Fish catches have over time dwindled and currently the catch per unit effort is relatively low to be of significant economic importance to the fishing communities (Muhammad *et.al*, 2020). Studies indicate that the fish has been extensively harvested, putting it under threat (Akinyi *et al.*, 2012; Kasozi *et al.*, 2013). Similarly, recent researches indicates tremendous species decline (Mbabazi *et al.*, 2012).The fact that *Alestes baremose* is increasingly getting scares, yet greatly demanded in the market, makes it one of the species worth considering for commercial aquaculture. Despite the vast studies conducted to understand the reproduction biology of this fish in Africa, little documented information is available in Katsina State. Basic knowledge of fish species distribution, abundance, wellbeing, and reproductive potentials (fecundity, GSI, sex ratio, etc.) is therefore deficient, consequently, the fish in the Zobe reservoir is poorly documented and its future sustainability is unpredictable. This study will focus on contributing to the effort of other researchers by providing the information needed to guide the continuous utilization of the fisheries resources of the reservoir in the near future.

Materials and Methods

Study Area

Zobe Reservoir is in the Dutsin-ma Local Government Area of Katsina State, Northern part of Nigeria. It is an earth-fill structure with a height of 19 meters and a total length of 2,750 meters. The dam has a storage capacity of 179 Million cubic Acres and an irrigation potential of more than 7500 hectares (Muyiddeen, 2010).

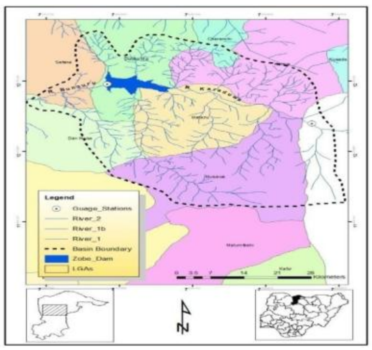

Figure 1: Map of Katsina showing inland waters and location of Zobe reservoir

Collection of specimens

A total of 193 fish samples of different sizes ***Standard length ranged from 8.00cm to 23.00cm, fish weight between 5g to 132.26g.*** were collected from the local fisherman's at one of Zobe reservoir's landing sites, Garhi village, Dutsin-ma Local Government Area, Katsina State. The study was carried out from April to November 2018. The collected fish samples were transported to the laboratory in clean iced containers for further examination. The total weight (TW) and Gonad weight (GW) were measured to the nearest 0.1g and 0.01g respectively. Total lengths (TL), Standard length (SL), and Fork length (FL) were measured using a measuring board calibrated in centimeters.

Gonadosomatic Index

The Gonadosomatic index (G.S.I), which indicates the percentage of the fish weight used in egg production, was computed using the formula:

$$\text{G.S.I} = \frac{\text{Weight of gonads} \times 100}{\text{Body weight}} \qquad \text{(Ogbeibu, 2005)}$$

Fecundity

Fecundity (absolute fecundity), which is the total number of eggs in the ovaries of a fish before spawning, was estimated using the gravimetric method by direct counting of spawnable eggs in the female ovaries (Ezenwaji and Offiah, 2003).

$$\textbf{Absolute fecundity} = \frac{\text{No. of ova in the subsample} \times \text{Total ovary weight}}{\text{Weight of subsample}}$$

Sex Ratio

Monthly sex ratio of Male/ Female *Alestes baremose* was computed. Chi-square was used to determine if there are significant differences between the sexes and commonly expected ratio of 1:1.

Results

Sex ratio and Gonadosomatic index

Table 1 showed the monthly sex ratio and gonadosomatic index (GSI). A ratio of 1:1 was recorded during the study period except in April and July where a ratio of 1:2 and 2:1 was recorded respectively. The fecundity studies was computed in a tabular form where 15 matured female *Alestes* were studied.

Table 1: Mean Gonadosomatic Index (GSI) and sex ratio of *Alestes baremose* collected from Zobe reservoir

Month	Sex **R**atio	**GSI**
April 2018	1:2	1.99±0.69
May 2018	1:1	0.46±0.23
June 2018	1:1	0.25±0.08
July 2018	2:1	0.31±0.04
August 2018	1:1	0.17±0.33
September 2018	1:1	0.35±0.73
October, 2018	1:1	0.25±0.06
November, 2018	1:1	0.25±0.26

Mean± SD

Table 2. Fecundity of selected fish samples at stage IV and V

S/No.	**Sex**	**Gonad stage**	**Fecundity**
1	F	V	22021
2	F	IV	67909
3	F	IV	7513
4	F	IV	45164
5	F	V	17451
6	F	V	6809
7	F	V	11040
8	F	IV	2058
9	F	IV	12733
10	F	IV	888
11	F	V	8577
12	F	V	33333
13	F	V	21000
14	F	IV	18167
15	F	IV	9872

Discussion

Sex ratio and Gonadosomatic index

A sex ratio of 1:1 was recorded. The differences in monthly sex ratios were not significant at ($p<0.05$) which is in line with the 1:1 distribution. Naimat (2003) found out that the sex ratio of *A. baremose* was dominated by females in the Jabel Aulia reservoir in Sudan. This may be a result of differences in the geographical location of the two reservoirs. Apochi *et al.,* 2017 reported a sex ratio of *A. baremose* in Lower River Benue, in favor of females than the males which did not conform to the current findings.

Gonadosomatic index, however, shows a similar fluctuating pattern. The highest monthly GSI was recorded in May with 0.71±0.69 for males. The female's highest values were recorded in April with 1.99±0.69. The lowest monthly males GSI was recorded in November with 0.21±0.14 and females in the month of August with 0.17±0.33. The female overall mean GSI was 3.78%. An increase in the GSI indicates an increase in the development of gonads while a drop in October indicates spent stages of the fish. Higher GSI values were also reported in Uganda by Kasozi *et al.,* 2013. GSI decreases abruptly as soon as breeding season is over. The annual variation of GSI was recorded in the present study.

Fecundity Studies of *Alestes baremose*
Fifteen (15) gravid female samples of stage IV and V were used to estimate fecundity using the gravimetric method. The fish, with the highest number of mature females, was recorded in May with 8, and the lowest number of mature females was recorded in April with only 1. There were no mature females recorded in the remaining months. The average fecundity was 18,969 eggs with a mean value of 888 eggs. The fish, with the highest number of eggs, was recorded, in the month of May with 67,909 eggs. The lowest value was recorded in June with 888 eggs.

A baremose a normal fecund fish, unlike higher fecund fish with millions of eggs (Adeniyi, 2013). Fecundity showed a linear relationship with Total Length, Bodyweight, and Gonad weight as reported by Khan *et al.,* (2002). Nyakuni (2009), the observed number of eggs per female *O. niloticus* ranged from 412 to 2380 eggs with an overall mean fecundity of 854 oocytes which is lower compared to the findings of other investigators on the same species elsewhere which did not agree with the findings of the current study. Generally, female tilapia produces only a few hundred offspring's per spawn as females tenaciously protect their offspring for several days after incubation to ensure survival in the wild (Nyakuni, 2009), a strategy parents use to ensure that majority of their eggs survive to the juvenile stages (Moyle & Cech, 2000 and Nyakuni, 2009). The low fecundity of *O. niloticus* in Albert Nile could probably be a result of a combination of different factors such as food abundance, the quality of food, and small sizes at maturity of the brooding females as asserted by (Nyakuni, 2009). High fecundity values recorded in the present study, may be attributed to the high exploitation of the fish in the reservoir that makes it necessary for the fish to produce in large numbers to ensure survival. The absolute fecundity of *Schizothorax curvifrons* reported by (Qadri *et al*., 2015) varied from 4762 to 17196 ova. The average fecundity recorded was 9764, whereas the average relative fecundity was 43/g body weight. Qadri *et al.* (1983) recorded the fecundity of *S. richardsonii* from Kashmir waters from 2598 to 27846 eggs for the fish of 220 to 475 mm length.

Conclusions
A sex ratio of 1:1 was recorded, throughout the study, where females had a slightly higher percentage with 50.1% than males with 49.9%. Gonadosomatic index is an indication of the percentage of the fish weight used in egg production showed that the average GSI was 3.78%. This indicated that a lot of energy is being used in the process of gonad development and maturation. *A. baremose* is a normal fecund fish with an average of 18909 eggs.

Recommendations
1. Firsthand information is required in management of fisheries resources in the reservoir and the state which will enable the fishermen to acquire knowledge on fish stock assessment.
2. There is need for more awareness and sensitization on the effect of over exploitation of fish by the government on the local fishermen.

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Dietary composition and feeding strategy of the big eye grunt *Brachydeuterus auritus* (VALENCIENNES, 1832) off The Lagos coast

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Abstract
Brachydeuterus auritus is one of the most important demersal fishery resources caught in large biomass in the Gulf of Guinea. Diet composition of fish is important for proper fishery management and fish cultivation; it also reveals the foraging status of fish. The dietary composition, trophic level, feeding intensity and feeding strategy of *B. auritus* (n = 686) off the Lagos Coast was studied between July, 2015 and September, 2016. The overall Vacuity Index was 13%. The diet of *B. auritus* was dominated by crustaceans such as Euphasiids (Krill) and shrimps. Euphausiacea was the major diet (% IRI = 30.8%, GII = 61.6%, IOP = 8.3%) while the highest food item based on IOP was squid (% IRI = 22.2%, GII = 54.2%, IOP = 26.6%). The species exhibited a mixed feeding strategy with varying degrees of specialization and generalization on different prey types. The species is a tertiary consumer off the Lagos Coast.

Keywords: *Brachydeuterus auritus*, Diet composition, Euphausiacea, IRI, Feeding strategy.

Introduction
The Big eye grunt, *Brachydeuterus auritus* is one of the most important demersal fishery resources caught in large biomass in the Gulf of Guinea (Bannerman and Cowx, 2002). They are bottom feeding predators and named for their ability to produce sound by grinding their teeth (Ben Tuvia and McKay, 1986). Knowledge of diet composition of fish is important for proper fishery management and fish cultivation; it also reveals the foraging status of fish. The Lagos Coast supports both artisanal and industrial fisheries in Nigeria.

The present study was carried out to investigate the dietary composition, trophic level, feeding intensity and feeding strategy of *B. auritus* off the Lagos Coast, Nigeria. Information obtained will be useful for the rational exploitation of the species.

Materials and Methods
Collection of fish samples and examination of fish
Samples for this project were purchased monthly at the Liverpool fish market, Lagos between July, 2015 and September, 2016. 686 specimens were examined. The stomach of each specimen was removed and the condition of fullness rated as empty, quarter-full, half-full, three-quarter full and full stomachs were recorded.

Feeding intensity was calculated as follow:

$$\text{VI (\%)} = \frac{\text{Number of empty stomachs}}{\text{Number of stomachs examined}} \text{ X } 100$$

where VI = Vacuity index.

Stomach content analysis were emptied and examined. Food items were identified. Percentage frequency of occurrence (%O), number (%N) and volume (%V) were used to analyse the diet composition. Index of Relative Importance (IRI) was calculated as follow:

IRI = (%V + %N) x %O. The value of IRI were then computed as a percentage.

$$\%\text{IRI} = \frac{100\text{IRI}}{\sum_{i=1}^{n}\text{IRI}}$$

The Geometric Index of importance (GII) was calculated as follow: GII = (%N + %V + %O)/ $\sqrt{3}$

The Index of Preponderance (IOP) was calculated as follow: IOP = $V_iO_i/\sum V_iO_i$ X 100

Results and Discussion
Out of the 686 stomachs examined, overall vacuity Index was 13% (Figure 1). The 13% Vacuity Index (VI) recorded for *B. auritus* in this study was ($0 \leq VI < 20$) this classifies it as an edacious species according to Euzen (1987) and Valinassab *et al.,* (2011). Low vacuity index observed in this study is an indication of high feeding intensity.

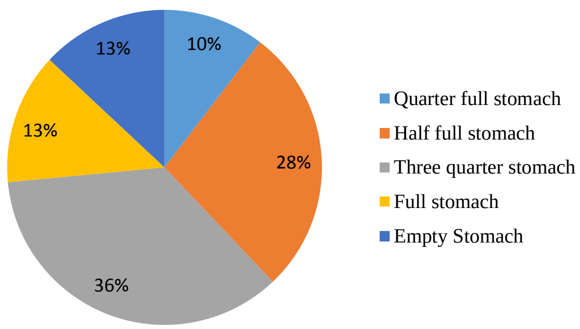

Figure 1: Variations in the fullness of stomachs of *Brachydeuterus auritus* off the Nigerian Coast

The diet of *B. auritus* off the coast of Lagos was dominated by Euphausiacea (Krill), which are holoplanktonic crustaceans, crabs and shrimp was the major diet (% IRI = 30.8%, GII = 61.6%, IOP = 8.3%) while the highest food item based on IOP was squid (% IRI = 22.2%, GII = 54.2%, IOP = 26.6%)(Table 1, Figure 2).

The species consumed a variety of food items off the Nigerian coast. The dietary compositions reflect carnivorous/predatory feeding habit for the species. The species exhibit a mixed feeding strategy (Figure 3) with varying degrees of specialization and generalization on different prey types. The species is a secondary consumer off the Nigerian Coast. The trophic level is 3.8.

Table 1: Summary of stomach contents analysis of *B. auritus* off Nigerian coast.

Food items	%N	%O	%V	%IRI	GII	IOP
Crab	20.4	36.4	16.1	15.5	42.1	13.4
Euphausiacea	33.8	67.3	5.4	30.8	61.6	8.3
Shrimp	7.2	25.6	13.4	6.2	26.7	7.8
Fish egg	13.5	31	2.7	5.9	27.3	1.9
Cuttlefish	6.8	36.4	17.4	10.3	35.0	14.5
Squid	11.4	64.3	18.1	22.2	54.2	26.6
Fish	6.9	33.7	16.2	9.1	32.8	12.5
Unidentified food mass	-	61.8	10.7		-	15.1

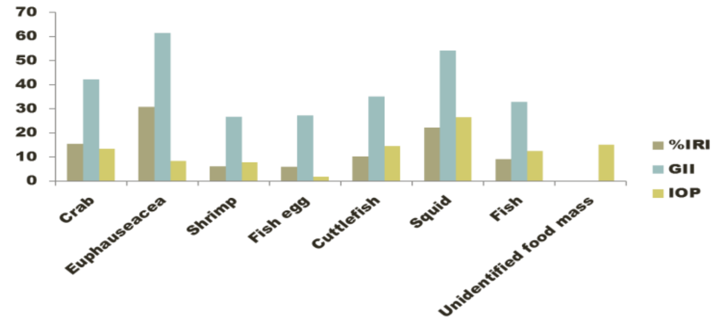

Figure 2: Summary of the diets of *B. auritus* based on compound indices of the food

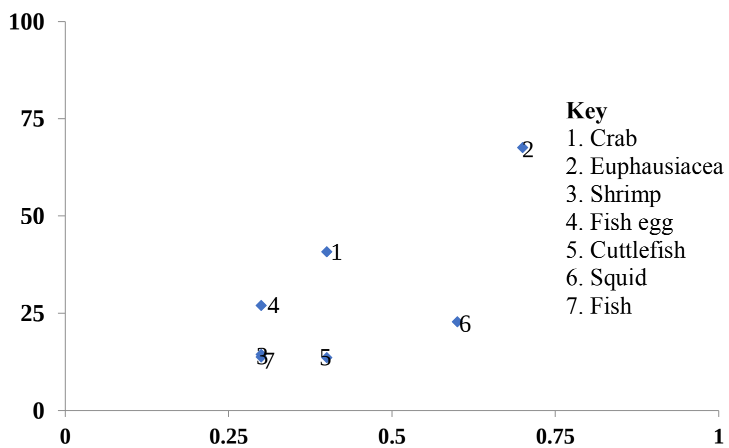

Figure 3: Feeding Strategy diagram of *Brachydeuterus auritus*

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Species Composition, Dominace And Similarity Index of *Macrobrachium vollehovenii* and *Macrobrachium felicinum* In Akor River, Ibere Ikwuano, Nigeria

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Abstract
Occurrence and abundance of *Macrobrachium vollehovenii* and *Macrobrachium felicinum* were studied in Akor River Ibere Ikwuano Nigeria. Duration of the study was for 24 months and the area density method was employed for the study. The River was delineated into three sections, Station A, B and C and fish specimen were collected fortnightly. Species composition, dominance and similarity index were calculated using suggested methods. Chi square test was used to compare the dominance of both species in the River. Results shows that Station A had a total catch composition of 1,407 (29.4%), Station B, 1,689 (34.73%) and the highest catch was recorded at station C 1,763 (36.2%) with overall total of 4,859 catches. Results also showed that *Macrobrachium vollehovenii* dominated more in the river with a total number of 3,620 (75%) of the catches while *Macrobrachium felicinum* had a total of 1,239 (25%) of the catches. Ponderal index was 53.7 and 44.7 for *Macrobranchium vollehovenii* and *Macrobrachium felicinum* respectively and a similarity index of 1 for both species. Statistical analysis showed that there was significant difference between dominance of these species in the River ($p<0.05$). We therefore recommend that due to continual presence of these species in the River as a non-target species and consequent discard of this species, there is need to develop appropriate and reliable means of estimating discards of these species in the River.

Keywords: Occurrence, Abundance, *Macrobrachium* species, Fresh water

Introduction

In recent times studies have shown that freshwater prawns are present in all biogeographically regions, with the exception of Antarctica (Grave *et al*, 2008). However, the Oriental region harbours the majority of species (Grave *et al*., 2008). In freshwater rivers and creeks in the Niger Delta of Nigeria, *Macrobrachium* fishery predominates. Three species namely, *Macrobrachium felicinum* (Niger River prawn), *Macrobrachium vollenhovenii* (African River Prawn) and *Macrobrachium macrobrachion* (Brackish river prawn) dominate the catches of the fisheries subsector (Powell, 1983) cited in Ukagwu (2015). Studies carried out in Akor river Ibere has shown the presence of *Macrobrachum* species in the river with high level of anthropogenic activities such as swimming, washing, dredging, lumbering and fishing. However, no work has been done on catch composition and dominance with respect to the fishing gear used in the region. This study is aimed to determine the catch composition, dominance and similarity index of *Macrobrachium* species for sustainable of fishery resources.

Materials and methods

Survey and Sampling site

Ibere is in Ikwuano Local government area of Abia state between latitudes 05.34829°N and Longitude 007°.34468' E with elevation of 77m. The Ibere region which is located in the northern part of Ikwuano LGA is a mountainous region. *Macrobranchium Vollenhovenii* and *Macrobrachium Felicinum* species were identified by use of the keys of Powell (1983) and Holthius (2000). The Jaccard similarity coefficient was used for comparing the similarity and diversity of the prawn species in Akor River. Dominance of the fish species was calculated using the formula suggested by Idodoh-Umeh and Victor, (1990) where any species which account for 10% of the total fish population or more by number and by biomass is termed to be dominant specie.

$$Cj = \frac{j}{a + b-}$$

Cj = Similarity between any two zones a and b

j = No. of species common to both zones and b

a = No. of species at zone a

b = No of species at zone b

if Cj =1 = Complete similarity

0 = Complete dissimilarity

Results

Catch composition, dominance and similarity index

The pooled numbers of prawn species in the different stations are presented in Table 1. The most dominant prawns found at the three different stations were *Macrobrachium vollenhonvenii* followed by *Macrobrachium felicinum*. At station A, there were a total of 1,407 individuals in twenty four months, *Macrobrachium vollenhovenii* specie had 1,044 individuals representing 74.2% of the catches while *Macrobrachium felicinum* made up 26.8% of the total catches with 363 individuals. At station B. there was a total catch of 1,689 prawns;*Macrobrachium vollevovenii* specie had 1,235 individuals representing 73.1% of the catches while *Macrobrachium felicinum made* up 26.8% of the catches with 454 individuals. At station C, maximum prawn diversity was recorded, there were a total of 1,763 prawns, *Macrobrachium vollehovenii* made up 76.06 % of the catches with 1,341 individuals while *Macrobrachium felicinum* made up 23.9% of the total catches with 422 individuals. In general, *Macrobrachium vollehovenii* made up 74.6% of the total catches in the three stations with 3,624 individuals while *Macrobrachium felicinum* made up 25.4 % of the total catches with 1,239 individuals' both of which were dominant in the river.

Species biomass

The total weight of prawn or biomass of the two species collected station by station during the study was recorded. The biomass and percentage of each specie in the community. At station A, the predominant species by weight was *Macrobrachium vollenhovenii* with a biomass of 4,526g or 64% of the total biomass in the station and then followed by *Macrobrachium felicinum* which has a biomass of 2,792g or 39% of the total population in the station. At station B, the predominant specie by weight was *Macrobrachium vollenhovenii* with a biomass of 3,908g or 53.1% of the total biomass and followed by *Macrobrachium felicinum* with a biomass of 3,447g or 46.9% of the total prawn community. At station C, the predominant specie was *Macrobrachium felicinum* with a biomass of 3,332 or 47% of the prawn community followed by *Macrobrachium vollenhovenii* with a biomass of 3,090(44%) of the total prawn community. Overall dominant prawn in the river was *Macrobrachium vollenhovenii* which had a biomass of 11,524g (53%) of the entire prawn biomass.

Table 1. The composition of *Macrobrachium vollehovenii* species during the dry and wet seasons in the locations

Season	Station A	Station B	Station C	Total
Dry season	324 (31%)	405 (33%)	651(49%)	1,380 (38%)
Rainy season	720 (69%)	830 (67%)	690 (51%)	2,240 (62%)
Total	1,044	1,235	1,341	3,620 (75%)
***Macrobrachium felicinum* specie during the dry and wet seasons**				
Dry season	168 (46%)	194 (43%)	126 (30%)	488 (39%)
Rainy season	195 (54%)	260 (57%)	296 (70%)	751(61%)
Total	363	454	422	1,239 (25%)
Grant Total				4,859

Table 2. Table showing the occurrence and dominance of the species in the three stations

Specie	Station A	Station B	Station C	Total	PI (%)	SI
MV****	1,044	1,235	1,341	3,620	53.8	1
MF****	363	454	422	1,239	44.7	1
Total	1,407	1,689	1,763	4,859		

MV = *Macrobrachium vollehovenii* MF= *Macrobrachium felicinum*

********= Dominant > 10% PI = Ponderal Index SI= Similarity Index****

Discussion

The composition of these species reported in this study compares favorably with Nwosu and Wolfi (2006) who reported the presence of *Macrobrachium vollehovenii* in high numbers in the Cross River estuary of the Niger delta. There were drastic changes in fish community during the period of this study, more numbers of Prawns were caught during the wet season than the dry season. This corroborates with the report of Powell, (1983) who affirmed that these species are more abundant in the rivers during the rainy season than the dry season. It is likely that some rare events like feeding and migrations of these species during rainy season could have led to their presence in these three stations.

Because of the gears used, this study could not account for the very small prawns. The ponderal index (PI) is the ratio between weight of one species and the weight of all the species expressed in percentage. Any fish species with a ponderal index of 1% or more is regarded as a permanent resident of a fish community (Luazanne, 1983). In macrobenthic communities, any taxon constituting 15% or more by number is considered dominant (Idodo-Umeh and Victor, 1990). A dominant fish species is however defined as any species which account for 10% or more both by number and by biomass (Idodo-Umeh and Victor, 1990). Regarding species biomass, a possible explanation for this could be as a result that some prawns were caught during the dry season months with peak catches being in May and June. This may be due to the dry season, occasioned by the receding flood and evaporation, leading to concentration of fishes in smaller volume of water thus might contribute to reduction in weight (Farhadian and Pouladi, 2014).The difference in the size range of prawns inhabiting the river, with small shrimps in Akor River could be due to differences in fishing activity. These variations could also be seen statistically leading to the differences ($p<0.05$) between the two species. Observations in the area revealed that most of the fishermen concentrate more on the vertebrates than the invertebrates as they considered the *Macrobrachium* spp irrelevant.

Conclusion and Recommendation

This study revealed the presence of *macrobrachium* species in large number during the period of study namely *Macrobrachium vollenhovenii* and *Macrobrachium felicinum.* These two species dominated the three stations that were studied and had more of females than the males which can be used for fish post larval production and therefore recommend that this commercially important specie discovered to be resident in Akor river which is a hinterland location, a clearly defined policy on the management of *Macrobrachium* species need to be developed in view of its potential for export /foreign exchange generation.

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Diet of the Common Cuttlefish, *Sepia officinalis (*Cephalopoda: Sepiidae) (Linnaeus, 1758), Off Lagos Coast, Nigeria

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Abstract

Cephalopods are relevant in the marine ecosystem because they play predator and prey in many aquatic food chains. The common cuttlefish (*Sepia officinalis*) is known as one of the economically important species in the Class Cephalopoda. The objective of the study was to determine the composition of the diet of *S. officinalis* and its relation to the size, sex and season off Lagos coast, Nigeria. Sample of cuttlefishes were caught by the use of bottom trawl nets between August 2019 and January 2020. The frequency of occurrence, numerical and fullness methods were used for analysing the food items. Of the 1,082 specimens examined, 90 (8.3%) were empty stomach and 992 (91.7%) were found with prey. Food items sighted were grouped into eight major categories; these were fish parts (bones, eyes and scales), crustaceans (shrimp; appendages and whole crab; appendages and whole), Annelids, filamentous algae, Diatoms, sand grains, plant materials and unidentified food masses with crustaceans being the most abundant in large and medium size (Mature individuals) while in the small size (immature individuals) fishes were dominant in their stomach contents. Therefore, food items in their stomach indicated that they were euryphagous; feeding on wide range of organisms (opportunistic feeders). Sex of the cuttlefish did not affect the occurrence and importance of food items while size of the cuttlefish, depth, and bottom type, time of day and geographical locations probably did.

Keywords: *Sepia officinalis,* Lagos coast, Diets, Opportunistic feeders

INTRODUCTION

Cuttlefish (*Sepia officinalis*), (Linneus, 1758) are marine invertebrates belonging to the family Sepiidae, class Cephaopoda (that includes Squid, Octopuses and Nautiuses) and phylum Mollusca. They are refers to cuttlefish due to presence of fins. There are over 120 species of cuttlefish currently recognised and are primarily bottom- dwellers over a range of habitats, including rocky, sandy, and muddy substrates, sea grass, seaweed, coral reefs. They are characterized by short life cycles, fast growth rates and high food conversion, having high energy requirements (Pascual, 1978; Domingues *et al.,* 2001). They are of significant commercial value to artisanal and industrial fisheries (Reid *et al*., 2005). Investigations regarding the dynamics of the feeding biology of *S. officnalis* in this part of the world remain scarce, being limited to few reports like (Piczon du Sel, G., A. Blanc and J. Daguzan, 2000. It is on this basis that this study was carried out aiming at providing useful information on the food and feeding habits of *sepia officinalis* off Lagos coast, Nigeria.

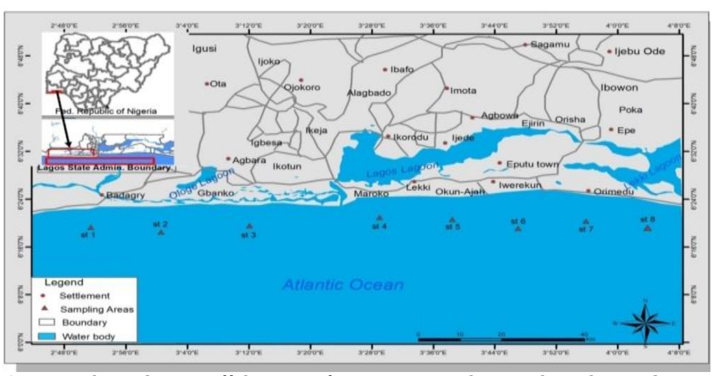

Figure 1: The study area, off the coast of Lagos, Nigeria showing the eight sampling stations

Source: Self Acquired from Department of Geology, Nigerian Institute for Oceanography and Marine Research, Victoria Island (NIOMR)

MATERIALS AND METHODS

The study area which is off Lagos coast (Figure 1) extends from Badagry to Ibeju-Lekki Local Government Areas of Lagos State, Nigeria. The study area is located between longitudes 2° 45’ and 3° 60’ and latitude 6° 20’ and 6 ° 34’. Eight sampling stations (1, 2, 3, 4, 5, 6, 7 and 8) were selected based on ecological and/or anthropogenic factors at approximately 10 nautical miles away from the shore. The distance between one station and the next is about 5 nautical miles to cover the entire Lagos coastline.

COLLECTION OF SPECIMENS

The specimens of *Sepia officinalis* (Plate 1) were collected on board off Lagos coast using bottom trawl net. A total of 1,082 specimens of the cuttlefishes was collected between the months of August, 2019 and January, 2020 and was preserved in ice on chest at the point of collection and immediately transferred to the deep freezer at -20°C in the Department of Marine Science laboratory, where they was kept prior to laboratory work.

PLATE 1: Dorsal view of Cuttlefish (*Sepia officinalis*).
Source: Field work (2020).

STOMACH ANALYSIS

Cuttlefishes samples were removed from the freezer and allow to thaw and thereafter, cuttlebone were removed and a pair of forceps was used to carefully remove the stomach below the cuttlebone region of each sample and placed in a petri dish. The state of fullness of each cuttlefish’s stomach was recorded in the proforma as 0\4 1\4, 2\4, 3\4 and 4\4 representing empty stomachs, quarter-filled, half-filled, three-quarter filled and filled stomach respectively. Two methods were used to analyse the stomach content. The method used for the analysis of these stomach contents were numerical and frequency of occurrence methods.

DATA ANALYSIS

Chi-square test (Legendre and Legendre, 1979) was used to determine the population dynamics and to compare the diet by life stage and season within life stage.

RESULTS

The food and feeding habits of specimens of the *S. officinalis* cuttlefish was examined. The analysis monthly variation in vacuity index stomachs of *S. officinalis* showed that the least vacuity index stomachs occurred in January 2019 with 7.7% in which the highest occurrence of vacuity index stomach occurred in October 2018 with 13.2% while no vacuity index stomachs occurred in November 2018, July 2019 and October 2019 illustrated in Table 1. The resu lts of vacuity index (VI) in relation to size (three groups) (small size group, 4.45 – 11.11cm; medium size group, 11.12 – 19.69cm and large size group, 19.70- 27.60cm) of *S. officinalis* obtained off Lagos coast is shown in table 2; the highest VI of 9.33% was in the small size group (4.45 – 11.11cm), while the lowest VI of 5.55% was recorded in the large size group (19.70 – 27.60cm). In the study, small groups represent immature ones, while medium and large sizes represent mature ones.

Table 1: Monthly Vacuity Index of *Sepia officinalis* off Lagos (August, 2018 – Jan, 2020)

Year	Month	Number examined	Number with empty stomachs	Number with prey	% Empty stomach
2018	Aug,2018	79	8	**71**	11.4
	Sept.	70	8	**62**	10.0
	Oct.	68	9	**59**	13.2
	Nov.	68	0	**68**	0
	Dec.	46	6	**40**	10.9
2019	Jan.2019	39	2	**37**	7.7
	Feb.	33	4	**29**	12.1
	Mar.	35	6	**29**	17.1
	Apr.	32	5	**27**	15.6
	May.	67	8	**59**	11.9
	Jun.	70	6	**64**	8.6
	Jul.	79	0	**79**	0
	Aug.	86	6	**80**	6.9
	Sept.	84	8	**76**	9.5
	Oct.	68	0	**68**	0
	Nov.	67	6	**61**	8.9
	Dec.	56	5	**51**	8.9
2020	Jan, 2020	35	3	**32**	8.6
	Total	**1,082**	90	**992**	

Table 2: Vacuity Index of *Sepia officinalis* in relation to size off Lagos coast, Nigeria. (August 2018 – January 2020)

Size (Dorsal width)	Range (cm)	Number Examined	Number with Empty Stomach	% Empty Stomach
Small	4.45 – 11.11	600	56	9.33
Medium	11.12 – 19.69	429	31	7.23
Large	19.70 – 27.60	53	3	5.66

The Fullness Index (FI) of *S. officinalis* stomachs off Lagos coast, (August 2018 – January 2020). A total of 1,082 *S. officinalis* were randomly selected off Lagos coast between Aug., 2018 and Jan., 2020 were examined. Of the 1,082 specimens examined, 992 (91.7%) were found with prey. Out of the 600 *S. officinalis* stomachs with food, 200(33.33%) stomach were full (4/4) fed; 257(42.82%) stomachs were ¾ fed; 114(19%) stomachs were 2/4 fed; 29(4.83%) stomachs were ¼ fed in small size group. Out of 429 with prey, 143(33.33%) stomach were full (4/4) fed; 184(42.89%) stomachs were ¾ fed; 82(19.11%) stomachs were 2/4 fed; 20(4.66%) stomachs were ¼ fed in medium size group and 53 with prey, 18(33.96%) stomach were full (4/4) fed; 22(41.51%) stomachs were ¾ fed; 10(18.87%) stomachs were 2/4 fed; 3(5.66%) stomachs were ¼ fed in Large size group. The highest FI value of 257(42.83) for three quarter-fed (3/4) was recorded in size group of 11.12 – 19.69cm (small size) while the lowest FI value of 3(5.66) for one quarter-fed (1/4) was recorded in size group of 19.70 – 27.90cm (large size) illustrated in table 3.

Table 3: Fullness Index by size of *S. officinalis* stomach off Lagos coast, Nigeria (Aug., 2018 – Jan., 2020)

Size (Dorsal width)	Range (cm)	Number Examined	$\frac{1}{4}$ Full Stomach No (%)	$\frac{2}{4}$ Full Stomach No (%)	$\frac{3}{4}$ Full Stomach No (%)	$\frac{4}{4}$ Full Stomach No (%)
Small	4.45 – 11.11	600	29 (4.83)	114 (19)	257 (42.83)	200 (33.33)
Medium	11.12 – 19.69	429	20 (4.66)	82 (19.11)	184 (42.89)	143 (33.33)
Large	19.70 – 27.60	53	3 (5.66)	10 (18.87)	22 (41.51)	18 (33.96)

The food items examined in the stomachs of *S. officinalis* were grouped into eight major categories. These were fish parts (bone, eye, scale and eye), crustaceans (shrimp, broken appendages and crab), Annelids, filamentous algae, diatoms, sand grains, plant materials and unidentified food masses. Crustaceans were the most abundant and important food item sighted by numerical method (46.6%) and occurrence (5.6%) method. Fish fragments were next of importance with 18.5% by numerical method and 4.9% by occurrence methods. Plant materials contributed 14.8% by numerical method but occurred in 3.2% of the stomachs. Diatoms occurred as 10.9% (numerical) and 2.1% (occurrence). Filamentous algae also accounted for 8.8% by numerical methods and 2.5% by occurrence methods. Also, Sand grains and unidentified mass occurred as 1.5% and 1.9% respectively, shown in (figure 2). The food items in relation to size of the species are shown in figure 2 and 3. The study revealed a significant change in the diet according to their life stage. The small size group preyed mainly upon small crustaceans by numerical (51.9%) and occurrence (29.345%) and fish fragments were next in importance by numerical (42.3%) and occurrence (15.57%) while, medium size group had the most diverse diets, fish fragments was the major prey group by numerical (47.1%) and occurrence (24.7) and crustacean fragments were next importance by numerical (42.6%) and occurrence (28.0%). The large size group showed a clear preference for larger fishes and crabs by numerical (0.96%) and occurrence (2.89%) and crabs by numerical (0.51%) and occurrence (0.30%). Although the cuttlefish are known for their opportunistic feeding behaviour, a preference for some prey according to length and behaviour could be perceived during this study.

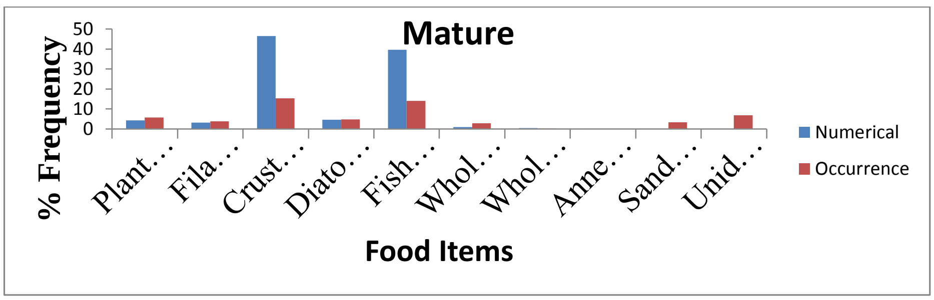

Figure 2: Stomach Content of Mature ones (Maturity stages III and IV) of *S. officinalis* off Lagos coast (Aug'18- Jan' 2020).

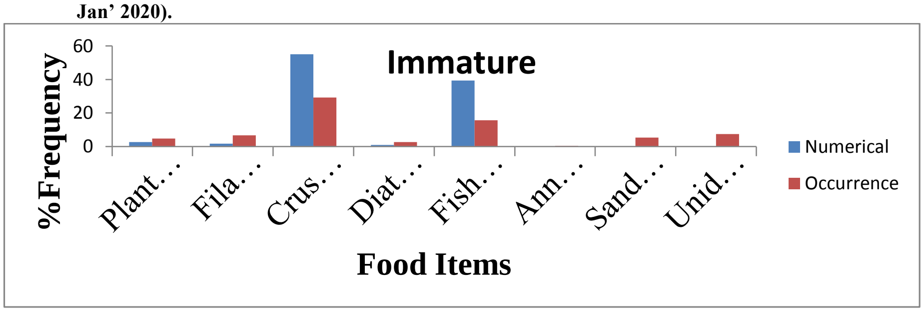

Figure 3: Stomach Content of Immature ones (Maturity stages I and II) of *S. officinalis* off Lagos coast (Aug'18 - Jan '2020).

DISCUSSION

The diet of most aquatic organisms would change based on some factors, either intrinsic(e.g size, behaviour and taxonomy) or extrinsic (e.g. biotope, region) (Pauly *et al.*, 1998) while food preference would be determined by the age of fish, prey accessibility and mobility, prey abundance, prey energy content, prey size selection and seasonal changes (Stergiou and Fourtouni, 1991). The incidence of some empty stomachs in cuttlefish observed during the period of sampling may vary according to maturity and reproductive activity and this could be that the cuttlefish have digested some of the food taken before they were captured. Castro and Guerra (1990) noticed a larger number of empty stomachs found within smaller animals (ML\65 mm) and a higher feeding intensity in mature females. The monthly variation in vacuity index stomachs of *S. officinalis* showed that the least vacuity index stomachs occurred in January 2019 with 7.7% this could be attributed to low rainfall which could directly affect availability of prey in the area while highest occurrence of vacuity index stomach occurred in October 2018 with 13.2% could also be attributed to high rainfall which could lead to abundance of preys available in the study area while no vacuity index stomachs occurred in November 2018, July 2019 and October 2019, it showed that the organisms were well feed and the environment was also favourable for them. Diets variation of cuttlefish in this study showed they exhibited opportunity feeding behaviour. Similar observation was made by Ana Neves *et al.,* (2009) on feeding habits of the cuttlefish *S. officinalis* during its life cycle in the Sado estuary Portugal. Differences in terms of the importance of the different types of prey in the diet of *S. officinalis*, as well as occurrence of more species, are probably consequences of habitat differences, predator size and the number of analyzed stomachs (Castro and Guerra, 1990; Pinczon du Sel *et al.*, 2000). The study showed a significant change with the size of the cuttlefish. Though, Food items such as filamentous algae, diatoms and annelids could probably incidental, since they appeared little and only in stomachs where crustaceans or fishes occur. Also sand grains in their stomachs could reveal benthic habits of cuttlefish off Lagos coast. However, the study showed that smaller cuttlefish, which correspond to very young - ones with an average of 25 mm ML, showed a strong preference for smaller crustaceans such as mysids and amphipods. Similar result was reported by Darmaillacq *et al.,* (2004), that mysids improve better growth during the first week of life on cultured cuttlefish, whereas bigger food item such as shrimps became more preferable afterwards. The proportion of *G. decadactylus* in cuttlefish stomachs could be as a result of high abundance in the study area during the period of sampling. Therefore, as cuttlefish grow, their food preferences also change, and fish and larger shrimps became the most preferred food items.

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Species composition, dominace and similarity index of *Macrobrachium vollehovenii* and *Macrobrachium felicinum i*n Akor River, Ibere Ikwuano, Nigeria

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Abstract
Occurrence and abundance of *Macrobrachium vollehovenii* and *Macrobrachium felicinum* were studied in Akor River Ibere Ikwuano Nigeria. Duration of the study was for 24 months and the area density method was employed for the study. The River was delineated into three sections, Station A, B and C and fish specimen were collected fortnightly. Species composition, dominance and similarity index were calculated using suggested methods. Chi square test was used to compare the dominance of both species in the River. Results shows that Station A had a total catch composition of 1,407 (29.4%), Station B, 1,689 (34.73%) and the highest catch was recorded at station C 1,763 (36.2%) with overall total of 4,859 catches. Results also showed that *Macrobrachium vollehovenii* dominated more in the river with a total number of 3,620 (75%) of the catches while *Macrobrachium felicinum* had a total of 1,239 (25%) of the catches. Ponderal index was 53.7 and 44.7 for *Macrobranchium vollehovenii* and *Macrobrachium felicinum* respectively and a similarity index of 1 for both species. Statistical analysis showed that there was significant difference between dominance of these species in the River (p<0.05). We therefore recommend that due to continual presence of these species in the River as a non-target species and consequent discard of this species, there is need to develop appropriate and reliable means of estimating discards of these species in the River.

Keywords: Occurrence, Abundance, *Macrobrachium* species, Fresh water

Introduction
In recent times studies have shown that freshwater prawns are present in all biogeographically regions, with the exception of Antarctica (Grave *et al*, 2008). However, the Oriental region harbours the majority of species (Grave *et al*., 2008). In freshwater rivers and creeks in the Niger Delta of Nigeria, *Macrobrachium* fishery predominates. Three species namely, *Macrobrachium felicinum* (Niger River prawn), *Macrobrachium vollenhovenii* (African River Prawn) and *Macrobrachium macrobrachion* (Brackish river prawn) dominate the catches of the fisheries subsector (Powell, 1983) cited in Ukagwu (2015). Studies carried out in Akor river Ibere has shown the presence of *Macrobrachum* species in the river with high level of anthropogenic activities such as swimming, washing, dredging, lumbering and fishing. However, no work has been done on catch composition and dominance with respect to the fishing gear used in the region. This study is aimed to determine the catch composition, dominance and similarity index of *Macrobrachium* species for sustainable of fishery resources.

Materials and methods
Survey and Sampling site
Ibere is in Ikwuano Local government area of Abia state between latitudes 05.34829°N and Longitude 007°.34468' E with elevation of 77m. The Ibere region which is located in the northern part of Ikwuano LGA is a mountainous region. *Macrobranchium Vollenhovenii* and *Macrobrachium Felicinum* species were identified by use of the keys of Powell (1983) and Holthius (2000). The Jaccard similarity coefficient was used for comparing the similarity and diversity of the prawn species in Akor River. Dominance of the fish species was calculated using the formula suggested by Idodoh-Umeh and Victor, (1990) where any species which account for 10% of the total fish population or more by number and by biomass is termed to be dominant specie.

$$Cj = \frac{j}{a + b-}$$

Cj = Similarity between any two zones a and b
j = No. of species common to both zones and b
a = No. of species at zone a
b = No of species at zone b
if Cj =1 = Complete similarity
0 = Complete dissimilarity

Results

Catch composition, dominance and similarity index

The pooled numbers of prawn species in the different stations are presented in Table 1. The most dominant prawns found at the three different stations were *Macrobrachium vollenhonvenii* followed by *Macrobrachium felicinum*. At station A, there were a total of 1,407 individuals in twenty four months, *Macrobrachium vollenhovenii* specie had 1,044 individuals representing 74.2% of the catches while *Macrobrachium felicinum* made up 26.8% of the total catches with 363 individuals. At station B. there was a total catch of 1,689 prawns;*Macrobrachium vollevovenii* specie had 1,235 individuals representing 73.1% of the catches while *Macrobrachium felicinum made* up 26.8% of the catches with 454 individuals. At station C, maximum prawn diversity was recorded, there were a total of 1,763 prawns, *Macrobrachium vollehovenii* made up 76.06 % of the catches with 1,341 individuals while *Macrobrachium felicinum* made up 23.9% of the total catches with 422 individuals. In general, *Macrobrachium vollehovenii* made up 74.6% of the total catches in the three stations with 3,624 individuals while *Macrobrachium felicinum* made up 25.4 % of the total catches with 1,239 individuals' both of which were dominant in the river.

Species biomass

The total weight of prawn or biomass of the two species collected station by station during the study was recorded. The biomass and percentage of each specie in the community. At station A, the predominant species by weight was *Macrobrachium vollenhovenii* with a biomass of 4,526g or 64% of the total biomass in the station and then followed by *Macrobrachium felicinum* which has a biomass of 2,792g or 39% of the total population in the station. At station B, the predominant specie by weight was *Macrobrachium vollenhovenii* with a biomass of 3,908g or 53.1% of the total biomass and followed by *Macrobrachium felicinum* with a biomass of 3,447g or 46.9% of the total prawn community. At station C, the predominant specie was *Macrobrachium felicinum* with a biomass of 3,332 or 47% of the prawn community followed by *Macrobrachium vollenhovenii* with a biomass of 3,090(44%) of the total prawn community. Overall dominant prawn in the river was *Macrobrachium vollenhovenii* which had a biomass of 11,524g (53%) of the entire prawn biomass.

Table 1. The composition of *Macrobrachium vollehovenii* species during the dry and wet seasons in the locations

Season	Station A	Station B	Station C	Total
Dry season	324 (31%)	405 (33%)	651(49%)	1,380 (38%)
Rainy season	720 (69%)	830 (67%)	690 (51%)	2,240 (62%)
Total	1,044	1,235	1,341	3,620 (75%)
***Macrobrachium felicinum* specie during the dry and wet seasons**				
Dry season	168 (46%)	194 (43%)	126 (30%)	488 (39%)
Rainy season	195 (54%)	260 (57%)	296 (70%)	751(61%)
Total	363	454	422	1,239 (25%)
Grant Total				4,859

Table 2. Table showing the occurrence and dominance of the species in the three stations

Specie	Station A	Station B	Station C	Total	PI (%)	SI
MV****	1,044	1,235	1,341	3,620	53.8	1
MF****	363	454	422	1,239	44.7	1
Total	1,407	1,689	1,763	4,859		

MV = *Macrobrachium vollehovenii* MF= *Macrobrachium felicinum*

******= Dominant > 10% PI = Ponderal Index SI= Similarity Index**

Discussion

The composition of these species reported in this study compares favorably with Nwosu and Wolfi (2006) who reported the presence of *Macrobrachium vollehovenii* in high numbers in the Cross River estuary of the Niger delta. There were drastic changes in fish community during the period of this study, more numbers of Prawns were caught during the wet season than the dry season. This corroborates with the report of Powell, (1983) who affirmed that these species are more abundant in the rivers during the rainy season than the dry season. It is likely that some rare events like feeding and migrations of these species during rainy season could have led to their presence in these three stations. Because of the gears used, this study could not account for the very small prawns. The ponderal index (PI) is the ratio between weight of one species and the weight of all the species expressed in percentage. Any fish species with a ponderal index of 1% or more is regarded as a permanent resident of a fish community (Luazanne, 1983). In macrobenthic communities, any taxon constituting 15% or more by number is considered dominant (Idodo-Umeh and Victor, 1990). A dominant fish species is however defined as any species which account for 10% or more both by number and by biomass (Idodo-Umeh and Victor, 1990). Regarding species biomass, a possible explanation for this could be as a result that some prawns were caught during the dry season months with peak catches being in May and June. This may be due to the dry season, occasioned by the receding flood and evaporation, leading to concen tration of fishes in smaller volume of water thus might contribute to reduction in weight (Farhadian and Pouladi, 2014).The difference in the size range of prawns inhabiting the river, with small shrimps in Akor River could be due to differences in fishing activity. These variations could also be seen statistically leading to the differences ($p<0.05$) between the two species. Observations in the area revealed that most of the fishermen concentrate more on the vertebrates than the invertebrates as they considered the *Macrobrachium* spp irrelevant.

Conclusion and Recommendation

This study revealed the presence of *macrobrachium* species in large number during the period of study namely *Macrobrachium vollenhovenii* and *Macrobrachium felicinum.* These two species dominated the three stations that were studied and had more of females than the males which can be used for fish post larval production and therefore recommend that this commercially important specie discovered to be resident in Akor river which is a hinterland location, a clearly defined policy on the management of *Macrobrachium* species need to be developed in view of its potential for export /foreign exchange generation.

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Industrial Fishing In Nigeria: A Recent Assessment Of Fish Landings

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Abstract
The landings of two selected industrial fishing companies were sampled for a period of one year at their jetties located at the Apapa area of Lagos. Fish landings were very irregular and the arrival of vessels from fishing trips could not be predetermined. The products (fish) composition consisted of big fishes, mix 1, mix 2, mix 3k and mix 4. Categorization of fish was based on size (length) which diminishes in size as the "mix" increases from 1 to 2, to 3 and to 4. Sorting of fish showed that each bag weighed 10kg composed of different species packaged and frozen. Though specified sizes dominated the various "mix" categories, other sizes were encountered scantily. The study showed that the depletion in fish production in Nigeria requires stock assessment that may inform fishing regulations and policies that could assist in stock improvement for sustainability in the industry.

Keywords: Industrial fishing, fish composition, diminishing sizes, stock assessment, fishing regulations.

Introduction

This study was informed by observed continuous decrease in the quantities and sizes of fish landings which pose very serious threat to economic survival of fishing companies and indication that Nigeria would further increase her foreign expenditures on fish importation with the risk of higher consumption of unwholesome frozen fish by the populace. Despite the increasing demand for fish, growth in fish production in capture fisheries and aquaculture in Africa has been slow (Chan, 2014; OECD/FAO, 2017). Capture fisheries represent the most important source of fish supply in Nigeria. Nevertheless, over-fishing and lack of effective fisheries management have caused decline and/or stagnation in fisheries development.

With a population of about 193,976,000 (FAOSTAT 2018) and annual fish demand of 3,280,000mt (FDF 2018), Nigeria is the largest consumer of fish and fish products in Africa relying heavily on fish importation. The Industrial and artisanal fisheries combine to exploit the marine resources of Nigeria providing an annual average of about 700,000 metric tons of fish (Giwa et al 2018). The earlier immediate causes of Nigeria's poor performance in capture fisheries are the customary problems such as poor infrastructure base, poor capital outlay, poor marketing systems poor data base, high exchange rates and the escalating insecurity issues in the Niger Delta which hosts the marine fishing areas. These factors amongst others, caused drastic fall in the number of fishers, length of fishing trips and consequently, quantity of fish landed from the sub-sectors.

Nigeria's primary responsibility lies in providing opportunities for production, consumption and export of fish and fish products. Although viable data on the subject is lacking, the aggregate economic loss due to depleting local fish production is significant and requires focused policy initiatives to restore. The number of registered fishing vessels which increased from 23 in 1985 to 125 in 1992 and further to 462 in 2013 has depleted to only 150 in 2017; about 6 of the 10 registered fishing companies in 2017 carried out fishing though very sporadically. The consequences have been enormous job losses, heavy reliance on fish importation, huge expenditures of foreign exchange on fish imports, capital flight, sharp practices in the foreign exchange market and above all, consumption of unwholesome imported fish and fish products. The continuous rising cost of fishing inputs. This study was conducted to establish the frequency of fish sizes in order to determine the trend of fish sizes and composition produced by the Nigeria industrial fishing subsector to facilitate the consideration of appropriate fishery policies in order to avoid crisis in the industry.

Materials and Method

Physical performance of length-weight frequencies was adopted for two selected fishing companies which were members of the Nigerian Trawler Owners Association (NITOA). 1 bag of fish was selected at random from each category of the sizeable bags and ¼ of each bag was sampled for total length (TL). Statistical analysis using excel was applied to determine the trend of the various sizes, and species.

Results and Discussion

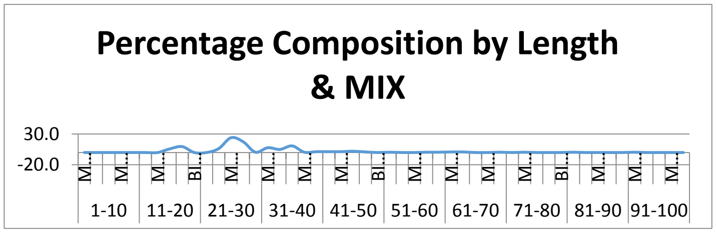

Figure 1: Percentage Composition by Length & MIX

The highest concentration of fish size for all categories was found to be between lengths 21 to 30 cm as demonstrated in figure 1. This was closely followed by 11 to 20 and 31 to 40 cm bracket. Generally, the fishes in MIX1 packages were larger than those in MIX2, which in turn, were larger than those in MIX3.

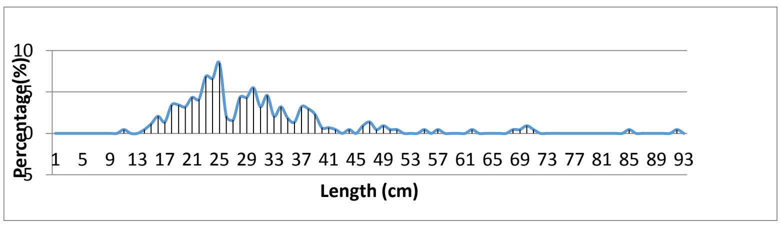

Figure 2: Percentage Distribution of Sample by Length

Over 80% of the landings were between length frequencies of 24 and 25 cm (figure 2) and larger sizes were scanty.

Table 1: Fish Landing Categorization

Company	MIX 1	MIX 2	MIX3/3K	MIX 4	BIG FISHES	%
A	63	115	241	188	42	95
B	9	9	8	10	1	5
Total	72	124	249	198	43	100

MIX3 were more abundant in the catches, contributing 249 of the observed total (Table 1). While company A produced 95% of the total sampled fish, company B provided 5%. Fish species encountered are presented in figure 3. They included grunters 12%, red snappers 5%, spade fish 10% and sole fish contributed 4%. Croakers were more available at 37% and followed by shinny nose (23%). However, the tables and figures are indicative of the dominance of juvenile fishes in the landings of the companies.

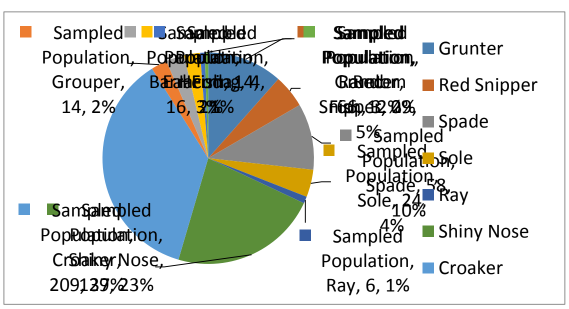

Figure 3: Sample Size by Species

Conclusion and Recommendation

All the simple analyses adopted showed that juveniles were prominent in commercial fish production and this is a pointer to more dangers ahead. The gears used in the process of production as well as area fished remain questionable and require knowledge about them. Therefore, the study justified the claim in the industry that more of their landings were juveniles which impact negatively on their income and reinvestment. The long term consequences of this are drastic reduction in fish production, loss of jobs, increase in crime rates resulting from unemployment and high cost or poor intake of fish-sourced protein. Therefore, there is urgent need for further study to perform fish stock assessment in order to provide avenues for policy consideration for sustainable fisheries management.

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Fish Species Compostion And Abundance of Kondo River At New Libata, Kebbi State, Nigeria

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Abstract
This study assessed fish species composition and abundance diversity of Kondo River at New Libata, Kebbi State. This was done for a period of four (4) months between November 2018 and February 2019. Twenty nine (29) species belonging to thirteen (13) families were recorded. The families Cichlidae and Cyprinidae were the most diverse with five (5) species each. Fish of least dominance include *Labeo coubie, Alestes dentex, Malapterurus electricus* and *Parachanna obscura*. *Citharinus citharus* was also the most abundant fish species at the Shore and Bottom of the river, and, *Coptidon zillii* at the Surface. This study need to be continued to cover the remaining months, monitoring of the fishery should be taken seriously, especially the activities of fishermen as well as organize workshop on management to sensitize them, and the findings of this study could be used as baseline information for further research work in other water bodies.

Keywords: Fish diversity, Kondo River, Cichlidae, Cyprinidae, Citharinus citharus

Introduction

Nigeria lies between Longitudes 2° 49" and 14° 37"E and Latitudes 4° 16" and 13° 52" N of Equator. It is blessed with vast expanse of inland fresh water and brackish ecosystems from the coastal region to the arid zone. According to Akeem (2011), there are thirteen lakes and reservoirs with a total surface area of 953,600 ha representing about 1% of the country, they are of significant importance because they hold populations of diverse fish species. Species that are of great commercial value and importance vary in their composition depending on the water body. These fish species serve as a source of protein and food in the face of ever increasing population in the developing countries. In addition, the lake fisheries had serve as a source of livelihood to the riparian communities and biodiversity of tremendous conservation values.

There are about 268 different freshwater fish species in Nigeria, inhabiting over 34 well -known fresh water bodies (rivers, lakes and reservoirs) and constitute about 12% of Nigeria's total surface area put about 94,185,000 ha (Ita, 1993). Fish stocks in rivers are generally replenished from their adjacent flood plains after each flood season during which fish breed. Considering this facts, therefore, that lakes, wetlands and reservoirs are supplied by their inflowing rivers, the rivers are characterized by higher species diversity (Ita, 1993).

Fishing activities in Kondo River is so high and it has been observed that the fishermen are found of using different fishing gears including gillnets of smaller mesh sizes and fishing is done all year round without opening and closing season, these activities of fishermen may lead to over - exploitation and possible extinction of certain species.

Survey of fauna of any water body is necessary because it provides a checklist of organisms present in the water for subsequent exploitation, conservation and sustainable management of the resources. Therefore, this study tends to assess the composition, abundance and diversity of fish species in Kondo River. This will give insight on the type of fish species found in the river, their abundance, diversity or richness.

Materials and Method

Study Area

Kondo River is located between southern part of New Libata and northern part of Warra, with some settlement such as Yunawa, Teteko and Kwanga along the river.

Sampling Stations

Three sampling stations were selected for this study. Station I (Yunawa): The communities engaged in fishing activities and rainy season farming. Station II (Teteko): Located close to Yunawa where the fishing activity is low. Station III (Kwanga).

Experimental fish sampling

A fleet of gillnets made up of nine multifilament nets (1' - 7') stretched meshes was used to sample the shore, surface and bottom the water at the three sampling stations. Each net measured 30 meters long and 3 meters deep. The nets was set simultaneously to sample the shore, surface and bottom habitats at about 5pm and was checked at about 8am the next day. Fish caught in each net was removed, transferred into labeled plastic bowls according to mesh sizes. Fish were sorted and identified using manual according to Idodo - Umeh (2003). This was done for four (4) months (November 2018 to February 2019).

Data Analysis

Data obtained were computed as percentages of number and weights as follows;

Percentage number = number of individual fish / Overall total number of fish x 100

Percentage weight (g) = weight of individual fish/Overall total weight of fish x 100

These were used to determine fish abundance for each habitat and months for the entire river. This was done using Special Package for Social Sciences (SPSS) version 20.

Results

Table 1 shows fish abundance (%) based on habitat in Kondo River at new Libata, Kebbi State. There were variations in the number of fish caught at the shore, surface and bottom of the river during the period of study. Bottom had the highest abundance 162 (34.91%) followed by Shore 157 (33.84) and the lowest was Surface 145 (31.25%). *Citharinus citharus* was the most abundant at Shore 47 (29.90%) and Bottom 44 (27.2%), while at surface, *Coptidon zillii* was the most abundant 33 (23.0%) followed by *Citharinus citharus* 24 (17.0%).

Chrysichthys nigrodigitatus, *Bagrus docmac* and *Alestes dentex* were the least in abundance each with 1 (0.64%) at the Shore, *Bagrus bayad*, *Clarias gariepinus*, *Heterobranchus bidorsalis*, *Hyperopisus bebe*, *Labeo coubie*, *Labeo parvus* and *Malapterurus electricus* at the Surface each with 1 (0.70%) while *Bagrus bayad*, *Clarias gariepinus*, *Mormyrops anguilloides*, *Barbus occidentalis* and *Parachanna obscura* at the Bottom of the river each with 1(0.62). The abundance of fish across the habitat did not differ (P>0.05) significantly.

Discussion

Fish composition entails the entity of fish found in the aquatic organism in terms of species and family, their presence or absence in a particular location. Twenty nine (29) species of fish belonging to thirteen (13) families were recorded in Kondo River during the period of study. Balogun *et al*. (2000) reported eighteen species from nine (9) families in Zaria River, while Fapohunda and Godstates (2007), recorded fourteen species from seven (7) families in Owena River. This shows that Kondo River is endowed with more fish species than these water bodies. This could be due to conduciveness of the environment for fish survival, the size of the water and duration of sampling amongst other factors. The families Cichildae, which comprise the Cichids and Cyprinidae (Cyprinids) had the highest number of different species with five (5) each. This tallies with the works of Balogun and Auta (2001) and Adeosun *et al*. (2011). The abundance of fish reveals the species with the highest population in the water body. Such information plays a significant role in management of the fisheries, because it is a guide for setting management strategies. *Citharinus citharus*, and *Coptidon zillii* were both, the most abundant species in the water body. This implies that these species dominated the river during the period of study. Conduciveness of the river, which include availability of food, good breeding ground and their prolific nature could have contributed to this observation. In addition, the Cichlids are known for their high ability to reproduce that is why *Coptidon zillii* was among the dominant fish species. *Alestes dentex*, *Labeo coubie*, *Malapterurus electricus* and *Parachanna obscura* which were least could be due low population in the river, low prolific ability amongst other. Similarly *Citharinus citharus* and *Coptidon zillii* both recorded highest weights could be due to the number caught as well as sizes in the river among other factors.

Fish species abundance across the habitats, showed the dominance of *Citharinus citharus* in the Shore and Bottom, while *Coptidon zillii* dominate the Surface habitat. Balogun and Auta (2001) reported the dominance of Cichlids such as *Coptidon zillii* at the Shore, and Cyprinids such as *Barbus spp.* and *Labeo spp.* at the surface and bottom habitat, which is contrary to the findings of this study. This could be due to difference in difference in period and duration of sampling, preference of such habitats in the water body and availability of food.

Table 1 : Fish abundance (%) at various habitat in Kondo River at new

	Shore		Surface		Bottom	
Family/species	**No**	**% No**	**No**	**% No**	**No**	**% No**
Cichlidae						
Chromidotilapia guentheri	18	11.50	4	2.80	6	3.70
Coptidonzillii	30	19.10	33	23.0	34	21.0
Sarotherodon galilaeus	6	3.82	4	2.8	-	-
Oreochromis niloticus	-	-	8	5.5	-	-
Hemichromis fasciatus	6	3.82	-	-	6	3.70
Mochokidae						
Synodontis membranaceus	5	3.18	4	2.8	6	3.70
Synodonits shall	3	1.91	-	-	3	1.85
Claroteidae						
Auchenoglanis occidentalis	3	1.91	8	5.5	10	6.17
Chrysichthys nigrodigitatus	1	0.64	5	3.4	-	-
Chrysichthys auratus	-	-	4	2.8	-	-
Bagridae						
Bagrus bayad	-	-	1	0.70	1	0.62
Bagrus docmac	1	0.64	4	2.8	3	1.85
Clariidae						
Clarias gariepinus	2	1.27	1	0.70	1	0.62
Heterobranchus bidorsalis	-	-	1	0.70	6	3.70
Citharinidae						
Citharinus citharus	47	29.90	24	17.00	44	27.2
Mormyridae						
Mormyrus rume	14	8.92	12	8.30	10	6.17
Mormyrops anguilloides	-	-	3	2.10	1	0.62
Hyperopisus bebe	-	-	1	0.70	8	4.94
Alestidae						
Alestes dentex	1	0.64	-	-	-	-
Brycinus leuciscus	-	-	4	2.8	3	1.85
Cyprinidae						
Labeo senegalensis	-	-	3	2.10	-	-
Labeo coubie	-	-	1	0.70	-	-
Labeo parvus	5	3.18	1	0.70	4	2.47
Barbus occidentalis	2	1.27	3	2.10	1	0.62
Barbus callipterus	-	-	2	1.40	-	-
Polypteridae						
Polypterus senegalus	8	5.10	2	1.40	5	3.09
Distichodontidae						
Distichodus rostratus	5	3.19	11	7.60	9	5.56
Malapteruridae						
Malapterurus electricus	-	-	1	0.70	-	-
Channidae						
Parachanna obscura	-	-	-	-	1	0.62
Total	**157**	**100**	**145**	**100**	**162**	**100**

Conclusion

Twenty nine (29) fish species belonging to thirteen (13) families recorded showed high diversity, when compared to other water bodies within the locality. Cichlidae and Cyprinidae are the most diverse in fish species.

Citharinus citharus and *Coptidon zillii* were the most abundant species in the water body. Both species of fish also recorded highest weight throughout the period of study. While *Citharinus citharus* dominated the Shore and Bottom of the river, *Coptidon zillii* dominated the Surface.

Recommendations

This study should be continued or done to cover the remaining months as this is anticipated to reveal more fish species. Monitoring of the fishery especially the activities of fishermen should be done, as this will reveal the trends or changes in fish species diversity of the river. Organize workshop and sensitization programmes on fisheries management especially for fishermen

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Variations of fishing gears used by fishermen in some communities of Lagos East coast.

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Abstract
Artisanal fisheries employ the use of various type of fishing gears with local variations in the water body where they are being use. Fishing gear efficiency is dependent on several factors, such as fishing techniques to be used, fish species and the materials for construction. The type of fishing gear used by fisherfolks varies from one particular area to another. Survey of fishing gear and operational methods was carried out on six fishing communities (Orimedu, Akodo, Magbon Oga, Magbon Alade, Igando, and Idado) along Lagos East coast between latitudes 6°26'19.32"N and longitudes 3°50'32.88"E and latitudes 6°26'3.30"N and longitudes 3°56'1.62"E. The configurations of gear mesh size, twine diameter, length, were determined. Five types of fishing gears were recorded (1) Beach Seine 5% (2) Purse Seine 23% (3) Gill Net constructed from different types of materials, Monofilament gill net (Polyamide) 64% and Multifilament gill net (Cotton), (4) Stow Net and (5) Mini Trawl Net other gear constitute less than 5%. Fifteen (15) species from 13 families were caught with the fishing gears and canoes. However, this is the first record of a Mini-Trawl net used by artisanal fishery in Nigeria and foresee the spread of the use of this illegal fishing gears among fishermen if adequate measures are not taken to stop the menace.

Keywords: Gillnet, Twine Diameter, Mini-Trawl Net and Artisanal fishery

Introduction
The different changes in fishing gear design and methods of operation have long been employed by different net makers and fishers to achieve desired selective properties of fishing gear toward target and preferred catch compositions (Valdemarsen & Suuronen, 2003; Graham *et al*., 2007; Eigaard *et al.*, 2014; Breen, 2016). It is worthy of note that fishing gear designs and operational methods are major factors in determining what types of species and quantity being harvested, while a fishing canoe may be described as a floating platform used to transport the crew, gear to and from the fishing grounds and equipment for support during the fishing operation. The international organization for standardization (ISO) defined netting as a meshed structure of indefinite shape and size, compose of one yarn or one or more system of yarn interlaced or join (ISO,1974). The raw materials of the netting consist of fibre of which two main group may be distinguished as natural and manmade fibres (Emmanuel, 2010). The knowledge of size selectivity of fishing gear is crucial to management of a fishery for the purpose of maximizing yield and protecting juvenile fish. The Nigerian coastline is dotted with many fishing villages of variable sizes, fishing canoes and a host of fishermen. This communities contributes significantly to Nigerian economy having 740,378 fishermen in full time fishing activities and 635,044 part time and contributing about 67.7% of the total domestic fish production with 694,867.00 metric tonnes (FDF, 2015). Fishermen involved in artisanal fisheries in Nigeria make use of gears that are made up of natural and synthetic materials. The effort to improve fishing techniques and gears which is targeted at replacing the low yield in the traditional fishing methods has been reported by some authors (Akanni, 2008). According to Watson *et al.*, (2006) fishermen are interested in new and improved fishing gears such as canoes, buoys, floats, nets, and mechanization with the aid of an outboard engine for improved catch efficiency and landings. This survey documented current state of fishing gears used in 6 communities along the Lagos East coast and identify possible areas where improvement measures can be effected to increase fish catch and landings in the artisanal fishery.

Material And Methods
Field survey of fishing gear and construction details was carried out in 6 fishing communities along Lagos East coast communities (Orimedu, Akodo, Magbon Oga, Magbon Alade, Igando, and Idado) between latitudes 6°26'19.32"N and longitudes 3°50'32.88"E and latitudes 6°26'3.30"N and longitudes 3°56'1.62"E (Fig. 1). One hundred and twenty (120) standardize questionnaires on fishing gears were administered to willing participants among the fishermen encountered at the beach to determine number of fishermen per community, identified fishing gears used, and the configuration of the gear. The gear configuration was determined by direct measurement using Keson Fiber Glass Meter tape model OTR10M50 and Neiko Digital Micrometer Gauge, Model: JEW95VC150, Electronic Carbon Fiber Composite Digital Caliper model NPH-00194 was used to the nearest 0.1 cm and 0.1 mm respectively according to Bolaji et al., (2017).

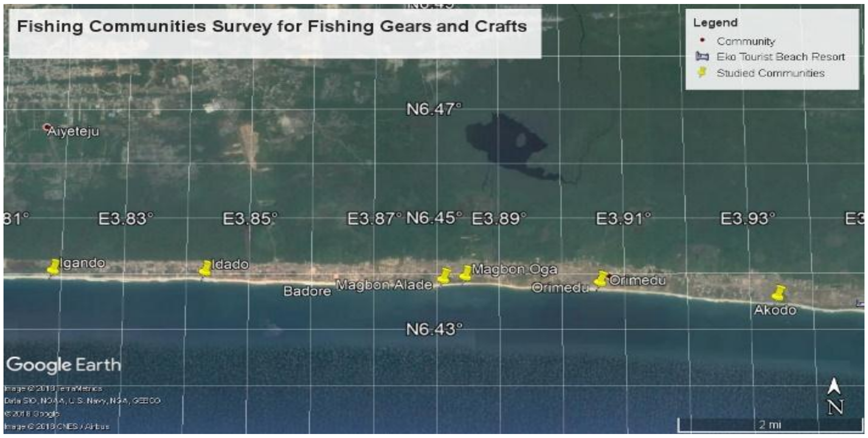

Fig: 1 Fishing Communities Survey for Fishing Gears

Result

A total of 862 fishermen using 478 canoes was recorded from 6 fishing communities studied along Lagos East Coast, and the largest concentration of fishermen were recorded from Orimedu consisting of 44.54% followed by Akodo with 33.41% and Magbon Oga 11.14%, Magbon Alade 6.68% and Igando 4.01% while Idado 0.22% contributed the least percentage of fishermen (Fig. 2).

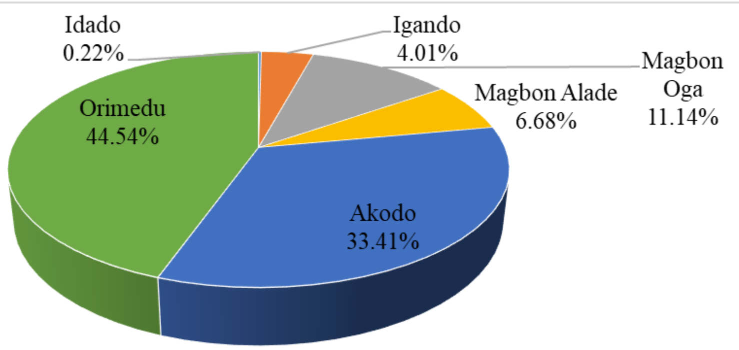

Fig. 2: Percentage Distribution of Fishermen

Fishing Gears

Five types of fishing gears were recorded in the communities studied along Lagos East coast, the first two are surrounding nets namely (1) Beach Seine and (2) Purse Seine; then (3) Gill Net constructed from different types of materials, Monofilament gill net (Polyamide) and Multifilament gill net (Cotton), (4) Stow Net (Cotton) and (5) Mini Trawl Net (Polyethylene). The highest gear recorded in most of the communities studied are Monofilament gill net constituting 64% followed by Purse Seine 23%, Beach Seine was 5% while other gear constitute less than 5%. Multifilament gill net is the least encountered gear along the Lagos East which contribute 1% and was only encountered at Igando Community, while Purse Seine and Beach Seine are commonly used gears at Magbon Alade and Orimedu Communities (Fig. 3). The average characteristic of the gears encountered is presented in Table 1.

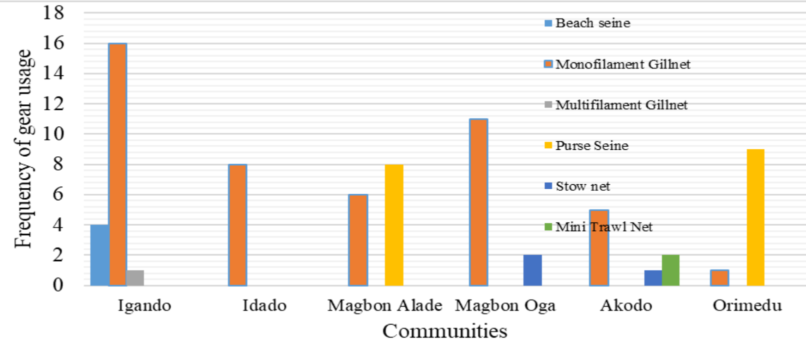

Fig. 3: Fishing Gears Used Along Lagos East Nigeria

Table 1: Average characteristics of gears used along Lagos East Nigeria

Gear Types	No. of Floats	Mesh Size (mm)	Twine Diameter (mm)
Monofilament Gillnet	897.57	49.78	0.19
Multifilament Gillnet	600.00	101.00	0.95
Purse Seine	3042.73	43.38	0.48
Beach seine	1500.00	21.20	0.51
Mini Trawl Net	850.00	42.15	2.67
Stow net	No float observed	9.40	0.97

Discussion

Nigeria artisanal or small scale fisheries is gradually becoming less attractive as a total of 862 fishermen recorded from 6 communities (averaging 144 per community) on Lagos east coast indicated low participation in the sector when compared to Falaye, (2008) which reported a total of 500,000 fishermen from 189 fishing communities in the country averaging about 2,645 fishermen per community and FDF, (2015) which reported 1,456,447 as total fishermen in the country. According to Jim-Saiki *et al.* (2016) the artisanal sector produces 81.9% of the total domestic fish production in Nigeria with 4% contribution to the nations GDP, there is an urgent need to make the artisanal sector more attractive and lucrative for the fishermen in order to sustain and improve production. The high concentration of fishermen was recorded between Orimedu and Akodo accounting for 78% of the total fishermen, this is as a result of high concentration of half dugout canoe (Ghana boat) that carries up to 15 fishermen or more per fishing trip while the plank canoe is operated mainly by an individual or 2 fishermen, similar observation was made by Abass *et al.* (2010) for the same community. Some authors Akanni, (2008); Falaye, (2008); Abass *et al.* (2010); Lawison *et al.*, (2012); and Jim-Saiki *et al.* (2016) have reported use of gillnet in as the most commonly used in Nigeria fisheries and monofilament gill net is the most preferred fishing gear. A similar observation was made along the Lagos east coast constituting about 64% of the gears used, although fragile and damaged easily, the fishermen prefer the gear because of its assuming high performance and low cost of construction when compared to other types of fishing gears used in the sector. Similar observations of monofilament preference have been reported by some authors GFCM, 2012; Gilman, 2015; and Daudu, 2020. Similar observations of monofilament preference have been reported by some authors Lawison *et al.*, (2012); GFCM, (2012); Gilman, (2015); and Daudu, (2020). Although GFCM, (2012) and Gilman, (2015) reported that monofilament with twine diameter of 0.5mm has been banned in the Mediterranean, the average twine diameter of monofilament gillnet used in this region is 0.19mm which is still within an acceptable standard range of 30µm to 3mm (Tausif *et al.*, 2018). Monofilament is known for high performance and it catches average size fishes which are of low market value when compared to its counterpart multifilament gillnet that catches larger size fishes with higher market. A Mini-Trawl net was recorded among the fishing gears used by artisanal fishery at Akodo community, this is the first record of a trawl net in the Nigerian artisanal fisheries sector operated by pair trawling in a non-trawling zone according to the Nigerian Fishery Act, (1992) under section 14 paragraph 10 states "No motor fishing boat- (a) shall trawl or pair trawl within the first five nautical miles of the waters of the Nigeria continental shelf". The use of a Mini-Trawl net by artisanal fishermen is therefore illegal, dangerous and is not a sustainable fisheries practice. The use of the Mini-Trawl net will lead to adverse effect on the recruitment of fishes and in turn dangling fisheries resources will be available for the industrial fisheries sector. This study presents the first record of a Mini-Trawl net used by artisanal fishery in Nigeria and foresee the spread of the use of this illegal fishing gears "Mini Trawl Net" among the artisanal fisheries sector if adequate measures is not put in place to curb and stop the menace.

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Variation of Fishing Gears used By Fishers Folks in Some Coastal Communities of Lagos State

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Abstract
Artisanal fisheries employ the use of various fishing gears which includes gillnet, castnet, purse seine beachseines, hook and line, traps, etc with local variations in the water body where they are being use. Fishing gear efficiency is dependent on several factors, such as fishing techniques, the fish species and the materials for construction. The type of fishing gear used by fisherfolks varies from one particular area to another. Survey of fishing gear and operational methods was carried out on six fishing communities Igando, Idado, Magbon alade, Magbon oga, Orimedu and Akodo along Lagos East coast between 6°26'19.32"N and 3°50'32.88"E and 6°26'3.30"N and 3°56'1.62"E. The configurations of gear mesh size, twine diameter, length, were determined. Five types of fishing gears were recorded (1) Beach Seine 5% (2) Purse Seine 23% (3) Gill Net constructed from different types of materials, Monofilament gill net (Polyamide) 64% and Multifilament gill net (Cotton), (4) Stow Net and (5) Mini Trawl Net other gear constitute less than 5%. Fifteen (15) species from 13 families were caught with the fishing gears and canoes. However, this is the first record of a Mini-Trawl net used by artisanal fishery in Nigeria and foresee the spread of the use of this illegal fishing gears among fishermen if adequate measures are to not taken to stop the menace.

Keywords: Gillnet, Twine Diameter, Mini-Trawl Net and Artisanal fishery

Introduction
It is important to note that fishing gears designs and their operational methods are the major factors in determining what types of species and quantity of fish being harvested. Fishermen involved in artisanal fisheries in Nigeria make use of gears made up of natural and synthetic materials. The effort to improved fishing techniques and gears which is targeted at replacing the low yield in the traditional fishing methods has been reported by some authors (Akanni, 2008). Fishery management requires a good knowledge of fishing gears. There is great divergence the efficiency of different forms of fishing gear, in their adaptability to certain conditions, and in their desirability for specific job (Eyo and Akpati, 1995). fishermen are happy to have new and improved fishing gears such as canoes, buoys, floats, nets, and mechanization with the aid of an outboard engine for improved catch efficiency and landings (Watson et al., 2006).This survey documented current state of fishing gears used in 6 communities along the Lagos East coast and identify possible areas where improvement measures can be effected to increase fish catch and landings in the artisanal fishery.

Material and Methods
Field survey of fishing gear and operational methods was carried out on six fishing communities along Lagos East coast between 6°26'19.32"N and 3°50'32.88"E and 6°26'3.30"N and 3°56'1.62"E (Fig. 1). One hundred and twenty (120) standardize questionnaires on gears were administered to willing participants among the fishermen encountered at the coast to determine number of fishermen per community, types of fishing gear used among the communities was documented. Fishing gears were identified and construction configuration details were determined by direct measurement according to Bolaji *et al.*, (2017). The configuration of the gear covers mesh size, diameter, thickness , length was measured and were determined using Keson Fiber Glass Meter tape model OTR10M50 and Neiko Digital Micrometre Gauge, Model: JEW95VC150, Electronic Carbon Fiber Composite Digital Caliper model NPH-00194 was used to the nearest 0.1 cm and 0.1 mm respectively

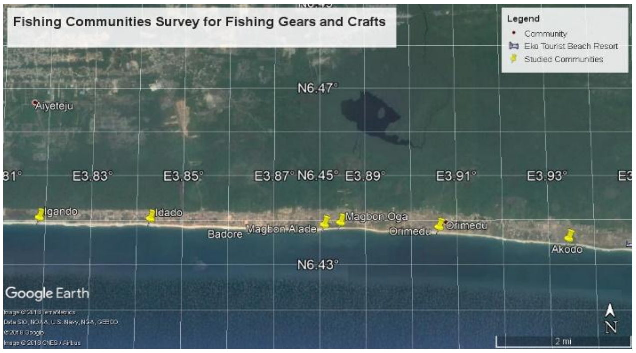

Fig. 1 Fishing Communities Survey for Fishing Gears

Result

Fishing Gears

Five types of fishing gears were recorded in the communities studied along Lagos East coast, the first two are surrounding nets namely (1) Beach Seine and (2) Purse Seine (3) Gill Net constructed from different types of materi als, Monofilament gill net (Polyamide) and Multifilament gill net (Cotton), (4) Stow Net (Cotton) and (5) Mini Trawl Net (Polyethylene). The highest gear recorded in most of the communities studied are Monofilament gill net constituting 64% followed by Purse Seine 23%, Beach Seine was 5% while other gear constitute less than 5%. Multifilament gill net is the least encountered gear along the Lagos East which contribute 1% and was only encountered at Igando Community, while Purse Seine and Beach Seine are commonly used gears at Magbon Alade and Orimedu Communities

Table 1: Average characteristics of gears used along Lagos East Nigeria

Gear Types	No. of Floats	Mesh Size (mm)	Twine Diameter (mm)
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Multifilament Gillnet	600.00	101.00	0.95
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Stow net	No float observed	9.40	0.97

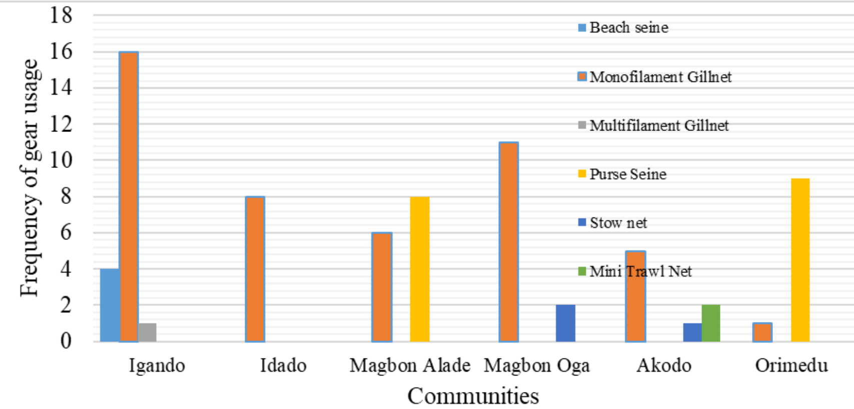

Fig. 3: Fishing Gears Used Along Lagos East Nigeria

Table 2: Gears used by different canoes and catches diversity

Canoe	Gears	Family Name	Common Name	Scientific Name
Half-Dugout (Ghana Boat)	Purse Seine	Scombridae	Skipjack Tuna	*Katswonus pelamis* (Linnaeus, 1758)
			West African Spanish Mackerel	*Scomberomorus tritor* (Cuvier, 1832)
		Clupeidae	Bonga shad	*Ethmalosa fimbriata* (Bowdich, 1825)
Plank Canoe	Beach Seine Monofilament Gillnet Multifilament Gillnet Mini Trawl Net		Round Sardinella	*Sardinella aurita* (Valenciennes, 1847)
		Pristigasteridae	West African Ilisha	*Ilisha africana* (Bloch, 1795)
		Sciaenidae	Croakers	*Pseudotolithus sp*
		Sphyraenidae	Barracuda	*Sphyraena sp.*
		Cynoglossidae	Tonguesoles	*Cynoglossus sp.*
		Haemulidae	Grunter	*Pomadasys sp.*
		Palinuridae	Lobsters	*Panulirus regius* (Latreille, 1804)
		Portunidae	Crab	*Callinectes amnicola* (de Rochebrune, 1883)
		Polynemidae	Threadfin	*Galeoides decadactylus* (Bloch, 1795)
		Tetraodontidae	Smooth Puffer	*Lagocephalus laevigatus* (Linnaeus, 1766)
		Rhinobatidae	Common Guitarfish	*Rhinobatos rhinobatos* (Linnaeus, 1758)
	Stow net	Palaemonidae	Estuarine Prawn	*Nematopalaemon hastatus* (Aurivillius, 1898)

DISCUSSION

Small scale fisheries is gradually becoming less attractive as a total of 862 fishermen was recorded from 6 communities on Lagos east coast which have a large difference with the report of Falaye, 2008 reported a total of 500,000 fishermen from 189 fishing communities in the country averaging about 2,645 fishermen per community and FDF, 2015 which reported 1,456,447 as total fishermen in the country. Jim-Saiki *et al.* (2016) reported that the artisanal sector produces 81.9% of the total domestic fish production in Nigeria with 4% contribution to the nations GDP, there is an urgent need to make the artisanal sector more lucrative for the fishermen in order to improve and sustain fish production.The fishing gears used shows that a single gear type is used on half dugout canoe (Ghana Boat) which is purse seine net that target small pelagic fishes which landings are characterised by low species diversity or single species of fish, similar observation have been reported by some authors (Falaye, 2008; Lawison *et al.*, 2012; Ambrose & Isangedighi, 2016) unlike the plank canoe which uses multiple types of fishing gears that are operated at the different time of the year depending on target species and have high species diversity.

Monofilament gill net is the most widely used fishing gear along the Lagos east coast constituting about 64% of the gears used in the area although fragile and damaged easily, the fishermen prefers the gear because of its assuming high performance and low cost of construction when compares to other types of fishing gears used in the sector. Monofilament is known for high catch number of average size fishes which are of low market value when compared to its counterpart multifilament gillnet that catches larger size fishes with higher market. Similar observations of monofilament preference have been reported by some authors GFCM, 2012; Gilman, 2015; and Dauda, 2020. Although GFCM, 2012 and Gilman, 2015 reported that monofilament with twine diameter of 0.5mm has been banned in the Mediterranean, the average twine diameter of monofilament gillnet used in this region is 0.19mm which is still within an acceptable standard range of 30µm to 3mm.

A Mini-Trawl net was recorded among the fishing gears used by artisanal fishery at Akodo community, this is the first record of a trawl net in the Nigerian artisanal fisheries sector operated by pair trawling in a non-trawling zone according to the Nigerian Fishery Act, 1992 under section 14 paragraph 10states "No motor fishing boat- (a) shall trawl or pair trawl within the first five nautical miles of the waters of the Nigeria continental shelf". The use of a Mini-Trawl net by artisanal fishermen is therefore illegal, dangerous and is not a sustainable fisheries practice. The use of the Mini-Trawl net will lead to adverse effect on the recruitment of fishes and in turn dangling fisheries resources will be available for the industrial fisheries sector. This study presents the first record of a Mini-Trawl net used by artisanal fishery in Nigeria and foresee the spread of the use of this illegal fishing gears "Mini Trawl Net" among the artisanal fisheries sector if adequate measures is not put in place to curb and stop the menace. Fifteen (15) species from 13 families was landed in the fishing gears of the canoes used in during the study period which is more than Abass *et al.* (2010) which reported 10 species belonging to 5 families and Ambrose & Isangedighi (2016) who reported 16 species from 12 families caught from purse seine fishery, although only 3 species was recorded in the landings for purse seine gear. The species composition is similar to Jim-Saiki *et al.* (2016) which reported the species composition has been commercially important species in the region, the species composition constitute several economically important species both for the artisanal and industrial fishery. During the study period, large quantity of Sea Urchin were sighted on several fishing gears and on the beach suggesting a bloom in the species which could impact fishing activities and removal of catch from the net could expose the fishermen to puncture wounds.

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Fish Weight and Species Diversity of Traditional and Modified Malian Traps in Tagwai Dam of Niger State, Nigeria

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Abstract
Over the last century riverine ecosystem have suffered from intense fishing, resulting to over exploitation and extinction of several species of fish. This study seeks to determine fish weight and species diversity of Tagwai Dam using traditional and modified Malian traps. The traps were designed using computer paint application and constructed with *Mimosa pigra* wooden frame. Traditional Malian trap (TMT) has cone shape, while the modified Malian traps has semi-circular (MSCMT) and rectangular shape (MRMT) respectively. The traditional Malian traps were enclosed in 3.75 cm mesh-size while the modified Malian traps were both enclosed in a netting material of 5 cm mesh-sizes (Standard). A total of 236 fishes were caught by both traps. traditional Malian trap caught fishes comprising of *Sarotherodon galileus. Tilapia zilii, Clarias gariepinus, Oreochromis niloticus* and *Synodontis membraneceous*. While modified semi-circular Malian trap caught fishes of similar species and modified rectangular Malian traps caught fishes which were similar species with addition of *Hydrocynus forskalii.* The total weight of the fish caught were 7,247.20 g, 4,154.20 g and 4,209.78 g for (TMT), (MSCMT), and (MRMT) respectively. There was no significant difference ($p>0.05$) in the biomass and species of fish caught with the Traps. This shows that despite the large netting mesh size of the modified Malian traps and low number of catches, it has the potential of competing favourably with its traditional counterpart. Therefore, modified Malian traps of this nature are recommended as tools in the study of ichthyofaunal composition and sustainable management of fishery resources.

Keywords: Mesh size, Cone shaped Malian trap, Semi-circular shaped Malian trap, Rectangular shaped Malian trap, Tagwai Dam.

Introduction

Nigeria is blessed with abundant natural water bodies with diverse fish resources. Most Nigeria's populations dwelling near water bodies such as lakes, lagoons, reservoirs, rivers, swamps and coastal lagoons depend heavily on the resources of such water bodies for their main source of livelihood (Abubakar *et al.,* 2006). The fish productivity of most Nigeria inland waters is generally on the decline (Jamu and Ayinla 2003). The decline of these fishes has been attributed to several causes ranging from environmental degradation of the water bodies to inadequate management of the fisheries resources. For sustainable exploitation of these resources, a crucial management tool is to have a comprehensive understanding of the ichthyofaunal composition of the water bodies. Lawson and Olusanya (2010) reported that species diversity is the number of different species in a given area. They are commonly used in conservation studies to determine the balance of ecosystem and their species. Information generally on fish abundance studies of natural water bodies is helpful in the sustainable management of the aquatic resources. Lawson and Olusanya (2010) further noted that for the sustainability of fish resources to be attained, it is pertinent to have adequate knowledge of species diversity, composition and relative abundance of the water bodies. Also, the avoidable decline of fisheries resources in an area occasioned by overexploitation and inadequate management of inland waters could be unraveled through the availability of relevant information of various parameters of species in the river. According to Suter (2007), species diversity and relative abundance studies have been advocated for ecological risk assessment in the aquatic system. Fish abundance studies could also help identify the presence of species of importance and economic value to the livelihood of the people living in an area. However, Jamu and Ayinla (2003) reported that the yields of most inland waters are generally on the decline as result of improper management of fisheries resources, environmental degradation such as water pollution. This study is aim at determine the fish species diversity and weight of Tagwai dam reservoir with a view of providing information on the ichthyofaunal composition of the dam and the potential of modified alian traps in relation to its traditional counterpart.

Materials and methods

Study Area

The research was carried out at Tagwai Dam located in Minna, Niger State. The geographical co-ordinates of the Dam are Latitude 6°39' to 6°44' East and Longitude 9°34' to 9°37' North to South East of Minna-Suleja Road (Fig. 1). (Alkali, 1994).

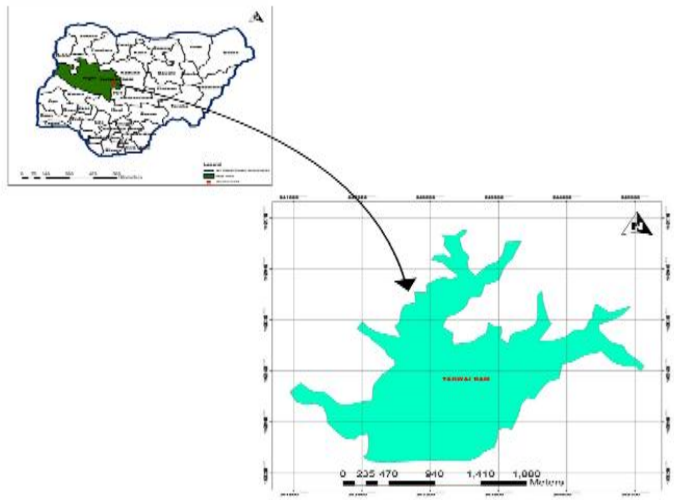

Figure 1. Nigeria and Niger State inset (Tagwai Dam)
Source: (Abdullahi, 2015)

Traditional Malian trap

Wooden stick of giant sensitive plant (*Mimosa pigra*) were used as wooden frame for the construction. The diameters of the stick ranges from 3 cm to 4 cm respectively (Fig. 2). The sticks were then bent to form round shape of different diameters 130 cm, 100 cm and 70 cm respectively, and tied tightly with (rope size number 9) to avoid loosening. Wooden frames of 75 cm height were mounted and tied on the round bottom. The same procedure was repeated for the middle and the tops. Thereafter, the structures were covered with polyamide netting material (3.75 cm) mesh-size. 3 spaces for non-return valves were carved out and they were finally fixed. 6 traditional Malian Traps were constructed (plate I)

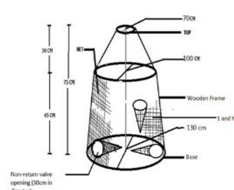

Figure 2: A sketch of a traditional Malian
Source: (Field Design, 2018)

Plate I: Traditional Malian traps after construction trap (TMT)
Source: (Field work, 2018)

Modified semi-circular Malian trap

Again, the giant sensitive plant (*Mimosa pigra*) was used for the construction of modified Malian trap. 100 cm length, and 50 cm width of the wooden stick were tied together to form rectangular base. See (Fig. 3). This was followed by the mounting of bent wooden frame of 50 cm height. The frame was supported with straight wooden sticks strongly tied together as shown in Plate III. Thereafter, the structures were covered with polyamide netting material of 5 cm or (2 inches) mesh-size (Recommended standard mesh-size). 4 spaces from different angle of the trap were carved out and the non-return valves were fixed. Six modified semi-circular Malian Traps were constructed (Plate II).

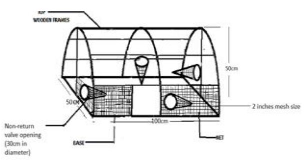

Figure 3: A sketch of a modified semi-circular Malian trap Source: (Field work, 2018)

Plate II: Modified semi-circular Malian trap after construction. Source: (Field design, 2018)

Modified Rectangular Malian Trap

The construction process was similar to figure 2, only the shape was rectangular (plate III).

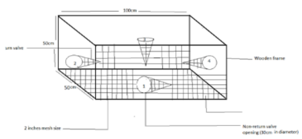

Figure 4: A sketch of modified rectangular Malian trap Source: (Field work, 2018)

Plate III: Modified rectangular Malian trap Source: (Field work, 2018)

Traps Setting, Inspection, Monitoring and Collection of Catches

After conveyance, the traps were set and monitored twice in a week for a period of 26 weeks (6 Months) making the total of 48 fishing visits conducted in different locations of the Dam. At each monitoring visits, the traps were lifted out of water and the weaved top opening was loosed to collects the trapped fish into a cooler jug. Thereafter, the loosed top opening was weaved back and the traps were set again for subsequent monitoring. Both the traditional and modified traps were moved backward to the littoral part as the water volume increases to prevent their vulnerability to flood.

Determination of fish weight

The weight of the fish was determined by placing the fish on the top tray of the weighing balance (Citizen model) and the reading was observed and recorded for each of the trapped fish.

Identification of species

Monograph of Olaosebikan and Raji (2013) was used to observe the similarity in the morphological features of the trapped fishes and those in the monograph and each species was identified in the process.

Results

Number and weight of fish caught with traditional and modified Malian traps

Table 1. depicts the monthly number and weights of fish caught with traditional and modified Malian traps. The total weight of the fish caught were 7,247.20 g, 4,154.20 g and 4,209.78 g for (TMT), (MSCMT), and (MRMT) respectively. There was significant difference ($p>0.05$) in the biomass of fish caught with the traps

Table 1: Number and Weight of the fish Caught with Traditional and Modified Malian Traps

Months	TMT	MSCT	MRT	TMT (g)	MSCMT (g)	MRMT (g)
July	29	27	25	232.25 ± 73.13^a	413.68 ± 137.5^a	478.61 ± 160^a
August	33	7	5	351.62 ± 115.5^a	58.3 ± 8.66^b	69.05 ± 18.92^b
September	19	6	2	179.32 ± 54.2^a	23.9 ± 8.42^b	40.37 ± 6.2^c
October	12	3	4	86.15 ± 20.3^b	26.75 ± 8.43^b	27.9 ± 8.3^d
November	20	7	4	181.2 ± 54.93^a	25.72 ± 8.46^b	41.6 ± 5.77^c
December	18	9	7	177.33 ± 53.54^a	144.03 ± 41.58^a	44.12 ± 4.62^c
TOTAL	131	58	47			

Data on the same column carrying different superscript are significantly different from each other (P<0.05).

Where: ±**SDM**= standard deviation of the mean; **TMT**= traditional malian trap; **MSCMT**= modified semi-circular malian trap; **MRMT**= modified rectangular malian trap

Fish Species Diversity of Traditional and Modified Malian Traps

Table 2 expressed the family, species and number of fish caught with traditional and modified Malian traps. A total of four family, and six species were caught. The highest family of fish caught was *Cichlidae* accounting for 113 *S. galileus*, 45 *T. zillii*, and 5 *O. niloticus* amounting to total of 163, followed by *Mochokidae* with a value of 62 *S. membranaceous* recorded, next is *Claridae* accounting for the total of 6 *Clarias gariepinus* recorded and the lowest was *Characidae* accounting for 5 *H. forskalii* recorded.

Table 2: Fish species diversity of traditional and modified malian traps

		Shape of Traps		
Family	Species	TMT	MSCT	MRT
Claridae	*C.gariepinus*	1	3	2
Alestidae	*H. forskali*	0	0	5
Cichlidae	*O. niloticus*	3	2	0
Cichlidae	*S. galileus*	61	27	25
Mochokidae	*S. mebraneceous*	39	13	10
Cichlidae	*T. zilli*	27	13	5
Total		131	58	47

Where: **TMT**= Traditional Malian trap; **MSCMT**= Modified semi-circular Malian trap; **MRMT**= Modified Rectangular Malian trap

Discussion

The study on fish weight and species diversity of traditional and modified Malian traps revealed the potential of the traps in catching different species of fishes with their corresponding weight. A total of 236 fishes weighing 15, 611.18 g of different size and species were caught. Ayanwale *et al.* (2013) reported that variation in mesh- size of gears influenced number of catches. This conform with the result of this study in which there was a variation in mesh size used for traditional and modified Malian traps. Akinnigbagbe and Osibona (2017) reported 47.7 g as the highest mean fish weight in their study of Fish weight and species diversity of traditional and modified traps in selected fishing communities in Lagos lagoon. The reason for the differences could be as a result of differences in study location. There was no significant different (p>0.05) observed in weight of fish caught among the three different shapes of the traps in this study. This agreed with the report of Ago *et al.* (2012) who observed no significant difference (p>0.05) in the catch (number and weight) of the two gear types used in their study. Agbelege *et al.* (2004) also reported 37.68 kg as the total biomass of fish caught with no significance difference in the biomass of fish caught in the 4-v and 6-v traps. This also tally with the result of this study. Trisnani *et al.* (2016) reported (18 kg) of fish using common *Payang* fishing trap while modified *Payang* fishing trap caught (15 kg) of fish with no significant difference (p>0.05) observed in the two weights. This also conform with the result of this study.

In this research, a total of four family comprising of six species were caught. The highest family of fish discovered was *Cichlidae*.This finding is in line with Ayanwale *et al*. (2013) who reported *Cichlidae* as the Preponderance fish family comprising of *S. galileus* and *T. zillii* in Tagwai dam. Thus, they further reported *Mormyridae* as one of the abundant species in the Dam also. This contradicts the finding of this research in which *S. mebraneceous* was the next in abundant after *Cichlidae*. This could be as a result of differences in gear used, time of the study, over exploitation or migration of this aforementioned species. The finding of this study does not conform with that of Ipinjolu *et al.* (2004) who reported *O. niloticus* as the most abundant species in their study. The variation in their species result with this study could be attributed to location of the study. Mshelia *et al.* (2015) reported *Cichlids* as the dominant species in Lake Alau. Similar reports were observed by Balogun *et al.* (2000) in Zaria reservoir; Kangimi lake (Balogun and Auta, 2001) and Ero reservoir (kester *et al*, 2007). The finding of Trisnani *et al. (*2016) where trevally fish sp. was reported to be the dominant fish species using traditional and modified Payang fishing traps were used also disagreed with the finding of this study.

Conclusion

The study revealed that Modified Malian traps can compete favourably with its traditional counterpart in trapping different species, size and weight of fish in Tagwai Dam. The species of fish caught with the traps shows an extinction of few valuable species such as *Mormyrus* and *Alestes* species which were hitherto reported to be among the dominant species in the Dam. Therefore, information obtained on the ichthyofaunal composition in this study can be use in sustainable management of the dam.

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Stomach content analysis of mangrove oyster *Crassostrea gasar* from Badagry creek, Lagos Nigeria

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Abstract

Mangrove oyster, *Crassostrea gasar* is a very important marine shellfish resource in West African coast; it belongs to the lamellibranchs class, in the order Dysonta and Family Ostreidae. To investigate the stomach content composition of *C.gasar*; representative samples of the species were used. The samples were preserved immediately after collection in 90% ethanol for preservation of the flesh and gut contents. The valves of oysters were separated and the gut and stomach were dissected. The volumetric, numeric and percentage occurrence data of the food content were calculated and recorded. A total of 650 stomachs were analyzed. Dominant food items identified in the stomach were phytoplankton, substrate particles and detritus. The phytoplankton comprised of 38 genus which belongs to 10 families and they include; Diatomophyceae (Diatoms) (36.8%), Bacillariophyceae (Diatoms) 0.7%, Cyanophyceae) 19.6%, Chlorophyceae (10.2%) amongst others. In conclusion, *C.gasar* diet analysis revealed that they are filter-feeders foraging mainly on phytoplankton.

Keywords: Bivalves, Oyster, filter feeders, Plankton.

Introduction

The Mangrove oyster, *Crassostrea gasar* is a very important marine shellfish resource in West African coast; it belongs to the lamellibranchs class, in the order Dysonta and Family Ostreidae. It is widely spread along the west coast of Africa from Senegal to Angola (Lapague *et al*., 2002, Ansa and Bashir, 2007). *C.gasar* inhabits the estuarine/ coastal mangrove swampland along Niger delta and Lagos Coast, they can be found attached permanently to mangrove trees and any other hard substrate in water. They are usually in clusters attached to the prop roots of the mangrove; they thrive in intertidal brackish water with wide salinity and temperature tolerance range. *C. gasar* is massively harvested by grassroots artisanal and commercial fisher folks for food. Compared to finfishes, they exhibit an efficient conversion rate of primary production as well as relatively low cost of rearing (Abiogba and Henadou, 2006; Adite *et al.*, 2013). Also with regards to its ecological importance, *Crassostrea gasar* stands out as an indicator of environmental quality and it is used to measure the degree of contamination of aquatic ecosystem, since it accumulates pollutants that could even lead to chromosomal changes and mutations Adite *et al.*, 2013).

Materials and Methods

The creek lies within longitude $2^{\circ}42'$E to $3^{\circ}24'$E and stretches between $6^{\circ}22'$N to $6^{\circ}42'$N sharing boundary with republic of Benin. It is equidistant from the entrance of Lagos and Cotonou harbor and is influenced by tides and floods from the Lagos and Cotonou Harbor through Lake Novo and Porto- Novo.

Stomach content Analysis

To investigate the food and feeding ecology of *C.gasar*; representative samples of the species were used. The representative samples were preserved immediately after collection in 90% ethanol to allow better entrance of the alcohol and better preservation of the flesh and gut contents. The valves of oysters were separated and the gut and stomach were dissected. The content from the gut and stomach were emptied into a glass slide for examination under a binocular microscope to identify the contents. The preys were identified to the lowest possible taxonomic level using identification guides of Needham (1962), Newell and Newell (1966), Compere (1977), Botes (2003). After identification, each food item of sub sample was separated; counted and volumetric percentage of each prey was estimated.

The volumetric, numeric and percentage occurrence data of the food content were calculated and recorded using the formula.

Volumetric Analysis; Percentage volume of food item = $\frac{\text{Volume of the particular food item}}{\text{Total number of all food items}} \ x\ 100$

Numeric analysis: the number of individual of each food type in each stomach is counted and expressed as a percentage of the total number of food items in the sample studied as described by Hyslop, (1980) in Adite *et al*, 2013. The numeric analysis of each food item ingested by *C.gasar* was computed as follows;

$$\text{Percent number of a food item} = \frac{\text{total number of a particular food item}}{\text{total number of all food items}} \times 100$$

Frequency of occurrence method

The stomach contents of *C.gasar* are examined and the individual food organisms sorted and identified. The number of stomachs in which each item occurs is recorded and expressed as a percentage of the total number of stomachs examined, empty stomach are excluded.

$$\text{Frequency of Occurrence} = \frac{\text{total number of stomachs with the particular food item}}{\text{Total number of stomachs with food}} \times 100$$

Index of Relative Importance (IRI)

Index of Relative Importance according to Leo Pinkas., 1971, is an integration of the measurement of number, frequency of occurrence and volume or weight) It determines on the most important and most preferred food of fishes.

Index of Relative Importance = (% N_i + %V_i) % O_i

Where; N_i, V_i and O_i, represent percentages of number, volume and frequency of occurrence of Prey i respectively.

Results

A total of 650 stomachs were analyzed. Dominant food items identified in the stomach containing food were phytoplankton, substrate particles and detritus. The phytoplankton comprised of 38 genus which belongs to 10 families and they include; Diatomophyceae (Diatoms) (36.8%), the most common species encountered in this family were; *Melosira*, *Nitzchia*, *Closterium*, *Synedra*, *Pleurosigma*, *Gomphonema*, *Gyrosigma*, *Cyclotella*, and *Stephanodiscus*.

The family Bacillariophyceae (Diatoms) 0.7% also comprised of 4 species namely; *Coscinodiscus*, *Coconeis*, *Diatoma* and *Surirella*. Chlorophyceae (10.2%) the green algae, was represented by the following genus; *Chlorella*, *Pediastrum*, *Tetraspora*, *Microspora*, *Protococus*, *Ulothrix*, *Cladophora*, *Chaetophora*, *Cosmarium* and *Ankistrodesmus*.

The blue-green algae (Cyanophyceae) with 19.6% volumetric proportion had 5 representative genuses which are; *Oscillatoria*, *Gleocapsia*, *Microcystis*, *Anacystis*, *Trichodesmium*.

Zygnemataceae had just one representative *Zygnema*, likewise the family Ceratiaceae a dinoflagellate represented by the genus *Ceratium*.

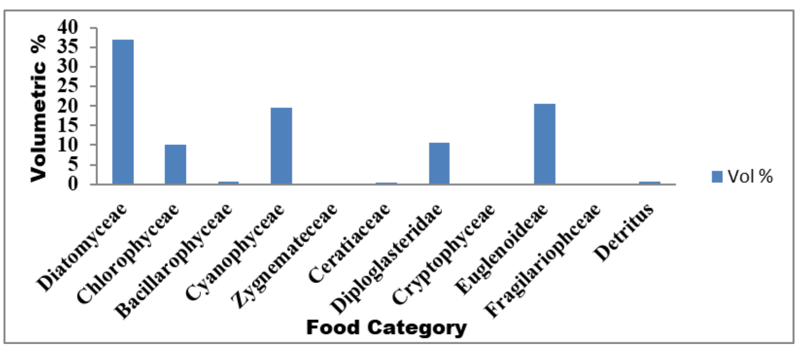

Fig. 1: Volumetric percentage (%) of food ingested by *Crassostrea gasar* from Badagry Creek

Numerically, the Diatomophyceae dominated the diet composition of the oysters, with 47.9%. This was closely followed by the Blue-green algae (Cyanophyceae) with 26.94%. The Chlorophyceae (green algae) had a numeric proportion of 15.06%. The Nematode *Diplogateroides* were also high in number 6.8%. Detritus and substrates (1.38%) were the next with high number.

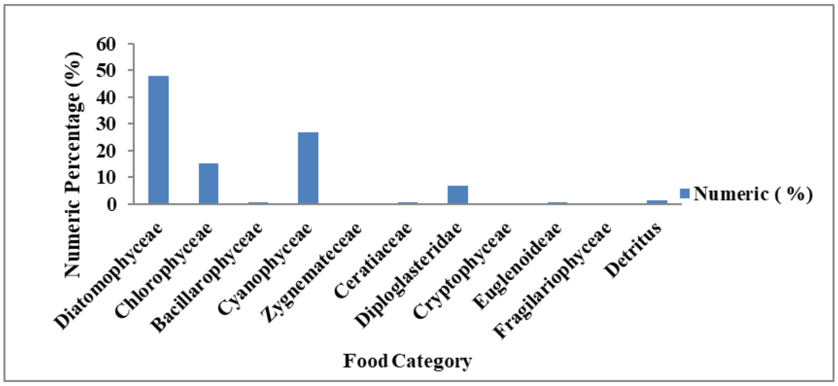

Fig. 2: Numeric percentage (%) of food ingested by *Crassostrea gasar* from Badagry creek

Percentage Occurrence

The most occurred prey in the stomach of the oysters were *Oscillatoria* (14.49%) found in 87 stomachs, *Microspora* (11.66%), found in 70 stomachs, the Nematode (*Diplogasteroides*) were next with 10.32% and they were found in 62 stomachs, *Navicula* (9.99%) were found in 60 stomachs, *Phacus* (9.16%) were found in 55 stomachs. *Nitzchia* were also high in occurrence with 7.83% and they occurred in 47 stomachs, following closely was *Melosira* (7.16%) were found in 43 stomach. *Ankistrodesmus* (4.33%) occurred in 26 stomachs, *Gleocapsia* (3.66%) were recorded in 22 stomachs and *Chlorella* (2.16%) was recorded in 13 stomachs. The lowest percentage of occurrence were 0.16% which occurred in 1 stomach each were *Fragillaria*, *Tabellaria*, *Zygnema* and 0.17% were *Cryptomonas*,*Trichodesmium*, *Coconeis* and *Stephanodiscus* respectively.

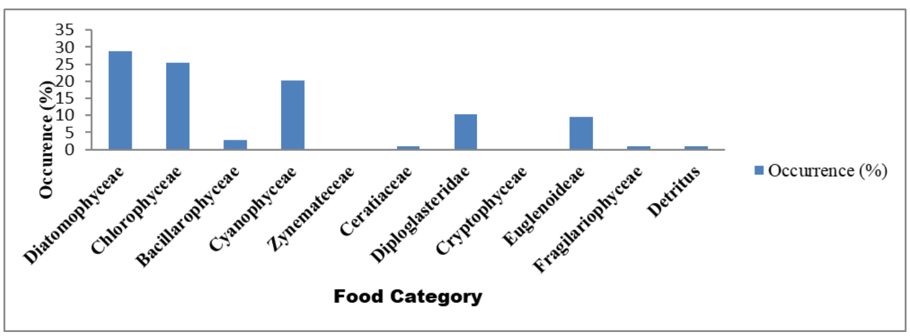

Fig. 3: Percentage (%) occurrence of food ingested by *Crassostrea gasar* from Badagry creek

Index of Relative Importance (IRI) of the food items

The % IRI value showed the order of relative importance from the various food items ingested by the Oyster. *Oscillatoria* dominates the food category with 25.38% followed by the green algae *Phacus* with 17.55%. The Nematode (*Diplogasteroides*) was 16.29% followed by *Niztchia* (13.96%), *Melosira* (6.81%) *Ankistrodesmus* (6.15%), *Navicula* 5.67%), Detritus (2.04%), *Cyclotella* (1.54%), *Gleocapsia* (1.53%) and *Synedra* (1.31%) the remaining food items fell below the 1%.

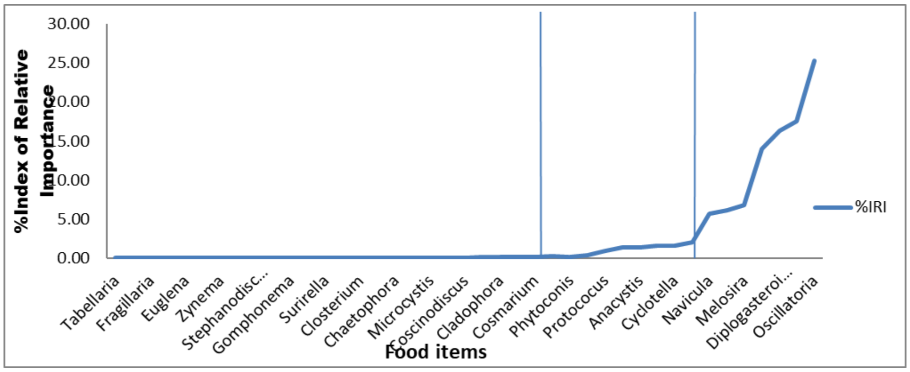

Fig. 4. Diet Preference of *Crassostrea gasar* from Badagry creek

Discussion

Information on the feeding ecology of *C.gasar* is important for proper fisheries management and aquacultural purposes. The stomach content analysis of *C.gasar* from the Badagry creek constituted mainly Phytoplankton, Zooplankton, Sand grains, and detritus, this is consistent with the report of Kouakou *et al* (2019), Akinjogula (2014), Sylvio (2008) who worked on the Stomach content analysis of *Crassostrea* sp from the Ebrie Lagoon in Ivory Coast and Lagos Lagoon, from the result of this study, none of the stomach analyzed was empty throughout the stations and during the period of study, the Vacuity index was 0%. This was consistent with the report of Kouakou *et al* (2019). Ishmael (2015) also reported that Oysters can filter between 5 to 16 Liters of water in I hour under optimum condition and it takes 80 to 150mins for the food to complete digestive process within the Oyster system. Therefore, he concluded that this makes the oyster stomach to always have food item. This was contrary to the observations of Adite *et al* (2013) who recorded vacuity index (stomach emptiness) of 20.16% and 20.5%. They attributed the stomach emptiness to the possibility of the oyster collection time. Suggesting that at high tides the water flow is highly disturbed thereby affecting the oysters, causing them to close their valves to resist external pressure from the flow velocity, hence affecting the food intake.

There was no difference in the stomach content of the male and female *C.gasar*, they both constituted of phytoplankton, zooplankton, detritus and sand grain. This was also in consistence with reports from Rizkalla and Fatlas (1997), Ishmail (2015) and Kouakou (2019). In terms of size classes, the stomach content was similar, there was no Ontogenetic shift in the diet of the small sized and adult oysters. This result was consistent with Kouakou *et al* (2019). Bernard (2010) also reported similar observation from his study on *C.gigas*. Rico-Villa *et al* (2010) also reported that *C.gasar* pick up the attitude of being Planktonophagous from their Veliger stages and grow up to adult remaining filter feeding planktonophagous bivalves. Although this report is contrary to the report of Adite *et al* (2013) who recorded that *C.gasar* undergoes ontogenetic diet shift. He stated that the smaller oyster consumes more of *Polycystis* (Chlorophycae) whereas the larger individual consumed more of *Crucigenia* sp. However, he stated that the diatoms (*Melosira*) and substrates particles occurred most frequently in all the size classes and hence were not associated with size class.

Analysis of the index of relative importance of the food items from the stomach of *C.gasar* identified the *Oscillatoria* (25.30) as the most preferred food item, followed by the *Phacus* (17.55). Nematode; Diplogasteroides (16.29). The phytoplankton *Melosira* (6.8) was next and *Navicula* (5.67). They all were greater (> 3), according to Pinkas *et al* *(*1971) % IRI > 3 are the primary food item consumed by an organism. %IRI of >0.1 to <3 are secondary food items. % IRI < 0.1 are considered incidental food item.

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An assessment of marine fish resource exploitation in Ogun state, Nigeria.

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Abstract
The artisanal sector of Ogun State fisheries of Nigeria for the period 1995 – 2007 was analyzed by applying Gordon-Schaefer Surplus Production Model on time series of total catch and effort. The objective was to assess the performance of artisanal fishing in the coastal and near-shore areas of the state. Static reference points such as open access equilibrium, maximum economic yield and maximum sustainable yield were established in addition to the more dynamic optimal yield solution. Performance analyses show that MSY at 21.2394 unit effort, sustainable yield is at 53.6395 metric tons with economic rent of N242.393 million. Also, the results showed that the fishery has expanded beyond the economically optimum point where the current level of effort is further beyond that of maximum sustainable yield; an indication that there is already over-fishing in the inshore waters where majority of artisanal fishermen concentrate. The major constraint is assumed to be institutional and legal framework inadequacies for fisheries management. Also, social and equity considerations have been the bottlenecks for the implementation of regulatory measures which cause further unemployment.

Keywords: *Artisanal fisheries***,** *Optimality, Sustainable fishing, Overfishing, Policy intervention*

Introduction

Fisheries worldwide are under pressure and management policies have often struggled to achieve sustainable fishing practices, economic efficiency and equity of access to resources (Cochrane 2000; Mora *et al* 2009). The idea that industrial fishery is solely responsible for this global crisis has been questioned by evidence showing the significant impact of small-scale fisheries (Zeller et al. 2007). However, despite their present problems, small-scale fisheries could be the only type of fisheries that, if appropriately managed, would be able to ensure the sustainable use of coastal, fisheries resources (Pauly, 2006). Moreover, because small-scale coastal fisheries contribute greatly to nutrition, food security and alleviating poverty, as well as playing essential social roles, their sustainable management has become an important aim and challenge for governments worldwide. Appropriate regulations need to be based on a thorough understanding of the current state of fisheries. Besides biological information on exploited fish stocks and fish mortality rates, information on the cultural, environmental, political and socio-economic dimensions of fisheries is also needed (Whitmarsh *et al* 2000 and Unal and Franquesa 2010).

Combined fisheries and conservation objectives can be achieved by merging diverse management actions; however, this leads to a different set of problems, including the difficulty in ensuring that fishers adhere to the rules. Therefore, managers need objective arguments to support their decisions. Economic indicators back up these arguments because they can be used to estimate the effect of management policies and thus support the measures proposed. Estimating the economic performance of artisanal fishing and the cash flow generated by the fishing industry is thus a fundamental prerequisite, firstly for formulating and then for implementing any management plan. Consequently, the economic analysis of fisheries and other related indicators also need to be carried out at the level of the individual production unit (boat). However, it is often difficult to access data necessary for constructing these indicators, particularly for small-scale fisheries, for which there is less information (Worm et al. 2009). Currently, data on fishing activity are usually generated by the fishers themselves, as well as by fishery inspectors, economists and biologists sampling catches at random (Griffiths et al. 2007). However, official information, when it does exists, is often biased and generally does not refer to the fishing ground where the vessels operate but only to the ports where they are based or the fishing cooperatives in which they are registered.

The sustainable harvesting of the marine resource in general, requires that the catch rate should not exceed the growth rate of fish. That is, where we have Maximum Sustainable Yield (MSY), which is the biological optimum. Beyond such a point, harvesting is unsustainable, because then overfishing, which is judged on the basis of decline in CPUE, change in catch composition and increasing catch of juveniles occurs. Another aspect that needs to be considered in the harvesting of marine resources is the maximization of the economic rent. This refers to attaining the economic equilibrium, which is referred to as the Maximum Economic Yield (MEY).Fishermen like any other economic agent are driven by the profit maximization objective at least in the short run. With this, there is every reason to believe that fishermen and fishing efforts (gear and fishing hour) will increase as fish catch command high prices in the market.

The study was conducted to determine the performance of fishing activities in terms of Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY) and the performance of the coastal/near-shore fisheries in Open Access (OA) to provide information for fisheries resource management and policy formulation.

Materials and Methods

The study was conducted in Ogun State, Nigeria from March to August 2017. The research baseline data is time series data of catch and fishing effort per unit between 1995 and 2007 as obtained from the Federal Department of Fisheries. To achieve the objectives, both the primary and secondary data were analyzed using the Gordon-Schaefer model (Schaefer 1954 and Fauzi 2010). The models use the logistic growth functions of fish and Schaefer's production function as a basis for analysis. The function of logic growth of fish populations in the Schaefer model is given as: $F(X) = rx(1 – X/K)$ ……(1). Where: r is the intrinsic growth rate, X is the fish stock and K is the carrying capacity of the environment. The maximum growth rate will occur in the condition of K/2 and the fish stock under this condition referred to as the Maximum Sustainable Yield (MSY). In fisheries activities, human intervention (fishermen) is expressed in the production function as follows: $h(X,E) = qXE$….. (2). where: h is the catch, q is the coefficient of catch-ability and E is the fishing effort (unit). Considering fishing activity as the utilization of resources, the growth of fish stock in Schaefer's model can be written as: $\Delta X/t = F(X) - h(X,E)$…... ………………………(3)

The management of fish resources requires that the state long-term balance (equilibrium) of fish stock is constant, which means also that the growth rate of fish is equal to the rate of fishing, so that the production function for the Gordon-Schaefer model (GS model) can be expressed as: $hGS = qKE - q^2K /r\ E = aE – bE^2$ …………………………(4)

Using the Ordinary Least Square method (OLS), parameters a and b can be obtained. The fisheries performance of both models will be shown in the equlibrium of OA, MSY and MEY. Equation (4) refers to the relationship between effort and yield and can be described in terms of the effort-yield curve.

Results and Discussion

Table 1: The Data of Fisheries Extracted

Year	*N*	*Production mean (tones year-1)*	*Effort mean (unit)*	*Price (million tones-1)*	*Cost (million Np unit-1 year-1)*
1995-2007		*3,714.23*	*21.704*	*475.52*	*585.14*

The result of the above analysis using (GS) models is shown as follows:

Gordon-Schaefer (GS) hGS = -244.1 +72.34 E – 1.674 E2

t-statistic *3.245* *(4.8666)*

N=13; R^2=67.; F =12.47; dW=1.87

Estimated performances of the fishery on the management conditions of OA, MSY and MEY are shown in Table 2

Table 2: Fishery Performance

		Gordon-Schaefer	*Actual*
Open access	Effort (unit)	42.478	21.704
	Catch (tonnes yr-1)	52.3256	3,714.23
	Economics rent (Npa yr-1)	0 0	
MSY	Effort (unit)	21.658	21.704
	Catch (tonnes yr-1)	536.3946	3,714.23
	Economics rent (Npa yr-1)	242,393.4	
MEY	Effort (unit)	21.2394	21.704
	Catch (tonnes yr-1)	781.2965	3,714.23
	Economics rent (Rpa yr-1)	358,849.1	

From Table 2, it is shown that excess profits or economic rent (TR-TC) is lower at MSY than at MEY. Profits are clearly maximized at EMEY level of effort. This is the level where an exclusive and secured owner of the resource will select in order to make the most economic use of his/her resources. Also, under OA, fishermen could attempt to maximize profits but for lack of exclusive property rights over the resource they have no incentive to take into account the effect of their fishing effort on other fishermen's catch. The guiding variable for expansion of effort is the expected average revenue of effort rather than the marginal revenue. That is, under OA, the profit-maximizing rule for the individual fisherman (but not society as a whole) is to expand effort as long as the average revenue (AR) exceeds the average cost (AC), no matter what this might do to other fishermen's revenues and to his own future revenues. Thus, the effort for the fishery as a whole expands to the point where AR = AC.

Fisheries management based on the concept of MSY of the GS model, the amount of effort that can be operated (to catch fish) in order that the stocks remain sustainable is at 21.2394 units, sustainable yields is at 53.6395 tons yea r-1 and at an economic rent amount of N242.393 million year-1. Fisheries management based on the concept of MEY of the GS model, the amount of effort that can be operated to catch fish in order that the stocks remain sustainable is at 21.2394 units, sustainable yields at 781.297 tons year-1 and the economic rent amount of N358.849 million, year-1.

Compared with the average actual catch of 3,714 tons, the artisanal fishery shows biological and economical overfishing. Also, when it is related to the actual condition of catches from 1995 to 2007, artisanal fisheries have shown the phenomenon of overfishing.

Rising profits call for controlled expansion of the fishery while falling profits call for interventions to limit entry; zero profits suggest the need for reduction of effort while negative profits call for promotion of mobility and assistance for resettlement of surplus fishermen. Finally, widely fluctuating profits call for stabilization policies to enable a planned expansion or contraction of the sector and improved information flow to induce more stable responses to external shocks.

Conclusion and Recommendations

There is gross over exploitation of the artisanal fisheries resources in Ogun State of Nigeria. The sustainability of this resource is under threat unless the government checks the level of influx or regulates participation. Policies that recognize and incorporate indigenous fishing communities will most likely be successful if sufficient authority is delegated to the local level. These will help the local communities acquire the direct responsibility for management and protection of the fishery and other marine resources. To this end, a great emphasis should be placed on educating local fishing communities on the effects of unsustainable fishing practices as well as the benefits of managed fishery resources. Thus, the present study calls for policy intervention to rescue the stocks from the existing high fishing pressure that could lead to depletion.

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Fishing and natural mortalities as factors depleting the silver catfish, *Chrysichthys nigrodigitatus* resource of the Cross River, Nigeria.

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Abstract
Recent studies have revealed some worrisome peculiarities of *Chrysichthys nigrodigitatus*, including low genetic diversity, predisposition to climate change and pollution. Studies were therefore conducted to ascertain the status of the fisheries. Times series of length frequency was conducted for 16 months. The objective was to determine the population parameters and exploitation rate. Asymptotic length was 105cm, growth rate was 0.68 yr $^{-1}$, total mortality, 2.48 yr $^{-1}$, fishing mortality was 1.49 yr $^{-1}$ while natural mortality was 0.99 yr $^{-1}$. Exploitation rate was 0.60 **yr $^{-1}$**, indicating overfishing. A comparison of the natural mortality rate with those of previous studies within a decade, revealed drastic progression in the natural mortality rate. The modal classes of the exploited population in the decadal trend showed a concomitant decrease. These suggest a grave danger in the fishery with the potential of depletion of the resource. Urgent management and conservation interventions are imperative.

Keywords: Fishing mortality, natural mortality, silver catfish, Cross River.

Introduction
Chrysichthys nigrodigitatus forms the most commercially important single species fishery in the Cross River, Nigeria. Holzloehner, *et al*., (2007), reported that the species is the third most important commercial fish species in the Cross River estuary after *Pseudotolithus elongatus* and *Ethmalsoa fimbriata*. The fisheries provide several employments to the teeming population in the riverine communities of Niger Delta of Nigeria, thus enhancing the socio-economic status of the people. da Costa, *et al*., (2010) listed the species under IUCN Red list of threatened species. Moreover, Uyoh *et al.,* (2020) reported that *Chrysichthys nigrodigitatus* of the Cross River has very low genetic diversity and that such low genetic diversity can lead to population eradication in the face of environmental variability. The reported influence of rainfall and other climatic factors, Ama-Abasi & Uyoh, (2020), the low genetic diversity, Uyoh *et al.,* (2020) and the listing of the species under the IUCN list of threatened species necessitated the present study. The objective was to determine the exploitation rate and the status of the fisheries in order to enable holistic and concerted approach to management decisions.

Materials and methods
The study area is the lower Cross River between latitudes 05º 00. 07. 97$^{/}$ and 05º 45.67$^{/}$ N and longitudes 008º 06.438$^{/}$ and 07º 58.248 $^{/}$ E. Time series of *C. nigrodigitatus* was conducted from January 2017 to April 2018. The method of Gulland and Rosenberg (1992), improved upon by Sparre and Venema (1992) was used for the length frequency data collection. Seven fishing ports were chosen for the sampling. Fish samples were measured using a wooden metre board to the nearest 1.0 cm total length and weighed on a Salter balance to the nearest 0.1 g.

Growth parameters were determined following the method of Ama-Abasi, Holzloehner, and Enin, (2004) as provided by FiSAT (FAO-ICLARM Fish Stock Assessment Tool) software version 1.2.2 (2000-2005. The length–converted catch curve was employed to estimate the total mortality, as incorporated in FiSAT. Natural mortality, fishing mortality and exploitation rates were all calculated as given by FiSAT (Gayanilo & Pauly, 1997). We also analysed previous works to compare the level of variation on some of the population parameters like natural mortality with this study.

Results and discussion
The best estimates of growth parameters were as follows: asymptotic length, (L□) 105 cm; growth rate (K) 0.68 per year, the goodness of fit (Rn) was 0.163, growth performance index, (□) was 3.88. Total mortality (Z) was estimated at Z=2.48 year^{-1}, while natural mortality (M) was 0.99 year^{-1}. Fishing mortality (F), was 1.49 year^{-1}. The exploitation rate (E) was estimated as 0.60 year^{-1}.

The exploitation rate of 0.60 for *C. nigrodigitatus* fishery of the Cross River, implies that the fishery is over exploited. It implies that high fishing effort is being exerted on the *C. nigrodigitatus* fishery. Such exertion is observed mainly in the rainy season months of April to July when the reproductive activities are at the peak leading to high catch rates, and as the rainy season runs to a close in November and December (Ama-Abasi and Uyoh 2020).

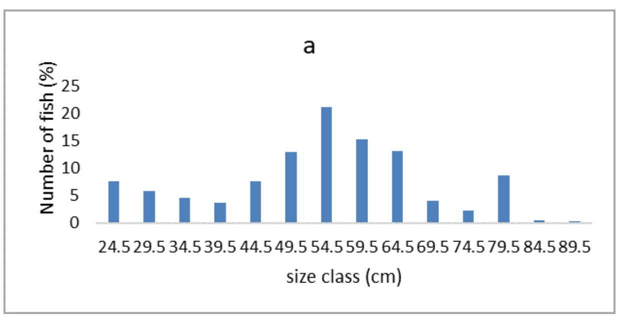
Commented [U1]: This is the symbol for asymptotic length, L infinity

Commented [U2]: This is th symbol for growth perforemance index. (phi prime)

The natural mortality of 0.99 year^{-1} represents 40% of the instantaneous rate of total mortality. That means natural mortality contributes to 40% of the deaths of *Chrysichthys nigrodigitatus* in the Cross River. Possible causes of this natural death are pollution, Kanu and Idowu (2017), and high temperatures. High mean temperatures in rivers restrict the spread of some organisms while clearance of riverside vegetation increases water temperature and together with the loss of tree root habitats, can cause dramatic reduction in fish production (Ringler and Hall 1975). Moreover, Uyoh *et al*., (2020) and Adelieje, *et al.,* (2020) reported that *Chrysichthys nigrodigitatus* population of the Cross River has very low genetic diversity. Such low genetic variation could lead to spontaneous wipe out of populations in the face of environmental variability and may likely contribute to the increase in natural mortality observed here.

When comparing the percentage of natural mortality of previous works, Ajang *et al.,* (2013), 19%, Udoh *et al.,* (2015), 37% and this study, 40 %, there has been drastic progression in the percentage natural mortality in the past 10 years. Jorgensen and Holt (2013), stated that several studies are now noticing temporal trends towards increasing natural mortality. Swain (2011), and Swain and Chouinard, (2008) reported that Atlantic cod, *Gadus morhua* in the Gulf of St. Lawrence had natural mortality of 0.1- 0.2 year^{-1} in the 1980's but by 2000's it had risen to value as high as 0.6 yr^{-1}. Jorgensen and Holt, (2013) opined that such increases in natural mortality may be part of the explanation collapsed stocks are not recovering. This drastic increase in the percentage natural mortality of *Chrysichthys nigrodigitatus* of the Cross River is very worrisome and portends severe threat to the fishery and its sustainability. A combination of fishing mortality and the increase in natural mortality of *Chrysichthys nigrodigitatus* in the Cross River signals a dangerous trend towards the depletion of the fishery resource.

The supposition of resource depletion can readily be confirmed from figure 1 where the size classes of 15 - 35 cm alone form 70% of the total catch while the rest formed 30%. Another worrisome scenario is the rapid decline in the number of bigger size classes available for the fishery. Udoh et al., (2015) recorded the highest percentage catch from the size class of 40-60 cm (62.29%) and size class of 14.5-34.5, 20.6%. In contrast, this study has recorded higher percentage catch of 70% from the size class of 15-35 cm and 20.6% for size class of 40-60 cm. Also, from Figure 1, there is a rapid shift in the modal class between 2008 and 2018. This shift in the size class available for exploitation over a decade shows a systematic move towards the depletion of the resource, which calls for an urgent management intervention. Consequently, the fishery requires reduction in catching efficiency by increasing the mesh size to reduce exploitation pressure on the young fish. The catching of the small fish might have been enhanced by the spiny nature of the first fin ray of the pectoral and dorsal fins. This feature increases the catchability efficiency of the gear so that a young fish that could have escaped from the net with a given mesh size, were it to be girthed, is entangled at the spines.



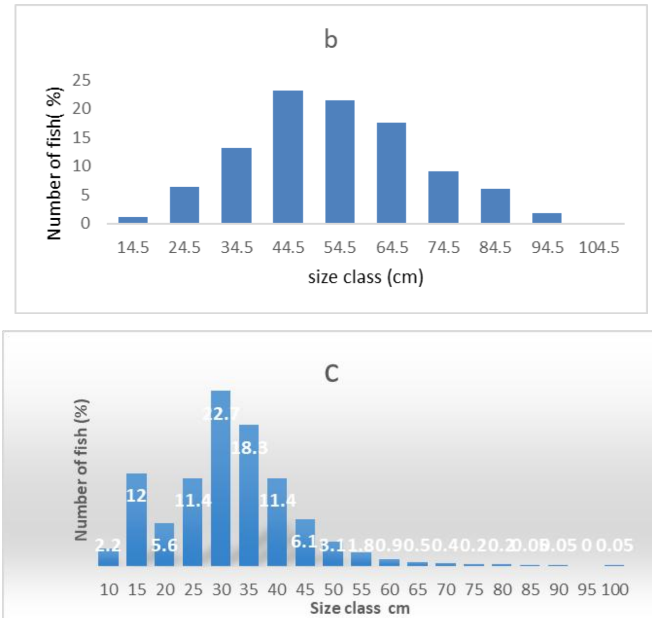


Fig. 1: A decadal trend in the modal class of exploited population of *Chrysichthys nigrodigitatus* in the Cross River, (a) 54.5 cm, Ajang *et al* (2013), (b) 44.5cm, Udoh *et al*., (2015) (c) 30cm, This study

Conclusion

With the exploitation rate at 0.60, the *Chrysichthys nigrodigitatus* fisheries of the Cross River is experiencing overfishing. The observed overfishing, coupled with high natural mortality, the threat towards the depletion of *Chrysichthys* resource, and possible impact of climate change, the inclusion of the species under IUCN list of threatened species is justified. It is recommended that there should be a further reduction in the effort through the willingness of the riverine communities and the fisherfolks to regulate the number of boat-days, especially during the spawning period in May to July and in November and December when the young ones are preponderant. Also, as a conservation strategy, *Chrysichthys nigrodigitatus* should be domesticated, as proposed by Ama-Abasi and Uwalaka, (2019). Domestication will shield the species from the vagaries of environmental variability like climate change, pollution and overexploitation.

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Stomach Content and Feeding Habit of West African Fiddler Crab *Uca tangeri* From a Tropical Mangrove Lagoon, Lagos, Nigeria.

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Abstract
A total of 500 samples of West African fiddler crab *Uca tangeri* were collected and analyzed for stomach analysis for 6 months, March-August 2012. Analysis of the stomach contents and the feeding habit showed that *Uca tangeri* are opportunistic omnivores as their stomach content showed blue green algae, *Navicula cuspidate*, *Nitzschia lineris*, *Sctonema* sp, *Oscillatoria limnosa*, sand grains and unidentified material. By numerical method, *Uca tangeri* had the most important food items consisting of algae filament with 62.9%,*Navicula cuspidate* 32%,*Nitzschia linearis* 2.61% ,*Oscillatoria limnosa* 1.18% and *Scytonema sp* 1.33% while by frequency of occurrence *Uca tangeri* algae filament 1.35%, *Navicula cuspidate* 0.76%, *Nitzschia linearis*, 0.27%, *Oscillatoria limnosa* 1.17% and *Scytonema* sp 1.19%.

Keywords: *Uca tangeri*, stomach analysis

Introduction.
Crabs with other macro-benthic invertebrates, constitute the link between the unavailable nutrients in detritus and useful protein materials in fish and shellfish. Benthic organisms feed on debris that settle on the bottom of the water and in turn serve as food for a wide range of fishes (Adebisi, 1989; Ajao and Fagade, 1990; Oke, 1990; Idowu and Ugwumba, 2005).

The West African fiddler crab (*Uca tangeri*) is a specie of fiddler crab that lives along the Atlantic coasts of southwestern Europe and western Africa. It is the largest specie in the genus *Uca*, with a carapace of 50 millimetres (2.0 in) width, and up to 25 mm (1.0 in).

Crabs of the family Ocypodidae belonging to the subfamily Ucinae known as fiddler crabs are composed of small crabs (Callander *et al.,* 2013), found along sea beaches and brackish inter-tidal mud flats, lagoons and swamps. The West African fiddler crab, *Uca tangeri*, lives in the eastern Atlantic Ocean and consists of 94-97 species of semi terrestrial intertidal crabs that excavate burrow into muddy or sandy substrate and are characterized by cheliped asymmetry in male adults of at least one species. (Rosenberg, 2001). *Uca tangeri* is highly valued and the most consumed crabs of high demand in West African. (Jadamec *et al.,* 1999; Enzenoss *et al;* Oyewole and Edom, 2005). It plays ecological role in the mangrove ecosystem where it helps to clean up the mangrove areas by its feeding habits on the fallen leaves (Olafsson *et al*., 2002).

The shell and flesh of *Uca tangeri* is highly proteinous compared to other mollusk with protein ranging between 17.1g/100gm to 21.21gm/100cm. (Ackman 1990). Crabs are scavengers, feeding on polychaetes, crustaceans, mollusces and dead fishes, they are opportunistic omnivores, cannibalistic or carnivores, but the grasped crab *Varuna litterata* and *Sesarma huzardii* are mainly herbivorous. Lawal-Are (2009) reported that *C. amnicola* from the Lagos Lagoon was an opportunistic omnivore feeding mainly on fishes, crustaceans, molluscs, annelids and occasionally on plant materials. *Uca* spp fiddler crabs burrow in intertidal areas and are important consumers of detritus, bacteria, fungi, and benthic micro algae in coastal marsh, mangrove, sand flat, and mudflat habitats (Backwell *et al.,* 2006). Unlike most intertidal organisms, fiddler crabs are semi terrestrial and are active at low tide, the female, with two feeding claws, can feed more efficiently than the male. Some species feed in flocks (droves) at the edge of the water (Klassen and Ens, 1993). According to Radhakrishnan (2000).. The objective of this study was to study the stomach content and feeding habit of *Uca tanger*i from a tropical mangrove.

Materials and Method
Study Area
The study site is the coastal mangrove area of Ilubirin of the Lagos lagoon and is located at the southwestern part of Nigeria

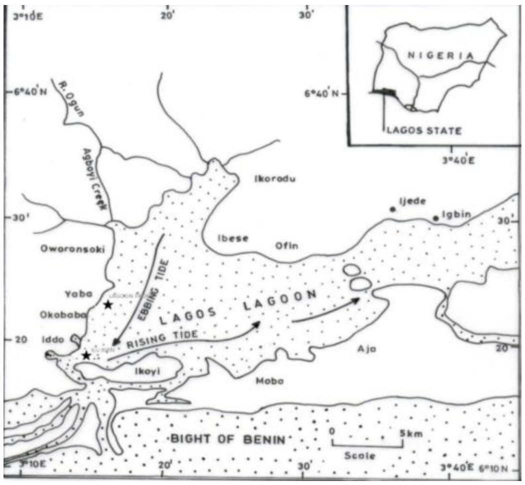

Figure 1: Map showing the study area

Collection of specimen
Samples of the fiddler crab *Uca tangeri* were collected from Ilubirin area of Lagos lagoon. They were caught with hand and collection was done randomly over a period of six month each on weekly basis between the months of March to August 2012. The crabs were immediately preserved in an ice-chest with ice block and transferred into deep freezer (-20C) in the laboratory prior to the analysis.

Laboratory procedure
The crabs were removed from the freezer and allowed to thaw. Excess water was removed from the specimen using filter paper. Identification was done based on Schneider (1990).

Stomach analysis
The cardiac stomach of each specimen was dissected and the contents were extracted into a Petri dish. The extracted contents were mixed with little water and examined under a binocular microscope for the food types using the numerical and occurrence methods based on Hyslop (1980).

Numerical method
Food items in the number of individuals of each were counted. They were added to give totals for each kind of item in the whole sample. The grand total was obtained for all food items and expressed as a percentage of the total number of foods found in all crabs examined.

Frequency of occurrence method
Stomach content was examined and the individual food organisms sorted and identified. The number of stomachs in which each occurs was recorded and expressed as a percentage of the total number of stomachs with food. The method gives information only on the organisms fed on. Its disadvantage is that it does not give information on quantities or numbers and it also takes into consideration the accumulation of food resistant to digestion.

Results
The crabs fed mainly on five food items which included blue green algae, plant material, *Navicula cuspidate, Nitzschia linearis* and numerous unidentified material. The food items are represented in the table and figures below

Table 1: Summary of stomach content *Uca tangeri* from ilubirin area of Lagos lagoon

FOOD ITEM	NUMERICAL METHOD		FREQUENCY OF OCCURRENCE	
	number	**percentage**	**number**	**Percentage**
Algea (blue-green)	6367	62.9	135	1.35%
Navicula custidate	3250	32.0	76	0.76%
Nitzschia linearis	265	2.61	27	0.27%
Oscillatoria limnosa	120	1.18	17	0.17%
Scytonema sp	135	1.33	19	0.19%
Plant material	-	-	-	
Unidentified material	-	-	-	
Sand grains	-	-	-	
Total	10157	100.02		

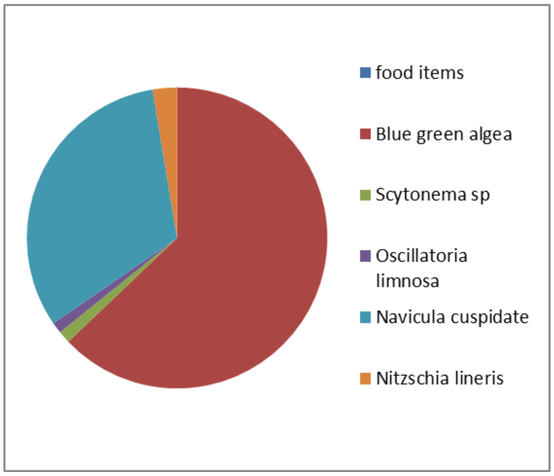

Figure 2: - Chart of summary of food items *Uca tangeri* from March-August, 2012

Table 2: Monthly variation of empty stomach for *Uca tangeri* from Lagos lagoon (March-August,) 2012.

Month	***Uca tangeri***	**%of empty stomach**
March	52	15.4%
April	45	15.6%
May	67	59.7%
June	109	8.2%
July	119	56.4%
August	116	31%
Total	500	

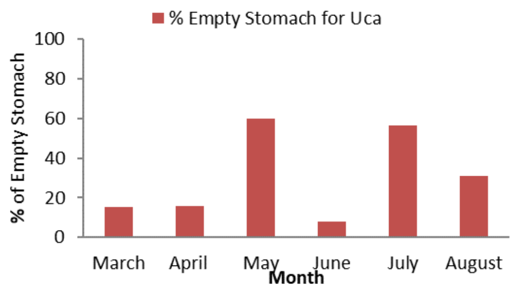

Figure 3: - Monthly variation of empty stomach for *Uca tangeri* from March-August, 2012.

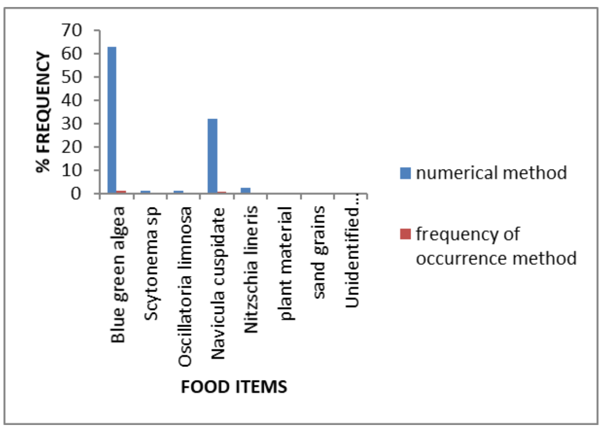

Figure 4: Summary of food items/percentage frequency *Uca tangeri* from March – August, 2012.

Discussion

Analysis of the stomach contents and the feeding habit revealed that *Uca tangeri* are opportunistic omnivores as stomach content showed blue green algea *Navicula cuspidate*, *Nitzschia linearis*, *Scytonema* sp, *Oscillatoria limnosa*, sand grains and unidentified material. Previous studies have also found a difference in feeding rates of *Uca pugnax* increased its feeding rate when there was a high concentration of food in the sediment (Rosenberg, 2001). In contrast, Weis &Weis (2004) showed that, in four species of fiddler crabs in Indonesia, the highest feeding rate was in *U. vocans*, which had poor food, and the lowest proportion of time spent feeding was in *U. tetragonon*, which had the most abundant food source. While it is generally thought that female fiddler crabs feed faster than males because they have two feeding claws, it is not always true. Of the four studied species, Weis & Weis (2004) found this to hold in only two species, in both *U. annulipes* and *U. sendensis*, females fed faster than males

The stomach content analysis carried out showed conformity with Lawal-Are and Bilewu(2009) for *Portunis validus* off Lagos's coast Nigeria, the percentage empty stomach content was lowest in June(8.2%) April (15.4%) and March(15.6%) for *Uca tangeri* and while Olalekan El *et al*(2013) report lowest empty stomach for March and April for both *C. armatum* 53(2.05%) and *C. guanhumi*, 66(5.79%)which is due to the low environmental condition at the period of collection and abundance of food. *U. tangeri* showed leaf preference because of the flora associated to their habitat, they showed high level of omnivorous feeding habit, as shown in the stomach content analysis indicated that they both feed on plant materials, unidentified items, which could be crustaceans, fish fragments (bone and scales), sand grains and this supports the work of Micheli *et a*l.(1991). The wide opportunistic feeding pattern of *Cardiosoma armatum* and *Cardiosoma guanhumi* was due to their accidental predatorship (Lawal-are 2009). The large amount of sandgrains discovered was attributed to the burrowing nature of the crabsand inherent soil habitat (Olalekan El *et al* 2013). The feeding habits of fiddler crabs play a vital role in the preservation of wetland environments by sifting through the sands; they aerate the substrate and prevent anaerobic conditions.

Conclusion

The dietary composition of *uca tangeri* indicated that Lagos lagoon is suitable for commercial crab production.

Recommendation

There is need for a conscientious effort in the development of commercial crab culture in Nigeria and the mangrove ecosystem should be effectively monitored for the conservation of this species.

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Food and feeding habit and condition factor of tiger shrimp, *Penaeus monodon* (Fabricius), in the Lagos Lagoon, Nigeria.

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Abstract
The food and feeding habits and condition factor (K) of *Penaeus monodon* collected from Lagos Lagoon between February and May 2012 were studied. Food and feeding habits was on the basis of quantitative and qualitative analysis of gut contents. The gut analysis was carried out using the numerical method (NM) and frequency of occurrence method (FO). The main food items of *P. monodon* observed in this study were crustaceans and diatoms and accounted for 57.98% and 57.33% by frequency of occurrence (FO) method respectively, while the numerical method (MP) accounted for 2.50% and 22.50% respectively. Sexual differences in feeding preferences were also noticed in this study as the feeding activities of females were significantly higher ($p < 0.05$) than the males. The present study shows that *P. monodon* is omnivorous but mainly depending on animal food items.

Keywords: *Penaeus monodon,* Lagos Lagoon, Feeding, Omnivorous.

Introduction

The giant tiger shrimp, *Penaeus monodon* (Fabricius), is one of the largest species among the Penaeids shrimps in the world, reaching about 270mm in body length. It is widely distributed throughout the greater part of the Indo-West Pacific region. It is widely farmed outside of its native range, including West Africa and various locations in the western Atlantic (Fuller *et al*., 2014). Three biologically-rich and culturally important large river deltas are among the areas that have been targeted for this new aquaculture development: the Niger Delta, the Tana Delta and the Rufiji Delta (EJF, 2004). According to Dublin-Green and Tobor (1992), the coastal waters of Nigeria are characterized by abundance of important living resources including shrimps, predominantly members of the family penaeidae. The study of food and feeding and assimilation of shrimps are of fundamental importance in understanding the rate of growth, population concentration, gonadal maturation and other metabolic activities. Mostly shrimps have been described as omnivorous scavengers and detritus feeders. Investigations regarding the dynamics of the feeding biology of *P. monodon* shrimps in this part of the world remain scarce, being limited to few reports like (Adetayo & Kusemiju, 1994, Khan *et al*., 2001 and Umbria *et al*., 2003). It is on this basis that this study was carried out aiming at providing useful information on the food and feeding habits of *P. monodon* caught from Lagos Lagoon, Nigeria.

Materials and Methods

Lagos Lagoon in Nigeria is located between longitudes 3°20' and 3°50'W and latitudes 6°24' and 6°36'N. It is the largest lagoon system in the West African coast, covering 208 km. The lagoon is an open two tidal estuary; it is fed in the north by Ogun River, Majidun, Agoyi and Ogudu creeks. The southern margin is bounded by Five Cowries and Badagry creek and in the east by Lekki and Epe lagoons. Ogun River remains the major source of water to the lagoon, discharging a large volume of water into the lagoon. The lagoon opens into the Atlantic Ocean via Lagos habour. It is shallow in depth and in most places; it is little more than 1.5 metres deep. The lagoon is surrounded by marshy ground which is permanently white mangrove forest. Figure 1.shows the map of Lagos lagoon.

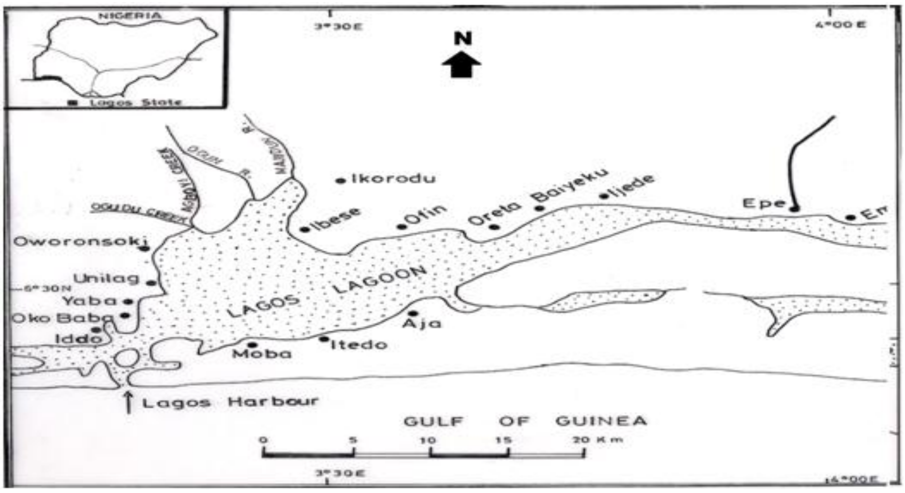

Figure 1: -Map of Lagos Lagoon
Source: - Adesalu and Nwankwo (2010).

Collection of Specimens
The specimens of *P. monodon* for this study were collected from the Lagos Lagoon by artisanal fishermen using cast net. 400 specimens of the shrimps were collected between the months of February and May 2012 from makoko jetty off the Lagos Lagoon and were preserved in ice on chest at the point of collection and immediately transferred to the deep freezer at -20°C in the University of Lagos at Department of Marine Science laboratory, where they were kept prior to laboratory work.

PLATE 1: Giant Tiger Shrimp, *Penaeus monodon* from Lagos Lagoon.

Stomach Analysis
Shrimps samples was removed from the freezer and allow to thawed and thereafter, they were beheaded and a pair of forceps was used to carefully remove the stomach from the head region of each shrimp sample and placed in a petri dish. The state of fullness of each shrimp's stomach was recorded in the proforma as 0\4 1\4, 2\4, 3\4 and 4\4 representing empty stomachs, quarter-filled, half-filled, three-quarter filled and filled stomach respectively. The content of each stomach was mixed with water to form a solution. With the aid of a dropper, the content was placed on a glass slide and observed under a binocular microscope to reveal the food items eaten by the shrimps and counted individually. Two methods were used to analyse the stomach content. The method used for the analysis of these stomach contents were numerical and frequency of occurrence methods.

a) **Frequency of Occurrence Method**: The number of stomach in which each food item occurred was recorded. The results were then expressed as percentages of the total number of specimens with food. The merit of this method is that it gives estimates of the proportion of the population that feeds on a particular food item as well as the various types of organisms fed upon. For the demerits, the results are often biased by the accumulation within individuals of remains of certain food organisms which were resistant to digestion by Oribhabor and Ogbeibu (2012).

b) **Numerical Method**: Food items in each stomach were identified and counted. They were summed to give the total for each kind of food item in the whole sample and a grand total of all items are obtained. The total of each kind of food item was recorded and expressed as a percentage of the total number of all food items. The merit of this method is that it is easy to draw conclusions as to the relative significance of the different food items while the demerit is that organisms occurring in large numbers may not necessarily constitute the most important food item by Oribhabor and Ogbeibu (2012).

Statistical Analysis
Chi- square test was used to determine the population dynamics. Regression analyses of dependent variables were used after calculating their regression constant, regression correlation and correlation factors of the shrimp

Results and Discussion
The food and feeding habits of 400 specimens of the *P. monodon* shrimps was examined. The monthly variation of the empty stomachs in percentage is illustrated in Table 1. The highest percentage of empty stomachs (37.0%) was recorded in February, followed by (24.0%) in March and April. The main food items of *P. monodon* are represented in figure 3 below. *P. monodon*, fed majorly on crustaceans (shrimps, crabs) and diatoms (Coscinodiscus) accounted for 57.98% and 57.33% by frequency of occurrence method respectively. While for numerical method they accounted for 2.50% and 22.50% respectively. The algal filaments accounted for 17.26% by frequency of occurrence and 8.30% in numerical method. Fish fragments also accounted for 15.64% by frequency of occurrence method and 2.20% in numerical method. The plants materials observed in *P. monodon* constituted about 94.14% by frequency of occurrence method and 64.40% in numerical method. Unidentified materials and sand grains were also observed in *P. monodon*.

Table 1: Summary of stomach contents of *P. monodon* in Lagos Lagoon from February to May, 2012.

Food items	Numerical method	% Frequency	Frequency of Occurrence Method	% Frequency
Plant material	4,850	64.40	289	94.14
Filament algae	628	8.30	53	17.26
Crustaceans	190	2.50	178	57.98
Diatoms	1,691	22.50	176	57.33
Fish Fragments (bones and eggs)	167	2.20	48	15.64
Unidentified masses	-	-	289	94.14
Total	7,526	100		

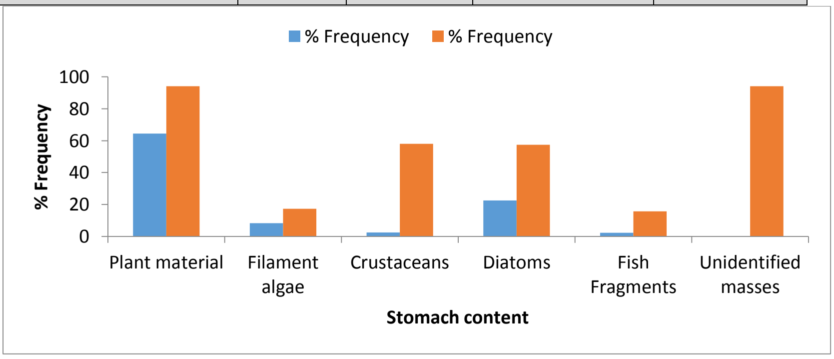

Figure 3: Summary of stomach content in *P. monodon* in Lagos Lagoon from February – May, 2012.

The period of this study fell within two marked seasons, rainy and dry season. The dry season was characterized by influx of sea water into the Lagoon and high evaporation, while the rainy season was characterized by influx of run-off water from the rivers and creeks and rains, these influxes create changes in the water nutrient load which in turn causes food diversities in the water body necessary for the penaeid development. The analysis of feeding items by the method of points (numerical) and frequency of occurrence can provide indication of the preference for one or more food categories within the population studied (Hyslo, 1980). The variation of the stomach contents of penaeid shrimp in this study showed that they are planktivores feeding majorly on phytoplankton and the stomach content also showed predatory tendency. Crustaceans and diatoms constitutes the most important food items accounting for 57.98% and 57.33% respectively by frequency of occurrence method while 2.50% and 22.50% respectively was recorded for the numerical method. Furthermore, the feeding activity (determined from stomach fullness) of the females were significantly higher ($p < 0.05$) than that of males. Bello-Olusoji *et al*., (2005) reported that *P. monodon* food also consisted of crustacean (small crabs and shrimps) and molluscs, making up 85% of ingested food. The remaining 15% consisted of fish, polychaetes, ophiuroids, debris, sand, and silt which closely agree with the findings of this study. This indicates that the giant tiger prawn is more of a predator of slow-moving benthic macro invertebrates rather than a scavenger or detritus feeder. All these findings supports the results of this study that *P. monodon* is an omnivore with preference for crustaceans particularly when in the natural environment. In conclusion, *P. monodon* fed majorly on phytoplankton, crustacean, diatoms, filament algae, debris and sand even though some samples show empty stomach and supports the findings of Baskar *et al*., (2013) that the empty stomach may be as a result of complete digestion of ingested food materials before capture

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Assessment of Sea Turtle Bycatch in Artisanal Gillnet Fisheries off The Niger Delta

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Abstract
The fisheries resources of Nigeria exclusive economic zone of the central Gulf of Guinea are exploited by industrial and artisanal sector, the primary fishing methods are pelagic and demersal method, The Niger Delta Region is one of the most important deltas in Nigeria, it occupies a significant position in fisheries, this includes a wide variety of fishing activities and different fishing vessels and gears, These are some of their target species, herring species called bonga *(Ethmalosa fimbriata)* and *Sardinella*. Most artisanal canoes range in size from 7–12 m and are powered by 9.5 to 40 horsepower outboard engine. A total of 335 sea turtle were captured by the drift net as bycatch, Sea turtle face different human-induced threats, like marine pollution, loss of nesting habitat due to growing degradation, Large vertebrates like cetaceans, and sea turtles, they are commonly affected by artisanal fisheries, they are incidentally capture as bycatch. Two different species of sea turtles were caught, namely, green turtle and the Leather bag, the most abundance were green turtle about 310, the maximum is at the months of June, July August and September for both 2017 and 2018, the Leather bag turtle were 25, No Leather bag was caught in January, March, April, September and October in both year 2017 and 2018, the maximum catch was July, November and December. This study has given a reliable information on the amount and species composition of sea turtle caught as a bycatch in the drift net fishery in the Niger Delta, it provides information on the value of this fishery, it will also enable policy makers and regulators with other stakeholders, such like NGO's to find way to tackle this problem, this research can also give a detailed information on how to manage the fishery to avoid bycatch which can possibly lead to extinction

Keywords: Sea Turtle, Bycatch, Gillnet, Niger Delta, Artisanal Fishing

Introduction

The Niger Delta Region is one of the most important deltas in Nigeria, it occupies a significant position in fisheries, this include a wide variety of fishing activities and different fishing vessels and gears operating both on artisanal and industrial fishing, Artisanal fisheries target primarily small coastal pelagics, such as the herring species called bonga *(Ethmalosa fimbriata)* and *Sardinella and some demersal like* marine catfish *(Arius)*, brackishwater catfish *(Chrisichthys)*, snapper *(Lutjanus)*, grunters *(Pomadasyidae)*, and groupers *(Epinephelus)* (Etim, Belhabib, & Pauly, 2015) (Tobor, 1991). Intense fishing activity is cause by overexploitation of fish resources (Colloca et al., 2017). Sea turtle face different human-induced threats, like marine pollution, loss of nesting habitat due to growing degradation (Lotze et al., 2011)., Large vertebrates like cetaceans (Bearzi et al.,2008), and sea turtles (Casale,2011), they are commonly affected by industrial and artisanal fisheries, they are incidentally capture as bycatch.

Nigeria has five different Species of sea turtles in our waters (Amadi,1991 and Adegbile O. M et al., 2015), namely, Chelonia mydas (Atlantic Green turtle), Eretmochelys imbricata (Atlantic Hawksbill turtle) and Demochelys coriacea (Leatherback turtle), Caretta caretta (Atlantic Loggerhead), Lepidochelys olivacea (Olive ridley turtle), Sea Turtles are endangered species and they are listed in major international convention The green turtle is among the largest sea turtles, green turtles are found both in tropical and subtropical waters and they are so classified as endangered, green turtles are threatened by overharvesting of their eggs, loss of nesting beach sites, hunting of adults, and also threatened by gillnet fishing gear. Amadi 1991 and Adegbile O. M.,et al., 2015., Fishing was considered the most important threat to sea turtles (77%) and major threat facing leatherback sea turtles are fishing gears like longline, gillnets with small mesh sizes Guebert F,. Barletta M., and F Costa. M., (2013)

Materials and Methods

The study was carried out over 2 years (January 2017 to December 2018) landing sites (Bayelsa State and River State) offshore the Niger Delta Nigeria With a coordinates3^0.5'E by 5^0.40'N; and 5^0.00'E by 7^0.7' E. Eight migrant Ghanaians fishermen and 2 observers were employed to assist in sample collection. Fishing was done two to four times in a month using drift gill net. Sea turtle by-catch from catches were sorted and recorded afterwards.

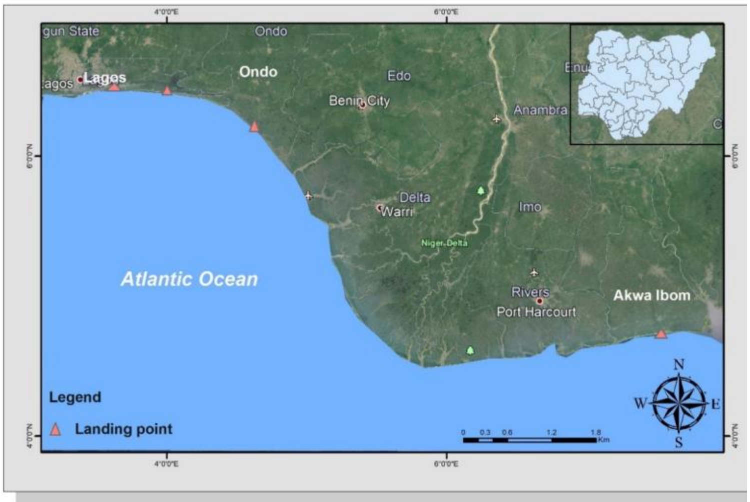

Figure 1: The 2 coastal states of the study areas.

Result

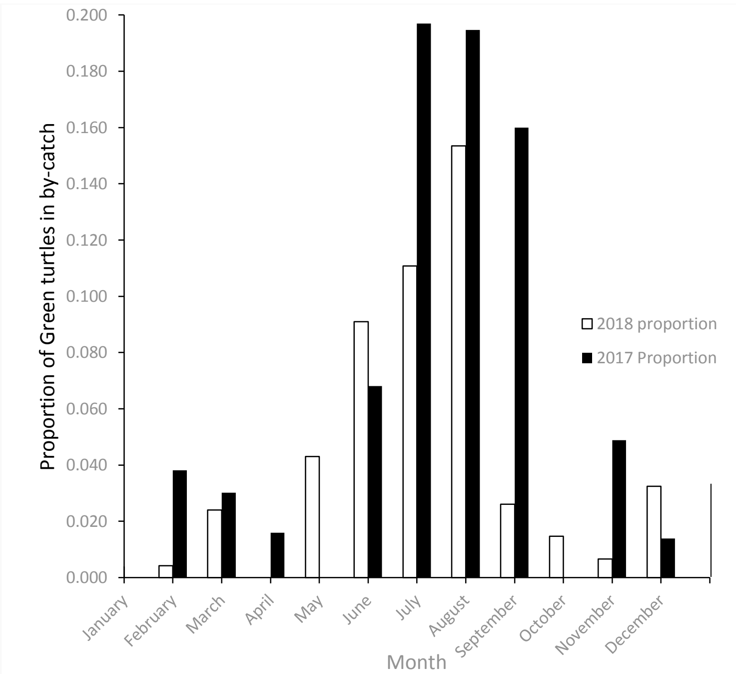

Figure 2: Result Of Green Turtle Caught By Drift Net In 2017/2018

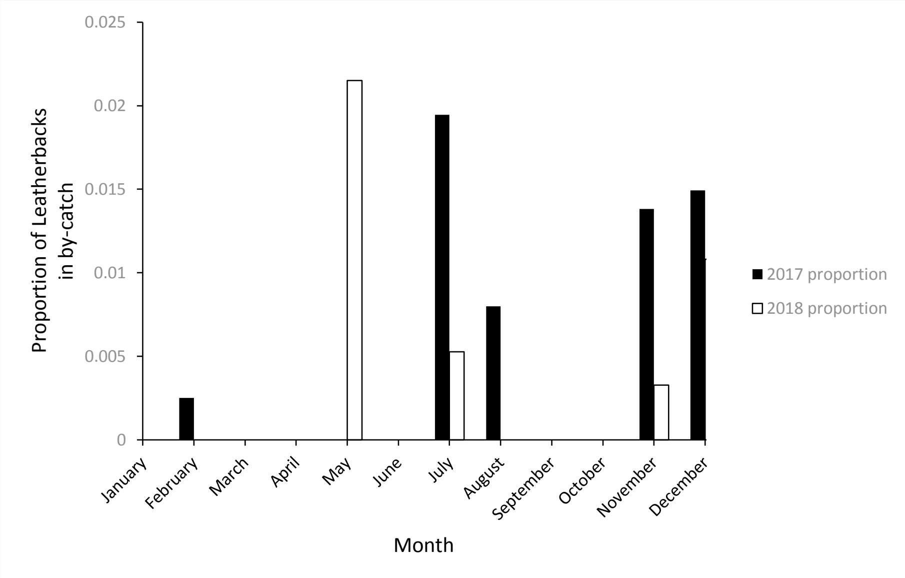

Figure 3. Result Of Green Turtle Caught By Gillnet In 2017/2018

Discussion

Fishing was considered the most important threat to sea turtles (77%) The threat facing leatherback sea turtles and green turtle are fishing gears like longline, gillnets with small mesh sizes Guebert F,. Barletta M., and F Costa. M., (2013) they are classified as endangered Amadi (1991) and Adegbile O. M., (2015). About 335 sea turtles are caught by gillnet in Niger Delta in 2017 to 2018, this shows that gillnet fishing is one of the major threats to sea turtles.

Conclusion

This study has revealed a reliable information on the kind of threat gillnet fishing cause to green turtle and leather back face in the Niger Delta Nigeria as bycatch, it provides information on the value of this fishery, it will also enable policy makers and regulators with other stakeholders, such like NGO's to find way to tackle this problem, this could give a hint on how to manage the fishery to avoid bycatch

Acknowledgements

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Nutritional composition of commercial fishes from Ikpoba reservoir and their potential contribution to recommended nutrient intake.

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Abstract
Global concern for good health and well-being of human populations especially in underdeveloped and developing nations has necessitated the need for routine nutritional assessment of their food sources. This study was undertaken to determine the nutrient composition of commonly consumed freshwater fish species in Ikpoba reservoir and to assess the potential contribution of selected key nutrients in the fishes to recommended nutrient intakes (RNI). The fishes were captured over a period of twelve months (February 2018 to January 2019) and three composite samples from each species were analysed using accredited methods. The result of the proximate composition of *Clarias gariepinus* and *Tilapia zilli* showed moisture content of 61.09% and 63.39 %; protein value of 15.15 % and 15.71%; lipid value of 6.03% and 1.48 %; and ash content of 4.58 % and 5.09 % respectively. The mineral content of fish species showed that sodium ranged from 3.32 to 5.64 mg/100g, potassium from 8.14 to 12.64 mg/100g, magnesium from 2.56 to 4.42 mg/100g, calcium from 1.75 to 5.85 mg/100g, iron from 5.47 to 9.35 mg/100g and zinc from 1.40 to 3.66 mg/100g. The potential contribution of each species to recommended nutrient intakes (RNIs) for preschool children and adults; indicated that the fish species contributed ≥25% of RNIs for iron and zinc for preschool children from a standard portion. This work has increased the knowledge on the nutritional value contribution to RNI of fishes in combating nutritional deficiencies and food security in Nigeria.

Keywords: Proximate composition, mineral content, *Clarias gariepinus*, *Tilapia zilli*, Ikpoba Reservoir.

Introduction
Fish is one of the healthiest sources of animal protein and other important nutrients required in human diets. It contributes significantly to food security, provides relief from malnutrition and a relatively cheap and easily available means for nutritional diversification in several underdeveloped and developing countries (FAO, 2018; Oboh *et al.,* 2019). In Nigeria, fish is an irreplaceable animal-source food which accounts for about 40% of the total animal protein consumed by its citizens (FAO, 2018).). Also, population growth and the increasing awareness on the nutritional value of fish has resulted in the increased demand and consumption of fish. Despite the abundance of freshwater bodies containing assortment of fishes; malnutrition chiefly caused by inadequate intake of micronutrients remains prevalent particularly among preschool children in various parts of the country (Olufunke *et al.,* 2016; Olowole and Agboola, 2018).

The nutritional composition of fish is the relative amounts of moisture, fat, protein, ash, carbohydrate and mineral contents (Adewumi *et al.,* 2014). Fishes of various species do not provide the same nutrient profile to their consumers; as values of fish body composition parameters vary considerably within and between species, and influenced by several factors such as age (Anthony *et al.,* 2000), gender (Lawson *et al.,* 1998) and diet (Shulman *et al*., 2005; Moss *et al.,* 2009). The knowledge of the nutrient composition is a good indicator of its physiology which is an invaluable tool needed for routine analysis of fishery resources, the quality and quantity of the nutrients available to the consumer and policy development (Saliu *et al.,* 2007; Oboh *et al.,* 2019).

Reliable and updated scientific documentation of food composition data are of vital importance to diverse nutrition based activities, such as establishing and assessing nutrient requirements, epidemiological research, clinical practice, government policy development and implementation, and for educational purposes (Greenfield and Southgate, 2003). The Ikpoba reservoir serves as a source of commercial important fish species to the artisanal fishing households and surrounding communities. With the global sustainable development goals of zero hunger, good health and wellbeing in purview, it is pertinent to determine the nutritional status of these fish species to ascertain their suitability in meeting human nutritional requirements. Therefore, the aim of this study is to determine the proximate and mineral composition of *Clarias gariepinus* and *Tilapia zilli* from the Ikpoba reservoir, and estimate the potential contribution of selected key nutrients – calcium, iron, zinc to the recommended nutrient intakes (RNI) for preschool children and adults in Nigeria.

Materials and Methods
Study Area
This study was carried out at the Ikpoba reservoir (Latitudes 006˚22'50" N and 006˚22'43" N and Longitudes 05˚38'36" E and 05˚38'46" E) situated in Benin City, Edo State.

Fish Collection and Identification: Fish species (*Clarias gariepinus* and *Tilapia zilli)* selected for sampling were based on the local diet content and commercial importance. The fish specimen were collected fresh from the reservoir over a period of twelve months (February 2018 to January 2019) with the assistance of artisanal fishermen and properly identified using taxonomic guides.

Analytical Methods: Proximate components (moisture content, protein, fat and ash) and mineral contents were determined by the standard analytical methods of the Association of Official Analytical Chemists (AOAC, 1995).

Data management and presentation of data: All statistical analysis were computed using Microsoft® Office Excel 2013 version and Statistical Package for Social Sciences (SPSS) version 21. Variations among means were determined using analysis of variance (ANOVA). The data are presented as means ± SD per 100 g of the three composite specimen of each species of fish and reported to the same units of expression.

Calculation of potential contribution to Recommended Nutrient Intakes (RNI): The potential contribution of each species to daily RNI was calculated in reference to the average RNI values for each nutrient as recommended for adults/ adolescents (8 years and above) and children (1 – 3 years). Percentage contribution to daily RNI It is calculated from an assumed standard portion (36.4g/ day) of each fish species as a percentage of the average RNI. The micronutrients of interest - calcium, iron and zinc were selected based on reported deficiency studies in Nigeria. The per capital consumption of fish as food in Nigeria is 13.3 kg (World Fish Centre, 2015), which is equivalent to 36.4g portion per day.

Results

Proximate composition

The moisture, protein, fat and ash composition of *C. gariepinus* and *T. zilli* are shown in Table 1. For *C. gariepinus,* range of values for moisture content (54.73 – 66.31%), protein (14.32 – 16.5%0, fat (5.63 – 6.70%) and ash (4.13 – 5.13%) were recorded. For *T. zilli,* range of values for moisture content (57.31 – 68.16%), protein (14.55 – 16.44%0, fat (1.22 – 1.96%) and ash (3.16 – 7.24%).

Table 1: Analytical values of the proximate composition of the fish species.

	Moisture (%)	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)
C. gariepinus	61.09 ± 3.73^{a}	15.15 ± 0.39^{a}	6.03 ± 0.25^{b}	4.58 ± 0.28^{a}
T. zilli	63.39 ± 3.20^{b}	15.71 ± 0.49^{b}	1.48 ± 0.19^{a}	5.09 ± 1.16^{b}

Values are presented as means ± standard deviations (SD) of the fish species analysed in triplicates. Dissimilar superscript indicates significant difference ($p < 0.01$).

Mineral composition

The sodium, potassium, magnesium, calcium, iron and zinc composition of *C. gariepinus* and *T. zilli* are shown in Table 2. For mineral content in the fishes, ranges of sodium (4.26 – 5.48 mg/100 g), potassium (8.14 – 9.12 mg/100 g), magnesium (2.63 – 4.42 mg/100 g), calcium (4.43 – 2.17 mg/100 g), iron (5.47 – 8.32 mg/100 g) and zinc (2.67 – 3.65 mg/100 g) were recorded in *Clarias gariepinus*. *Tilapia zilli,* value ranges for sodium (3.32 – 5.64 mg/100 g), potassium (9.22 –12.64 mg/100 g), magnesium (2.56 – 3.34 mg/100 g), calcium (1.75 – 2.53 mg/100 g), iron (7.75 – 9.35 mg/100 g) and zinc (1.40 – 2.74 mg/100 g) were recorded.

Table 2: Analytical values of mineral composition of the fish species.

	Sodium (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
C. gariepinus	4.87 ± 2.76^{b}	8.56 ± 2.78^{a}	3.87 ± 3.87^{b}	5.13 ± 4.06^{b}	7.43 ± 6.59^{a}	3.16 ± 2.95^{b}
T. zilli	4.70 ± 5.69^{a}	10.34 ± 8.95^{b}	2.87 ± 2.16^{a}	2.17 ± 1.87^{a}	8.56 ± 3.85^{b}	2.12 ± 3.22^{a}

Values are presented as means ± standard deviations (SD) of the fish species analysed in triplicates. Dissimilar superscript indicates significant difference ($p < 0.01$).

Discussion

Moisture content varies between 60 and 80%, and influences the taste, texture, weight, appearance and shelf life of fish (Ninan, 2003). The moisture content of fish species which ranged from 54.73% to 68.16% were within acceptable limits. Nutritionally, protein is the most important constituent of fish which determines its wholesomeness and quality (Ninan, 2003). The total protein content in *C. gariepinus* and *T. zilli* ranged from 14.32 to 16.44 g/100g and can be ascertained to be of good dietary quality (WHO, 2007).

Fish lipids are leading sources of polyunsaturated fatty acids predominantly Omega – 3- fatty acids which play an important role in human health (Oboh *et al.*, 2019). According to Ackman (1989) categorization of lipid content in percentage of total body weight; *C. gariepinus* (6.03%) belongs to the medium fat (4 – 8%) category which implies that they are good sources of fish oil, while *T. zilli* (1.48 %) belong to the lean fish category an indication of poor fish oil source for food therapy in humans. The ash content of fish species gives a measure of the total mineral content in the tissue of the fish (Adewumi *et al.*, 2014), The observed mean ash content of 4.55 g/100g and 5.09 g/100g for *C. gariepinus* and *T. zilli* respectively indicate that the fish species are good sources of minerals such as sodium, potassium, magnesium, calcium and iron.

Fishes are sources of essential mineral elements in a readily usable form, with mineral concentrations varying among species (Oboh *et al.*, 2019). The mean content of sodium, potassium, magnesium, calcium, iron and zinc recorded in *C. gariepinus* (4.87 mg/100 g, 8.56 mg/100 g, 3.87 mg/100 g, 5.12 mg/100 g, 7.43 mg/100 g and 3.16 mg/100 g) and *T. zilli* (4.70 mg/100 g, 10.34 mg/100 g, 2.87 mg/100 g, 2.17 mg/100g, 8.55 mg/100g and 2.12 mg/100g) were generally consistent with ranges reported for other fish species and seafood (FAO/ INFOODS, 2013; Oboh *et al.*, 2019).

Pertaining to the fishes' contribution to nutritional intake, none of the fish species meet ≥ 25% of the required nutritional intake (RNI) of calcium for adults and children. Both fish species were identified to meet ≥ 25% of the RNI of iron and zinc for children from a standard portion, while unable to meet the RNI for adults (Table 3). Low dietary calcium intake among children especially from poor households have been linked to reported incidences of rickets in Nigeria (Okonofua *et al.*, 1991). This implies that the reliance of these fish species as source of dietary calcium predisposes both children and adults to calcium deficiency and its attendant negative effects on physical development. With reported studies on the high prevalence of iron and zinc deficiency anemia among preschool children (< 5 years) in various parts of the country (Olufunke *et al.*, 2016; Ibeawuchi *et al.*, 2017; Olowole and Agboola, 2018); the consumption of *C. gariepinus* and *T zilli* obtained from the reservoir will contribute significantly to dietary intakes of iron and zinc in preschool children in communities surrounding the Ikpoba reservoir in Edo State.

Table 3: Potential contribution of fish in a Standard Portion, and to average daily RNI (%). Recommended Nutritional Intake (RNI).

Average daily RNI	Calcium (mg)		Iron (mg)		Zinc (mg)	
	Adults	Children	Adults	Children	Adults	Children
	1000	700	16	7	10	3
C. gariepinus	1.87 (0.20%)	1.87 (0.30%)	2.71 (16.94%)	2.71 (38.71%)	1.15 (11.50%)	1.15 (38.33%)
T. zilli	0.80 (0.08%)	0.80 (0.11%)	3.12 (19.50%)	3.12 (44.57%)	0.77 (7.70%)	0.77 (25.67%)

*Assumed standard portion is equivalent to 36.4g/ day for Nigerians
*Children here refers to toddlers (1 – 3 years). *RNI – Recommended Nutritional Intake

Conclusion and Recommendation

The consumption of fish as a source of animal protein and a readily available substitute for meat especially among poor communities has necessitated their nutritional quality evaluation. Presented data indicate that *C. gariepinus* and *T. zilli* are good sources of animal protein, while *C. gariepinus* was a good source of fish oil. The mineral percentage contribution to required nutritional intake (RNI) of the fishes indicate that they can only be used as food-based strategy to ameliorate reported nutrient deficiencies of iron and zinc in pre-school children in the surrounding communities. The mineral insufficiency of the fishes to meeting the RNI of calcium, iron and zinc in adults from a standard portion, implies that the fishes should not be solely relied upon to meet their dietary needs. It is recommended that other sources of animal protein be included in their diets and the portion of fish consumed be increased. This work has increased the knowledge on the nutritional value contribution to RNI of fishes in combating nutritional deficiencies and food security in Nigeria.

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Catch effects of monofilament and multifilament gillnet of different mesh size in Shabu stream

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Abstract
Catch effect of monofilament and multifilament gillnet of different size (20mm,30mm,and 40mm)was investigated in Shabu stream (a perennial stream) of Lafia LG Nasarawa state for a period of 4 months (July – October 2019). The nets were set in the evening (between 5:00 pm – 6:00 pm).and were hauled in the morning (between 7:00 am – 8:00 am) thereby maintaining a soaked time of 14 hours. Data was analysed using descriptive statistics. The result revealed that monofilament gillnet is more efficient than multifilament gillnet. 20mm mesh size of monofilament is the most efficient in catchability in term of number and weight as it recorded highest number of 134(52.96%), followed by 30mm with 81 (32.01%) and 40mm has the lowest of 48 (18.97%). For multifilament, in term of number, 30mm recorded highest of 20 (55.55%), followed by 40mm with 9 (25%); while 20mm has the lowest with 7 (19.44%). The family Cichlidae is most abundant, follow by the family Characidae, while the family Mormyridae has the lowest number. Recommendation was made for 20mm monofilament as the appropriate mesh size to be use in the stream because it recorded the highest catchability.

Keywords: Catchability, Monofilament gillnet, Multifilament gillnet, Shabu stream.

Introduction

Fishing gear can be described as any kind of equipment used in harvesting, cropping, or capturing fish from any water body (Nuhu and Yaro, 2005), while fishing method is how the gear is used.

Gill nets are among the most selective gears in terms of both species caught and the size range retained and are thus used to target desired species and size of fish. The principles behind gill net have not changed over the years but equipment and materials have changed. It widely recognized as an efficient and selective type of gear (Bjoringsoy, 1996). A multifilament net is a thin braided or twisted twine (very tin rope) where strings or filaments are weaved, making up the net mesh while a monofilament net is one where the net is made of single strand of a synthetic polythene material that look like a stand of modern fishing line.

The capture fishery world over is becoming more and more developed even in the small-scale sector. Gillnet fishery is one of the most important fisheries in Nigeria. It has been in existence as early as 1940 (Bankole *et al.*, 2003). The number of gillnets has increased tremendously over the years and between 1993 and 1999 there was a three-fold increase in the number of gillnets used in Nigerian waters (Agbelege *et al.*, 2003). In contrast, overall catches have remained stable indicating a decline in CPUE. This decline in CPUE has been countered by a decrease in mesh size and the 1999 Frame Survey revealed that over 95% of all gill nets used in Nigeria were below the legal minimum mesh size (Agbelege *et al.,* 2003). Banda *et al.* (2001) pointed out that small meshed monofilament are increasingly becoming popular as a result of decreased catch rate of target fish species though they are technically illegal. However, use of under-meshed multi species fishing gears, excessive fishing effort are the causes of overexploitation of the fisheries resources. Under-meshed fishing gears according to FAO (2014) are unselective of which fish they catch. Presently adoption of small mesh sizes for monofilament and multifilament gillnets are common in small-scale fishery mainly aiming to increase by catch targeting fish. This study aims at determining the catch efficiency of different mesh size (20mm, 30mm and 40mm) of monofilament and multifilament gill nets of fish species in Shabu stream.

Materials and methods

Study Area

Shabu stream is a perennial water body located in Lafia North in Lafia L.G.A of Nasarawa State, between latitude 8°32¹ N and 8°34¹N of the equator and longitude 8°30¹E and 8°34¹E. A total number of twelve (12) gill nets (20mm,30mm 40mm monofilament and 20mm, 30mm, 40mm multifilament of six different mesh sizes) measuring 7 meter in length and 2 meter depth were constructed in fishing gear and craft laboratory of Faculty of Agriculture, Nasarawa State University.

The nets were set in the evening (between 5:00pm – 6:00pm) and were hauled in the morning (Between 7:00am-8:00am) thereby maintaining a soaked time of about 14hour. The fish catch were sorted in their respective species using fish identification keys prepared by Idodo-Umeh,G. (2003).The number and weight of fish species caught were recorded accordingly.

Data Analysis
Data obtained were subjected to descriptive statistics.

Results and discussion
The result of fish species caught by number and their percentages in the three different mesh sizes of monofilament gill net in Shabu stream from July 2019 to October 2019 is represented in table 1.

The result indicated that a total of 263 fish were caught during the study period. 20mm monofilament gillnet caught the highest number of fish (134) belonging to seven families (*Cichlidae, Clariidae, Characidae, Schilbidae, Clupeidae, Mochokidae* and *Mormyridae*) with a relative percentage of 52.96% followed by 30mm gillnet with 81 individual fish belonging to the six families, with relative percentage of 32.0 1% while 40mm gillnet has the lowest number-of 48 individuals fish with a relative percentage of 18.97%.Table 2 show the weight and percentages of the fish caught by the respected mesh size of monofilament gillnets. The resu lt shows that a total of 8,863g fish was caught by the monofilament gillnets. 20mm gillnet caught the highest weight of fish (6,095g) with percentage of 68.76%, followed by 30mm with 1,578g (17.80%) the lowest weight of 1,190g (13.42%) was recorded in 40mm gillnet. Table 3 shows the fish species composition by number caught by multifilament gillnets in the study area. A total of thirty six (36) fish species belonging to seven families (*Cichlidae, Clariidae*, *Characidae, Schilbidae, Clupeidae. Mochokidae* and *Mormyridae*) were caught. 30mm multifilament gillnet recorded the highest number of individuals fish (20) with a relative percentage of 55.55%, followed by 40mm gillnet with 9 individual fish species and a relative percentage of 25.00% while 20mm caught the lowest number of individual fish species (7) with a relative percentage of 19.44%. Table 4 show the weight and percentages of the fish caught by the respective mesh size of multifilament gillnets. The result shows that a total of 3,114g fish was caught by the multifilament gillnets. 30mm gillnet has the highest weight of fish caught (1,458g) representing 46.82%, followed by 40mm with 966g (31.02%) and the lowest weight was recorded in 20mm with 683g (21.93%). The result of catch effect of monofilament and multifilament gillnet of different mesh size (20mm, 30mm and 40mm), from the study shows that monofilament gillnet caught more fish (by number and weight) than multifilament. This affirmed with study of Parish (1959) in which he affirmed that the efficient of gillnet is largely influence by the behaviour of fish in relation to visibility of the gear which in turns is related to the type of materials selected for it fabrication. Though efficiency and sustainability of monofilament twine against multifilament twine as fishing gear materials are still controversial; by many authors, but Molin (1959) found monofilament gillnet is seven times more efficient that cotton and four time than multifilament nylon twine. Parish (1959); while describing the fishing experiment with monofilament gillnet in fresh water; stressed the need for having materials with low visibility and he confirms that monofilament gillnet have better catch efficiency over the multifilament ones. In terms of catch composition of fish species in different mesh size, the 20mm monofilament has the highest catch of 134 (52.96%) follow by 30mm with 81 (32.01%) and 40mm with 48 (18.97%). This agreed with Solarin (1998) and Emmanuel *et al*. (2010) who stated that finest materials gave the best catching result in Lagos lagoon. The high caught in 20mm compared to 30mm and 40mm shows that there is decline in big fish in the water body, which is an indication that there is likely over fishing in the stream. The knowledge of the efficiency of gillnet is important for the restoration of the population in the fish stock. The study further revealed that the family *Cichlidae* is the most abundant fish caught by the gillnet, follow by the family *Characidae*, while the family *Mormyridae* has the lowest.

Conclusion
The study has revealed that monofilament gillnets are most efficient in catchability in terms of number and weight than multifilament gillnets. Whereas in term of mesh size 20mm monofilament is most efficient as it catches more species both in number and weight than other mesh sizes, however for the multifilament gillnet 30mm mesh size was more efficient in catch-ability both in number and weight than 20mm and 40mm mesh size. The study further shows that the family *Cichlidae* is the most abundant in the stream as its recorded highest catchability in terms of number and weight. High catches by small mesh size is likely an indication that the fish species is being depleted in the water body which may be due to overfishing and other factors.

Table 1: Fish species composition by number caught by different mesh sizes of monofilament gillnets in Shabu stream from July 2019 to October 2019

Fish family	Fish species	Mesh size of monofilament gillnets (mm)							
		20mm		30mm		40mm		Total	
		No	%	No	%	No	%	No	%
Cichlidae	*Tilapia zilli*	29	21.6	24	29.6	11	22.9	64	24.33
	Oreochromis niloticus	12	8.6	7	8.64	3	6.25	22	8.37
	Hemichromis niloticus	8	5.9	5	6.17	6	12.5	19	7.22
Characidae	*Alestes nurse*	18	13.4	13	16.0	7	14.5	28	14.45
	Microalestes elongates	7	5.2	-	-	2	4.16	9	3.42
	Alestes brevis	13	9.7	8	9.87	3	6.25	24	9.12
Clariidae	*Clarias lazera*	4	2.9	1	1.2	-	-	5	1.90
	Clarias gariepinus	2	1.4	1	1.2	1	2.08	4	1.52
	Clarias anguillaris	2	1.4	-	-	-	-	2	0.76
Schilbidae	*Schilbe mystus*	6	4.4	2	2.4	2	4.16	10	3.80
	Schilbe intermedius	7	5.2	4	4.93	-	-	11	4.18
Clupeidae	*Sardinella maderensis*	14	10.4	9	11.1	-	-	23	8.75
Mochokidae	*Synodontis bentosoda*	3	2.2	3	3.7	6	12.5	12	4.56
	Synodontis clarias	5	3.7	4	4.93	6	12.5	15	5.70
Mormyridae	*Mormyrus rume*	4	2.9	-	-	1	2.08	5	1.90
Total		**134**	**100**	**81**	**100.0**	**48**	**100.0**	**253**	**100.0**
Relative %		**52.96**		**32.01**		**18.97**			

Table 2: Weight and percentage of fish species caught by respective mesh size of monofilament gillnets in Shabu stream from July 2019 to October 2019

Fish family	Fish species	Mesh size of monofilament gillnets (mm)							
		20mm		30mm		40mm		Total	
		Wt(g)	%	Wt(g)	%	Wt(g)	%	Wt(g)	%
Cichlidae	*Tilapia zilli*	600	9.84	56	3.54	200	16.80	856	9.65
	Oreochromis niloticus	800	13.12	66	4.18	175	14.70	1041	11.74
	Hemichromis niloticus	700	11.48	40	2.53	195	16.38	935	10.54
Characidae	*Alestes nurse*	29	0.47	100	6.33	56	4.70	185	2.0
	Microalestes elongates	400	6.56	-	-	78	6.55	478	5.39
	Alestes brevis	200	3.28	102	6.46	49	4.11	351	3.96
Clariidae	*Clarias lazera*	900	14.76	400	25.34	-	-	1300	14.66
	Clarias gariepinus	600	9.84	250	15.84	146	12.26	996	11.23
	Clarias anguillaris	500	8.20	-	-	-	-	500	5.64
Schilbidae	*Schilbe mystus*	400	6.56	180	11.40	48	4.0	628	7.0
	Schilbe intermedius	300	4.92	120	760	-	-	420	4.73
Clupeidae	*Sardinella maderensis*	150	2.46	70	4.43	-	-	220	2.8
Mochokidae	*Synodontis bentosoda*	270	4.42	90	5.70	44	3,69	404	4.55
	Synodontis clarias	217	3.56	104	6.59	38	3.19	359	4.0
Mormyridae	*Mormyrus rume*	29	0.47	-	-	161	13.52	190	2.14
Total		**6,095**	**99.94**	**1,578**	**99.94**	**1,190**	**99.9**	**8,863**	**99.62**
Relative %		**68.76**		**17.80**		**13.42**			

Table 3: Fish species composition by number caught by different mesh size of multifilament gillnets in Shabu stream from July 2019 to October 2019

Fish family	Fish species	Mesh size of multifilament gillnets (mm)							
		20mm		**30mm**		**40mm**		**Total**	
		No	%	No	%	No	%	No	%
Cichlidae	*Tilapia zilli*	2	28.57	-	-	-	-	2	5.55
	Oreochromis niloticus	-	-	1	5	-	-	1	2.77
	Hemichromis niloticus	-	-	4	20	-	-	4	11.11
Characidae	*Alestes nurse*	-	-	3	15	-	-	3	8.33
	Microalestes elongates	2	28.57	-	-	-	-	2	5.55
	Alestes brevis	1	14.28	4	20	-	-	5	13.88
Clariidae	*Clarias lazera*	-	-	1	5	2	22	3	8.33
	Clarias gariepinus	-	-	2	10	-	-	2	5.55
	Clarias anguillaris	-	-	-	-	1	11	1	2.77
Schilbidae	*Schilbe mystus*	-	-	1	5	2	22	3	8.33
	Schilbe intermedius	-	-	1	5	1	11	2	5.55
Clupeidae	*Sardinella maderensis*	1	14.28	-	-	1	11	2	5.55
Mochokidae	*Synodontis bentosoda*	-	-	-	-	1	11	1	2.77
	Synodontis clarias	-	-	1	5	1	11	2	5.55
Mormyridae	*Mormyrus rume*	1	14.28	2	10	-	-	3	8.33
Total		**7**	**100.0**	**20**	**100**	**9**	100.00	36	100.0
Relative %		**19.44**		**55.55**		**25**			

Table 4: Weight and percentage of fish species caught by different mesh size of multifilament gillnets in Shabu stream from July 2019 to October 2019

Fish family	Fish species	Mesh size of multifilament gillnets (mm)							
		20mm		**30mm**		**40mm**		**Total**	
		Wt(g)	%	Wt(g)	%	Wt(g)	%	Wt(g)	%
Cichlidae	*Tilapia zilli*	108	15.81	-	-	-	-	108	3.46
	Oreochromis niloticus	-	-	107	7.33	-	-	107	3.43
	Hemichromis niloticus	-	-	260	17.83	-	-	260	8.34
Characidae	*Alestes nurse*	-	-	242	16.59	-	-	242	7.77
	Microalestes elongates	172	25.18	-	-	-	-	172	5.52
	Alestes brevis	181	26.50	281	19.27	-	-	462	14.83
Clariidae	*Clarias lazera*	-	-	113	7.75	192	19.87	305	9.79
	Clarias gariepinus	-	-	163	11.17	-	-	163	5.26
	Clarias anguillaris	-	-	-	-	123	12.73	123	3.94
Schilbidae	*Schilbe mystus*	-	-	58	3.97	177	18.32	235	7.54
	Schilbe intermedius	-	-	103	7.06	96	9.93	199	6.39
Clupeidae	*Sardinella maderensis*	167	24.45	-	-	221	22.87	388	12.45
Mochokidae	*Synodontis bentosoda*	-	-	-	-	108	11.18	108	3.46
	Synodontis clarias	-	-	93	6.38	49	5.07	149	4.78
Mormyridae	*Mormyrus rume*	55	8.0	38	2.60	-	-	93	2.98
Total		**683**	**100**	**1458**	**100**	**966**	**100**	**3114**	**100**
Relative %		**21.93**		**46.82**		**31.02**			

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The Effects of Imported Fishes on Nigeria Fishing Industry

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Abstract
The study was conducted among fish importers and fish marketers in Lagos State, Nigeria. The selection was based on availability of frozen imported fishes, processed imported fishes, imported fish transaction intensity, accessibility, the receptive nature of the markets and their categorisation. The categories were Ijora-Olopa frozen International fish market and Ajegunle market. Whereas artisanal fishery constitutes the most important livelihood the in fishing industry of Nigeria, imported fishes are important sector in the Nigeria fishing industry. This paper investigates imported fishes supplied and value chain contribution in Nigeria. The Artisanal, Aquaculture and Industrial Fishery are traditionally considered in Nigeria as renewable and only form of resource found in wide coverage (all water bodies) which makes fishes readily available throughout the world. Result from the study revealed that Nigeria fish self-sufficiency ratio dropped from 58% in 1996 to 42% in 2005 while import decency ratio of fish in Nigeria grew from 41% in 1996 to 60% in 2005 and may probably drop with positive government interventions. An assessment of imported fishes in Nigeria and the constraints provides useful information on ways to improving fishing industry for sustainability, and hence providing the basis for solving major social and economic problems.

Keywords: Effects, imported fishes, Nigeria fishing industry

Introduction

Nigeria is endowed with substantial marine and inland fisheries resources, with land area of 923,768km, continental shelf area of 247,934Km and a length of coast line of 853Km. Despite the availability of these land and water resources, Nigeria's fish production has not been able to sustain her demand. There has been growing reliance on fish food for the provision of the much needed animal protein due to high growth rate in Nigeria's population and increasing awareness of the nutrient content of fish and fish products. Otubusin (2011) stated that fish production in Nigeria comes from three sources; artisanal (inland rivers, lakes, costal and brackish water), aquaculture (fish farming) and industrial fishing (trawling). But over the years a larger proportion of imported fishes dominate Nigeria markets, thus making her net importer of fishery products giving its total fish imports of about USD 1.2 billion, FDF (2015). Presently, Nigeria is the fourth largest importer of fish in the world, following China, Japan and the United States.

Nigeria Fisheries Statistics (NFS 2016) reported that Nigeria's annual fish demand is estimated at about 3.32 million metric tons, but domestic production is only about 1.12 million metric tons. The deficit of 2.2 million metric tons is largely supplied through fish importation from Asia, Thailand, Chile, Norway, Iceland, Europe, United State of America, African countries, including Mauritania, Algeria, Mali and Mauritius. The major imported fish to Nigeria include barracuda, shining nose, Argentina silus, mackerel, trito, blue whiting, herrings, croaker fish and many others. Smoked imported fishes include African catfish, Thailand, tusk, cod, apama and many others.

However, in recent years, there has been growing campaign for development of aquaculture, though the production level has increased, but has not been able to cater for the great difference between supply and demand. Despite such deficit the Minister of Agriculture and Rural Development, Sabo Nanono is optimistic that following Federal Government's effort to encourage local production, Nigeria may stop fish importation in 2020. Moreover, with a huge potential to meet local fish demand through increased domestic fish production, Nigeria will become an exporter of fishery products and several social problems reduced, such as unemployment will be solved.

The Raw Materials Research and Development Council (2007) pointed out that over 10 million people are directly or indirectly engaged in fishery in Nigeria. Imported frozen and processed fish industry recorded a significant rise in 2015, contributing about 806,000 metric tons, at about $1,126,428,414.41(FDF 2015). Thus there are no clear targets for imported fishes in Nigeria, because the market is dependent on available species supplied. The management process through which goods and services move from concept to the customer, profitability and income from a particular species will, to a significant extent, depends on its demand and marketing outlets.

The future of imported fish in Nigeria is dependent and related to her overall growth pattern and marketing is an integral part. Therefore, this study was aimed at determining the types of imported fishes and their sources for the purpose of establishing the existing marketing/distribution channels.

Methodology

The study was carried out in four (4) markets in Lagos State; Ijora Olopa International frozen fish market, Oyingbo fresh and frozen fish market, Boundary- Ajegunle and Liverpool market were purposively selected. Unstructured questionnaires were administered directly for the purpose of speed and accuracy. Markets, observation of cold rooms and direct interviews were conducted for further confirmation of some issues raised in the questionnaires. Physical inspection and identification of source of imported frozen fishes were conducted.

Analysis of data:

Both general and specific information collected during the study were presented using narrative, descriptive, table and charts.

Results and Discussion

The pie chart (Figure 1) depicts the shares of fish demand (50%), domestic production (24%) and deficit (26%). This deficit is augmented through imports at a cost of about $1.2 billion annually (FDF 2015).

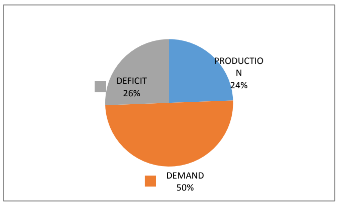

Figure 1: Status of Nigeria's fish Supply and Demand

Figure 2 is typical marketing channel for imported fish. The wholesalers fish broker compete to obtain the product for further distributions in order to make profit, while the consumer bears the whole cost.

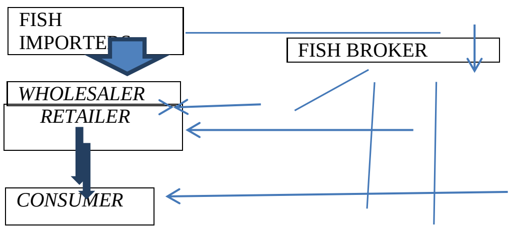

Figure 2: Typical Channel of Impoted Fish Distribution

Table 1: Imported Frozen/Dried Fish and Country of Origin

English Name of Fish	Scientific Name	Country of Origin	KG	Prices
Yellow Croaker	*Pseudotolithus sp*	Brazil, Russia Argentina	20	19,000
Tilapia	*Oreochomisniloticus*	China	10	
Mullet		Mauritanie	20	8,500
Moon	*Mugilsp*			
Herring fish	*Sardinellagibossa*	Vietnam	20	9,000
Horse mackerel.	*Trachurussp*	Chile, Mauritanie	20	12,900
Tritors (Titus)	(*Scomberjaponicus*)	Ferro Island, Uruguay, USA Argentina, Mauritania.	18 20 25	14,000 15,000 19,000
Thailand (smoked)		Thailand	7.70	35,000
Cod fish (smoked)		Norway, Iceland	30	600,000
Tusk (smoked)		Norway, Iceland	45	300,000
Apama (smoked)		Norway, Iceland	30	70,000

Smoked fish from Thailand is popularly called the country'sname.Fishes are mainly handled by retailers who are not ready to disclose the source of the products. The frozen fish are sold in cold rooms, structured market stores and in open places.Thailand fish weighsbetween 6.40 – 7.70kg.The flesh, bone, head of Cod, Tusk and Apama stock fish are imported either in smoked or processed form from majorly Norway and Iceland. They are most expensive and sold differently in Nigeria markets. The "stock fish" as popularly called is favoured by Nigeria's hoteliers and the rich.

Conclusion and Recommendation

Frozen imported or processed fish is a lucrative business in Nigeria, whereas, the variance between production and consumption implies high market potentials in the fishing industry. Presently, Nigeria's demand for fish is making importers take advantage of poor domestic fish production from artisanal, industrial and aquaculture. The result is that many industrial fishing companiesare adopting fish importation leading to loss of jobs, and foreign exchange transfer to other countries. In order to intensify fish production in Nigeria, priority attention should be given to the three traditional sources of fish production (artisanal, industrial and aquaculture) such that the level of out could sustain the population.

It has been established that fish culture has been growing from 25 to 33% per annum since 2003 following the growing publicity and attention being giving to it. Governments and the private sectors have contributed to aquaculture development through various programmes and this is evident the farmed cat fish market which surpasses $27 million annually Graham Susan (2006).

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POSTHARVEST

Dermestes maculatus degeer, 1774 (Coleoptera: Dermestidae): A threat to fish preservation (review)

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Abstract
Fish is a cheap and fairly accessible source of protein, poly-saturated fatty acids vitamins and respectable amount of minerals. It's also a source of income generation, poverty alleviation, foreign exchange earnings and provision of raw materials for the animal feed industry. Despite its nutritional and economic importance, Literatures were reviewed and reported that fish have being infested by various pests, especially *Dermestes maculatus*, during harvest, transport and or storage. This accounts for qualitative, quantitative as well as economic loss of dried fishes in most of the producing areas in Nigeria. Realization of serious limitations offered by the use of conventional pesticides, in prevention and control of this infestation, ignite the interests in the use of plant-derived pesticides. Extracts, powders and essential oils obtained from plants were reported to be effective and have little health or environmental risks and therefore, a promising technology for preservation of dried fishes.

Keywords: Botanicals, Damages, Dermestes maculatus, Fish preservation, Infestation

Introduction
Fish consumption provides readily available dietary nutrients to a large number of people worldwide and makes a significant contribution to human nutrition (Mufutau, 2012). Fish protein composed of a very high profile of essential amino acids, which are relatively deficient in other animal protein (Abolagba *et al*., 2015). It is a good source of vitamins A, B, D, E and K and respectable amount of minerals such as phosphorus, calcium, iron, iodine, fluorine and magnesium (Yem *et al* 2006). It is equally high in poly-saturated fatty acids which are important factor for lowering blood cholesterol level (Conquer and Holub, 2002; Okunade, 2011). In addition fish is a source of income, poverty alleviation, foreign exchange earnings and provision of raw materials for the animal feed industry (Akinwumi, *et al*., 2007). Nigeria has an estimated annual per capita fish consumption of 17.5 kg, and a projected fish demand of 3.61 million metric tonnes (FDF, 2018). However fish is easily perishable in tropical climates, therefore needs to be preserved quickly after capture (Omojowo *et al* 2009), which is why preservation methods such as freezing, smoke-drying, sun drying and heat treatment have been applied to extend the shelf-life of the product and to ensure its all seasons availability (Ikenweiwe, *et al*., 2010). Despite its nutritional and economic importance, fish was reported to be infested by *D. maculatus*, during harvest, transport and or storage (Zakka et al., 2013). The aim of this paper is to review existing literatures on the effect of *D. maculatus* infestations on smoked dried fishes and the botanicals that were used as an alternative to conventional pesticides in the control of these beetles.

Effects of *Dermestes maculatus* on smoked- dried fishes
Both adult and larva of *D. maculatus*, feeds on dead and dried animal material, such as; dried meat, dried fishes, cheese, bacon, dog treats, poultry and body parts such as bone, hair, skin, and feathers (Collinson Cloud, 1986; Veer et al. 1996). A pre-dominant pest of dried fish and is recognized mostly as a cosmopolitan pest of stored items especially those containing animal protein (Nta *et al*., 2019). *Dermestes maculatus* accounts for about 71.5% of dried fish infestation and a substantial loss in dry weights of about 43-62.7% in most of the producing areas in Nigeria, causing qualitative and quantitative damages (Babarinde, 2018). This depends on fish species, period of storage and insect developmental stage but larval stage is the most destructive than the adult stage (Ajao *et al.*, 2018). Within three months of storage, the larva have been reported to cause 13% and 19% weight losses of Tilapia. niloticus and Alestes sp. respectively, with the products reduced to powder mixed with insect exuviae and dead larvae (Akinwumi, 2011). Similarly the larva have been found to cause up to 93% infestation of dri ed fish and up to 62.7% loss in dry weight (Ayeloja , 2020). Feeding by the larvae and adults causes 20% quantitative loss of dried fish and quality losses in a storage period of six months (Ahmed *et al*, 2013). About 50% losses were recorded due to the infestations of *D. maculatus*, this resulted to net reductions in the amount of nutrients, quantity, general declining in consumer acceptability and market prices (Odeyemi *et al.* 2000; Atijegbe, 2004). Proximate analysis conducted before and after eight weeks of storage of smoked dried *Heterotis niloticus, Clarias gariepinus, Oriochromis niloticus and Proteptenus annectens*, exposed to *D. maculatus*, shows significant decrease in protein and fat content of the products. The protein content of C*larias gariepenus* reduced from 72.00 to 50.90% and the percentage weight loss was 32% in *C. gariepinus* and 24.4% in *O. niloticus* (Ajayi *et al*, 2006 and Chris *et al.*, 2014). Similarly the weight and proximate composition of fifty smoked *C. gariepinus* (117.5 ± 0.05 g) infested with larvae of *D. maculatus* and stored for 14, 28, 42, and 56 days, were decreased as the storage duration increased (Oke *et al* 2014). A significant differences among the mean weight of two samples of fish, was recorded to be; 19.13kg and 18.98kg respectively after exposure to *D. maculatus* compared with the mean weight of the control 20.09k. Proximate composition of the fishes were also decreased as : crude protein from

60.07% to 40.27%; fat from 8.35% to 5.90%; moisture content from 11.67% to 10.67; fiber from 12.93 to 11.93; ash from 4.02% to 3.54% and carbohydrate 12.67% to 5.89% (Uneke, B. I, 2015). Similarly, the nutritive quality of *Clarias gariepinus* was found to be depleted after exposure to the beetles for 56 days. The crude protein reduced from 80.92±0.49 - 66.45±0.56, fat content 8.23±0.20 - 4.89±0.15, moisture content 146.32±9.22 - 142.55±2.95 (Victor, 2019). The weight loss of dried *Chrysichthys nigrodigitatus, Heterobranchus bidorsalis and Oreochromis niloticus* was recorded as 15.00 ± 1.15g to 14.00 ± 1.53g, 29.00 ± 3.05g to 22.66 ± 1.20g, 20.00 ± 0.58g to 14.33 ± 2.96g respectively, after the fish species were exposed to *D. maculatus* larvae and adults for 35 days at ambient laboratory conditions Ajao et al, (2018).

Methods of controlling *Dermestes maculatus*

Management of insect pests in many storage systems rely primarily on applying synthetic insecticides (Mufutau, 2012). However, realization of the serious limitations offered by the use of these chemicals, as fish protectants, biological methods were now given a great consideration, especially using plant-derived pesticides which are eco-friendly, readily available in the environment and can be used in the control of various insects in stored products (; Nowsad *et al.,* 2009; Lithi *et al*., 2012; Olayinka - Olagunju, 2014; Babarinde *et al.*, 2018; Ogban, 2019).

Plants powders and extracts

A significant ($p< 0.05$) mortality of larvae of *Dermestes maculatus* was observed when exposed to smoked dried Clarias gariepinus treated with oil-powder mixture of *Dennettia tripetala* Baker (pepper fruit), *Eugenia aromatica* Hook (clove), *Piper guineense* (Schum and Thonn) (black pepper) and *Monodora myristica* (Dunal) (African nut-meg) (Akinwumi, 2011). Similarly varying amounts of pulverized Hot pepper, Black pepper, Sweet basil, African Nut-meg and Ginger, under ambient conditions, were applied at a dose of 1.0, 2.0 and 3.0 g per 25 g of dry fish along with 5ml of conventional pesticide (Dichlorvos), against hide beetles. The Black pepper was observed to be highly effective causing longest delay in oviposition (6.67 – 9.33days) and significant delay in fecundity (Jatau et al, 2016), however, 2.0g powders of Piper guineenses was reported to give mortalities of 83.33% and 76.67% for larva and adult of D. maculatus respectively and 2.0g of Zingiber officinale powder causes larval and adult mortalities of 76.67% and 73.33% respectively after 24 hours and 72 hours. (Obiakor *et al*., 2013). A mixture of the powder of Seeds of Alligator pepper (Aframomum melegueta, Schumann), African nutmeg (Monodora myristica, Gaertn) and pods of Aridan fruits (Tetrapleura tetraptera, Schumach and Thonn) were found to significantly ($P<0.05$) impaired progeny development of the beetle larvae (Amadi and Dimpka, 2018). Meanwhile Citrus peel powder was reported to have 100% mortality of D. maculatus, within five days of post treatment, where by the mortality of the beetle increased with an increase of the treatment and the duration of the days (Shuaibu, *et al* 2017). Similarly the oil extracts of Corchorus olitorius, Solanum nigrum, Lycopersicon esculentum and Telferia occidentalis, were significantly ($p<0.05$) effective in killing all the adults, eggs, larvae and pupae of D. maculatus when applied at concentrations of 0, 2%, 4%, 6% and 8% on the disinfected muscle of smoked Clarias gariepinus (Nta et al, 2019).

Essential oils (EOs)

EOs, are complex chemical compounds with multiple mode of action that enhance their activity due to the synergistic action between the constituents (Mossa; 2016). They are active against variety of insects, fast penetrating and no toxic residue in the treated products (Mossa; 2016).They have surface tension, that may cause a reduction in the level of oxygen supply to the insects and consequently lead to suffocation and death (Nta.,et al 2019). Clove essential oils has been widely studied for its insecticidal and repellent activities against many species of pests (Chaieb et al. 2007, Kafle and Shih 2013, Rojas et al. 2014). Neem seed oil (NSO),was also reported to reduce oviposition and causes high mortality rates on both adult and larvae of the smoked fish pests of *D. maculatus* (Mufutau., 2012). The essential oils of Cocos nucifera, Zingiber officinale Roscoe, Jatropha curcas and Allium sativum were reported to have larvicidal and repellent effects on the larvae of D. maculatus, the oils caused significant mortality ($P < 0.05$) of the larvae on treated fish at 96 h after infestation (Ogunduyile, 2015). Similarly ginger essential oil (GEO) was reported to have a pesticidal effect against adult and larva of *Dermestes maculates*, infesting *Clarias gariepinus*), at 32 $\pm 2^0$C and 70 ±3% humidity. As 25.80 and 36.23% mortality were recorded in 0.99 and 1.33 ll/ml air were respectively in both adult and larva (Babarinde *et al* 2018). Insect mortality in fish treated with the oil extracts of red chilli, neem and garlic, was 100% effective, these plants were reported to contain some insecticidal activities which can impair the physiological development of the stages of insect pest (Nowsad, *et al* 2009).

Conclusion

From the literatures reviewed, it could be concluded that the infestations of dried fish by *D. maculatus*, during harvest, transport and or storage resulted in qualitative, quantitative and economic loss. The conventional pesticides used in prevention and control of the infestation, were realized to be harmful to human health, environment and non -target organisms. Therefore biological method especially using plant extracts, powders and essential oils were reported to be effective and have little health or environmental risks and therefore, a promising technology for preservation of smoked dried fishes. Hence dried fishes vendors should be encourage and oriented on proper and effective methods of fish preservations, Further researches should be conducted using available plants materials especially essential oils to determine their efficacy on developmental stages of *D. maculatus*

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Preference and Perception of Fish Processors on the Influence of Wood Types on the Quality of Smoke-dried Fish in Katsina State

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Abstract

The research examined the preference and perception of fish processors on the influence of wood types on the quality of smoke-dried fish in Katsina State. A total of 31 fisherfolks from two fish processing sites in Katsina State, Makera and Dannakola were administered well-structured questionnaire and guided interview. The data obtained were analysed using descriptive statistics. The mean age of the fish processors was 36.4 years, they were all males with the majority (51.6%) having Arabic/Quranic education. Over 75% of them are married and their mean monthly income was N45,532.30. Neem tree (*Azadirachta indica*) was the most preferred and the most used fuelwood, while winter thorn (*Faidherbia albida)* was the least preferred and the least used. Majority of the respondents hardly notice the specific wood species that gave the best fish quality of smoked fish. However, neem tree was the most favoured to influence the quality of the smoke-dried fish among the few that perceive the influence of wood type on the quality of smoke-dried fish. While it has been established that the choice of wood type varies with location, the most favoured wood types as fuelwood for fish smoking in Katsina State is neem tree (*Azadirachta indica*).

Keywords: Smoke-dried fish, fuelwood, fish quality, fish processor, Katsina State

Introduction

Fish is an integral part of the human diet and a cheap source of animal protein. Its consumption varies globally and per capita consumption has always been on the increase with global average rising from 13.4 kg between 1986 and 1995 to 20.5 kg in 2018 (FAO, 2020a). Fish constitute over 50% of animal protein consumed in Nigeria, with the higher amount consumed in the southern part of the country (Dauda and Yakubu, 2013). According to FAO (2020b), the per caput fish consumption in Nigeria stood at 13.3 Kg as at 2013 while the total fish production as at 2015 was 1,027,000 tonnes with over 65% of from artisanal fisheries. Sadly, despite production far below demand, a meaningful quantity of fish produced from artisanal fisheries in Nigeria is ended up as waste due to high perishability nature of the fish. It is therefore important to properly handle fish and process fish to a form that can retain it in high quality for a long time as fast as possible. Fish is known to be preserved and or processed by chilling, frozen, salting, smoking, frying etc (Okunade and Bolorunduro, 2014). Smoke-drying is the most commonly used method to increase shelf-life of fish in Nigeria, and it has been perfected with various traditional and modern smoke-drying methods and facilities. According to Okunade and Bolorunduro (2014), 70-80% of fish produced in Nigeria are marketed smoked. However, artisanal fisherfolks who are responsible for a higher fraction of local fish production still utilise more of traditional methods and facilities. The use of simple ovens like improved banda, chokor kiln, oven drum etc are still very common among the local fish processors (Olokor *et a*l., 2007). These simple ovens use firewood as the fuel source and the types of wood are largely varied due to location. Interestingly, wood smoke is not the same among the tree species, and apart from the quality of fish being affected, it may also put both the processor and consumers at health risks. Hardwoods are generally regarded as better than softwoods as they produce light smoke with a limited amount of polycyclic aromatic hydrocarbons (PAHs) (Eyo 2001, Atanda *et al*., 2015). It is uncertain whether fish processors have detail understanding of the influence of wood types on the quality of smoke-dried fish, hence the needs for continuous research and educating them on the needs for preference for wood fuel source based on fish quality and their health. This research was carried out to examine the fish processor's perception of the influence of wood types on the quality of smoke-dried fish in Katsina State, Nigeria

Materials and methods

Study area

The study was carried out in Katsina State (latitude $12^0$15'N, longitude $7^0$30'E), the State is located in North-western Nigeria with a landmass of 24,192 Km^2 and estimated population of 6,483,429 as at 2006 census (Dauda and Ibrahim, 2015). The State has several reservoirs of different sizes, including, Jibia, Ajiwa, Zobe, Daberam, Sabke, Malumfashi, Mairuwa, Gwaigwaye among others. However, active fish processing is only notable in Makera area of Zobe reservoir, Dutsin-ma Local government area and Dannakola area nearby Daberam reservoir in Daura Local government area.

Data collection

Data was collected with the use of structured questionnaire and guided interview from the two sites with active fish processing that is Makera and Dannakola, total enumeration was done in Dutsin-ma that has only 10 fish processors while 21, half of the population was sampled in Dannakola leading to 31 respondents. Information was collected on the demographic characteristics of the fish processors, preference and perceived knowledge of wood types on the quality of the smoked fish.

Data analysis

The data were analysed using descriptive statistics (frequency counts, percentages and means).

Results and Discussion

The results of the demographic characteristics are shown in table 1, the dominating age range was 20-29 years (29%) following by 30-39 years (25.8%), the mean age of the respondents was 36.4 years. All the respondents were males and 77.4% of them are married. Arabic/Quranic education was the dominant educational status and the majority (87.1%) of them engaged in only crop farming as their other occupations. The mean monthly income of the respondents from fish processing stood at ₦45, 532 (including their working capital), with a larger percentage (22.6%) having less than ₦ 20,000 as monthly take home. Majority of the fisherfolks (74.2%) had annual income from their farming activities between ₦100,000 and ₦200,000 and the mean annual income from other activities was ₦143,225.81. The observed age distribution of over 80% of the processors as young with potential agility to work, all males and the majority with Quranic education is similar to the report of Dasuki *et al*., (2014) for artisanal fishermen of Makera zone Dutsin-Ma. The region is characterised by females staying indoor and does less of outdoor works (Dauda *et al*., 2013). The mean income ₦45,532, which represents both their capital and profit is low and this further suggests that artisanal fisherfolks are poor (Oladoja and Adeokun, 2009) and the needs for other sources of income like crop farming that majority of the respondents were engaged.

Table 1: Demographic characteristics of the fish processors

Characteristics	Category	Frequency	Percentage	Mean
Age (years)	<20	4	12.9	36.4±2.4
	20-29	9	29.0	
	30-39	8	25.8	
	40-49	5	16.1	
	50-59	4	12.9	
	60-69	0	0	
	>70	1	3.2	
	Total	**31**	**100.0**	
Sex	Male	31	100	
	Female	0	0	
	Total	**31**	**100.0**	
Marital status	Single	6	19.4	
	Married	24	77.4	
	Divorced	1	3.2	
	Total	**31**	**100.0**	
Educational status	No formal	0	0	
	Arabic/Quranic	16	51.6	
	Primary	7	22.6	
	Secondary	7	22.6	
	Tertiary	1	3.2	
	Total	**31**	**100.0**	
Other occupation	Crop production	27	87.1	
	Others	2	6.5	
	None	2	6.5	
	Total	**31**	**100.0**	
Income from fishing (monthly) ₦	11000-20000	7	22.6	₦45,532.3±17,619.9
	21000-30000	3	9.7	
	31000-40000	5	16.1	
	41000-50000	3	9.7	
	51000-60000	6	19.4	
	61000-70000	3	9.7	
	>70000	4	12.9	
	Total	**31**	**100.0**	
Income from other sources(annually) ₦	None	2	6.5	₦143225.81±17619.86
	100000-200000	23	74.2	
	210000-300000	4	12.9	
	310000-400000	1	3.2	
	410000-500000	1	3.2	
	Total	**31**	**100.0**	

The majority (61.3%) of the respondents purchased the fuelwood used for smoking. Neem tree (*Azadirachta indica*) was both the most preferred and the most used fuelwood in Makera and Dannakola, Katsina State, while winter thorn (*Faidherbia albida*) was the least preferred and the least used among the fish processors (Table 2).

While the most preferred and most used were said to be favoured by availability, durability, production of light smoke and better quality smoked fish, the least preferred and least used species were not favoured due to presence of spine that can injure the users, heavy smoke and burning out too fast of fuelwood. Smoke generated by fuel woods are not the same for all tree species (Agbabiaka *et al*., 2012) and this may influence the chemical reaction between the smoke and the fish and hence affect the quality of smoke-dried fish (Atanda *et al*., 2015). The best fuelwood may be a function of location as the availability and distribution of tree species vary from one place to another.

Table 2: Preference for wood species among the fish processors

Wood species	Category	Frequency	Percentage
Wood source	Self-fetching (alone)	0	0
	Purchase (alone)	19	61.3
	Both	12	38.7
	Total	31	100.0
Most preferred	*Azadirachta indica*	23	74.2
	Combretum micranthum	5	16.1
	Piliostigma reticulatum	3	9.7
	Total	**31**	**100.0**
Most used	*Azadirachta indica*	24	77.4
	Diospyros mespiliformis	1	3.2
	Combretum micranthum	3	9.7
	Piliostigma reticulatum	3	9.7
	Total	**31**	**100.0**
Least preferred	*Faidherbia albida*	12	38.7
	Bauhinia rufescens	1	3.2
	Ficus platyphylla	1	3.2
	Parkia biglobosa	3	9.7
	Lannea acida	4	12.9
	Piliostigma reticulatum	4	12.9
	Balanites aegyptiaca	1	3.2
	Diospyros mespiliformis	2	6.5
	Vitellaria paradoxa	2	6.5
	Vachellia sieberiana	1	3.2
	Total	**31**	**100.0**
Least used	*Faidherbia albida*	12	38.7
	Bauhinia rufescens	1	3.2
	Ficus platyphylla	2	6.5
	Parkia biglobosa	4	12.9
	Lannea acida	1	3.2
	Olea europaea	1	3.2
	Piliostigma reticulatum	4	12.9
	Diospyros mespiliformis	3	9.7
	Vitellaria paradoxa	2	6.5
	Vachellia sieberiana	1	3.2
	Total	**31**	**100.0**

The results of fish processor's perception on the effect of wood quality are shown in table 3 , Majority of the processors are not sure of the influence of the wood types on the quality of fish in terms of colour, smoking time, soot deposit, smell, taste and shelf-life. Among the few that were convinced that wood types affect fish quality, mostly mentioned the neem tree as the best fuelwood in the study area. This further corroborates the position of Atanda *et al*. (2015) who reported differences in quality of fish smoked with different wood types. Interestingly, neem tree was not among the fuelwood experimented by Atanda *et al*. (2015), and the kola nut tree noted to be the best in Port Harcourt, Rivers State is not available in Katsina State.

Table 3: Perception of fish processors on the effect of wood species on quality of fish smoked fish in Katsina State

Perception	Category	Frequency	Percentage
Does wood type affect the colour	Yes	12	38.7
	No	19	61.3
	Total	**31**	**100.0**
Species that gives the best colour	Not applicable	20	64.5
	Piliostigma reticulatum	2	6.5
	Azadirachta indica	7	22.6
	Anogeissus leiocarpus	1	3.2
	Combretum micranthum	1	3.2
	Total	**31**	**100.0**
Does wood type affect the smoking time	Yes	1	3.2
	No	30	96.8
	Total	**31**	**100.0**
Species that gives least smoking time	Not applicable	30	96.8
	Azadirachta indica	1	3.2
	Total	**31**	**100.0**
Does wood type affect soot on the fish	*Yes*	3	9.7
	No	28	90.3
	Total	**31**	**100.0**
Species that gives the least soot	Not applicable	28	90.3
	Azadirachta indica	3	9.7
	Total	**31**	**100.0**
Does wood type affect the smell	Yes	4	12.9
	No	27	87.1
	Total	**31**	**100.0**
Species that gives the best smell	Not applicable	27	87.1
	Azadirachta indica	3	9.7
	Anogeissus leiocarpus	1	3.2
	Total	**31**	**100.0**
Does wood type affect the taste	*Yes*	3	9.7
	No	28	90.3
	Total	**31**	**100.0**
Species that gives the best taste	Not applicable	28	90.3
	Azadirachta indica	3	9.7
	Total	**31**	**100.0**
Does wood type affect the shelf life	Yes	4	12.9
	No	27	67.1
	Total	**31**	**100.0**
Species that gives the highest shelf life	Not applicable	27	87.1
	Faidherbia albida	1	3.2
	Azadirachta indica	3	9.7
	Total	**31**	**100.0**

Conclusion

The results established that various tree species are being used as fuelwood in fish smoking in Katsina State, and that availability is one of the major factors that determine the most used. Neem tree is the most preferred and the most used in the state, it is also perceived to give the best quality smoked fish. However, it is important to carry out fish smoking experiments to confirm the best fuelwood in the State and educate the fisherfolks accordingly for the safety of both the processors and the consumers.

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Development and evaluation of cookies supplemented with fish protein concentrate.

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Abstract
Cookies was prepared and fortified with fish protein concentrate (FPC) at (0, 5, 10, 15, 20 %) level of inclusion while the control had no FPC. Cookies formed showed that the higher the FPC, the higher the acceptance. The cookies with 20% fish inclusion was not significantly different at $P<0.05$ from those of 15 and 10% fish inclusions respectively. The control had the best shelf stability till the fourth week. The cookies that have 5-15% fish protein inclusion were only acceptable till the third week while the cookies with 20% fish inclusion were only acceptable within the first two weeks and after the second week; the cookies could no longer be assessed because of fungal growth. Therefore, the cookies of 10-15% fish inclusion are more stable on the shelf and are therefore recommended as it will increased the protein intake of cookies consumers who are primarily school-aged children who really need more of fish protein intake.

Keywords: Cookies, Fish protein concentrate and shelf stability.

INTRODUCTION

Fish are known for their high nutritional quality, relatively low in fat, saturated fat, cholesterol and high in polyunsaturated fatty acids, protein and minerals such as Calcium, phosphorus, sodium, potassium and magnesium (Huang and Lai, 2010). Fish protein concentrate (FPC) is the product resulting from the removal of water and oil from fish, thus increasing the concentration of the protein and other nutrient materials (Techochatchawal and Therdthai, 2009). Several works have been carried out on improving the protein base of common snacks. This work was carried out to evaluate the percentage of FPC inclusion in Cookies will be most acceptable to consumers and at the same time shelf stable. The objective of this work therefore is to increase protein availability and intake, enhancing the production of shelf stable value added fish products and to improve the income of the fisher folks.

MATERIALS AND METHODS

Fresh catfish was procured from New Bussa, washed and used to prepare FPC using the methods of Yadav *et. al.*, (2014). Cookies preparation was carried out according to American Association of Cereal Chemists (AACC, 2000). Ingredients weighed as follows: 100g of wheat, FPC fortification levels (0, 5, 10, 15, and 20 %), 5.0g of sugar; 50.0g of eggs, 28.0g of butter and 15ml whole Milk. The Eggs was initially homogenized with a blender for 40-60 seconds. Then, sugar was added and mixed for 20-30 seconds in a blender; half of the flour and all other ingredients was included and mixed for 20-30 seconds. The remaining flour was added and mixed for 140 seconds to give a total mixing time of 3 – 4 minutes. Cookies were formed in sheet with a diameter of 50mm and baked at 180^{o}c for 20 minutes or until they are golden brown. The Cookies was cooled at room temperature.

Statistical Analysis:

The mean and standard error (mean ± SE) for the obtained results was calculated using SPSS computer program under Window [SPSS, 1999].

MICROBIOLOGICAL ANALYSIS

Isolation and identification: Isolation and identification of bacteria were investigated according to Bergey's manual of determinative bacteriology (Holt *et al.*, 1997).

Sensory Evaluation: The sensory evaluation of Cookies was estimated by ten panelists (Plate 1) for appearance, odour and taste as the method described by Zhou *et al.*, 2013.

ORGANOLEPTIC ASSESSMENT

The Cookies overall acceptability score was given to the control i.e. 0% and those of 5%, 10%, 15% and 20% FPC using a hedonic scale of 1- 5. The score 5 = Excellent, 4= very good, 3 = good while products scoring 2 – 1 are being regarded as unacceptable. The organoleptic attributes of the cookies are presented in Table 1. The trend of scores is as follows: 20% fish protein inclusion has the highest level of acceptance more > 15% fish inclusion >10% inclusion > 5%. However, 20% is not significantly different at $P<0.05$ from those of 15 and 10% fish inclusions respectively. The least acceptable was the control followed by the 5% fish inclusion which was significantly different at $P<0.05$ from the cookies with 5% fish inclusion.

TABLE 1: Organoleptic Attributes of Cookies Supplemented with Different Level of Protein Concentrate

Treatment	Taste	Flavour	Texture	Appearance	Overall-acceptability
Control	3.0 ± 1.1^{a}	2.8 ± 1.4^{a}	3.1 ± 0.2^{a}	3.2 ± 1.2^{a}	3.0 ± 1.6^{a}
5% fish inclusion	3.7 ± 0.2^{b}	3.5 ± 0.9^{b}	3.6 ± 0.4^{b}	3.8 ± 0.2^{b}	3.6 ± 0.1^{b}
10 % fish inclusion	4.2 ± 0.2^{c}	4.1 ± 0.1^{c}	3.9 ± 0.3^{c}	4.0 ± 0.1^{c}	4.1 ± 1.3^{c}
15% fish inclusion	4.3 ± 0.1^{c}	4.5 ± 0.3^{c}	4.1 ± 0.1^{c}	4.3 ± 0.7^{c}	4.2 ± 0.6^{c}
20% fish inclusion	4.5 ± 0.4^{c}	4.3 ± 0.2^{c}	4.6 ± 0.5^{c}	4.6 ± 0.1^{c}	4.5 ± 0.3^{c}

SHELF-LIFE STUDY

The Cookies prepared were kept on the shelf for six weeks and samples were taken at one week interval for organoleptic analysis. The organoleptic attributes of the cookies are presented in Tables 2. The trend of scores for the overall acceptability of the freshly prepared cookies (0% fish inclusion) and those stored on the shelf for six weeks are as follows: freshly prepared has the highest quality > those stored for 1 week >2nd week > 3rd week > 4th week > 5th week > 6th week. Similarly, the freshly prepared is not significantly different at $P<0.05$ from those stored for one to the fourth week respectively which are still very good and well acceptable. However, the cookies were no longer acceptable after the 4th week.

TABLE 2: Organoleptic attributes of freshly prepared cookies of (0% inclusion) and those stored for six weeks

Treatment	Taste	Flavour	Texture	Appearance	Overall-acceptability
Day 1 / Control	3.0 ± 1.1^{a}	2.8 ± 1.4^{a}	3.1 ± 0.2^{a}	3.2 ± 1.2^{a}	3.0 ± 1.6^{a}
Week 1	3.1 ± 0.1^{a}	3.0 ± 1.1^{a}	2.9 ± 1.6^{a}	3.0 ± 0.3^{a}	3.0 ± 1.1^{a}
Week 2	2.9 ± 1.4^{a}	2.8 ± 1.7^{a}	2.9 ± 0.2^{a}	2.7 ± 1.5^{a}	2.8 ± 1.3^{a}
Week 3	2.8 ± 1.1^{a}	2.5 ± 1.4^{a}	2.6 ± 0.2^{a}	2.5 ± 0.8^{a}	2.6 ± 0.2^{a}
Week 4	2.9 ± 0.7^{a}	2.6 ± 1.2^{a}	2.5 ± 0.2^{a}	2.4 ± 1.2^{a}	2.7 ± 1.6^{a}
Week 5	2.1 ± 0.3^{b}	1.7 ± 0.5^{b}	1.9 ± 0.7^{b}	1.9 ± 0.6^{b}	1.9 ± 0.8^{b}
Week 6	1.8 ± 0.4^{b}	1.7 ± 0.4^{b}	1.6 ± 1.2^{b}	1.7 ± 1.1^{b}	1.7 ± 0.1^{b}

Plate 1: Samples of Various concentration Fish in Cookies.

Table 3 below showed the result of the organoleptic studies, the trend of scores for the overall acceptability of freshly prepared Cookies (with 5% fish inclusion) and those on shelf for six weeks are as follows: freshly prepared has the highest quality > those stored for 1 week >2nd week > 3rd week > 4th week > 5th week > 6th week. However, the freshly prepared is not significantly different at $P<0.05$ from those stored for one week but significantly different at $P<0.05$ and better in quality from those stored till the second week. Similarly, the cookies stored till the second and third weeks are not significantly different at $P<0.05$respectively which are still good and acceptable too. However, the cookies were no longer acceptable after the third week.

TABLE 3: Organoleptic attributes of day (0) cookies (5% inclusion) and those stored for six weeks

Treatment	Taste	Flavour	Texture	Appearance	Overall-acceptability
Day 1 / Control	3.7± 0.2[a]	3.5± 0.9[a]	3.6± 0.4[a]	3.8± 0.2[a]	3.6± 0.1[a]
Week 1	3.3± 1.1[a]	3.2± 0.3[a]	3.3± 0.8[a]	3.4± 0.1[a]	3.3± 0.3[a]
Week 2	2.7± 0.2[b]	2.6± 0.1[b]	2.4± 0.1[b]	2.7± 0.1[b]	2.6± 0.7[b]
Week 3	2.5± 0.1[b]	2.4±7 0.3[b]	2.6± 0.3[b]	2.5± 0.03[b]	2.5± 0.2[b]
Week 4	2.0± 0.05[c]	1.8± 0.6[c]	1.7± 0.5[c]	2.0± 0.2[c]	1.9± 0.1[c]
Week 5	2.0± 0.3[c]	1.4± 0.4[c]	1.7± 0.4[c]	1.2± 0.6[c]	1.6± 05[c]
Week 6	1.2± 0.3[c]	1.4± 0.4[c]	1.2± 0.4[c]	1.4± 0.06[c]	1.4± 0.1[c]

Furthermore, the result of the organoleptic studies of freshly prepared Cookies (with 10% fish inclusion) and tho se on shelf for six weeks shows this trend. The overall acceptability; freshly prepared has the highest quality > those stored for 1 week >2nd week > 3rd week > 4th week > 5th week > 6th week (Table 4). However, the freshly prepared is not significantly different at P<0.05 from those stored for one week but significantly different at P<0.05 and better in quality from those stored till the second week. Similarly, the cookies stored till the second and third weeks are not significantly different at P<0.05respectively which are still good and acceptable too. However, the cookies were no longer acceptable after the third week. Similarly, Table 5 also showed the trend of scores for the overall acceptability of freshly prepared Cookies (with 15% fish inclusion) and those on shelf for six weeks are as follows: freshly prepared has the highest quality > those stored for 1 week >2nd week > 3rd week > 4th week > 5th week > 6th week. However, the freshly prepared is significantly different at P<0.05 from those stored for one week. Also, those of one week is also significantly different at P<0.05 and better in quality from those stored till the second week. However, the cookies stored till the second is not significantly different at P<0.05 respectively from those of the third week which are still fairly good and acceptable too. However, the cookies were no longer acceptable after the third week.

TABLE 4: Organoleptic attributes of day (0) cookies (10% inclusion) and those stored for six weeks

Treatment	Taste	Flavour	Texture	Appearance	Overall-acceptability
Day 1 / Control	4.2± 0.2[a]	4.1± 0.1[a]	3.9± 0.3[a]	4.0± 0.1[a]	4.1± 1.3[a]
Week 1	4.0± 0.5[a]	4.0± 0.1[a]	3.9± 0.1[a]	3.8± 0.1[a]	3.9± 0.07[a]
Week 2	3.2± 1.1[b]	3.0± 0.3[b]	3.2± 0.8[b]	301± 0.1[b]	3.1± 0.3[b]
Week 3	2.9± 0.3[b]	2.9± 0.4[b]	3.1± 0.4[b]	2.8± 1.1[b]	2.9± 0.1[b]
Week 4	1.8± 0.05[c]	1.9± 0.6[c]	1.7± 0.5[c]	2.0± 0.2[c]	1.9± 0.1[c]
Week 5	1.7± 0.3[c]	1.8± 0.4[c]	1.8± 0.4[c]	1.6± 0.6[c]	1.6± 0.08[c]
Week 6	1.3± 0.3[c]	1.2± 0.4[c]	1.2± 0.4[c]	1.4± 0.06[c]	1.4± 0.1[c]

TABLE 5: Organoleptic attributes of freshly prepared cookies of (15% inclusion) and those stored for six weeks

Treatment	Taste	Flavour	Texture	Appearance	Overall-acceptability
Day 1 / Control	4.3± 0.1[a]	4.5± 0.3[a]	4.1± 0.1[a]	4.3± 0.7[a]	4.2± 0.6[a]
Week 1	3.4± 0.4[b]	3.5± 1.6[b]	3.5± 0.8[b]	3.3± 0.7[b]	3.4± 0.6[b]
Week 2	2.7± 1.4[c]	2.6± 1.7[c]	2.6± 0.2[c]	2.7± 1.5[a]	2.8± 1.3[c]
Week 3	2.4± 1.1[c]	2.5± 1.4[c]	2.6± 0.2[c]	2.5± 0.8[a]	2.5± 0.2[d]
Week 4	1.1± 0.3[d]	1.3± 0.5[d]	1.9± 0.7[d]	1.9± 0.6[d]	1.9± 0.8[d]
Week 5	1.2± 0.5[d]	1.1± 0.7[d]	1.3± 0.1[d]	1.2± 0.2[d]	1.2± 0.8[d]
Week 6	****	****	****	****	****

**** Organoleptic analysis not carried out because of mould growth.

Table 6 below showed the result of the organoleptic studies, the trend of scores for the overall acceptability of freshly prepared Cookies (with 20% fish inclusion) and those on shelf for six weeks are as follows: freshly prepared has the highest quality > those stored for 1 week >2nd week > 3rd week > 4th week > 5th week > 6th week. However, the freshly prepared is significantly different at P<0.05 from those stored for one week. Also, those of one week is also significantly different at P<0.05 and better in quality from those stored till the second week.

However, after the second week, the cookies could no longer be assessed because of mould growth and were no longer acceptable after the second week.

TABLE 6: Organoleptic attributes of freshly prepared cookies of (20% inclusion) and those stored for six weeks

Treatment	Taste	Flavour	Texture	Appearance	Overall-acceptability
Day 1 / Control	4.5±0.4^{a}	4.3± 0.2^{a}	4.6± 0.5^{a}	4.6± 0.1^{a}	4.5± 0.3^{a}
Week 1	3.3± 0.4^{b}	3.5± 1.6^{b}	3.2± 0.8^{b}	3.3± 0.7^{b}	3.4± 0.6^{b}
Week 2	2.8± 1.1^{c}	2.5± 1.2^{c}	2.4± 0.2^{c}	2.7± 1.1^{c}	2.6± 0.3^{c}
Week 3 - 4	****	****	****	****	****
Week 5 - 6	****	****	****	****	****

**** Organoleptic analysis not carried out because of mould growth.

CONCLUSION AND RECOMMENDATION

The observation noted in this study was that the higher the fish protein percentage inclusion, the higher the acceptance. However, when subjected to statistical analysis, the 20% fish inclusion was not significantly different at P<0.05 from those of 15 and 10% fish inclusions respectively. The cookies that served as the control without fish protein inclusion had the best shelf stability till the fourth week. Furthermore, the cookies that have 5-15% fish protein inclusion were only acceptable till the third week. However, the cookies with 20% fish inclusion were only acceptable within the first two weeks and after the second week; the cookies could no longer be assessed because of fungal growth and were no longer acceptable after the second week. This showed that the higher the fish protein inclusion, the shorter the shelf life. In conclusion, since cookies of 20% fish inclusions which had highest acceptance when freshly prepared but had the shortest shelf stability and is not significantly different in acceptability at P<0.05 from cookies of 10-15% fish inclusion. Therefore, the cookies of 10-15% fish inclusion are more stable on the shelf and are therefore recommended as it will increased the protein intake of cookies consumers who are primarily school-aged children who really need more of fish protein intake.

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Preference and Perception of Fish Processors on the Influence of Wood Types on the Quality of Smoke-dried Fish in Katsina State

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Abstract
The research examined the preference and perception of fish processors on the influence of wood types on the quality of smoke-dried fish in Katsina State. A total of 31 fisherfolks from two fish processing sites in Katsina State, Makera and Dannakola were administered well-structured questionnaire and guided interview. The data obtained were analysed using descriptive statistics. The mean age of the fish processors was 36.4 years, they were all males with the majority (51.6%) having Arabic/Quranic education. Over 75% of them are married and their mean monthly income was N45,532.30. Neem tree (*Azadirachta indica*) was the most preferred and the most used fuelwood, while winter thorn (*Faidherbia albida)* was the least preferred and the least used. Majority of the respondents hardly notice the specific wood species that gave the best fish quality of smoked fish. However, neem tree was the most favoured to influence the quality of the smoke-dried fish among the few that perceive the influence of wood type on the quality of smoke-dried fish. While it has been established that the choice of wood type varies with location, the most favoured wood types as fuelwood for fish smoking in Katsina State is neem tree (*Azadirachta indica*).

Keywords: Smoke-dried fish, fuelwood, fish quality, fish processor, Katsina State

Introduction

Fish is an integral part of the human diet and a cheap source of animal protein. Its consumption varies globally and per capita consumption has always been on the increase with global average rising from 13.4 kg between 1986 and 1995 to 20.5 kg in 2018 (FAO, 2020a). Fish constitute over 50% of animal protein consumed in Nigeria, with the higher amount consumed in the southern part of the country (Dauda and Yakubu, 2013). According to FAO (2020b), the per caput fish consumption in Nigeria stood at 13.3 Kg as at 2013 while the total fish production as at 2015 was 1,027,000 tonnes with over 65% of from artisanal fisheries. Sadly, despite production far below demand, a meaningful quantity of fish produced from artisanal fisheries in Nigeria is ended up as waste due to high perishability nature of the fish. It is therefore important to properly handle fish and process fish to a form that can retain it in high quality for a long time as fast as possible. Fish is known to be preserved and or processed by chilling, frozen, salting, smoking, frying etc (Okunade and Bolorunduro, 2014). Smoke-drying is the most commonly used method to increase shelf-life of fish in Nigeria, and it has been perfected with various traditional and modern smoke-drying methods and facilities. According to Okunade and Bolorunduro (2014), 70-80% of fish produced in Nigeria are marketed smoked. However, artisanal fisherfolks who are responsible for a higher fraction of local fish production still utilise more of traditional methods and facilities. The use of simple ovens like improved banda, chokor kiln, oven drum etc are still very common among the local fish processors (Olokor *et a*l., 2007). These simple ovens use firewood as the fuel source and the types of wood are largely varied due to location. Interestingly, wood smoke is not the same among the tree species, and apart from the quality of fish being affected, it may also put both the processor and consumers at health risks. Hardwoods are generally regarded as better than softwoods as they produce light smoke with a limited amount of polycyclic aromatic hydrocarbons (PAHs) (Eyo 2001, Atanda *et al*., 2015). It is uncertain whether fish processors have detail understanding of the influence of wood types on the quality of smoke-dried fish, hence the needs for continuous research and educating them on the needs for preference for wood fuel source based on fish quality and their health. This research was carried out to examine the fish processor's perception of the influence of wood types on the quality of smoke-dried fish in Katsina State, Nigeria

Materials and methods

Study area

The study was carried out in Katsina State (latitude $12^0$15'N, longitude $7^0$30'E), the State is located in North-western Nigeria with a landmass of 24,192 Km^2 and estimated population of 6,483,429 as at 2006 census (Dauda and Ibrahim, 2015). The State has several reservoirs of different sizes, including, Jibia, Ajiwa, Zobe, Daberam, Sabke, Malumfashi, Mairuwa, Gwaigwaye among others. However, active fish processing is only notable in Makera area of Zobe reservoir, Dutsin-ma Local government area and Dannakola area nearby Daberam reservoir in Daura Local government area.

Data collection

Data was collected with the use of structured questionnaire and guided interview from the two sites with active fish processing that is Makera and Dannakola, total enumeration was done in Dutsin-ma that has only 10 fish processors while 21, half of the population was sampled in Dannakola leading to 31 respondents. Information was collected on the demographic characteristics of the fish processors, preference and perceived knowledge of wood types on the quality of the smoked fish.

Data analysis

The data were analysed using descriptive statistics (frequency counts, percentages and means).

Results and Discussion

The results of the demographic characteristics are shown in table 1, the dominating age range was 20-29 years (29%) following by 30-39 years (25.8%), the mean age of the respondents was 36.4 years. All the respondents were males and 77.4% of them are married. Arabic/Quranic education was the dominant educational status and the majority (87.1%) of them engaged in only crop farming as their other occupations. The mean monthly income of the respondents from fish processing stood at ₦45, 532 (including their working capital), with a larger percentage (22.6%) having less than ₦ 20,000 as monthly take home. Majority of the fisherfolks (74.2%) had annual income from their farming activities between ₦100,000 and ₦200,000 and the mean annual income from other activities was ₦143,225.81. The observed age distribution of over 80% of the processors as young with potential agility to work, all males and the majority with Quranic education is similar to the report of Dasuki *et al*., (2014) for artisanal fishermen of Makera zone Dutsin-Ma. The region is characterised by females staying indoor and does less of outdoor works (Dauda *et al*., 2013). The mean income ₦45,532, which represents both their capital and profit is low and this further suggests that artisanal fisherfolks are poor (Oladoja and Adeokun, 2009) and the needs for other sources of income like crop farming that majority of the respondents were engaged.

Table 1: Demographic characteristics of the fish processors

Characteristics	Category	Frequency	Percentage	Mean
Age (years)	<20	4	12.9	36.4±2.4
	20-29	9	29.0	
	30-39	8	25.8	
	40-49	5	16.1	
	50-59	4	12.9	
	60-69	0	0	
	>70	1	3.2	
	Total	**31**	**100.0**	
Sex	Male	31	100	
	Female	0	0	
	Total	**31**	**100.0**	
Marital status	Single	6	19.4	
	Married	24	77.4	
	Divorced	1	3.2	
	Total	**31**	**100.0**	
Educational status	No formal	0	0	
	Arabic/Quranic	16	51.6	
	Primary	7	22.6	
	Secondary	7	22.6	
	Tertiary	1	3.2	
	Total	**31**	**100.0**	
Other occupation	Crop production	27	87.1	
	Others	2	6.5	
	None	2	6.5	
	Total	**31**	**100.0**	
Income from fishing (monthly) ₦	11000-20000	7	22.6	₦45,532.3±17,619.9
	21000-30000	3	9.7	
	31000-40000	5	16.1	
	41000-50000	3	9.7	
	51000-60000	6	19.4	
	61000-70000	3	9.7	
	>70000	4	12.9	
	Total	**31**	**100.0**	
Income from other sources (annually) ₦	None	2	6.5	₦143225.81±17619.86
	100000-200000	23	74.2	

210000-300000	4	12.9
310000-400000	1	3.2
410000-500000	1	3.2
Total	**31**	**100.0**

The majority (61.3%) of the respondents purchased the fuelwood used for smoking. Neem tree (*Azadirachta indica*) was both the most preferred and the most used fuelwood in Makera and Dannakola, Katsina State, while winter thorn (*Faidherbia albida*) was the least preferred and the least used among the fish processors (Table 2). While the most preferred and most used were said to be favoured by availability, durability, production of light smoke and better quality smoked fish, the least preferred and least used species were not favoured due to presence of spine that can injure the users, heavy smoke and burning out too fast of fuelwood. Smoke generated by fuel woods are not the same for all tree species (Agbabiaka *et al*., 2012) and this may influence the chemical reaction between the smoke and the fish and hence affect the quality of smoke-dried fish (Atanda *et al*., 2015). The best fuelwood may be a function of location as the availability and distribution of tree species vary from one place to another.

Table 2: Preference for wood species among the fish processors

Wood species	Category	Frequency	Percentage
Wood source	Self-fetching (alone)	0	0
	Purchase (alone)	19	61.3
	Both	12	38.7
	Total	31	100.0
Most preferred	*Azadirachta indica*	23	74.2
	Combretum micranthum	5	16.1
	Piliostigma reticulatum	3	9.7
	Total	**31**	**100.0**
Most used	*Azadirachta indica*	24	77.4
	Diospyros mespiliformis	1	3.2
	Combretum micranthum	3	9.7
	Piliostigma reticulatum	3	9.7
	Total	**31**	**100.0**
Least preferred	*Faidherbia albida*	12	38.7
	Bauhinia rufescens	1	3.2
	Ficus platyphylla	1	3.2
	Parkia biglobosa	3	9.7
	Lannea acida	4	12.9
	Piliostigma reticulatum	4	12.9
	Balanites aegyptiaca	1	3.2
	Diospyros mespiliformis	2	6.5
	Vitellaria paradoxa	2	6.5
	Vachellia sieberiana	1	3.2
	Total	**31**	**100.0**
Least used	*Faidherbia albida*	12	38.7
	Bauhinia rufescens	1	3.2
	Ficus platyphylla	2	6.5
	Parkia biglobosa	4	12.9
	Lannea acida	1	3.2
	Olea europaea	1	3.2
	Piliostigma reticulatum	4	12.9
	Diospyros mespiliformis	3	9.7
	Vitellaria paradoxa	2	6.5
	Vachellia sieberiana	1	3.2
	Total	**31**	**100.0**

The results of fish processor's perception on the effect of wood quality are shown in table 3, Majority of the processors are not sure of the influence of the wood types on the quality of fish in terms of colour, smoking time, soot deposit, smell, taste and shelf-life. Among the few that were convinced that wood types affect fish quality, mostly mentioned the neem tree as the best fuelwood in the study area. This further corroborates the position of Atanda *et al*. (2015) who reported differences in quality of fish smoked with different wood types. Interestingly, neem tree was not among the fuelwood experimented by Atanda *et al*. (2015), and the kola nut tree noted to be the best in Port Harcourt, Rivers State is not available in Katsina State.

Table 3: Perception of fish processors on the effect of wood species on quality of fish smoked fish in Katsina State

Perception	Category	Frequency	Percentage
Does wood type affect the colour	Yes	12	38.7
	No	19	61.3
	Total	**31**	**100.0**
Species that gives the best colour	Not applicable	20	64.5
	Piliostigma reticulatum	2	6.5
	Azadirachta indica	7	22.6
	Anogeissus leiocarpus	1	3.2
	Combretum micranthum	1	3.2
	Total	**31**	**100.0**
Does wood type affect the smoking time	Yes	1	3.2
	No	30	96.8
	Total	**31**	**100.0**
Species that gives least smoking time	Not applicable	30	96.8
	Azadirachta indica	1	3.2
	Total	**31**	**100.0**
Does wood type affect soot on the fish	*Yes*	3	9.7
	No	28	90.3
	Total	**31**	**100.0**
Species that gives the least soot	Not applicable	28	90.3
	Azadirachta indica	3	9.7
	Total	**31**	**100.0**
Does wood type affect the smell	Yes	4	12.9
	No	27	87.1
	Total	**31**	**100.0**
Species that gives the best smell	Not applicable	27	87.1
	Azadirachta indica	3	9.7
	Anogeissus leiocarpus	1	3.2
	Total	**31**	**100.0**
Does wood type affect the taste	*Yes*	3	9.7
	No	28	90.3
	Total	**31**	**100.0**
Species that gives the best taste	Not applicable	28	90.3
	Azadirachta indica	3	9.7
	Total	**31**	**100.0**
Does wood type affect the shelf life	Yes	4	12.9
	No	27	67.1
	Total	**31**	**100.0**
Species that gives the highest shelf life	Not applicable	27	87.1
	Faidherbia albida	1	3.2
	Azadirachta indica	3	9.7
	Total	**31**	**100.0**

Conclusion

The results established that various tree species are being used as fuelwood in fish smoking in Katsina State, and that availability is one of the major factors that determine the most used. Neem tree is the most preferred and the most used in the state, it is also perceived to give the best quality smoked fish. However, it is important to carry out fish smoking experiments to confirm the best fuelwood in the State and educate the fisherfolks accordingly for the safety of both the processors and the consumers.

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Effect of some spices' combination on the proximate composition of *Clarias gariepinus* processed under hot-flame from charcoal (Chorkor oven)

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Abstract

The effect of some spices' combination on the proximate composition of *Clarias gariepinus* processed under hot-flame from charcoal (Chorkor oven) was studied. Fifteen (15) kilogram of live table size *Clarias gariepinus* fish were procured from Lafia fish market for the experiment. Spices used; turmeric, pepper, rosemary, garlic, ginger, celery, cinnamon and parsley were also obtained from Lafia market. The fish sample was divided into five equal parts of 3kg each giving a total of 5 samples. Sample 1 was spiced with 5g each of ginger, turmeric, pepper and celery (GTPC), sample 2 was spiced with 5g each of ginger, turmeric, rosemary and pepper (GTRP), sample 3 was spiced with 5g each of ginger, turmeric, celery, and garlic (GTCG), sample 4 was spiced with 5g each of ginger, turmeric, garlic and parsley (GTGP) while sample 5 was only salted in brine solution and served as the control. The fish were processed under hot-flame from charcoal (Chorkor oven) and stored in a zip lock polythene bag for 6 weeks, after which each fish sample was nutritionally assessed in the laboratory so as to determine change in nutritional composition using the method of AOAC (2000). Results proximate composition evaluated revealed that there was no much difference in proximate values at both initial and final stage. However, *Clarias gariepinus* spiced with salt only had the highest crude protein contents of 43.75% and 43.31% at the initial and final stages. *Clarias gariepinus* brine salted had the lowest moisture contents of 8.05% and 9.00% respectively at both initial and final stages. Ash values were highest 6.63% and 6.60% in catfish spiced with ginger, turmeric, celery, and garlic at both initial and final stage whereas ether extract values were highest 16.00% and 16.05% in catfish spiced with ginger, turmeric, pepper and celery at both initial and final stages. Nitrogen free extract (NFE) values were highest 27.85% and 27.02% in catfish spiced with ginger, turmeric, rosemary and pepper at both initial and final stage. It is therefore recommended that fish processors should spiced and salt their fish before smoking so as to enhance its nutritional properties and shelf-life and fish intended to be stored for longer duration should be properly spiced, salted and smoked to the lowest moisture content so as to increase its shelf-life and prevent it from spoilage.

Keywords: Spices, Proximate Composition, *Clarias gariepinus*, Chorkor oven

Introduction

Fish is highly nutritious because it contains high biological value protein (Apata *et al.*, 2013). This favour the growth and multiplication of micro-organism by so doing, making it highly perishable, poisonous and unfit for human consumption when contaminated with microbes. Value addition ensure fish stability and shelf-life during the periods of drought, post-harvest when there is excessive slaughter and for products diversification, local methods of the fish preservation such as simple dehydration or drying of fish in natural condition or in an artificially created environment with addition of spices and seasonings are often employed to give traditional dried fish products long shelf life and preserve nutritional contents (Igene, 1987, Ipinjolu *et al.*, 2004; Isah and Okubanjo, 2012).

Spices such as ginger, garlic, pepper, black pepper and turmeric are grown locally in Nigeria and have been known to enhance aroma and flavor of foods (Peter, 2001). Such spices have anti-microbial properties. The concentration of the spices to be used should be effective and acceptable by consumers by actually enhancing the quality of such processed fish products. Spices have been increasingly used as natural preservatives and for their potential health promoting properties, for example, as antioxidants (Peter, 2001). Little research has been documented on the effectiveness of organic spices on fish shelf-life and value addition. Spices have been successfully used as aromatic/flavouring agents in food. This study therefore, examined the effect of combination of spices (ginger, garlic, pepper, rosemary, turmeric, celery and parsley) in preventing spoilage and extending the shelf-life of *Clarias gariepinus* subjected to hot-flame charcoal.

Materials and methods

Experimental Procedures

The experiment was carried out at the Fish processing unit of the Experimental Farm of the Department of Fisheries Technology of College of Agriculture Science and Technology Lafia, Nasarawa State. Fifteen (15kg) live *Clarias gariepinus* were procured from Lafia fish market and were transported to the experimental location. Common salt, turmeric, rosemary, pepper, garlic, ginger, celery and parsley were used as spices for this study. The fish samples were cut, washed thoroughly with potable water to remove sand and slime, and allowed to drain by the use of colander and covered with a sack material, and were weighed. The fish were divided into five (5) treatments of 3kg each as shown below.

Treatment I - Fish with ginger, turmeric, pepper and celery (GTPC): Here the cleaned fish was marinated in a mixture of 5g each of powdered ginger, turmeric, pepper and celery.

Treatment II - Fish with ginger, turmeric, rosemary and pepper (GTRP): Here the fish sample was marinated with a mixture of 5g each of powdered ginger, turmeric, rosemary and pepper.

Treatment III - Fish with ginger, turmeric, celery, and garlic (GTCG): Here the fish sample was marinated with mixture of 5g each of ginger, turmeric, celery, and garlic.

Treatment IV - Fish with ginger, turmeric, garlic and parsley (GTGP): Here the fish sample was treated with mixture of 5g each of ginger, turmeric, garlic and parsley.

Treatment V- Fish treated with salt. Here the catfish was immersed in brine solution.

Each sample 1,2,3,4, and 5 above were dried under hot flame from charcoal for at least 6 hours and allow to cool under room temperature before packaging.

The processed and preserved fish were stored in zip-lock polyethylene bags and stored at room temperature for a period of 6 weeks. Samples were subjected to visual observation and chemical analysis at first week (initial) and 6th week (final).

Proximate Analysis
At the onset and end of the experiment, the proximate composition of each of the sample was assayed according to the methods of AOAC (2000).

Results
The proximate composition of spiced smoked catfish processed under hot-flame from charcoal (Chorkor oven) is presented in Figure 1. The moisture content of the differently combined spices on catfish revealed no significant difference among the treatments statistically at the initial and final stage of the experiment. However, catfish spiced with combination of ginger, turmeric parsley and celery (GTPC) had the highest moisture content of 10.10% in the initial stage while catfish spiced with combination of ginger and pepper had the highest moisture content of 10.50% at the final stage. Catfish with no spices i.e. the control had the lowest moisture content of 8.05% and 9.00% at the initial and final stages respectively. Ash content result showed no significant difference among the treatments at the initial and final stage (Figure 2). At the initial and final stage, catfish spiced with combination of ginger, turmeric celery and garlic (GTCG) had the highest ash contents of 6.63% and 6.60% respectively while the control treatment had the lowest ash content of 5.87% at the final stage.

Crude protein contents also showed no significant difference among the treatments at both initial and final stage. Highest crude protein contents of 43.75% and 43.31% were obtained in the control at the initial and final stages while catfish spiced with combination of ginger, turmeric, pepper and celery (GTPC) had the lowest crude protein contents of 40.25% and 40.03% at the initial and final stage respectively (Figure 3). Ether extract contents showed no significant difference among the treatments at both initial and final stage (Figure 4). Catfish spiced with combination of ginger, turmeric, pepper and celery (GTPC) had the highest ether extract contents of 16.00% and 16.05% at the initial and final stages while catfish spiced with combination of ginger, turmeric, garlic and parsley (GTGP) had the lowest ether extract contents of 10.95% and 11.90% at the initial and final stages respectively.

Crude fibre results showed no significant difference among the treatments at the initial stage but crude fibre of catfish spiced with ginger and pepper was significant from other treatments at the final stage. Highest crude fibre content of 3.25% was obtained in the control at the initial stage while catfish spiced with ginger and pepper had the highest crude fibre content of 6.25% at the final stage (Figure 5). Nitrogen free extract (NFE) results also showed no significant difference among the treatments respectively at both initial and final stages (Figure 6). Highest NFE value of 27.85% and 27.02% were obtained in catfish spiced combination of ginger, turmeric, rosemary and pepper (GTRP) while catfish spiced with combination of ginger, turmeric, pepper and celery (GTPC) recorded the lowest NFE values of 24.25% and 20.77% at the initial and final stages respectively.

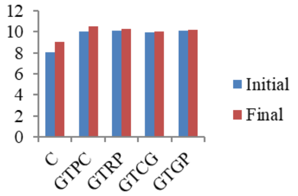

Figure 1: Moisture content of differently spiced smoked *Clarias gariepinus*

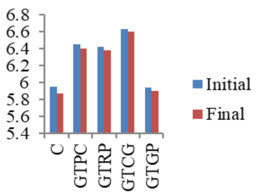

Figure 2: Ash content of differently spiced smoked *Clarias gariepinus*

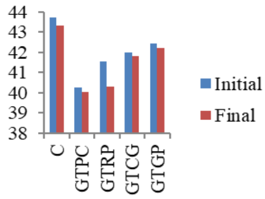

Figure 3: Crude protein content of differently spiced smoked *Clarias gariepinus*

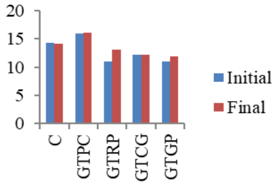

Figure 4: Ether extract content of differently spiced smoked *Clarias gariepinus*

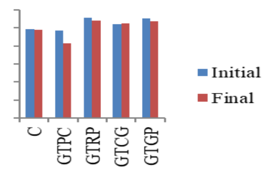

Figure 6: Nitrogen free extract content of differently spiced smoked *Clarias*

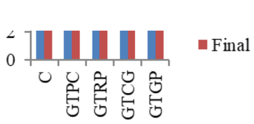

Figure 5: Crude fibre content of differently spiced smoked *Clarias gariepinus*

Key: *GTPC = ginger, turmeric, pepper and celery; GTRP = ginger, turmeric, rosemary and pepper; GTCG = ginger, turmeric, celery, and garlic; GTGP = ginger, turmeric, garlic and parsley;*

Discussion

The measurement of some proximate profiles such as protein contents, carbohydrates, lipids, moisture contents and ash percentage is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000).

The initial proximate value obtained for catfish in this study was between 8.05 - 10.50%, 5.94 – 6.60%, 40.03 – 43.75%, 10.95 - 16.05%, 2.95 – 6.25% and 24.25 – 27.85% for moisture, ash, crude protein, ether extract, crude fibre and Nitrogen Free Extract respectively. The result of moisture content in this study is in range with 10.86 as reported by Kumolu-Johnson *et al.* (2010) for smoked catfish from LASU fish pond. The main cause of decrease in moisture of the control treatment was due to osmotic migration of salt which migrate inside the fish and resulted in oozing water out of the fish (Horner, 1997). This reduction leads to increase in spice content and consequently extend shelf life of the products (Itou and Akahane, 2000). The ash value obtained in this study is lower compared to the findings of Fapohunda and Ogunkoya (2006) who reported 15.32 as ash value for smoked *Clarias gariepinus* from Akure and Ondo State, Nigeria. Ether Extract content of this study is in range with 17.0 as reported by Abolagba *et al.* (2015) in smoked *Clarias gariepinus* in Delta and Edo State. Crude protein content observed in this study was lower as compared to 68.61 by Fapohunda and Ogunkoya (2006), 66.5 by Abolagba *et al.* (2015) and 68.17 by Agbabiaka *et al.* (2012). However, the crude protein content in catfish observed was higher than 28.3% as reported for smoked catfish by Ande *et al.* (2012) in their study on proximate analysis of smoked and unsmoked catfish and tilapia in Ombi River, Lafia Nasarawa State Nigeria.

There was an insignificant reduction in protein content after storage. This may be due to the level of loss in protein which occurs as a result of salting and storage (Pace *et al.,* 1989), gradual degradation of the initial crude protein to more volatile products such as Total Volatile Bases (TVB), Hydrogen sulphide and Ammonia, leaching out of some extractable soluble protein fraction (Daramola *et al*., 2007). The highly susceptible of fish to oxidative rancidity can result from the high degree of unsaturation in the form of multiple double bonds in **fatty acid**s Obemeata *et al*. (2011). By comparing pre-storage and post-storage crude fat content, a significant difference ($p<0.05$) was recorded in both of sundried and smoked chela fish. Variation in crude fat content of both spiced and unspiced catfish could have been due to oxidation and crude fat break down into other components. That is, oxidation of poly-unsaturated fatty acids (PUFA) contained in the fish tissue to products such as peroxides, aldehydes, ketones and the free fatty acids as reported by Daramola *et al*. (2007). There might be high risks of rancidity during prolonged storage conditions due to the fatty nature of fish (Daramola *et al*., 2007).

Variation in the crude fibre content of fish during the period of assessment in this study could be accounted for by the fact that in these samples, there had been an oxidation of their poly-unsaturated fatty acids (PUFA) components, contained in their tissues to products such as peroxides, aldehydes, ketones and free fatty acids, (Daramola *et al*., 2007). There was no spoilage recorded in this study after the storage period due to proper storage and spices combinations. According to (Abhishek, 2011) spices have a significant antimicrobial effect, against various microorganisms and impart various nutritive health benefits to the body.

Conclusion

The spices used in this study were more effective in preserving fish products due to their nutrient properties and resistance against bacterial and enzymatic activity. Due to these properties sample of all the spices combination had long shelf life. The spices used in this study had high active phenolic antioxidant property which inhibited the free-radical mediated damages like lipid oxidation thus preventing oxidative rancidity, this helped to increase protection against insects, pests, bacteria, fungus and other pathogens acting as a natural preservative and a taste enhancing ingredient. So, this process can be recommended as a preservation technique in large scale dry fish production.

Recommendation

From the result of this study, it is therefore recommended that fish processors should spice and salt their before smoking for a longer shelf-life and prevent the fish from spoilage.

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Organoleptic characteristics and eating quality acceptability of traditionally smoke-dried freshwater fishes in Toru-orua, Bayelsa State

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Abstract
Organoleptic attributes and eating quality acceptance of traditionally smoke-dried *Clarias gariepinus, Heterobaranchus longifilis, Heterotis niloticus,* and *Parachanna obscura* in Toru-Orua, Bayelsa State, was studied. The fishes for organoleptic evaluation were prepared into a separate but same type of pepper soups and tasted by an untrained 28 member taste panel. Eating quality was evaluated with a chunk of the smoke-dried fishes. Organoleptic attributes results showed the panelists' preference in descending order of *Heterobranchus longifilis* > *Clarias gariepinus* > *Parachanna obscura* > *Heterotis niloticus*. Eating quality results in descending order was *Heterotis niloticus* > *Parachanna obscura* > *Heterobranchus longifilis* > *Clarias gariepinus*. Results also suggest that eating quality acceptability is greatly influenced by organoleptic characteristics of the lipid content of fish species.

Keywords: Organoleptic characteristics, eating quality, smoke-dried, acceptability.

Introduction
Smoke drying is a popular traditional method of processing and preserving fish in Nigeria (Eyo, 1999). This technology ensures a continued supply of fish in both urban and rural communities all year round. Also, this value-addition process provides a safe, wholesome and nutritious supply of desirable sensory quality fish in terms of flavour, odour, taste, texture, and appearance (Arannlewa et.al. 2005, Salu, 2008, and Kumolu-Johnson and Ndimele, 2011). However, this traditional value-addition process often results in uneven cooking, scorching, and burning due to the direct heating of the fish, bitterness, unattractive appearance, development of rancidity, limited shelf-life, and insect's infestation (Bellagha et.al, 2007).

This study therefore is carried out to assess the organoleptic characteristics and eating acceptability of four traditionally smoke-dried freshwater fishes in Toru-Orua, Sagbama Local Government Area in Bayelsa State. This information is intended to be useful to fishmongers, consumers, policymakers, and fisheries administrators in formulating fish preservation/processing policies and strategies.

Materials and method
The study was carried out at the Faculty of Agriculture, University of Africa, Toru-Orua (UAT), established in 2017 by the Bayelsa State Government. Toru-Orua once a rustic rural community known for fishing and farming is fast emerging as a University community hence a city in the making in Bayelsa State. This change in status is a result of the massive influx of students, staff, and business operators with all the attendant socio-economic activities including agro-based processing, marketing, and value-addition outfits on foods and fisheries products.

Toru-Orua is situated between Latitude 5° 5' 59" North and Longitude 6° 3' 51" East along the Forcados River in the Niger Delta. It's approximately thirty (30) kilometers from Bayelsa State Capital, Yenagoa. Based on purposeful bird's eye view of the town for processing activities, the fishes for the study were selected and purchased from processors using the traditional metal drum smoking kiln. The fishes selected for the study were African walking catfish (*Clarias gariepinus*), African Snakehead (*Parachanna obscura*), African Tongue sole (*Heterotis niloticus*), and African mud catfish (*Heterobranchus longifilis*). They were purchased and taken in air-tight containers to the laboratory for analysis.

Organoleptic characteristics assessment was carried out by 28 members untrained taste panel randomly selected from the UAT student community. Each fish specie was used to prepare traditional pepper soup for the panelists to assess. Ingredients used for the pepper soup were onions, red pepper, scent leaf, and salt which were added in similar quantity to the various pepper soups. The panelists scored each pepper soup labeled A, B, C, and D, for appearance, flavor, taste, and texture of the smoke-dried fish used. The scoring was based on a six (6) point Hedonic scale as described by Afolabi et.al. 1989, as shown below,

1. Dislike
2. Dislike moderately
3. Dislike slightly
4. Like slightly
5. Like moderately
6. Like very much

To ensure no bias being introduced, panelists were given water to wash their mouths before sampling the next experimental pepper soup dish. Panelist rating scores were tabulated and mean calculated then subjected to One-Way-Analysis of Variance (ANOVA) at a 5% significance level.

Eating quality evaluation was accomplished by cutting out a chunk of muscle from the dorsal muscle with a clean knife and presented to panelists to taste without them seeing or knowing the fish species. They were asked to rank the eating quality acceptance in,

1. Like very much
2. Like moderately
3. Like slightly
4. Dislike slightly
5. Dislike moderately
6. Dislike very much

Acceptability = Ranking 1 – 3,

The mean ranking and percentage of acceptance were calculated.

Results and discussion

Summary of the organoleptic evaluation by the 28 member taste panel (Table 1) showed that the *Heterobranchus longifilis* was the most preferred in this study. In descending order, the results obtained were *Heterobranchus longifilis* > *Clarias gariepinus* > *Parachanna obscura* > *Heterotis niloticus*. The low rating is given to *H. niloticus,* they feel was over its long bristle thoracic bones which influence their scoring. Similar low scoring was recorded in other tilapias in studies by Ahmed et.al, 2011 and Olopade et.al, 2013. In tilapias e.g. *Oreochromis niloticus,* the presence of small bones caused panelists to score tilapia lower than other fishes with less intramuscular bones.

Further analysis showed that the mean scores for taste, texture, and appearance in these fishes studied were statistically significant at $P \leq 0.05$ (Table 1). The major statistical difference was observed between *H. niloticus* and the other fishes. However, *H. longifilis* and *C. gariepinus* were observed to be similar at $P \leq 5\%$. This is understandable since both fishes belong to the catfish family Clariidae.

Eating quality acceptability of the four traditionally smoke-dried fishes in the study (Table 2), the panelists showed preferences in descending order as *H. niloticus* > *P. obscura* >

H. longifilis > *C. gariepinus*. The panelists ranked *H. niloticus* highest in terms of percentage acceptance (96.43%) and *C. gariepinus* lowest (64.29%). This difference in preference for eating quality could be explained in terms of the fish chemical body composition especially the content of fat and oil, water content, protein, and non-protein materials. This aspect was not covered in this preliminary study but it's known that *H. niloticus* and *C. obscura* are low-fat fishes which produce a fairly tough and dry flesh which gives it a distinct flavour when smoke-dried (Reed et.al. 1967) and is cherished locally in the Niger Delta (Alfred-Ockiya, 1979). The Clariidae studied are also preferred because they produced large chunks of juicy flesh full of oil when smoke-dried and offered ready to consume products especially for students.

Table 1: Summary of Organoleptic characteristics evaluation of *H. longifilis*, *C. gariepinus*, *P. obscura,* and *H. niloticus* smoke-dried in Toru-Orua, Bayelsa State by 28 member Taste Panel: 2020.

Fish Specie	Appearance	Flavour	Texture	Taste	Mean Rating	Rank
Heterobranchus longifilis	7.5	8.0	7.8	9.3	8.15^{d}	1
Clarias gariepinus	7.0	8.0	6.5	7.0	7.13^{a}	2
Parachanna obscura	6.5	7.5	7.5	7.0	6.88^{bc}	3
Heterotis niloticus	5.0	4.0	3.5	5.6	4.52^{a}	4

*Means followed by the same letter (a, b, c, d) are not statistically significant at $P \leq 0.05$.

Table 2: Summary of eating quality acceptability of some smoke-dried freshwater fishes in Toru-Orua, Bayelsa State by 28 member Taste Panel: 2020.

Rating	*Heterobranchus longifilis*	*Clarias gariepinus*	*Parachanna obscura*	*Heterotis niloticus*
1	10	5	10	14
2	9	7	8	8
3	5	6	7	5
4	1	7	3	1
5	0	*0*	*0*	*0*
Mean	5.6	5.6	7	7
% Acceptability	85.7	64.29	89.2	96.43
Rating	3	4	2	1

The overall eating quality acceptability of all fishes studied was rated as above average 64.29% to 96.43% hence adjudged acceptable by the student panelists who were often indifferent in terms of what to eat.

Conclusion

The study results showed that fishes that have a pleasant appearance, juicy flesh like the catfishes, and allied are preferred when smoke-dried in terms of organoleptic characteristics. Whereas, eating quality acceptance is based on the type of flesh produced after smoke-drying especially flesh that can be cut into large chunks and fairly tough and juicy flesh like beef meat giving it a strong flavour and taste but less muscular bones.

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TOXICOLOGY AND WATER QUALITY

Assessment of Nutrient Load in Wastewater and Sediment-Pore Water from Catfish Ponds in Monai Cluster Fish Farm, Southern Basin of Kainji Lake

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Abstract
This study was conducted to assess and quantify nutrients (nitrogen and phosphorus) in wastewater effluent and sediment-pore water samples collected from grow-out Catfish ponds in Monai cluster fish farm located in the Southern basin of Kainji Lake. A total of one hundred and five (105) catfish ponds were randomly sampled in the cluster in the space of three months (July to September, 2019). Sediment samples were collected using a bottom grab sampler (Birge-Ekman grab) and sediment-pore water was collected from sediment samples by centrifugation. Results of physicochemical analysis showed a pH range of 7.2-8.5, electrical conductivity range of 120 μΩ/cm -260 μΩ/cm and ammonia range of 0.02mg/l-1.04mg/l in both wastewater and sediment-pore water samples throughout the study period. Results for nutrient analysis showed marked concentrations of nutrients (N and P) in both wastewater and sediment-pore water samples. Mean nitrogen (total nitrogen) concentration was found to be higher in sediment-pore water samples (0.13mg/l) than the wastewater effluent sample (0.08 mg/l). Same trend was observed for phosphorus (orthophosphate) result recorded. Findings from this study showed the presence of viable nutrients (nitrogen and phosphorus) in wastes (effluent and sediments) from catfish ponds which can be recovered and harnessed in the fish farming value chain.

Keywords: Nutrients, Concentration, Sediments, Sediment-pore, Wastewater/effluent, Catfish, Ponds

Introduction

Wastewater and sediments from Catfish ponds are reservoirs of organic matter and viable nutrients such as nitrogen and phosphorus (Jamu *et al*., 2001; Boyd *et al*., 2002; Yeasmin, 2011). The discharge of untreated aquaculture wastewater and sediments containing these nutrients pollutes the soil and surface water, causing water pollution, eutrophication and sediment loading (Preston *et al*, 2001; Burford *et al*, 2003; Costanzo *et al*, 2004). Management of these waste nutrients (N and P) from fish ponds is still a relatively new area of research in Nigeria due to the sparsely reported literature in this area. Specifically, none of its kind has been conducted in the Kainji Lake Basin despite the huge aquaculture presence in this basin. Since sediments from catfish ponds have been identified as sinks for nutrient (N and P), it is important to recover these nutrients for utilization since they represent substantial amount of the overall input put into the fish farming enterprise (Lin and Yi, 2003). However, the potentials of waste nutrients from Catfish ponds for beneficial use is still an area that most fish farmers are uninformed of and it requires evident-based and demonstrable technologies that evaluate the cost effectiveness of integrated waste recovery and utilization strategies to entice them. However, before embarking on recovery and utilization of nutrients in sediments from fish ponds, there is the need to determine the individual concentrations of the various nutrients present (author). This is with the view of determining the most effective and convenient method of recovering these nutrients.

Materials and Methods

Collection of wastewater samples

Wastewater samples were randomly collected from grow-out Catfish ponds that are ready for harvest for a period of three months during the wet season (July-September, 2019). Samples for both physicochemical and nutrient analyses were collected by gently lowering a sterile plastic sampling bottle below the outlet pipe of the pond. This was done carefully so as not to trap in oxygen into the sample bottle during water collection. All samples were stored in ice coolers so as to preserve samples and quickly transported to the laboratory for analysis.

Collection of Sediment Samples

Sediment samples were collected from Catfish ponds in Monai cluster fish farm located in the Southern Basin of Kainji Lake using a modified random sampling technique called stratified random sampling (Simpson *et al*., 2005). In this technique, a total of ten (10) sub-samples were collected from different random locations (strata) in each pond and aliquots from each of these sub-samples were scooped and mixed thoroughly together to make up a representative sample. Samples were collected from the ponds using the Birge-Ekman grab sampler. This was done by gently lowering the grab into the pond with a graduated rope.

Collection of Sediment-pore Water

Sediment-pore water was collected by centrifuging 10ml of wet sediment at 1500rpm for 15 minutes as described in the hand book of sediment quality assessment by Simpson *et al*. (2005).

Analyses

Physicochemical analysis

Water samples were subjected to physicochemical analysis to determine the water chemistry. Temperature, pH, conductivity, total dissolved solids (TDS) and unionized ammonia (NH_3) were the parameters that were measured.

Nutrient analysis

Phosphorus as Orthophosphate ($PO_4 – P$)

Phosphorus as orthophosphate (PO_4-P) was determined using a rapid test colorimetric kit (API®, USA). Result was read in mg/l by comparing the colour formed with a colour chat.

Nitrogen

Estimated nitrogen concentration in each sample was taken as the sum of nitrite-nitrogen (NO_2 – N) and nitrate-nitrogen (NO_3-N) as described in the standard methods of AOAC (1999).

Nitrite-nitrogen (NO_2 - N)

Nitrite (NO_2) was also determined using a rapid test colorimetric kit (Multitest®, USA). Colour formed is compared with a colour chat and nitrite was read in mg/l.

Nitrate-nitrogen (NO_3-N)

Nitrate (NO_3) was also determined using the Multitest® rapid test kit by adding a scoop full of nitrate reagent powder inside the test cavity of the nitrite test earlier carried out on same sample according to the manufacture's instruction. Result was read by comparing the colour formed with a colour chat. Nitrate was read in mg/l.

Statistical analysis

Data obtained for nutrients analyses for surface pond water and sediment pore water were subjected to analysis of variance (ANOVA at $p<0.05$) using Microsoft EXCEL, 2010 to determine if there is any statistical significant difference between the two sets of samples with respect to nutrient concentrations.

Results

Results for physicochemical analyses showed that all parameters were within acceptable limits for fisheries, effluent discharge and irrigation respectively (table 1). Results for nutrient analyses showed marked concentrations of nutrients (N and P) in both wastewater and sediment-pore water samples. However, the concentrations of both nutrients recorded for sediment-pore water samples were higher than those recorded for the wastewater effluent samples. (table 2).

Table 1: Mean Physicochemical Characteristics for wastewater and sediment-pore water samples

MONTHS	PARAMETERS	W.W	S.D.P.W	EFFLUENT LIMITS Fisheries	Effluent discharge & Irrigation
July	Temperature (◦c)	30.2±0.4	29.3±0.2	*25-32	*25-40
	pH	7.2±0.3	8.0±0.5	*6.5 – 8.5	*6.5 – 8.5
	Conductivity (μΩ/cm)	120±25	160±38	*150-500	
	TDS (mg/l)	220±26	344±32	*Not >2000	*Not >2000
	Ammonia (NH_3) (mg/l)	0.05±0.0	0.04±0.0	*0.01-0.05	*≤ 2.0
August	Temperature (◦c)	28.5±0.2	27.0±0.4	*25-32	*25-40
	pH	7.4±0.3	8.2±0.1	*6.5 – 8.5	*6.5 – 8.5
	Conductivity (μΩ/cm)	100±36	140±54	*150-500	
	TDS (mg/l)	320±16	452±20	*Not >2000	*Not >2000
	Ammonia (NH_3) (mg/l)	0.02±0.0	0.05±0.0	*0.01-0.05	*≤ 2.0
September	Temperature (◦c)	29.4±0.7	28.7±0.5	*25-32	*25-40
	pH	7.2±0.2	8.5±0.5	*6.5 – 8.5	*6.5 – 8.5
	Conductivity (μΩ/cm)	140±20	260±40	*150-500	
	TDS (mg/l)	316±12	512±18	*Not >2000	*Not >2000
	Ammonia (NH_3) (mg/l)	0.15±0.2	1.04±0.0	*0.01-0.05	*≤ 2.0

*NESREA
S.W - surface water
S.D.P.W – Sediment pore water

Figure 1: Nutrient Loads in wastewater (W.W)

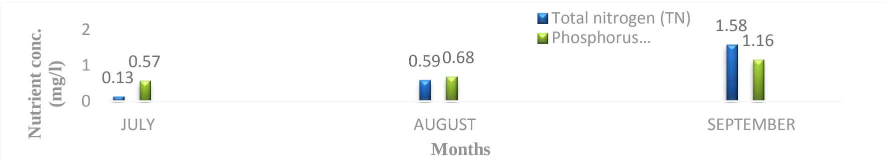

Figure 2: Nutrient Loads in sediment-pore water (S.D.P.W)

Discussion

The higher concentrations of both nitrogen and phosphate-phosphorus recorded in sediment-pore water samples over wastewater can be attributed to the activities of microorganisms, particularly decomposition of organic matter taking place in the benthic zone. This is because in sediments, dissolved inorganic nutrients newly formed by the organic decomposition process accumulate in the pore water due to the migration of nutrients from sediments to the sediment-pore interface by molecular diffusion. (Miller *et al*., 2015). The concentration of nutrients (TN and P) was higher in S.D.P.W than in effluent. This can be attributed to a certain processes such as rate of sedimentation, amount and type of organic matter present and decomposition processes in the benthic zone (Ziang and Zhou, 2011). According to Percuoco *et al*. (2015), dissolved nutrients can also be exchanged between pore water and upper water through various routes such benthic activity. The low concentration of nitrogen in the wastewater effluent as compared to the sediment-pore water could possibly be due to its assimilation by microorganisms. Chowdhury and Al Bakri (2010) reported that loss of nitrate-nitrogen from the water column could be due to its assimilation by organisms (fauna and flora) and de-nitrification into nitrogen gas. With regards to influence of environmental variables on nutrient abundance, light exposure and pH are important environmental factors that do influence the abundance and release rate of nutrients (Hou *et al*., 2013). In this study, higher concentration of nutrients recorded in sediment pore water can be attributed to higher pH value (8.0) recorded for sediment-pore over that of wastewater (7.2) and the indirect effect of light on activities of algae in surface water (Huang *et al*., 2010).

Conclusion and Recommendation

This study revealed the presence of viable nutrients (nitrogen and phosphorus) in sediment-pore water and effluent from catfish ponds to marked concentrations that can be recovered using appropriate technologies. Further studies should involve the recovery and utilization of available nutrients in bulk sediments from catfish ponds.

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Stoichiometric Nutrient Limitation and Microalgal Flora of A Former Sewage Disposal Site, at Iddo, Lagos Lagoon, Nigeria.

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Abstract
The physicochemical parameters, phytoplankton diversity and abundance of the surface water were investigated for five months (December 2018 – April 2019) to assess the stoichiometric nutrient limitation and microalgal flora of a former sewage disposal site at Iddo, Lagos Lagoon, following standard methods. Air temperature (30 – 34 °C), water temperature (30 – 32 °C), rainfall (0 – 222.9 mm), salinity (16.50 – 26.60 ‰), pH (7.12 – 7.75), conductivity (30100 – 46300 µS/cm), Total Dissolved Solids (20100 – 31800 mg/L), Total Hardness (3500 – 5520 mg/L), Dissolved Oxygen (6.00 – 6.70 mg/L) were observed to be higher in the wet months than the dry months. Phosphate-Phosphorus (0.52mg/L – 2.24 mg/L) increased drastically within the first two months and decreased gradually within the fourth sampling, while Nitrate-Nitrogen was generally high in the dry season. Some trace elements (Lead, Chromium, Nickel) were also detected, while others (Copper, Zinc, Iron, Manganese) showed minute variations. Chlorophyll *a* (11.00 µg/L – 16.00 µg/L) was also high in the dry season. The nutrient stoichiometry ratio between Nitrate and Phosphate (1.9:1 – 14.1:1) was observed to be less than the standard ratio (16:1). The phytoplankton structure was composed of Bacillariophyta with 26 species constituting 86.67 %, Cyanophyta had 4 species constituting 13.33 %, each different from numerical structure (Bacillariophyta accounting for 95.68 % of 556 individuals and Cyanophta 4.32 %). The species richness index (d) was highest in February with a value of 3.63 and lowest in April with a value of 0.60, while evenness (j) had the value (0.80 – 0.99) with the lowest recorded in December 2018 and the highest recorded in January 2019. The most abundant phytoplankton individual *Pleurosigma angulatum* (n=80), was recorded in February. The phytoplankton taxa were diverse but quantitatively low. The coefficient factors and factor analysis of phytoplankton spectrum indicated the influence of air temperature, water temperature, total suspended solids and total dissolved solids on its composition and abundance. The relative low level of nitrate in the study area shows limitation in the effluence of sewage into the area.

Keywords: Lagoon, Microalgae, Nutrients, Phytoplankton, Physicochemical parameters.

Introduction
Microalgae are very useful in monitoring pollution in aquatic ecosystems. As a group, they consist of many species that have populations composed of varying number of species and, therefore, an excellent group to treat statistically in analysing their reaction to varying ecological conditions (Nwankwo, 2004). Nutrient limitation is a fundamental concept in ecological research and, at its core, is a question of ecological stoichiometry. It is largely a function of the relative availabilities of the primary limiting nutrients, nitrogen (N) and phosphorus (P). Nutrient availability has a profound influence on the composition and distribution of microalgae. The availability of one nutrient may have an influence in the uptake of another. Different microalgae have different interaction with nutrients. In tropical and subtropical habitats, evidence suggests that some species of microalgae may be simultaneously limited by nitrogen and phosphorus. This investigated microalgae and their characteristics to access and determine nutrient limitation in a sewage disposal site at Iddo, Lagos Lagoon.

Materials and Methods
Study area
Iddo community is located within the North East of Lagos in the Lagos Mainland Local Government Area. The lagoon is located between latitudes 6° 22′ - 6° 38′ N and longitudes 3° 23′ - 3° 40′ E. Iddo community is exposed to two distinct seasons; the wet (May to October) and dry seasons (November to April). The study site is marked by the presence of high pollution rate resulting from the activities of surrounding residents which is evident by the deposition of refuse and sewage at the banks and surface of the creek.

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

Plankton Collection

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

Physicochemical analyses

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

Statistical analysis

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

Results

Physicochemical parameters

The physico-chemical properties of the water observed the highest surface water temperature (32℃) in February, 2019 and the lowest water temperatures (30℃) in December, 2018, March, 2019 and April, 2019. The lowest air temperature (30℃) was recorded in March, 2019 while the highest air temperatures (34℃) were recorded in January and February, 2019. Rainfall (0 – 222.9mm), salinity (16.50 – 26.60‰), pH (7.12 – 7.75), conductivity (30100 - 46300µS/cm), Total Dissolved Solids (TDS) (20100 – 31800mg/L), Total Hardness (3500mg/L - 5520mg/L), Dissolved Oxygen (6.00mg/L – 6.70mg/L) were observed to be higher in the wet months than the dry months.

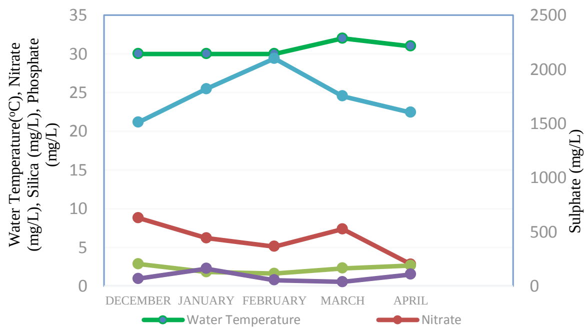

Figure 1. Relationship between Water Temperature and Nutrients for months of December, 2018 to April, 2019 Phytoplankton

The phytoplankton diversity was presented by two (2) Divisions namely: Bacillariophyta and Cyanophyta. The Bacillariophyta was represented by twenty-six (26) species from Orders (Centrales and Pennales). The Cyanophyta was represented by three (3) species from two (2) Orders (Oscillatoriales, Nostocales).

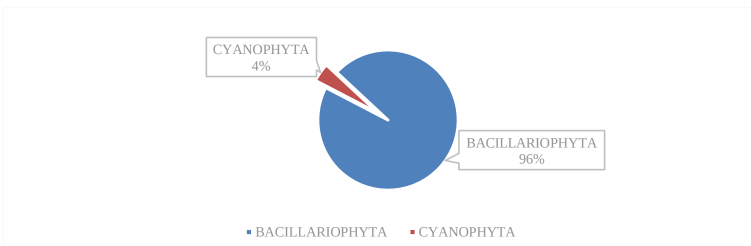

Figure 2: The relative abundance of phytoplankton at Iddo, Lagos Lagoon between December 2018 and April 2019

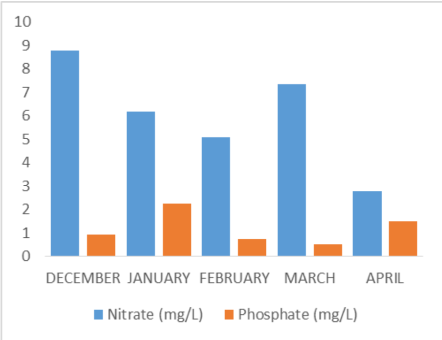

Figure 3: Nutrient stoichiometric representation of nitrate and phosphate at Iddo, Lagos Lagoon between December 2018 and April 2019

Discussion

The variation in the physical and chemical parameters observed during the five months (December, 2018 – April, 2019) sampling period at Iddo, Lagos Lagoon maybe as a result of the influence of seasonal changes and wastes discharge.

Air temperature was higher in months with low precipitation for the station. These observations may be due to increased insolation due to lower cloud cover and cessation of rainfall as previously reported by Nwankwo (1996), Onyema *et al*., (2007) and Onyema *et al*., (2007). The study revealed a direct relationship between Total Dissolved Solids (T.D.S), Total Suspended Solids (T.S.S), Transparency and Rainfall. In months with low precipitation T.S.S was low possibly due to low flood water inflow to the creek. The increase in salinity in months with low precipitation could be due to increased evaporation and reduction of flood water at the cessation of rainfall. Biochemical oxygen demand value greater than 8mg/L reflects a high level of pollution. The biochemical oxygen demand observed for the station ranged between 1 and 1.80 mg/L possibly indicating a moderately polluted environment which could be associated with the discharge of solid wastes, wood wastes and household wastes.

The high availability of nutrients (phosphate, silicate and sulphate) may have encouraged the growth and abundance of phytoplankton as indicated by chlorophyll *a* levels. The high levels of these nutrients may be due to the direct discharge of wastes into the creek from domestic and industrial sources.

Conclusion

Nutrient availability has a profound influence on the composition of phytoplankton. Therefore, this study ascertained that nitrate is limiting at Iddo end of the Lagos lagoon.

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Behavioural Responses and Mortality of *Clarias gariepinus* Juveniles Exposed to Acute Concentrations of Paraquat

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Abstract
Paraquat is the most common contact and non- selective herbicide for exterminating vegetative pest. Fish are ideal sentinels for detecting aquatic pollutants and are largely use as bio indicators of environmental pollution. This study is aimed to determine the behavioural changes, lethal concentrations (LCs) and mean lethal time (MLT) of *Clarias gariepinus* exposed to paraquat. A 96 hours renewable bioassay was conducted with various concentrations 0.0, 0.25, 0.50, 0.75, 1.0 and 1.25mg/l. behavioural changes and cumulative mortality were observed and recorded at 12, 24, 48, 72 and 96 hour. Behavioural changes such as air gulping, erratic swimming, loss of balance, excessive mucus secretion, discolouration and death were observed with severity increasing with increase concentration and duration of exposure. The LC_{50} values decrease from 0.191mg/l (0.171 – 0.222) in 12 hour to 0.107mg/l (0.065 – 0.150) in 96 hour while relative toxicity factor (TF) increased from 1 to 1.79 times respectively. The 96hrMLT values decrease from 91.18hours (54.09-105.64) at the lowest concentration to 16.22 hours (9.06 – 25.15) at the highest concentration with relative toxicity time (RTT) increasing from 1 to 5.62 times. Herbicide should be apply with caution and studies on the sub lethal effects of paraquat on the haematology, biochemistry and histology on *C. gariepinus* juveniles will be necessary.

Keywords: *Clarias gariepinus*, paraquat, behavioural changes, lethal concentration and lethal time.

Introduction

The use of herbicides in agricultural practices is on the increase, thereby causing ecological imbalance due to damage to non- target organisms (Annett *et al* 2014). According to Food and Agricultural Organisation (FAO, 2000), approximately three million people are poisoned and 200,000 die each year around the world from pesticide poisoning most of which are from developing countries. Paraquat (1, 1-dimethyl-4, 4-bipyridinium dichloride) is one of the most common contact and non-selective herbicide for exterminating vegetative pests. Due to availability, affordability and efficiency, its utilization has increased in recent years in Nigeria especially among the rural farmers. Direct and indirect contamination of aquatic environment with pesticides may cause fish kills, reduce fish productivity and elevates concentration of undesirable chemicals in edible fish tissues (Ogueji *et al.*, 2016).

Behaviour provides a unique perspective linking the physiology and ecology of an organism and its environment and allows the organism to adjust to external and internal stimuli to best meet the challenge of surviving in a changing environment (Adewum and Olakje 2011). Several researchers have reported the following behavioural changes; air gulping, stunned positioning, skin peeling, aggression, excessive mucus secretion, motionless, respiratory distress, erratic swimming (fast and spiral movement) and death when they exposed *C. gariepinus* to acute concentrations of various xenobiotics (Hassan *et al*., 2015; Nwamba *et al.*, 2018; Audu *et al.*, 2020). This study investigated the acute toxicity of paraquat on *C. gariepinus* juveniles using behavioural characteristics and mortality.

Materials and Methods

Experimental fish and Chemical:

Two hundred (200) apparently healthy juveniles of *C. gariepinus* with mean body weight and the length of 38.26±1.20 (g) and 17.50±1.55 (cm) respectively were bought from University of Calabar fish farm and transported to the wet labouratory of Fisheries Department CRUTECH, Obubra campus. They were acclimated for 14 days during which they were fed with Coppen feed at 3% body weight twice daily and terminated 24 hours prior to the commencement of the experiment (Reish and Oshida 1987). Paraquat (1, 1-dimethyl-4, 4-bipyridinium dichloride) was procured from a local agro- chemical dealer shop at Ofatura – Adun, Obubra.

Acute toxicity bioassays was conducted in the Wet laboratory of the Department of Fisheries and Aquatic Science for a period of 96hrs. During acute bioassay 180 juveniles were introduced into 18 plastic tanks of 60 litres capacity each containing 20 litres of water and 10 fish in triplicates. The fish were randomly selected and stocked in the tanks containing the following concentration 0.0, 0.25, 0.50, 0.75, 1.0, 1.25mg/l obtained from a serial dilution of the stock solution of 200mg/l. The test solution was not change (static) throughout the duration of the experiment (96hours). The behavioural changes such as erratic movement, air gulping, hyperactivity, loss of balance, excessive mucus secretion, discolouration, motionless and mortality were observed and recorded. The changes were ranked as, no visible sign (-), weak (+), moderate (++) and severe (+++) in 12, 24, 48, 72 and 96 hours. Dead fish was removed immediately to avoid contamination of the test solutions. Some water quality parameters such as dissolved oxygen, temperature, pH, conductivity and hardness were also monitored and recorded using the appropriate instrument and standard methods (APHA, 2009)

Statistical analysis.
Data obtained from the water quality parameters were subjected to simple descriptive statistic to determine the range and mean using SPSS version 20. Mortality data was used to determine the lethal concentrations (LCs) and mean lethal time (MLTs) values with their associated confidence limits using Probit analysis method described by Zar (1999)

Result

Water quality parameter of the test solutions

The result of the physicochemical parameters of the test solutions is presented in Table 1. The result shows that slight changes with the range values of 4.74 to 5.12mg/l, 26.88 to 27.16^{0}C, 7.46 to 7.79, 37.61 to 39.32(mg/l) $CaCO_3$ in dissolved oxygen, temperature, pH and hardness respectively. The mean values of 4.93± 1.50 mg/l, 27.16±0.56^{0}C and 38.05 ± 0.55 (mg/l) $CaCO_3$ were also recorded for dissolved oxygen, temperature and hardness respectively.

Table 1: Water quality parameters of test solutions

Parameter	Range	Mean ±SD
Dissolved Oxygen (mg/l)	4.74 – 5.12	4.93 ± 1.50
Temperature (^{0}C)	26.88 – 28.13	27.16 ± 0.56
pH	7.47 – 7.79	6.68 ± 2.60
Conductivity (µS/cm)	165.96 – 167.23	166.15 ± 2.20
Hardness (mg/l) $CaCO_3$	37.61 – 39.32	38.05 ± 0.55

Behavioural responses of *C. gariepinus* to test concentrations:

The result of the behavioural changes observed in fish exposed to the various concentrations of Paraquat is presented in Table 2. The fish were observed to show air gulping, erratic swimming, loss of balance, mucus secretion, hyperventilation, discoloration, motionless, loss of balance and death. However, severity of these changes depends on the level of concentration and exposure time to the Paraquat. None of these abnormal physical changes was observed at the control (0.0mg/l). There was Increase in weakness, motionless, discoloration, gulping and mucus secretion as concentration increase with exposure time.

Table 2: Behavioural Patterns displayed by *Clarias gariepinus* Juveniles Exposed to Various Concentrations of Paraquat

Concentration (mg/l)	Behavioural pattern	Duration of exposure (hr)				
		12	24	48	72	96
0.0	Air gasping	-	-	-	-	-
	Erratic swimming	-	-	-	-	-
	Loss of balance	-	-	-	-	-
	Hyperactivity	-	-	-	-	-
	Excessive mucus secretion	-	-	-	-	-
	Skin discolouration	-	-	-	-	-
	Motionless	-	-	-	-	-
	Death	-	-	-	-	-
0.25	Air gasping	-	-	-	+	+
	Erratic swimming	-	-	-	-	+
	Loss of balance	-	-	-	-	-
	Hyperactivity	-	-	-	-	+
	Excessive mucus secretion	-	-	-	-	-
	Skin discolouration	-	-	-	-	-
	Motionless	-	-	-	-	+
	Death	-	-	-	+	+
0.50	Air gasping	-	+	+	++	++
	Erratic swimming	-	+	++	++	+++
	Loss of balance	-	-	+	++	+++
	Hyperactivity	-	+	++	+++	+++
	Excessive mucus secretion	-	-	+	++	++
	Skin discolouration	-	-	-	+	+
	Motionless	-	-	+	++	++
	Death	-	+	++	++	++
0.75	Air gasping	+	++	++	+++	+++
	Erratic swimming	+	+	++	+++	+++
	Loss of balance	-	+	++	+++	+++
	Hyperactivity	+	++	+++	+++	+++
	Excessive mucus secretion	+	+	++	++	++
	Skin discolouration	-	+	++	++	+++

	Motionless	-	-	+	+	++
	Death	+	++	++	+++	+++
1.0	Air gasping	+	++	+++	+++	+++
	Erratic swimming	++	++	++	+++	+++
	Loss of balance	+	++	++	+++	+++
	Hyperactivity	+	++	+++	+++	+++
	Excessive mucus secretion	++	+++	+++	+++	+++
	Skin discolouration	+	++	+++	+++	+++
	Motionless	+	+	++	+++	+++
	Death	+	++	+++	+++	+++
1.25	Air gasping	++	+++	+++	+++	+++
	Erratic swimming	+++	+++	+++	+++	+++
	Loss of balance	+	++	+++	+++	+++
	Hyperactivity	++	+++	+++	+++	+++
	Excessive mucus secretion	+	++	+++	+++	+++
	Skin discolouration	+	+++	+++	+++	+++
	Motionless	+	++	+++	+++	+++
	Death	++	+++	+++	+++	+++

No visible sign (-), weak (+), moderate (++), severe (+++)

Lethal concentration (LC) and mean lethal time (MLT) and associated 95% confidence limit

The lethal concentrations (LCs) of paraquat on the fish expressed as percentage cumulative mortality at 10 (LC_{10}), 50 (LC_{50}) and 95% (LC_{95}), safe concentration (that will not kill the fish) and relative toxicity factor (potency of a given concentration) 12, 24, 48, 72 and 96 hours is presented in Table 3. The 12hrLC values increase from 0.092mg/l, to 0.318ml/l for LC10 and LC_{95} respectively while the LC_{50} values decrease from 0.191 to 0.107ml/l for 12 to 96hours respectively. While the relative toxicity factor increased from 1 to 1.79 at 12 and 96hours respectively. This implies that the concentration that will kill 50% of the *C. gariepinus* juveniles at 96hours (0.107mg/l) was 1.79 times less toxic (lower in concentration) than that of 12hours (0.191ml/l).

The result of the 96hrMLT increase within given concentration but decrease as the concentration increases Table 4. At the lowest concentration (0.25mg/l) of paraquat, 91.18 and 156.43 hours were required to kill 50 and 95% of *C. gariepinus* juveniles respectively whereas 16.42 and 66.07 hours was required to kill the same percentages of the fish at the highest concentration (1.25mg/l). However this trend decrease with increasing level of concentrations at 96hrsMLT_{50} from 91.18 to 16.22 hours in 0.25 and 1.25mg/l respectively. The relative toxicity time (RTT) of 96hrsMLT_{50} increased from 1 to 5.62 at lowest (0.25mg/l) and the highest (1.25mg/l) concentrations respectively. This implies that the lowest concentration (0.25mg/l) is 5.62 times more toxic than the highest concentration (1.25mg/l) at 50% mortality.

Table 3: Lethal concentrations and associated 95% confidence limit of paraquat on *C. gariepinus* juveniles for 96hours.

Exposure Time (hr)	Lethal Concentration at 95% Confidence Limit			Safe Concentration.	Toxicity Factor
	LC_{10}	LC_{50}	LC_{95}		
12	0.092 (0.061– 0.112)	0.191 (0.171– 0.222)	0.318 (0.272– 0.405)	0.019	1
24	0.044 (-0.133– 0.089)	0.148 (0.108– 0.232)	0.281 (0.210– 0.622)	0.015	1.29
48	0.030 (-0.186 – 0.079)	0.138 (0.093– 0.221)	0.276 (0.203– 0.652)	0.014	1.38
72	0.010 (0.245 – 0.064)	0.125 (0.075– 0.201)	0.273 (0.204 – 0.696)	0.013	1.53
96	0.004 (0.161 – 0.045)	0.107 (0.065– 0.150)	0.249 (0.190– 0.451)	0.011	1.79

T.F= Toxicity factor =LC_{50} value at 12hrs ÷ LC_{50} value of any other periods; safe concentration = LC_{50} value ÷ 100

Table 4: Mean lethal time (MLT) and associated 95% confidence limit of *C. gariepinus* juveniles exposed to paraquat for 96hours

Concentration. (mg/l)	Mean Lethal Time (MLT) and associated 95% Confidence Limit		Relative Toxicity Time (RTT)
	MLT_{50}	MLT_{95}	
0.25	91.18	156.43	1
	(54.09– 105.64)	(149.13– 206.14)	
0.50	43.45	115.55	2.10
	(33.19– 144.36)	(168.64– 275.36)	
0.75	37.13	98.18	2.46
	(21.08– 76.21)	(61.20 – 129.56)	
1.0	24.17	83.26	3.77
	(13.07– 31.15)	(61.19– 104.41)	
1.25	16.22	66.25	5.62
	(9.06– 25.15)	(42.19– 88.45)	

RTT= Toxicity factor =MLT_{50} value at lowest concentration (0.25mg/l) ÷ MLT_{50} value of any other concentration.

Discussion

The apparently close values of the water quality parameters in this study is an indication that there never contributed to the changes observed in the behaviour of the exposed fish. The values fall within the normal range of water quality for aquaculture (Adeniji & Ovie 1989). *Clarias gariepinus* juveniles on the various concentrations of paraquat were stressed progressively with time before death in this study. The stressful behaviour includes loss of balance, erratic swimming, air gulping, sudden quick movement, and excessive secretion of mucus, motionless, discolouration and general hypersensitivity. No such pattern was observed for fish in the control tanks. The observed behavioural pattern in this study are consistent with previous reports with some herbicides (Nwani *et al.,* 2010; Ogueji *et al.,* 2013; Ayanda *et al.,* 2015; Hasan *et al*., 2015; Nwamba *et al.,* 2018). The behavioural score showed stronger with increase the concentration such as aggression, stunted posture, erratic swimming and more frequently move at the bottom. Increased mucus secretion in fish exposed to toxicants is a defensive response by which fish attempts to reduce the entrance of toxicant through the skin and gill surfaces (Agbede *et al.,* 2000). Literatures have reported that increase utilization of energy substances (carbohydrate, protein and lipids) when fish is under xenobiotic leads to stress (Mommsen *et al.,* 1999). The mortality rate was concentration and time dependent, suggesting that the degree of exhaustion due to depleted energy sources may have been raised by increasing the concentration and exposure durations(Gabriel and Edori 2010; Nwamba *et al.,* 2018; Okey *et al*., 2018).

The value of 96hrsLC_{50} of 0.107mg/l reported in this study is higher than the 0.07mg/l earlier reported by Ayanda *et al*. (2015) for paraquat but lower than those reported for dichlorvos (17.21mg/l), glyphosate (0.53mg/l) and diazinon (7.3mg/l) by Nwamba *et al.* (2018), and Ayanda *et al*. (2015) respectively on clariid species. Hasan *et al.* (2015) reported a much higher LC_{50} value of 26.07mg/l of paraquat on common carp, *Cyprinus carpio* indicating they are most tolerant to paraquat than *C. gariepinus*. The lower the LC_{50} value of a toxicant the more toxic the substance. Toxicity of pesticides to organisms is affected by the strains of species, size, age, sex, temperature, water quality and formulation of the test chemicals (QECD, 1992). The decrease in the LC_{50} values, safe concentrations and increase in the toxicity factor with increase in duration of exposure in this study is in agreement with the reports of others researchers investigating acute toxicity of various chemicals on fishes (Nwamba *et al*., 2018; Okey *et al*., 2018). The mean lethal time (MLT) values for the species give an insight into the pattern of death of fishes with duration of exposure under acute toxicity of toxicants. The decline in 96hrMLT_{50} values and increase in the relative toxicity time with increasing concentrations of paraquat was in conformity with the works of several researchers (Gabriel and Okey 2009; Okey *et al* 2018). This implies that increase in concentration will decrease the time require to kill 50% of the juveniles which will however increase within a given concentration. Mortality is therefore effected by both concentration and duration of exposure.

Conclusion

The study demonstrated that stressful behaviour pattern showed severity in with increasing concentration with no sign of abnormality displayed by fish in the control tanks. The low 96hrLC_{50} value (0.107mg/l) is an indication that paraquat is highly toxic to *C. gariepinus* juveniles. The 96hrMLT_{50} for the various concentration decrease while the relative toxicity time (RTT) increase with increasing concentration of paraquat.

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Macro Benthic Invertebrates Assemblage in different Anthropogenic Activity Zones in Badagry Creek, South Western Nigeria.

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Abstract
Assessment of macro benthic invertebrate's assemblages and physic- chemical parameters of Badgry creek were investigated from July 2017 to May 2018. Five anthropogenic activity zones were created according to their ecological importance from the nine study stations established in the upper, middle and lower course of the creek. The five anthropogenic activities zones were Domestic waste (DW), Domestic waste combined Dredging (DW_DG), Dredging zone (DG), Aquaculture combined Dredging (AQ_DG), and Aquaculture zone (AQ). The mean values of macro-benthic diversity and dominance during the wet season were 0.70±0.12, 0.36±0.18, 0.84±0.11, 0.28±0.11, and 0.55±0.11; 0.61±0.07, 0.43±0.22, 0.50±0.06, 0.17±0.17, 0.44±0.09 for the DW, DW_DG, DG, AQ_DG, and AQ respectively. The dry season mean values for diversity and dominance were 0.85±0.15, 1.06±0.22, 1.10±0.11, 1.20±0.39, and 1.07±0.25; 0.55±0.08, 0.43±0.13, 0.40±0.05, 0.38±0.11 and 0.27±0.06 for the DW, DW_DG, DG, AQ_DG, and AQ respectively. Insecta assemblages were relatively poor and had low densities in the different anthropogenic activities zones, its occurrence and abundance were registered only during the dry season. However, Gastropoda had highest abundance and occurrence across the zones, the gastropoda were tolerant to all the human disturbance activities defined during the sampling period. The pH value range (7.1-7.8) was moderate across the study zones, salinity recorded in this study range (2.41-6.66ppt) salinity was highest in May 2018 (26ppt) at station 7. The alkalinity values range (20mg/L-80mg/L). The mean values of Nitrate and phosphate (0.18±0.22) and (0.02±0.04) were low compare to the value of Sulphate (11.83±34.83).

Introduction
Macro-invertebrates' species (benthos) are important ecosystem component within the ecosystem-based approach, due to their sessile, sedentary and relatively long life which are considered as important factors to be suitable and sensitive indicators of natural and anthropogenic variations (Pearson and Rosenberg 1978). A good indicator of temporal and chronic disturbances that has been proven is macro benthos (Dauer 1993).Therefore the assessment of the condition of benthic habitat is one of the evaluation criteria both in biological quality element, biodiversity and sea floor integrity. Habitat transformation and pollution are problems encumbered by estuaries worldwide with serve risks to their ecological resilience (Lotze et al 2006). The sedimentary organic matter and pollutants on estuaries are important drivers of ecological changes observed on benthic assemblages. Urbanization and population growth are associated with pollution pressures that Nigerian aquatic systems are subjected to (Edokpayi *et al*; Nwokoji *et al* 2010). The seasonal distribution of rainfall, the lagoon and creeks experience seasonal flooding which introduces a lot of detritus, nutrients, as well as other land based pollutants (Ogunwenmo and Osuala 2004; Edokpayi *et al* 2008). The present study aimed to assess the invertebrate assemblages across the different anthropogenic site in Badagry creek ii. Assessing the physicochemical parameters of the different anthropogenic site.

Materials and Methods

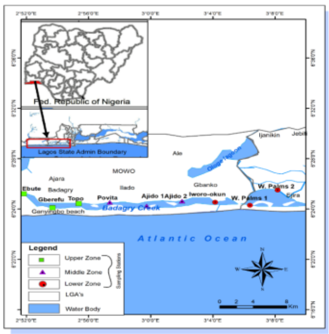

Figure 1: Map of Badagry creeek showing the sampling stations

Macroinvertebrate sampling:

Benthic macroinvertebrates were obtained from three quantitative replicates using a Van Veen grab (sampling surface area: 0.1m²) of which the contents were sieved over 1mm mesh sieve (prior to fixation). Inverte brates were preserved in 5% formaldehyde, mixed with Rose Bengal for further analysis. A multi-meter water checker (Horiba) model U- 10 was used to determine the pH, conductivity, salinity, Mercury in glass thermometer was used to determine the air and surface water temperature calibrated mercury in glass thermometer was dipped in water sample drawn for temperature.

Results

	Dry Season			Wet Season		
Species	*No/ m²*	*%*	*ranking*	*No/m²*	*%*	*ranking*
Parchymelania aurita	134	18.36	1st	128	20.31	1st
Parchy. fusca	75	10.27	2nd	50	7.94	4th
Neritina glabrata	40	5.48	6th	15	2.38	14th
Potad. moerchi	30	4.10	9th	15	2.38	14th
Pirenell conica	10	1.37	17th	14	2.22	17th
Clibin. africanus	70	9.59	3rd	75	11.90	2nd
Sesarma hilzardi	62	8.49	4th	60	9.52	3rd
Macrobrachium rosenbergii	52	7.12	5th	45	7.14	5th
Callinectes amnicola	26	3.56	10th	31	4.92	7th
Brachyodontes tenuistriatus	39	5.34	7th	35	5.56	6th
Brach. puniceus	15	2.05	15th	20	3.17	11th
C. gasar	17	2.33	14th	17	2.69	13th
Septaria spp	35	4.79	7th	30	4.76	8th
tivela tripla L	30	4.11	8th	25	3.97	9th
Libellulidae	20	2.74	11th	0	0	19th
megasoma spp	19	2.60	13th	0	0	20th
Assiminea bifasciata	20	2.73	12th	24	3.80	10th
Melanoides mueruensis	15	2.05	15th	20	3.17	11th
pitaria tumens	10	1.37	17th	15	2.38	16th
Amphipod	10	1.37	17th	5	0.79	18th

Table 1: Ranking of the numerically Abundant Macro Benthic Organism

Discussion

The pH value (7.1-7.8) of the creek was moderately within the range of values reported for rivers flowing through areas with thick vegetation (Uwadaie 2010), it also supported the findings of hydrochemistry of urban creek stated by Edokpayi et al 2010. Salinity recorded in this study (2.41-6.66). The salinity value was highest in May 2018 at staton 7 under the AQ_DG zone, the results from this study corroborated the pre vious reports of other works (Edokpayi et al 2008; 2010), it confirmed the creek to be brackish. The creek was slightly alkaline, the range value was (20mg/L - 80mg/L), high values of alkalinity was recorded across the different disturbance zone in the month of May 2018, pollution effects from run-offs from municipal, agricultural and industrial may increase the value of alkalinity (Ajao 1996). Biological oxygen demand BOD range value (3.12-4mg), the DW zone had higher value from other zones, this may be accounted for the domestic and sewage waste dumping in this zone that need oxygen for decomposition. The BOD recorded in this study was lower to the reports of Edokpayi et al 2010 from Ogbe creek (4.3-9.9mg/L).

Spatial Distribution of the Macrofauna

A total of twenty species of benthic macro fauna were obtained during the dry and wet season. The highest number of abundance was registered during the dry season, it decreased during the wet season. This value recorded was low to the forty-two species of benthic macro fauna that were obtained in Lagos lagoon from the reports of Ajao and Fagade 1990, this is indication that there is a level of human disturbance and pollution affecting the benthic macro fauna community in Badagry creek. The class insecta, phylum Arthropoda was not registered during the wet season across the different anthropogenic zones, probably due to changes in physico chemical parameters, salinity that was high and the water level that increases during the wet season. Higher abundance and occu rrence of macro fauna was registered during the dry season. However, Gastropods and Bivalves were relatively tolerant to physical and chemical variations in the environment and were present in a broad range of habitats, this result may likely agree with the findings that the specie exhibited less dependency on stable environments and have been recorded to be abundant in various disturbed systems, such as agricultural stream (Schafer *et al*., 2007, Li *et al*., 2019). The differences in macro benthic fauna occurence in the different anthropogenic zones in this study have been supported with habitat change and reduction theory (Ogbeibu and Oribhabor, 2004).

Conclusion

Conclusively variances in the number of species and numerical abundance are largely due to physical variability of the study area, and the predominant ecological conditions, including the level of contamination from anthropogenic sources of the study area at the time of the surveys. The study revealed that most of the macro benthic fauna occurred seasonal in the water body and the creek could be said to support a wide range of macro benthic invertebrates' species exhibiting different diversity patterns across the anthropogenic zones.

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Effects of covid-19 lockdown on plankton communities in the Lagos Lagoon

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ABSTRACT:
The effects of the Covid-19 global lockdown were assessed on plankton communities in Iddo and Liverpool, as parts of the Lagos lagoon with high levels of anthropogenic activities. There were notable changes in the abundance and distribution of plankton communities in the study areas as, during the lockdown, activities that would have continued to stress the environment were mandated to stop. As a result, planktons that thrive in low to medium pollutants were present or increased after the lockdown while species that thrive in heavy pollution were absent or reduced after the lockdown.

Keywords: Phytoplankton distribution, Covid-19 lockdown, Lagos lagoon

INTRODUCTION

The Lagos lagoon is the centre of the waterways in Lagos which connects creeks, rivers, wetlands and canals in southwestern Nigeria to the sea (Nkwoji *et al.*, 2010). A common sighting on the Lagos lagoon are the motorboats and canoes. This is due to a very high rate of human activity on the lagoon, ranging from transportation, fishing, aquaculture, trading and housing.

Phytoplanktons, although microscopic in nature, are the "grass of the sea" and their productivity sustains life in aquatic ecosystems. They occur freely in water bodies and like their primary producing counterparts on land, they are dependent principally on sunlight and nutrients to thrive (Akagha *et al*., 2020). Planktons are drifters carried to different parts of the water surface by currents commonly generated by winds. In the lagoons, they can also be moved about by propellers from motorboats or paddles from canoes (Aagarin *et al.*, 2020).

Human activities have often been observed to play a defining role in aquatic ecosystems while some assist the productivity in aquatic environment to expand and thrive, others have detrimental effects to the sustenance of ecosystems (Adesalu 2013). A form of pollution that can be easily observed in the Lagos lagoon is from industrial effluents. Where industries have been seen emptying their waste waters indirectly through drainage pipes into the lagoon or directly where workers are seen washing used cement bags into the Lagos lagoon.

The Covid-19 pandemic lead to a global shut down where everyone was mandated to stay indoors for an unspecified amount of time. The implication of the lockdown meant that industries that did not offer essential services (such as food and drugs) were to stay closed for business. During the pandemic lockdown, anthropogenic activities that would have otherwise impacted the lagoon were to be suspended, and as such, effluents that would have found their way into the lagoon were not dispersed.

The objective of this study is to compare the effect of the covid-19 induced lockdown on the phytoplankton community structure of 2 sampled stations with a high rate of anthropogenic activity within the Lagos lagoon.

Materials and Methods

Sample Stations:

2 stations within the Lagos lagoon were chosen based on anthropogenic activities (1: Iddo – cement and other industrial solid waste. 2: Liverpool – factory oil and wastewater discharge). The stations were sampled for 2 months (January and February) before the lock down and 2 months (June and July) after the ease of the lockdown.

Sampling Procedures:

A plankton net (53 µm) was towed slowly by a motorboat for 5 minutes. Water samples collected were fixed *in situ* with 10% formalin and taken to the lab for analysis.

Plankton Analysis:

A counting chamber of 1ml per view with 50mm X 20mm cells was used in this analysis. The counting chamber was mounted 2 times on a Nikkon 400 compound light microscope. The content of each cell within the counting chamber were counted and recorded.

Results

Composition, Abundance and Distribution of Plankton pre-lockdown:

Within the sampled months, iddo had a record of 10 species in January, *Coscinodiscus sp*, *Navicula sp* and *Vovox sp* were the abundant species. In February there were 5 species with low individual counts (table 1). In Liverpool, in January, there were 9 species with *Coscinodiscus sp.* the most abundant species. In February, *Coscinodiscus* *sp.* was also the most abundant among the 8 recorded species as seen in table 2. From fig. 1 and 2, the prevalent planktons were the diatoms with a percentage abundance of 56% and 80%.

Table 1: plankton composition in Iddo pre-lockdown

JAN 2020	S/N	Phylum	Division	Group/Class	Family	Species	Count/ml
	1	Crustacea	Crustacea	Maxillopoda		Nauplius larva	19
	2	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Coscinodiscus	50
	3	Algae	Ochrophyta	Bacillariophyceae	Naviculaceae	Navicula	25
	4	Algae	Cyanobacteria	Cyanophyceae	Oscillatoriaceae	Oscillatoria	10
	5	Algae	Chlorophyta	Trebouxiophyceae	Chlorellaceae	Closteriopsis	2
	6	Algae	Ochrophyta	Fragilariophyceae	Fragilariaceae	Fragilaria	12
	7	Rotifera	Rotifera	Monogononta	Brachionidae	Keratella	13
	8	Algae	Chlorophyta	Chlorophyceae	Volvocaceae	Volvox	25
	9	Annelida	Annelida	Polychaeta		Polychaete larva	6
	10	Algae	Ochrophyta	Coscinodiscophyceae	Lithodesmiaceae	Ditylum	5
		Total Count					**167**
		Number of Species					**10**
FEB 2020							
	1	Crustacea	Crustacea	Maxillopoda		Nauplius larva	3
	2	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Coscinodiscus	6
	3	Crustacea	Crustacea	Hexanauplia	Calanidae	Calanus	1
	4	Algae	Ochrophyta	Bacillariophyceae	Naviculaceae	Gyrosigma	1
	5	Algae	Ochrophyta		Striatellaceae	Striatella	1
		Total Count					**12**
		Number of Species					**5**

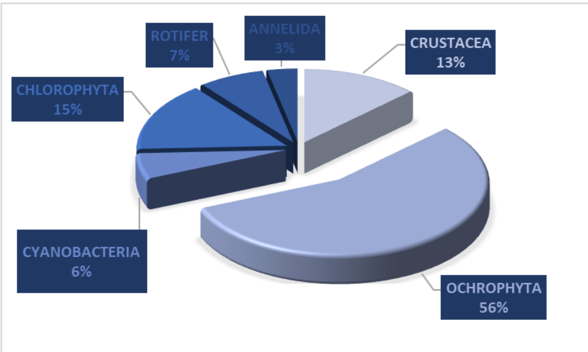

Figure 1: percentage abundance of plankton pre-lockdown in Iddo

Table 2: plankton composition in Liverpool pre-lockdown

JAN 2020	S/N	Phylum	Division	Group/Class	Family	Species	Count/ml
	1	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Cosinodiscus	40
	2	Algae	Ochrophyta	Coscinodiscophyceae	Melosiraceae	Melosira	15
	3	Crustacea	Crustacea	Maxillopoda		Nauplius larva	5
	4	Algae	Ochrophyta	Bacillariophyceae	Naviculaceae	Gyrosigma	16
	5	Algae	Cyanobacteria	Cyanophyceae	Oscillatoriaceae	Oscillatoria	17
	6	Ciliophora	Ciliophora	Oligotrichea	Codonellidae	Tintinnopsis	12
	7	Cercozoa	Cercozoa	Imbricatea	Euglyphidae	Trinema	2
	8	Algae	Ochrophyta	Xanthophyceae	Tribonemataceae	Tribonema	11
	9	Algae	Ochrophyta	Fragilariophyceae	Fragilariaceae	fragilaria	14
		Total Count					**132**
		Number of Species					**9**
FEB 2020							
	1	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Cosinodiscus	100
	2	Algae	Ochrophyta	Coscinodiscophyceae	Melosiraceae	Melosira	20
	3	Crustacea	Crustacea	Maxillopoda		Nauplius larva	6
	4	Algae	Ochrophyta	Bacillariophyceae	Naviculaceae	Gyrosigma	10
	5	Algae	Cyanobacteria	Cyanophyceae	Oscillatoriaceae	Oscillatoria	13
	6	Rotifera	Rotifera	Eurotatoria	Lecanidae	Lecane	3
	7	Algae	Ochrophyta	Bacillariophyceae	Stephanodiscaceae	Stephanodiscus	4
	8	Algae	Ochrophyta	Bacillariophyceae	Pleurosigmataceae	Pleurosigma	1
		Total Count					**157**
		Number of Species					**8**

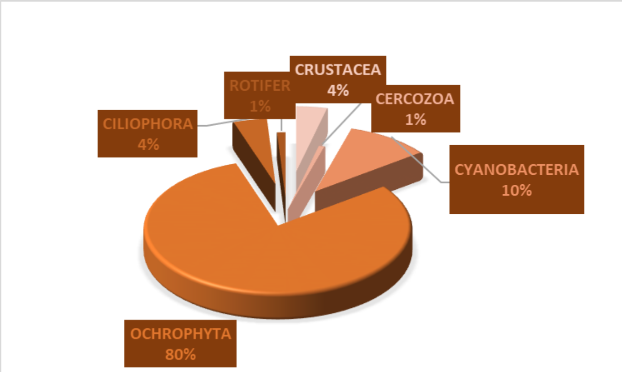

Figure 2: Percentage abundance of plankton pre-lockdown in Liverpool

Composition

Abundance and Distribution of Plankton post-lockdown:

From table 3, in June, iddo had 7 species amongst which *Tintinnopsis sp*. were the most abundant species. In July, among the recorded 8 species, *Tintinnopsis sp.* were also more abundant that other species. In Liverpool, in June, there were 8 species with *Coscinodiscus sp.* being the most abundant. In July, *Tintinnopsis sp*. were the most abundant amongst the recorded 9 species. From fig. 3 and 4, the prevalent planktons after the ease of the lockdown were the Ciliophoras with 74.95% abundance in Iddo while in Liverpool diatoms remained prevalent with 94.53% abundance.

JUN 2020	S/N	Phylum	Division	Group/Class	Family	Species	Count/ml
	1	Crustacea	Crustacea	Maxillopoda		Nauplius larva	21
	2	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Coscinodiscus	24
	3	Crustacea	Crustacea	Hexanauplia	Calanidae	Copepod	4
	4	Ciliophora		Oligotrichea	Codonellidae	Tintinnopsis	100
	5	Crustacea	Crustacea	Hexanauplia	Calanidae	Harpaeticoid	1
	6	Algae	Ochrophyta	Bacillariophyceae	Naviculaceae	Gyrosigma	3
	7					Achatini	1
		Total Count					**154**
			Number of Species				**7**
JUL 2020							
	1	Algae	Ochrophyta	Mediophyceae	Biddulphiaceae	Biddulphia	1
	2	Crustacea	Crustacea	Maxillopoda		Nauplius larva	20
	3	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Coscinodiscus	30
	4	Algae	Ochrophyta	Coscinodiscophyceae	Melosiraceae	Melosira	2
	5	Ciliophora		Oligotrichea	Codonellidae	Tintinnopsis	241
	6	Crustacea	Crustacea	Hexanauplia	Calanidae	Harpaeticoid	1
	7	Rotifera	Rotifera	Monogononta	Brachionidae	Keratella	1
	8	Algae	Ochrophyta	Bacillariophyceae	Surirellaceae	Surirella	6
		Total Count					**302**
		Number of Species					**8**

Table 3: plankton composition in Iddo post-lockdown

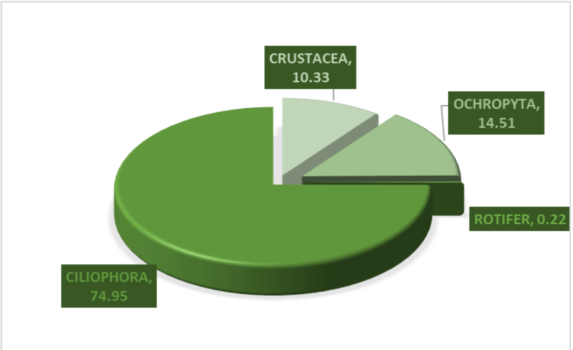

Figure 3: percentage abundance of plankton post-lockdown in Iddo

JUN 2020	S/N	Phylum	Division	Group/Class	Family	Species	Count/ml
	1	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Cosinodiscus	150
	2	Algae	Ochrophyta	Coscinodiscophyceae	Melosiraceae	Melosira	1
	3	Crustacea	Crustacea	Maxillopoda		Nauplius larva	9
	4	Algae	Cyanobacteria	Cyanophyceae	Oscillatoriaceae	Oscillatoria	9
	5	Algae	Chlorophyta	Chlorophyceae	Hydrodictyaceae	Pediastrum	1
	6	Rotifera	Rotifera	Eurotatoria	Lecanidae	Lecane	3
	7	Algae	Ochrophyta	Bacillariophyceae	Stephanodiscaceae	Stephanodiscus	1
	8	Algae	Ochrophyta	Bacillariophyceae	Pleurosigmataceae	Pleurosigma	2
		Total Count					**176**
			Number of Species				**8**
JUL 2020							
	1	Algae	Ochrophyta	Coscinodiscophyceae	Coscinodiscaceae	Cosinodiscus	650
	2	Algae	Ochrophyta	Coscinodiscophyceae	Melosiraceae	Melosira	5
	3	Crustacea	Crustacea	Maxillopoda		Nauplius larva	9
	4	Algae	Cyanobacteria	Cyanophyceae	Oscillatoriaceae	Oscillatoria	7
	5	Algae	Ochrophyta	Mediophyceae	Biddulphiaceae	Biddulphia	1
	6	Algae	Ochrophyta	Bacillariophyceae	Surirellaceae	Surirella	4
	7	Rotifera	Rotifera	Eurotatoria	Lecanidae	Lecane	5
	8	Algae	Ochrophyta	Bacillariophyceae	Stephanodiscaceae	Stephanodiscus	1
	9	Algae	Ochrophyta	Bacillariophyceae	Pleurosigmataceae	Pleurosigma	1
		Total Count					**683**
		Number of Species					**9**

Table 4: plankton composition in Liverpool post-lockdown

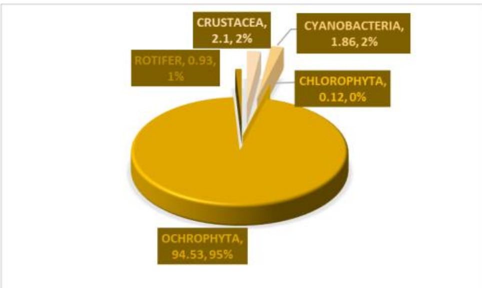

Figure 4: percentage abundance of plankton post-lockdown in Liverpool

Summary of Plankton Classes/Groups and Percentage Counts:

In Iddo, pre-lockdown, the division Ochrophyta were dominant species but Rotifers became dominant post-lockdown. In Liverpool, the division Ochrophyta were the dominating species pre-lockdown as well as post-lockdown.

Table 5: Summary of plankton collected from Iddo pre-lockdown

PRE-LOCKDOWN		
DIVISIONS	**NUMBER OF COUNT**	**PERCENTAGE COUNT**
CRUSTACEA	23	12.85
OCHROPHYTA	100	55.87
CYANOBACTERIA	10	5.59
CHLOROPHYTA	27	15.08
ROTIFER	13	7.26
ANNELIDA	6	3.35
TOTAL (PLANKTON)	**179**	
% OF TOTAL PLANKTON	**28.23**	

Table 6: Summary of plankton collected from Iddo post-lockdown

POST-LOCKDOWN		
DIVISIONS	**NUMBER OF COUNT**	**PERCENTAGE COUNT**
CRUSTACEA	47	10.33
OCHROPYTA	66	14.51
ROTIFER	341	0.22
CILIOPHORA	1	74.95
TOTAL (PLANKTON)	**455**	
% OF TOTAL PLANKTON	**71.77**	
GRAND TOTAL (PRE/POST LOCKDOWN)	**634**	

Table 7: Summary of plankton collected from Liverpool pre-lockdown

PRE-LOCKDOWN		
DIVISIONS	**NUMBER OF COUNT**	**PERCENTAGE COUNT**
CRUSTACEA	11	3.81
CERCOZOA	2	0.69
CYANOBACTERIA	30	10.38
OCHROPHYTA	231	79.93
CILIOPHORA	12	4.15
ROTIFER	3	1.04
TOTAL (PHYTOPLANKTON)	**289**	
% OF TOTAL PLANKTON	**25.17**	

Table 8: Summary of plankton collected from Liverpool post-lockdown

POST-LOCKDOWN		
DIVISIONS	**NUMBER OF COUNT**	**PERCENTAGE COUNT**
CRUSTACEA	18	2.1
CYANOBACTERIA	16	1.86
CHLOROPHYTA	1	0.12
OCHROPHYTA	816	94.53
ROTIFER	8	0.93
TOTAL (ZOOPLANKTON)	**859**	
% OF TOTAL PLANKTON	**74.83**	
GRAND TOTAL (PRE/POST LOCKDOWN)	**1148**	

Discussion

The Iddo and Liverpool areas of the Lagos Lagoon were picked for this study due to the nature of the anthropogenic activities that directly affect those areas. Before the Covid-19 global lockdown it was common to see men at work in Iddo, washing used cement bags directly into the lagoon while in Liverpool, factories are regularly seen discharging their wastewaters directly into the lagoon leaving the surrounding water covered with a thin film of oil. The effects of these frequent pollution can be seen in the distribution and abundance of planktons that are native to the Lagos lagoon as it has been recorded to reduce plankton diversity while nurturing pollutant tolerant species (Onyema, 2017).

In this study, there were notable changes in the abundance and distribution of the planktons within the sampled months before and after the lockdown. *Oscillatoria sp* which has been reported by researchers to tolerate organic pollution (Bulent *et al.,* 2013) was seen to reduce in abundance from 10% pre-lockdown to 2% post-lockdown in Liverpool. *Suriella sp.* reported to thrive in moderate organic pollution (Onyema, 2013) was only recorded in Iddo post-lockdown. *Ditylum sp.* as well as *Melosira sp.* were also reported by Onyema, 2013 to thrive in high cations levels. *Ditylum sp.* was only recorded in Iddo pre-lockdown while *Melosira sp.* was showed a decrease in abundance from high in Liverpool pre-lockdown to low post-lockdown in Liverpool. Coscinodiscus sp. remained prevalent pre- and post-lockdown in Iddo as well as Liverpool sample stations throughout the period of this study. This is agreement with works with according to Yakub *et al.,* 2011.

Conclusion

In conclusion, although the Covid-19 induced global lockdown was for about 3 months before it was eased in Nigeria, it nevertheless affected the distribution and abundance of plankton communities in the study areas. During the lockdown, activities that would have otherwise continued to stress the environment were mandated to stop. As a result, planktons that thrive in low to medium pollutants were present or increased after the lockdown while species that thrive in heavy pollution were absent or reduced after the lockdown.

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Mercury Accumulation in the Edible Bivalve *Crassostrea gasar* (Adanson, 1757) Collected from the Western Creeks of the Lagos Lagoon, Nigeria

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Abstract
The concentration of mercury in the edible bivalve, *Crassostrea gasar*, water and sediment of Abule – Agege and Makoko creeks were investigated from January to September 2019. The physicochemical parameters recorded over the sampling period were similar at the two creeks. In dry season, higher mean mercury content was observed at Abule-Agege Creek across samples; water (0.35 ± 0.005 mgl^{-1}), sediment (0.62 ± 0.01 µg/g), shell (0.20 ± 0.02 µg/g) and edible tissue (0.23 ± 0.01 µg/g). Except in water (0.40 ± 0.03 mgl^{-1}), higher mercury content was recorded in samples collected from Makoko Creek during wet season. Mercury concentration followed decreasing order as sediment > water > edible tissue > shell, across season and location. The concentrations of mercury in the examined edible tissue of the oysters were generally low when compare with the maximum permissible levels (0.5 - 1.5 µg/g).

Introduction
Mercury is a nonessential metal that occur naturally in the environment as a result of volcanic degassing of the Earth's crust and weathering of mercury rich geology (Yin *et al.*, 2013). While water from areas rich in mercury ores may exhibit high local mercury concentrations, industrial processes, agriculture and the combustion of fossil fuel are the most significant sources of aquatic contamination (Khoei and Bastami, 2013). The general human population is primarily exposed to mercury via food, where fish including bivalve is the major source of methylmercury exposure (Ja¨rup, 2003).

The Mangrove Oyster, *Crassostrea gasar* (Adanson, 1757) is a commercially important bivalve species exploited mainly for its flesh and is consumed boiled or fried. This study was aimed to assess mercury levels in the edible bivalve, *Crassostrea gasar* from the adjacent creeks of the Lagos Lagoon, to ascertain whether mercury concentrations in the oyster were within acceptable standard safety limits for human consumption.

Materials And Methods
Study Site
The Lagos Lagoon is a large expanse of shallow water covering an area of about 208 km^2 (Emmanuel and Kusemiju, 2005; Moruf and Lawal-Are, 2017). It serves as an important seaport, nursery ground for fisheries, and a source of food supply and for recreational purposes. In the western part of the Lagos Lagoon, the Abule Agege Creek is situated near the Faculty of Science and directly behind the Computer Science Department building of the University of Lagos, Akoka. The site lies between latitudes 6º 26' – 37' N and longitude 3º 23 – 4º 20'E (Moruf and Lawal-Are, 2015; Moruf *et al.*, 2018). Likewise, the Makoko Creek lies between Latitude 6°29′-41'N and Longitude 3°23 - 43'E (Adejumobi *et al.*, 2019).

Sampling
Water and sediment samples scooped from Abule-Agege and Makoko Creeks were collected into 70 ml plastic bottles and polythene bags respectively. To prevent adsorption of metals into the walls of the containers, the samples were acidified with 2 drops of concentrated HNO_3 (APHA, 2005) and stored in a refrigerator at temperature of 4ºC while the sediments in polythene bags were stored at 0ºC in a refrigerator before analysis. Monthly measurement of water temperature, salinity, pH, dissolved oxygen, biological oxygen demand and chemical oxygen demand of both creeks were taken for the period using a Hanna (HI 9028) multiparameter probe.

Oyster samples (*Crassotrea gasar*) were collected by scooping from the waterbed at low tides and dislodgement from mangrove branches and roots, from January - April, 2019 for the dry season and May - September, 2019 for the rainy season. The sampling was carried out at the early hours of each day, thrice a week for the period of sampling. Twelve replicates of samples for both wet and dry season were used for analysis in this study.

Laboratory Analysis
Mercury concentrations were analysed in digested water and sediment slurry samples according to the cold vapor method using a Perkin-Elmer Atomic Absorption System AA-2380 with automatic background correction and a Perkin-Elmer Mercury Analysis System 303-0830 as described by Khoei and Bastami (2013). After depurating the oyster samples, a sterile stainless steel knife was used to dislodge and remove the soft tissue of each oyster from the shell (Chiu *et al*., 2000). Both the flesh and the shell were then separately dried in an oven at 105^{0}C until constant weight was obtained and later separately homogenized using mortar and pestle. 10g of each homogenate was separately digested as described by APHA (2005). The completely digested subsamples were allowed to cool

at room temperature, and the undigested portions were filtered off through a Whatmann Glass Microfibre filter paper (GF/C) to obtain a clear solution and diluted to 50 mL in volumetric flasks with double distilled water. The Atomic Mercury Analyzer equipped with a mercury lamp at a wavelength 253.7 nm was used for the determination of total mercury in the oyster tissue samples.

Statistical Analysis

The result was analyzed using Microsoft Excel and STAT 7.0 statistical package.

Results

The summary of physico-chemical variables is shown in Table 1. Recorded values for water temperature varied from 28.92±0.1 °C (Makoko Creek) to 29.18±0.02 °C (Abule-Agege Creek). pH of 8.17±0.07 and 7.73±0.02 were observed in Abule-Agege Creek and Makoko Creek respectively. The higher pH value obtained at Abule-Agege Creek may be related to the growth of algae population, aquatic vegetation and photosynthetic activity, which increase total alkalinity. Salinity in ppt ranged between 12.03 and 16.62 across water bodies. Higher dissolved oxygen (5.34±0.02 mgL^{-1}) and biological oxygen demand (7.780±0.1 mgL^{-1}) were observed in Makoko Creek while the chemical oxygen demand was higher in Abule-Agege Creek with 16.01±0.1 mgL^{-1}.

Table 1: Physicochemical parameters of the western creeks of Lagos Lagoon, Nigeria

Sampling	Parameters	Range	Mean±SD
Abule-Agege Creek	Water Temperature (°C)	29.33 - 30.83	29.18±0.02
	pH at 25	7.83 - 8.70	8.17±0.07
	Salinity (ppt)	12.03 - 13.47	12.05±0.04
	Dissolved Oxygen (mgL^{-1})	5.17 - 5.23	5.20±0.02
	Biological Oxygen Demand (mgL^{-1})	5.33 - 7.00	6.57±0.05
	Chemical Oxygen Demand (mgL^{-1})	11.67 - 19.00	16.01±0.1
Makoko Creek	Water Temperature (°C)	25.40 - 30.43	28.92±0.1
	pH at 25	7.69 - 8.57	7.73±0.02
	Salinity (ppt)	12.43 - 16.62	14.23±0.05
	Dissolved Oxygen (mgL^{-1})	5.13 - 5.27	5.34±0.02
	Biological Oxygen Demand (mgL^{-1})	6.33 - 8.67	7.780±0.1
	Chemical Oxygen Demand (mgL^{-1})	9.00 - 15.67	12.34±0.02

The summary of mercury concentrations in water, sediment and tissues of edible bivalve species collected from the western creeks of Lagos Lagoon at different season are presented in Tables 2 and 3. In dry season, higher mean mercury content was observed at Abule-Agege Creek across samples; water (0.35 ± 0.005 mgl^{-1}), sediment (0.62 ± 0.01 µg/g), shell (0.20 ± 0.02 µg/g) and edible tissue (.23 ± 0.01 µg/g). Except in water (0.40 ± 0.03 mgl^{-1}), higher mercury content was recorded in samples collected from Makoko Creek during wet season. The higher mercury content of sediment in comparison with the water may be as a result of binding affinity of clay or could be attributed to exudates from the decaying plants from the mangrove flora around the creek and the preceding rain forests.

Table 2: The mean (± SD) mercury content in water, sediment and tissues of edible bivalve *Crassostrea gasar* (µg/g) from the western creeks of Lagos Lagoon during the Dry Season

Sample	Abule-Agege Creek	Makoko Creek
Water (mgl^{-1})	0.35 ± 0.05	0.29 ± 0.04
Sediment (µg/g)	0.62 ± 0.01	0.45 ± 0.08
Shell (µg/g)	0.20 ± 0.02a	0.17 ± 0.05
Edible tissue (µg/g)	0.23 ± 0.01a	0.21 ± 0.02

Table 3: The mean (± SD) mercury content in water (mgl^{-1}), sediment (µg/g) and edible bivalve, *Crassostrea gasar* (µg/g) from the western creeks of Lagos Lagoon during the Wet Season.

Sample	Abule-Agege Creek	Makoko Creek
Water (mgl^{-1})	0.36 ± 0.02	0.40 ± 0.03
Sediment (µg/g)	0.73 ± 0.02	0.68 ± 0.01
Shell (µg/g)	0.25 ± 0.05	0.28 ± 0.08
Edible tissue (µg/g)	0.32 ± 0.01	0.37 ± 0.05

Discussion

The physicochemical parameters recorded over the sampling period were similar at the two creeks. Water temperature variation is one of the factors in the coastal and estuarine system that may influence other physico-chemical characteristics, the distribution and abundance of flora and fauna (Ayo-Olalusi and Ayoade, 2017). In the present study, slightly higher temperature was recorded in Abule-Agege Creek. The decrease or increase in water temperature depends mainly on the climatic conditions, sampling times, sunshine hours and affected by specific characteristics of water environment such as turbidity, wind force, plant cover and humidity (Ahmed *et al.*, 2017). Hydrogen ion concentration (pH) is the master control parameter in aquatic environment for the chemical and biological transformation of water. The pH values of both study creeks were in alkaline side at all sites, with similar report by Nkwoji (2016) who obtained minimum pH of 7.17, mean pH 7.8±0.3 and maximum of 8.7 while assessing quality of Makoko water. Therefore, the recorded pH values are suitable for aquatic animals such as bivalves (Magami *et al.*, 2014). The recorded values for salinity, dissolved oxygen, biological oxygen demand and chemical oxygen demand in the present study are higher than the results of Lawal-Are *et al*. (2019) who reported mean salinity of 11.1±3.2ppt, dissolved oxygen of 5.3±0.1 mgL^{-1}, biological oxygen demand of 5.1±0.6 mgL^{-1} and chemical oxygen demand of 19.0±3.9 mgL^{-1} for Abule-Eledu Creek.

In the present study, the concentration of mercury followed decreasing order as sediment > water > edible tissue > shell, across season and location. According to Moruf and Akinjogunla (2019), sediment serves a major depository of metals holding more concentrations that water. The analysis of the oyster tissues showed that higher levels of mercury was present in the edible tissue than in the shell for both creeks. The results of the present study are similar to the findings of Obirikorang *et al.* (2010) where significant high mercury concentration in bottom-feeding bivalvia species was reported. Consequently, this agree with Khoei and Bastami (2013) who are of the view that nearly the entire mercury burden in benthic organism is from their diets.

The concentrations of mercury in the examined tissues of the oysters were generally low when compare with the maximum permissible levels in the food chemical codex as documented in Khoei and Bastami (2013) for benthic organisms. Levels recorded for this study were also less than those reported by Emmanuel and Samuel (2009) for brackish water fishes in a tropical lagoon and its adjacent creek in South-West Nigeria. However, it is suggested that since the oyster used for this study were collected from the creeks which are exposed to the influence of urban-runoffs and sewage effluent discharge (Moruf and Lawal-Are, 2018), hence the need for constant monitoring.

In conclusion, higher mercury concentrations were recorded in sediment than in water for both creeks. It is possible that the settling ability of mercury and the inability of the water to retain mercury due to the metal density allowed for this situation. Analysis of mercury risk levels associated with the consumption of oyster by humans revealed that they were safe to eat as far as the permissible level of mercury (0.5 - 1.5 μg/g) set by WHO (2005) was concerned.

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Seawater flux and its Consequences on Ayetoro coastal community of Ondo State, Nigeria.

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Abstract
Incessant Flooding occasioned by high tidal fluctuations, sea level rise and its accompanying negative impacts such as land degradation and seawater incursion into freshwater sources had informed the need to assess the hydrochemistry and anthropogenic pollutants in water, sediment and representative fish samples of Aiyetoro coastal waters. Thirteen sampling stations (including 2 groundwater stations and 3 control stations) were selected to determine the concentration and spatial distributions of hydro-chemical characteristics and heavy metals concentrations. The results of the ionic concentrations (e.g., Calcium Ca^{2+}, Magnesium Mg^{2+}, Sodium, Na^+, Potassium K^+, Nitrate NO_3^-, Phosphate PO_4^{3-}, Sulphate SO_4^{2-} and Chloride Cl^-) further showed higher values that exceed the World Health Organization (WHO) standard, Federal Environmental Protection Agency (FEPA), and Federal Ministry of Environment (FEMNV) permissible limit for portable water and coastal water sustainability for marine life. The result further affirms the high impact of land degradation and saline water intrusion. Low pH, Dissolved Oxygen (DO) at some stations indicate increased anthropogenic activities. Heavy metal analysis further showed high Lead (Pb) concentrations in water, Copper (Cu), Manganese (Mn), Chromium (Cr) in sediment and Cu, zinc (Zn), Pb, cadmium (Cd), cobalt (Co) and Nickel (Ni) in representative fish samples. This study establishes that sea-level rise, land degradation, flooding and human-induced anthropogenic activities have negatively impacted Aiyetoro community, hence an urgent need for bioremediation.

Keywords: Sea-level rise; seawater intrusion, pollution and remediation.

Introduction

Aiyetoro, a coastal community, in Ondo state, Southwest of Nigeria is known for its richness in seafood like, crabs, periwinkles, crayfish and diverse species of fish. Therefore, land degradation and seawater incursion in the community is a national and global health concern (Olatunji-Ojo et al., 2019). Land degradation and displacements as a result of high-water pressure, tides, waves and the accompanying effect of saline-water intrusions can lead to the occurrence of high economic loss due to the reduction of agricultural products such as fishing, which is the primary occupation of the Aiyetoro community. Over 30 per cent of land in Ayetoro community and its environs had been abandoned and approximately 2km distance along the Ilaje coastal waters had already been affected by seawater intrusion Additionally, there are reported cases of human-induced activities arising from marine transportations, oil exploration, local and international petroleum marketing, pipeline vandalization and seepages, and illegal sand mining activities in the Aiyetoro coastal waters. Residential and domestic sewage discharges (which is also a common phenomenon in Aiyetoro community) tend to trigger a high rate of flooding, and eventual sea-level rise, as a minor influence.

Meterials and methods

Eight sampling points (ST1…..ST8) were selected at about 500m-1km into the sea and three control points (CTR1,2,3) were chosen away from the anthropogenic prone areas and lastly Samples of groundwater (BR1,2) used by the community dwellers as a source of drinking water and groundwater. Sediments and fish samples were also collected from selected stations for further analysis.

Water temperature, pH, turbidity, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS) and salinity (SAL) were measured in-situ at every sampling station with Horiba U-52 multi-water parameters. Water samples meant for heavy metal analysis were kept in pre-cleaned 0.5-litre plastic containers and acidified with 2 to 3 ml of nitric acid (HNO_3) to ensure that the respective ions remain in solution pending chemical analysis. Water samples meant for cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and anions (SO_4^{2}, NO_3^-, PO_4^{3-}, Cl^-) analysis were kept in an airtight plastic ice-cold cooler at 4 °C and transported to the wet laboratory of the Emmandy Laboratory and Consultancy Limited, Ibadan, South-west Nigeria for heavy metals analysis. The cations and anions were determined using UV/VIS Spectrophotometer (Model- Jenway 6705) at a specified wavelength.

Sediment samples were collected with 0.25 m^2 Van-Veen Grab sampler at each station, aboard the research boat. Samples were stored in aluminum foil and labelled for heavy metals (HM). Before analysis, sediment and fish samples were sun-dried for 4 days and then sieved through a 200 μm sieve mesh. The sieved samples were further disaggregated and homogenized in a porcelain mortar and pestle and re-sieved. Approximately 0.5 g were leached with 20 ml of aqua regia (a mixture of nitric acid and Hydrochloric acid) (Ibanga et al. (2019). The heavy metals

(Pb, Cu, Ni, Cd, Co, Mn, Cr and Cu) concentrations were determined by Argillent 200A model Atomic Absorption Spectrophotometer (AAS).

Results

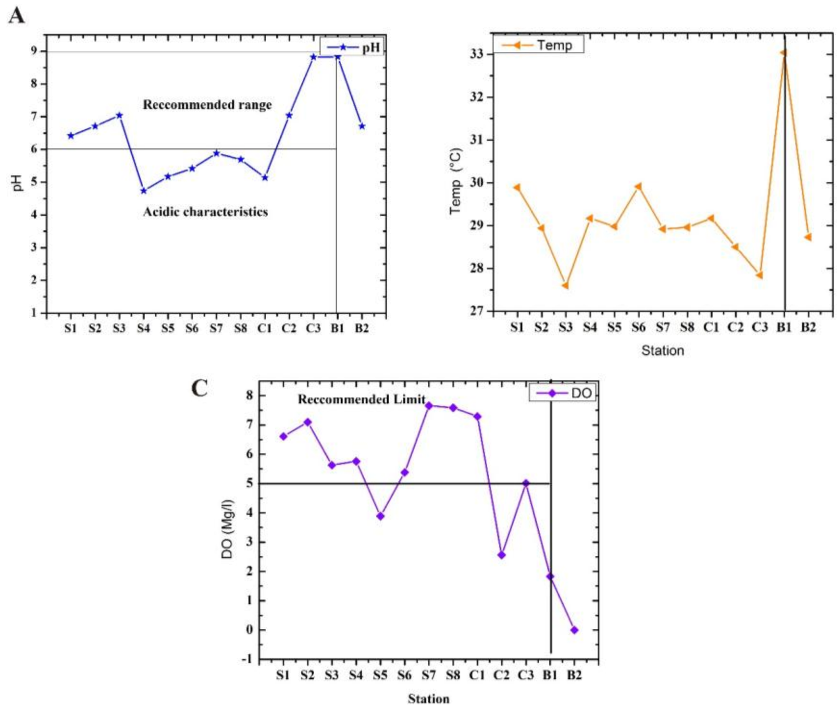

Figure 1(a) PH, 1(b) Temperature (c) Dissolved Oxygen of Ayetoro Coastal waters

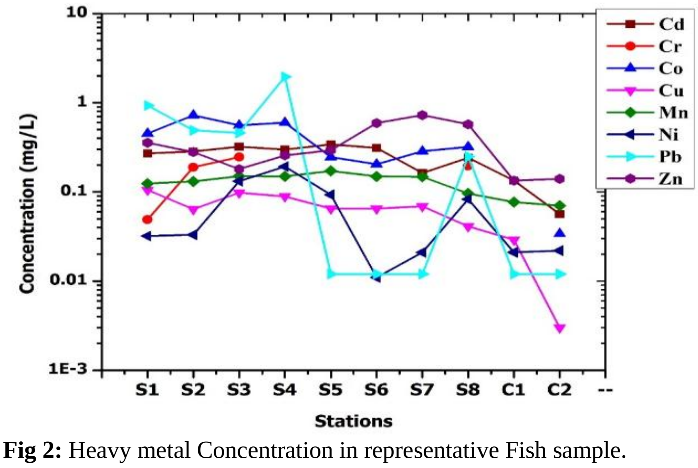

Fig 2: Heavy metal Concentration in representative Fish sample.

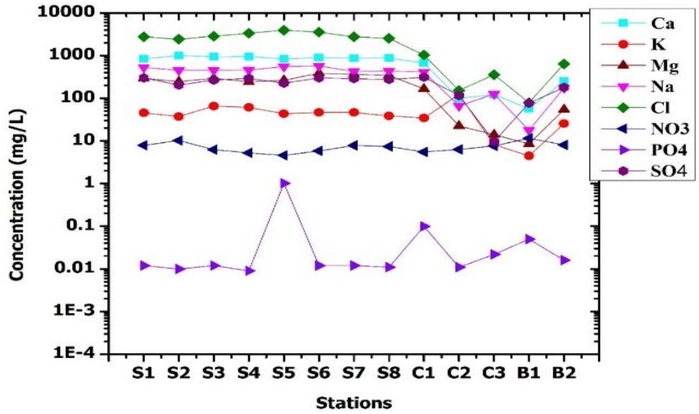

Fig 3: Heavy Metal concentration in Ayetoro surface and Ground water.

Table 1: Heavy metal concentrations in Aiyetoro coastal sediments (Mg/Kg)

S/N	Code	Pb	Mn	Cr	Cu
1.00	ST-1	2.40	52.95	204.50	77.40
2.00	ST-2	1.70	68.71	238.40	72.10
3.00	ST-3	2.10	63.34	293.10	218.00
4.00	ST-4	2.10	64.38	292.80	94.40
5.00	ST-5	1.40	98.72	226.30	104.40
6.00	ST-6	1.90	101.36	231.30	92.30
7.00	ST-7	1.30	80.17	71.40	139.10
8.00	ST-8	1.50	76.51	242.10	94.00
9.00	CTR1	1.40	30.72	90.40	42.20
10.00	CTR2	1.20	62.67	182.70	86.40
11.00	CTR3	1.50	22.92	185.00	108.10
Min		1.20	22.92	71.40	42.20
Max		2.40	101.36	293.10	218.00
Av		1.68	65.68	205.27	102.58

Table 2: Heavy metal concentrations in representative fish samples of Aiyetoro coastal water (Mg/Kg)

S/N	Cd	Cr	Co	Cu	Mn	Ni	Pb	Zn
F1	3.03	BDL	0.77	4.29	3.9	0.28	3.05	24.8
F2	1.71	BDL	0.25	1.96	2.2	0.27	ND	14.4
F3	2.33	BDL	BDL	2.75	2.67	0.23	ND	16.5
F4	2.13	BDL	2.04	2.29	3.05	0.17	2.31	17
F5	1.95	BDL	0.84	1.83	4.82	2.1	BDL	15.9
Min	1.71	BDL	0.25	1.83	2.2	0.17	2.31	14.4
Max	3.03	BDL	2.04	4.29	4.82	2.1	3.05	24.8
Av	2.23	BDL	0.975	2.624	3.328	0.61	2.68	17.72

Discussion

The concentration of heavy metals in water of the study area are shown in Fig D or, Appendices 1,2 &3). The results showed Mn (0.070-0.177mg/L), Cu (0.003-0.105 mg/L), Cd (0.163-0.322 mg/L), Pb (0.01-1.95 mg/L), Ni (0.02-0.09mg/L), Zn (0.13-0.73mg/L) Cr (0.005-0.246mg/L) and Co (<0.01-0.72mg/L). The permissible limit for metals in coastal waters are variable for Mn (5mg/L), Cu (<1mg/L), Cd (<1mg/L), Pb (<1mg/L). Ni (<1mg/L), Zn (<1mg/L), Cr (<1mg/L), and Co (<1mg/L) respectively (FEPA, 1991, FMNEV, 2001). All the metals (with the exception of Pb) falls within the aforementioned permissible limit for coastal waters in Nigeria. The high values of Pb (1.95mg/L) at station 4 is an indication of point source anthropogenic effluent of petroleum spills and combustion from vessels during transportation and downstream petroleum product transportation.

Sediments act as an ultimate sink of heavy metals from the particulate matter and surrounding environments (Ajani et al., 2017). The average grain/particle size analysis of sediment from the sampling stations are approximately sandy mud, 12%, silty mud 34% and clayey mud 54%. The combination of silty and clayey mud (86%) which are very fine soil texture (less than 63 microns) makes the sediments of the Mahin mud coast to be more prone to flooding relative to the beach sand in the Lagos coastal waters that are predominantly coarse to medium sandy texture (greater than 63 microns). The concentration of heavy metals in the sediment range from Cr, 71.40-293.10mg/kg; Cu, 42.20-218.00 mg/kg; Mn, 22.92-101.36 mg/kg Pb, and Pb, 1.20-1.68 mg/kg (Table 2). The trend of studied heavy metals in the Ayetoro coastal sediments were in the order of Cr > Cu > Mn > Pb. The higher Cr, Cu and Mn concentrations in Ayetoro coastal sediments further suggest point source effluent of petroleum spills and combustion from vessels during transportation and downstream petroleum product transportation. Cu, Pb, Cr and Cu have been reported as associated elements with petroleum spills and refining processes (Dara, 2001).

Heavy metal concentration in the gills and intestine of *Tilapia guineensis* and Euthynnus alleteratus species reveal variable Cd (1.71-3.03mg/Kg); Cr (below detection level, bdl); Co (bdl-2.04mg/Kg); Cu (1.83-4.28mg/Kg); Mn (2.20-4.82mg/Kg); Ni (0.17-2.10mg/Kg) and Pb (bdl-3.05mg/Kg). The higher concentration of the metals above the permissible limit highlighted in section 5 (permissible levels of heavy metals in coastal waters) indicated bioaccumulation of the heavy metals the fish gills an intestine. The main factors affecting bioa ccumulation of heavy metals in fish are the exposure of the fish to the heavy metals from the water column. These higher values above the permissible limit is an indication of a serious threat of the aforementioned metals (Cu, Zn, Pb, Cd, Co and Ni) with the exception of Mn and Cr (that are below the permissible limit) to the marine lives of Ayetoro coastal waters.

Conclusion

The result of this study showed that Ayetoro community and marine life had been negatively impacted by Our the resultant seawater intrusion and anthropogenic effluents,.Hence, there is an urgent need for remediation in order to save the community.

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Assessment and Management of impact factors on Marine mammals during geophysical survey in Nigeria coastal waters.

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Abstract
The oil rich region of the Niger delta region of Nigeria is also home/breeding ground for some indigenous as well serve as calving grounds for some migratory marine mammal species. Hence, the need for a science-based management to reduce risk of injury or fatality to these endangered species. This study aims at assessing Scientific management procedures for minimising negative impact of oil exploration on these invaluable resources. Two Marine Mammal Observers (MMO) and One Passive Acoustic Monitoring (PAM) Operator undertook visual observations for marine mammals and turtles, and acoustic detections, in accordance with the JNCC (2017) and Department of Petroleum resources (DPR) guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys. Cumulative effort was 1298hrs 38mins. MMO observation hours totalled 696hrs 34mins. 49.31% of MMO observation effort took place while the source was active and 50.69% with the source inactive. The total number of airguns starts was 104 while seismic source was tested on 24 occasions each preceded with soft start. PAM detection effort totalled 602hrs 11mins. 56.22% of effort took place while the source was active and 43.78% with the source inactive. The total number of airguns starts was 120 while seismic source was tested on 32 occasions each preceded with soft start. Pre-shoot watches of 30 minutes were carried out in accordance with the mitigation guidelines preceding all soft starts. There were 11 marine mammal sightings and 14 acoustic detection of marine. No compliance issues. mitigation actions were taken twice to minimise risk of injury to animals.

Introduction
Marine mammals are particularly relevant from an ecosystem-service perspective because of their large ranges; migratory behavior; past histories of exploitation; present iconic status across much of the world; cultural and economic importance for indigenous people; regulating effect on ecosystem structure; and monetary value for tourism (O'Connor 2009; Pompa et al. 2011; Roman 2014; NAMMCO 2017). For example, the climate-regulating ecosystem services provided by marine mammals inspired the International Monetary Fund to consider the benefits of marine mammal conservation (Chami et al. 2019). Similarly, it is striking that the European Commission changed its definition of "bioeconomy"; it now includes all value chains related to marine ecosystem services and thus by default, for example, marine mammal tourism (European Union 2018). Several marine mammals are and have historically been in conflict with societal interests, which increases the need for understanding of the complex ecosystem service trade-offs related to their management (Olsen et al. 2018). There are potential management benefits of making the gains and losses associated with marine mammals more explicit. Airgun arrays used during modern geophysical seismic surveys typically have source levels in the region of 220 to 248 dB re: 1 μPa at 1m, with highest energy produced in the 10.0 to 200.0 Hz frequency bandwidth (Greene & Richardson, 1988; Richardson & Würsig, 1997; Gulland & Walker, 2001).This is capable of interfering with the echolocation ability of cetaceans. Protection for Nigerian cetaceans could be improved if internationally accepted guidelines and indigenous scientific knowledge is strictly applied in oil exploration activities of the oil rich regions which are also habitat to diverse cetacean species.

Materials and Method
Two Marine Mammal Observer (MMO) carried out dedicated watches for marine animals from the bridge and bridge wings during day time (0:06- 18:00 UTC) and completed the relevant recording forms.

Passive Acoustic Monitoring (PAM) effort was carried out by one dedicated PAM operators located in the instrument room during night hours (18:00 – 0:06 UTC). PAM operator used headphones and monitored the PAM guard displays for any indication of marine mammal presence. Screenshots and recordings were captured on detection of marine mammals, screenshots of detections and acoustic recordings are stored with the project data. MMO conducted a Pre-Shooting Search by monitoring the 500m mitigation zone and adjacent waters for 30 minutes before initiation of the Soft Start procedure which last for 20 minutes. If no marine mammals have been spotted within the 500m mitigation zone the soft start may proceed. However, when animals are found within mitigation Zone, Soft start is delayed until 10 minutes after the animals have left the mitigation Zone.

Any break in airguns activity during daylight hours or darkness exceeding 10 minutes requires another 20-minute ramp-up. If the break is for less than 10minutes and is during daylight hours then shooting can recommence without a ramp-up as long as the MMO/PAM operator is on watch and there are no marine mammals within the 500 m mitigation zone around the source arrays. The acoustic source was a towed source of 6 string arrays with a maximum operating volume of 5220 in^3. The array comprised of 84 individual seismic elements ranging in volume from 60 to 220 in^3. The sub-array separation was 6 m, the source depth was 9 m and a shot point interval of 30 m was used.

Result.

The survey took place 20th of March to 27th of July, 2019 with a cumulative effort was 1298hrs 38mins (Fig 1). MMO observation hours totalled 696hrs 34mins. 49.31% of MMO observation effort took place while the source was active and 50.69% with the source inactive. The total number of airguns starts was 104 while seismic source was tested on 24 occasions each preceded with soft start. PAM detection effort totalled 602hrs 11mins. 56.22% of effort took place while the source was active and 43.78% with the source inactive. The total number of airguns starts was 120 while seismic source was tested on 32 occasions each preceded with soft start. Pre-shoot watches of 30 minutes were carried out in accordance with the mitigation guidelines preceding all soft starts. There were 11 marine mammal sightings and 14 acoustic detection of marine. No compliance issues. mitigation actions were taken twice to minimise risk of injury to animals. (table 1)

Table 1: Effort, sightings, Detections, incidence and Non-compliance

Survey activities	Visual (MMO) Daylight/ Good Visibility	Acoustic (PAM) Night/ Poor Visibility
Overall Effort (Hours)	696:34	602:11
Effort with Guns (Hours)	330:06	338:49
Pre-Watch Periods (No.)	134	148
Sightings / Detections (No.)	4	4
Mitigation	2	0
Soft Start (No.)	104	120
Gun Tests (No.)	24	32
Non-compliance	0	0
Distressed animal	1	0

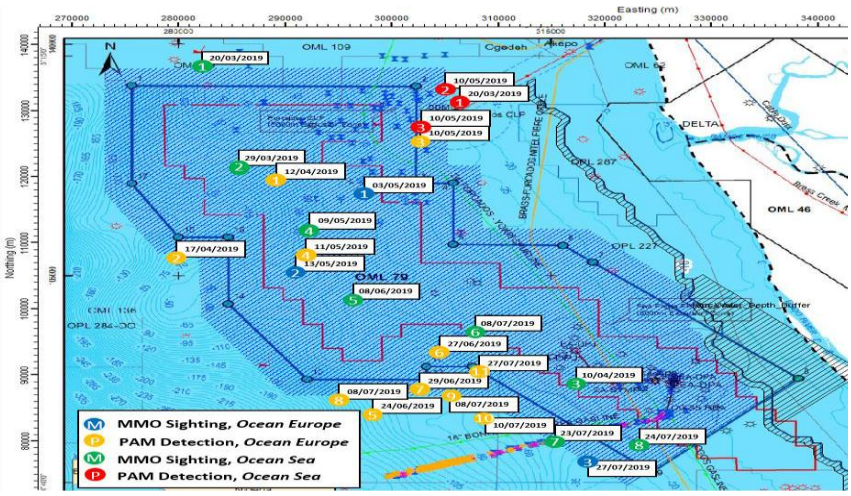

Fig 1: Spatial distribution of sightings and Detections of mammals on Survey area.

Discussion

Focus on marine mammal impact has primarily revolved around the sound source of the seismic vessel. Overall, the research into effects of seismic exploration on marine mammals is difficult and challenging. It involves several very different fields of science, from animal behaviour and physiology to airgun design, geophysics and visuals. Individually, these fields were complex and interactions between them even more so (Dragoset, 2000, Gordon et al., 2004, Tolstoy et al., 2009).

Mitigation measures carried out in this survey was in accordance with the guidelines of DPR stipulated in the consent license section relevant to the prevention of injury to marine mammals and sea turtles. There are two instances when softstart had to be delayed for 25 mins to allow the exit of two juvenile whales (*Megaptera noveangleae*) and 47 minutes for a school of 57 individual dolphins (*Delphinus capensis*) from the mitigation zone. In only one occasion, one animal (*Globicephala macrorhynchus*) was sighted within the mitigation Zone showing some symptoms of distress, necessitating an alteration of course by the vessel (Ocean Sea) from the direction of the animals. Considering the fact that the survey location has a dense traffic concentration comprising of supply vessels, security vessels and fishing vessels, the cause of the observed distress in a single animal could not be attributed to the seismic operation. Nevertheless, the onus was with the environmental regulators (MMO & PAM) responsible for the activity to assess and offer advice in accordance to stipulated guidelines. Daily, weekly and monthly report writing and submission helped in correcting operational infractions within a short time frame. Guidance on how to carry out such risk assessment and management is also provided in the JNCC, 2017.

Conclusion.

Marine mammal Protection has become a global area of discuss among climate change expert, this notwithstanding knowledge in this field among African scientist has been lagging. For Nigeria to contribute her quota in the conservation of this invaluable resource, internationally accepted guidelines and indigenous scientifically drafted guidelines need to become an integral part of enforceable regulation for oil exploration activities of the oil rich regions which are also habitat to diverse cetacean species.

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Selected Trace Metal Levels in Herring (*Clupea harengus*, Linnaeus 1758) and Atlantic mackerel (*Scomber scombrus*, Linnaeus 1758) from major Storage facilities in Maiduguri, Northeast, Nigeria

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Abstract
There is increasing awareness of implications of heavy metal accumulation in frozen fish imported into Nigeria food markets. Little is however, known on the contamination levels of these frozen fish in our markets. This study therefore, assess the accumulation level of metals in gills and muscle of frozen *Clupea harengus* and *Scomber scombrus* collected from cold rooms in Maiduguri metropolis. Six samples each of *C. harengus* and *S. scombrus* were randomly obtained and analysed for copper (Cu), cadmium (Cd), lead (Pb), nickel (Ni), mercury (Hg) and manganese (Mn) using atomic absorption spectrometry. Data obtained were analyzed using descriptive and regression statistics. The overall elemental concentrations of the heavy metals in the gills were in decreasing order of Mn>Hg>Cu>Ni>Cr>Cd>Pb for *C. harengus* and Mn>Cu>Ni>Hg>Cd>Cr>Pb for *S. scombrus*. However, the level of contamination in muscles decreases from Mn>Cu>Ni>Hg>Cd>Cr>Pb for the two species. The concentration of Cu (0.26±0.05 mg kg-^{1}), Cd (0.017±0.006 mg kg-^{1}), Ni (0.16±0.03 mg kg-^{1}), Cr (0.015±0.004 mg kg-^{1}) and Mn (0.62±0.05 mg kg-^{1}) were marginally higher in *C. harengus* muscle tissue while in gill of *S. scombrus* Cu (0.17±0.07 mg kg-^{1}), Cd (0.024±0.001 mg kg-^{1}), Pb (0.007±0.006 mg kg-^{1}), Ni (0.17±0.05 mg kg-^{1}) and Mn (0.51±0.08 mg kg-^{1}) were relatively higher. The heavy metals investigated in gills and muscle tissues of these species were within the standard limit for human consumption. However, there is the need for regular monitoring of the frozen fish coming to Maiduguri market to forestall the hazardous implications of heavy metals on humans.

Keywords: Frozen fish, *Clupea harengus*, *Scomber scombrus*, Heavy metals, Safety

Introduction
Fish makes vital contribution to food security and health of significant number of the world's population. It is especially important in the developing world including Nigeria where it serves as cheap source of essential nutrients to majority of people around the riverine communities. Fish does not only make a very significant contribution to nutrition but also confers therapeutic benefits against many human diseases (Ashraf *et al*., 2011). Interestingly, over two million metric tonnes of fish are imported into *Nigeria annually to meet the local demand* (Kikiope, 2018). The frozen fish varieties imported to Nigeria include mackerel (locally called *titus* or *alaran*), herrings (locally called *shawa*), horse mackerel (locally called *kote*), blue whiting (locally called *panla*), *Argentina silus* (locally called *ojuyobo*) and the popular croaker fish (*Pseudotolithus spp*). However, the herring *Clupea harengus* and Atlantic mackerel *Scomber scombrus* were the commonest in Maiduguri fish markets. Meanwhile, the contamination of the near-shore marine environment and food chain by heavy industries is common in many developed and developing countries. Heavy metal pollutants have therefore become a matter of great concern over the last few decades.

Heavy metals are natural trace components of the aquatic environment, which are not degraded with time, but concentration could increase through bio-accumulation (Aksoy, 2008). Metal accumulation in fishes are influenced by species, habitat, type of nutrition, development level and sexuality (Türkmen *et al*., 2005). As consumption of fish is a possible source of metal accumulation in humans, there is great interest in monitoring the concentration levels of heavy metals in frozen fish in our markets. Abubakar *et al*. (2015) and Kareem *et al*. (2016), made a critical evaluation of heavy metal concentration in imported frozen fish sold in Ibadan and Zaria, Nigeria, respectively. These authors reported high occurrence of some metals above recommended limits in liver, gill and muscle of Mackerel, Sardine and Croaker. The need to extend this investigation to other part of the country and update information justify the need for this research. The present study therefore, assesses the heavy metal levels in the muscle and gill of frozen Herring *Clupea harengus* and Atlantic mackerel *Scomber scombrus* in Maiduguri, Northeast, Nigeria.

Materials and Methods
This study was carried out in Maiduguri, Borno State, North Eastern Nigeria. Six samples each of the two commonly consumed frozen fish (Atlantic mackerel and Herring) were collected between October and November, 2019 from randomly selected cold rooms operating in Monday market. Thereafter, the weight and lengths of the fish were taken following standard procedure (Table 1). The fish were later dissected and muscles and gills removed from each pre-labelled sample and preserved at −20 °C in clean dry polyethylene bags. Composite samples of 2–5g of each sample were used for subsequent analysis.

The samples were digested with ultra-pure nitric and perchloric acids for gills in 4:1 at 100°C until the solution become clear. The solution was made up to known volume with deionized distilled water and analysed for Copper (Cu), Cadmium (Cd), Lead (Pb), Nickel (Ni), Mercury (Hg) and Manganese (Mn) using the Atomic Absorption Spectrophotometer (Perkin Elmer Atomic Absorption Spectrometer Pinnacle 900T, Perkin Elma, U.S.A). The obtained results were expressed as mg kg^{-1} wet weight. Accuracy of analytical procedure was ensured using certified reference material (DORM-3). Data generated were analysed using descriptive statistics and regression analysis at $\alpha_{0.05}$. The results were presented as Mean±Standard deviation (S.D).

Results and Discussion

The body size measurement of *Clupea harengus* and *Scomber scombrus* investigated is as shown in Table 1. The mean body weight of *C. harengus* (388.67±90.50g) was insignificantly larger than *S. scombrus* (256.67±6.51g). For total length, the two species were not significantly different (P>0.05). This result is in tandem with the body sizes reported by Kareem *et al*. (2016) and Wangboje *et al*. (2019) on *C. harengus* and *S. scombrus* in Ibadan and Warri, Nigeria respectively.

Table 1: Lengths and weights measurement of the investigated *Clupea harengus* and *Scomber scombrus* samples in Maiduguri

Parameters	*Clupea harengus*			*Scomber scombrus*			Sig. value
	Min.	Max.	Mean	Min.	Max.	Mean	
Weight(g)	298.00	497.00	388.67±90.50	240.00	273.00	256.67±6.51	0.036
SL (cm)	27.00	30.10	28.87±1.64	21.00	24.00	22.50±1.50	0.008
TL (cm)	31.00	36.00	33.67±2.52	24.00	29.00	26.67±2.52	0.027

Min minimum, *Max* maximum, *SL* standard length, *SL* total length, *p<0.005

The concentration of heavy metals in *Clupea harengus* and *Scomber scombrus* muscle was depicted in Table 2. Similar level of contamination in the order of Mn>Cu>Ni>Hg>Cd>Cr>Pb were found in the two species. It is evident from the table that *C. harengus* muscle has slightly higher Cu (0.26±0.05mg kg-^{1}), Cd (0.017±0.006mg kg-^{1}), Ni (0.16±0.03mg kg-^{1}), Cr (0.015±0.004mg kg-^{1}) and Mn (0.62±0.05mg kg-^{1}) than *S. scombrus* flesh (P<0.05). However, Hg (0.13±0.12mg kg-^{1}) and Pb (0.010±0.007mg kg-^{1}) was insignificantly higher in *S. scombrus* muscles(p<0.05). However, the heavy metal levels in muscle of investigated species in this study fell within the recommended threshold limit of Food and Agriculture Organization/World Health Organization. These results compared well with similar species as reported by Wangboje *et al*. (2019) in Warri market, Nigeria. Meanwhile, this result was comparatively lower to the findings of Kareem *et al.* (2016), Oluyemi and Olabanji (2011) in frozen *C. harengus* and *S. scombrus* from Ibadan and Ile-Ife markets, Nigeria respectively. Also, the Lead concentration obtained in the present study was lower than those recorded in *Scomber scombrus* from Zaria market, Nigeria (Abubakar *et al*., 2015).

Table 2: Mean concentration of heavy metals in *Clupea harengus* and *Scomber scombrus* muscles (mgkg-^{1})

Parameters	Muscle		Threshold limit
	Clupea harengus	*Scomber scombrus*	
Copper (Cu)	0.26±0.05	0.17±0.05	30.00 (FAO/WHO, 1989)
Cadmium (Cd)	0.02±0.01	0.01±0.01	0.10 (FAO/WHO, 2003)
Lead (Pb)	0.01±0.00	0.01±0.01	0.30 (FAO/WHO, 2011)
Nickel (Ni)	0.16±0.03	0.15±0.01	0.20 (FAO/WHO, 2005)
Chromium (Cr)	0.02±0.00	0.01±0.01	0.15 (WHO, 1985)
Mercury (Hg)	0.02±0.01	0.13±0.12	0.50 (FAO/WHO, 2011)
Manganese (Mn)	0.62±0.05	0.50±0.06	1.00 (FAO/WHO, 2003)

The level of contamination in gill was in the order of Mn>Hg>Cu>Ni>Cr>Cd>Pb for Herring and Mn>Cu>Ni>Hg>Cd>Cr>Pb for Atlantic mackerel (Table 3). Higher concentration level of mercury (0.17±0.13mg kg-^{1}) was found in *C. harengus*, while copper (0.17±0.07mg kg-^{1}), cadmium (0.02±0.00mg kg-^{1}), nickel (0.17±0.05mg kg-^{1}) and manganese (0.51±0.08mg kg-^{1}) levels were higher in *S. scombrus*. However, the values obtained for all investigated parameters were not statistically significant (p<0.05) between the species. The concentration of heavy metals obtained from the gill in this study was in consonance with the recommended range for consumption (FAO/WHO, 2003; 2011). This results however differ from the findings of Kareem *et al*. (2016) who reported higher Pb (2.52±0.28; 10.38±0.91mg kg-^{1}), Cd (0.78±0.17; 0.91±0.12mg kg-^{1}), Cu (3.93±0.60; 5.77±0.98mg kg-^{1}) and Hg (0.06±0.01; 0.09±0.00mg kg-^{1}) for Herring and Atlantic mackerel in Ibadan, respectively. Oluyemi and Olabanji (2011) also recorded higher concentration of Hg, Pb, Cr, Cd and Ni in gills of *C. harengus* and *S. scombrus* from Ile-Ife market, Nigera. Similar observations were reported by Abubakar *et al*. (2015) in in the gills of Atlantic mackerel sold in Zaria, Nigeria.

Table 3: Mean concentration of heavy metals in *Clupea harengus* and *Scomber scombrus* gills (mg kg-1)

Parameters	Gill		Threshold limit
	Clupea harengus	*Scomber scombrus*	
Copper (Cu)	0.16±0.06	0.17±0.07	30.00 (FAO/WHO, 1989)
Cadmium (Cd)	0.01±0.00	0.02±0.00	0.10 (FAO/WHO, 2003)
Lead (Pb)	0.01±0.01	0.01±0.01	0.30 (FAO/WHO, 2011)
Nickel (Ni)	0.12±0.02	0.17±0.05	0.20 (FAO/WHO, 2005)
Chromium (Cr)	0.02±0.00	0.02±0.01	0.15 (WHO, 1985)
Mercury (Hg)	0.17±0.13	0.15±0.08	0.50 (FAO/WHO, 2011)
Manganese (Mn)	0.41±0.03	0.51±0.08	1.00 (FAO/WHO, 2003)

Conclusion

The study revealed moderate concentration of heavy metals (Cu, Cd, Pb, Ni, Cr, Hg and Mn) in gills and muscle tissues of *Clupea harengus* and *Scomber scombrus* sold in Maiduguri metropolis. These heavy metals content is within the threshold limit of Food and Agriculture Organization/World Health Organization. Hence, the species are safe for human consumption in Maiduguri. There is however, the need for regular monitoring of the frozen fish coming to Maiduguri for human safety.

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Effect of ammonia (NH_3) toxicity in freshwater on the growth and haematology parametrs of *Clarias gariepinus* fingerlings

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ABSTRACT
The effect of ammonia (NH_3) toxicity on the growth and haematology of African catfish *Clarias gariepinus* (Burchell, 1822), in freshwater was studied and the objective was to determine the safe concentration level of ammonia (NH_3) in an aquatic environment. Fingerlings with average mean weight of 1.52 $\pm$ 0.30g was investigated under laboratory conditions at static bioassay for 96 hours and Acute 14 days respectively. Three replications each of five treatment concentrations (T1, T2, T3, T4 and control) were used for both toxicity exposures. Three hundred (300) fingerlings with 150 *Clarias gariepinus* for acute and 150 *Clarias gariepinus* for sub-acute exposures were researched A pre-experimental trial was carried out on trial and error basis to establish the LC_{50} concentration of the ammonia (NH_3) solution used. The 96th median lethal concentration LC_{50} of T4 (4.00), T3 (3.00), T2 (2.00) and Control (0.00) g.L^{-1} gave a mean value of 3.02$\pm$0.02 g.l^{-1} with upper and lower limits of 6.28 and 1.42 g.l $^{-1}$ respectively. Values for the 14days sub-acute exposures to ammonia (NH_3) concentrations of T4 (1.00), T3 (0.80), T2 (0.60) and control (0.00) g.1^{-1} were also obtained. Growth indices indicate significant decrease (P<0.05) in the total feed intake (TFI), specific growth rate (SGR), mean weight gain (MWG) and food conversion ratio (FCR) in all the treatment than in control. There were significant differences (P<0.05) in all haematological parameters: packed cell volume (PCV), haemoglobin concentration (HB), red blood corpuscles (RBC) and white blood corpuscles counts (WBC). Significant decreased (P<0.05) in the values of the above parameters using the various treatments relative to the control showed increase in T1 and T3 and decreases in T4. Decreases in the number of blood cells (HB and WBC) noticed may be due to ailments caused by anemia, haemodilution and haemolysis.

Keywords: acute exposure, ammonia (NH_3) toxicity, *Clarias gariepinus*, haematological parameters, sub-acute exposure.

INTRODUCTION

Stress has been linked to the main contributing factor of fish disease and mortality in aquaculture (Pelric e*t al.*, 2006). Stress in fish causes hormonal changes which decrease the effectiveness of inflammatory responses. Stress also impairs the production and release of anti-bodies. Fish reared under commercial aquaculture environments are confined to the production units and are predisposed to stress conditions. Chemical stressors from nitrogenous and metabolic wastes such as ammonia (NH_3) counteract the improved performance of cultivated fish. Knowledge about fish response to stressors is important to improve fish production and provide information on ways to effectively control and monitor stress in aquaculture (Pottinger, *et al.*, 1992; Pickering, 1993; Schreck, *et al.*, 2001). *Clarias gariepinus* is one of the most cultured fish in Nigeria (FAO, 1997). Its sustainability for culture is exhibited in almost every part of the tropics. This is due to its hardy nature and ability to grow and breed under a wide range of culture conditions. The study of the responses of *Clarias gariepinus* to water quality stressors i.e. ammonia (NH_3) is cogent with a view to improving knowledge about its effective production. Ammonia (NH_3) is present in the aquatic environment due to agricultural run-offs and decomposition of biological wastes. Ammonia (NH_3) is toxic to all vertebrates and causes convulsion, coma and death, probably owing to the fact that elevated NH4+ displaces K+ and depolarizes neurons. This in effect causes the activation of N-methyl-D-aspartate which is one of the three types of ionotropic glutamate receptor. The result is an influx of excessive Ca^{2+} and subsequent cell death in the central nervous system (NMDA). During exhaustive exercise and stress, fish increases ammonia (NH_3) production and become more sensitive to external NH_3. Fish have strategies that protect them from ammonia (NH_3) pulse consequent upon feeding. This invariably protects them from increases in external ammonia (NH_3). Hence, starved fish are more sensitive to external ammonia (NH_3) than fed fish (Randall, D.J. *et al.*, 2002).

Ammonia (NH_3) is the principal waste product of diet excreted by fish. In trace amounts, ammonia (NH_3 is odorless and tasteless. One of the methods of assessing the concentration of ammonia (NH_3) in water is to test the water. Of all the water quality parameters that affect fish, ammonia (NH_3) is the most important after dissolved oxygen (O_2) in water especially in intensive aquaculture systems. Ammonia (NH_3) causes stress and gill damage in fish even when available in small amounts. Fish exposed to low levels of ammonia (NH_3) over time are more susceptible to bacterial infection, poor growth and inability to tolerate handling by fish culturists.

Against this background, this study was designed to investigate the effect of ammonia (NH_3) toxicity in fresh water on the growth and haematology of *Clarias gariepinus* fingerlings The essence was to determine the tolerance of *Clarias gariepinus* in (NH_3) concentrated environments; determine the growth and survival rates of the fish when exposed to sub-lethal concentrations of ammonia (NH_3) in water, and assess the haematological responses of fish to ammonia (NH_3) toxicity.

MATERIALS AND METHODS

The research was carried out at the Laboratory of the Department of Fisheries and Aquaculture, Ebonyi State University, Abakiliki, Nigeria. Three hundred (300) active *Clarias gariepinus* fingerlings (1.52$\pm$0.30g) were collected from a reputable fish farmer in Abakiliki (Regina Pacis Farm) and transported to the Wet Laboratory in well oxygenated containers filled to capacity with water from the farm pond. The fish obtained were of the same genetic background and appeared healthy. They were immediately acclaimed for 14days under laboratory conditions and fed with 2mm multi-feed diet as maintenance ration at 3% body weight per day (bd.d^{-1}). Two distinct experimental periods were adopted for this study namely: the acute toxicity period and sub-acute toxicity period.

Records of fish weight were taken with an electronic sensitive weighing balance to ascertain the weight of fish before the commencement of the study. Fish were randomly stocked in 15 plastic containers (25 litres capacity) at 10 fish per container and inundated with 20 litres dechlorinated tap water which had the quality parameters (temperature, pH, Do, free $C0_{2,}$ total alkalinity and ammonia (NH_3) (APHA, 2000). The experiment was designed to have four (4) treatments of graded concentrations of (NH_3) and a control (without ammonia (NH_3) for ease of comparison of the response of fish to the various (NH_3) concentrations used. The treatments were replicated to provide 15 experimental treatments for the acute and sub-acute toxicity studies each. Blood samples were collected from the caudal peduncle of the fish with the aid of 2.5ml capacity syringes and hypodermal needles treated with an anti-coagulant (EDTA). The following haematological parameters were analyzed in the laboratory: Packed Cell Volume (PCV), White Blood Corpuscles (WBC), Red Blood Corpuscles (RBC) and Haemoglobin Concentration (HB).The (NH_3) was obtained from ammonia (NH_3) solution SG. 088, manufactured and packaged by Griffin and George, England.

Statistical analysis was applied to determine the effect of sub-acute (NH3) levels of fish growth and survival. Results obtained were subjected to one way analysis of variance (ANOVA) to determine significant differences between the treatment means and the control. The Durcan's multiple Range Test was used to separate the differences among treatment means. Differences were considered significant (P<0.05) (Steele and Torrie, 1990).

RESULTS

The total number of dead *Clarias gariepinus* fingerlings per day in the various ammonia (NH_3) concentrations re shown in Table 1. The mortality rate of the exposed fingerlings for acute toxicity studies increased from T4 (4.00 $g1^{-1}$ to T1 (1.00 $g.1^{-1}$). The result shows that mortality was 30% (T1=1.00$g.1^{-1}$), 56.67% (T2=2.00$g.1^{-1}$), 60% (T3=3.00$g1^{-1}$) and 73.33% (T4=4.00$g.1^{-1}$), with no record of mortality in control (T=0.0$g.1^{-1}$).

It was observed that the mortality rate of fish in T4 increased at 24h and gradually reduced at 96h; while mortality in T1 increased at 96h although values obtained were lower than those recorded with T4. The 96h median lethal concentrations (90h, LC_{50} determined graphically with probit versus log concentration. (Fig. 1) gave a mean value of 3.02$g1^{-1}$ with upper and lower confidence limits of 6.28 and 1.45$g.1^{-1}$ respectively. The threshold concentration also determined graphically from a plot of log of survival time versus log concentration (Fig.2) gave a value of 1.00$g.1^{-1}$. The safe concentration was determined by calculations from the product of multiplying $LC_{50}$by 0.01 (Koesoemendinate, 1980) and a value of 0.03$g.1^{-1}$ was obtained.

Table 2 illustrates the growth performance of *Claris gariepinus* fingerlings exposed to sub-acute concentrations of (NH_3) viz: Control (1.00), T1 (0.40), T2 (0.60), T3 (0.80) and T4 (1.00) $g.1^{-1}$ respectively within 14 days study periods. The analyzed data indicated that the mean number of fingerlings differed significantly (P<0.05) between all (NH_3) treatments but non-significantly (P>0.05) between T1 (0.40 $g1^{-1}$) and T4 (0.00 $g1^{-1}$).

The total feed intake (TFI) showed no significant difference (P>0.05) in all the treatments including the Control. The specific growth rate (SGR) showed significant difference (P<0.05) in all the treatments but the Control treatment did not show any significant difference (P>0.05) with T1 and T2. Similarly, no significant (P>0.05) difference was recorded between T3 and T4.

Furthermore, significant differences (P<0.05) existed among the mean weight gain (MWG) in all the treatments, while no significant difference (P>0.05) was derived between the control and T2. The same trend was exhibited for mean weight gain between T1 and T3. In addition, significant differences (P<0.05) were obtained by analyzing data on WBC was analyzed. The same pattern was shown with the red blood corpuscles (RBC).

DISCUSSION

The assessment of the total number of dead fish in this study (Table 1) when exposed to the various ammonia (NH_3) concentrations under acute toxicity situation indicated that the exposed fish showed signs of toxicosis. This physiological malfunction involved uncoordinated movements, air gulping, attempted escape, convulsion and quiescence before death. The results from this study agreed with Harris *et al* (1998) on fish toxicology.

In the sub-acute exposure of fish, differences recorded in the final number of fish may be attributed to environmental factors and/or ammonia (NH_3) concentration levels leading to mortality (T1 and T4).

Furthermore, available mortality results on the final weight of fish indicated hat the lowest observable effect gave the value of 0.4g.1^{-1} for the final weight. This result is consistent with the report of Saber *et al* (2004) which indicated that the observable effect of ammonia (NH_3) concentration on the growth performance of Nile Tilapia was 0.14 mg.1^{-}1 Un-Ionized Ammonia Nitrogen (UIA-N). This variation may be due to the concentration levels the fish species used. On the other hand, the final weight of the marine fish decreased when UIA-N.1^{-1} concentration increased (Foss et *al*, 2003; Lemarie *et al*, 2004). These authors reported that weight decreased with increasing concentrations of UIA-N.L-1. This trend was attributed to the decrease in daily feed intake, and decreases in food conversion efficiency.

From Table 2, food intake reduced with increases in ammonia (NH_3) concentration although with very little variation. This result agreed with the report of Foss et al *2*002:2003: 2004; Saber *et al* 2004.

The significantly lower (P<0.05) SGR values in T3 and T4 than those of the control, T1 and T2 in this study also agreed with the report of Saber *et al* 2004. Similarly, other researchers such as Harris et al (1990) and Foss *et al* 2003:2004) reported that SGR of fish decreased with increasing concentration of (NH_3) and this was attributed to decreases in food intake. The significant decrease in mean weight gain (MWG) exerted on fish by the various ammonia (NH_3) treatments as ammonia (NH_3) levels increased is also consistent with the report of Foss *et al (2*002:2003:2004), Lamarie *et al* (2004) and Saber *et'al* (2004). Furthermore, the significant decrease (P<0.05) of MWG between T3 and T4 compared to the control is attributed to decrease in daily food consumption. Wang and Walsh (2000) reported a reduction in MWG of fish under investigation and attributed this to some physiological disturbances in the fish. The higher FCR value in this study, showed lower conversion of food to muscles (Table 2). This result was in agreement with the report of Foss *et al* (2004), which stated that the mean FCR of fish decreased as the UIA concentration increased.

On haematological analysis, the significant (P<0.05) decreases in PCV, RBC and HB levels were in line with the results obtained by Fafioye (2002). The author noted significant (P<0.05) decreases in haematological parameters especially between the control fish and the fish of both *Clarias gariepinus* and *Oreochromis niloticus* exposed to aqueous and ethanoic extracts of *Rafia vinefera* and P*arkia biglobosa.* The decreased value of PCV may be due to anaemia, haemodilution or haemolysis of RBC (Fafioye, 2002). Saee (1997) also recorded a marked reduction in RBC count and HB concentration after the exposure of *O. niloticus* to acute ammonia (NH_3) concentration.

Recommendations

This study therefore recommends ammonia (NH_3) concentration within any water body especially those used for intensive aquaculture should not be above 0.9g per litre in order to support the growth and survival of fingerlings in such water body.

TABLE 1: Relationship Between the Exposures to Ammonia (Nh_3) Concentration with Mortality Rate of *Clarias gariepinus* Fingerlings

Plastic Container	Number of Test Fish	Number of Replicates	Conc. ($g.1^{-1}$)	24hrs	48hrs	72hrs	96hrs	Total Number of Mortality	Number of Fish	% Mortality	% Alive
Control	10	3	0	0	0	0	0	0/30	30	9	100
T1	10	3	1	2	1	1	5	9/30	21	30	70
T2	10	3	2	2	2	6	7	17/30	13	56.67	43.33
T3	10	3	3	9	2	3	4	18/30	12	60	40
T4	10	3	4	19	2	0	1	22/30	8	73.33	26.67

Values with similar superscript do not vary significantly at P$\leq$.0.5.
Values with different superscripts are significantly different P<0.05

TABLE 2: Mean Growth Performance of *Clarias Gariepinus* Fingerlings Exposed To Sub-Acute Concentration Of Ammonia (NH_3)

Growth Parameters	**Control ($0.00g.1^{-1}$)**	**T1 ($0.40g.1^{-1}$)**	**T2 ($0.60g.1^{-1}$)**	**T3 ($0.80g.1^{-1}$)**	**T4 ($1.00g.1_{-1}$)**
Initial Number of Fish	10.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.00
Final Number of Fish	10.00 ± 0.00	$8.67 \pm 33b^{c}$	9.00 ± 0.00^{bc}	7.00 ± 1.15^{ab}	16.33 ± 0.89^{a}
Initial Weight (g)	16.47 ± 3.47^{a}	19.23 ± 2.43^{a}	16.37 ± 2.00^{a}	18.40 ± 1.82^{a}	16.60 ± 0.78^{a}
Final Weight (g)	18.11 ± 3.82^{b}	18.21 ± 1.88^{b}	16.20 ± 1.98^{ab}	11.71 ± 4.42^{ab}	6.76 ± 1.60^{a}
TFI	1.72 ± 0.37^{a}	1.87 ± 0.21^{a}	1.63 ± 0.19^{a}	1.50 ± 0.28^{a}	1.17 ± 0.11^{a}
SGR	0.33 ± 0.02^{b}	0.14 ± 0.10^{b}	0.02 ± 0.02^{b}	3.04 ± 1.61^{a}	3.04 ± 0.86^{a}
MWG	0.82 ± 0.17^{c}	0.51 ± 0.42^{bc}	0.82 ± 0.01^{c}	3.44 ± 1.88^{ab}	4.91 ± 0.60^{a}
FCR	1.05 ± 0.00^{b}	6.89 ± 3.05^{a}	9.95 ± 0.00^{a}	3.40 ± 3.27^{ab}	0.12 ± 0.02^{b}
PSR	100 ± 0.00^{c}	86.67 ± 3.33^{bc}	99.00 ± 0.00^{bc}	70.00 ± 11.54^{ab}	63.33 ± 8.82^{a}

TFI = Total Feed Intake, SGR = Specific Growth Rate, MWG = Mean Weight Gain,

FCR = Food Conversion Ratio, PSR = Percent Survival Rate.

Values with similar superscript do not vary significantly at $P \leq .0.5$.

Values with different superscripts are significantly different $P<0.05$

TABLE 3: Haematological Parameters of *Clarias Gariepinus* Subjected To Sub-Acute Concentrations Of Ammonia (NH_3) For 14 Days

Growth parameters	**Control ($0.00g.1^{-1}$)**	**T1 ($0.40g.1^{-1}$)**	**T2 ($0.60g.1^{-1}$)**	**T3 ($0.80g.1^{-1}$)**
Ammonia (NH3) Free	18.99 ± 0.01^{b}	6.40 ± 0.00^{c}	6200.04 ± 0.04^{d}	3.97 ± 0.03^{d}
Control	18.32 ± 0.32^{b}	6.03 ± 0.03^{b}	6000.07 ± 0.04^{c}	3.81 ± 0.01^{c}
T1 ($0.40g.1^{-1}$)	16.65 ± 0.33^{a}	5.31 ± 0.01^{a}	5700.04 ± 0.31^{b}	3.60 ± 0.00^{b}
T2 ($0.60g.1^{-1}$)	20.99 ± 0.01^{d}	7.20 ± 0.00^{c}	7300.05 ± 0.03^{b}	4.31 ± 0.01^{b}
T3 ($0.80g.1^{-1}$)	16.64 ± 0.32^{a}	5.30 ± 0.00^{a}	$5500.02 + 0.01^{a}$	3.41 ± 0.01^{a}
T4 ($1.00g.1^{-1}$)	19.99 ± 0.01^{c}	6.52 ± 0.01^{d}	6300.03 ± 0.03^{c}	4.20 ± 0.01^{c}

PCV = Packed Cell Volume, HB = Haemoglobin, WBC = White Blood Corpuscles, RBC = Red Blood Corpuscles.

Values with similar superscript do not vary significantly at $P>.0.5$.

Values with different superscripts are significantly different $P<0.05$

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Relationship between heavy metals uptake in crab organs and sediment of Lagos Lagoon

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Abstract
Blue crab samples were collected from 6 sampling stations; Makoko, Okobaba, Iddo, Ajah, Ikoyi and Mid-lagoon of the Lagos lagoon, a crab fisherman was employed for crab fishing monthly for 24 months, (n=1750; circular lift nets 50-76mm) were transported alive to the laboratory. The crab was dissected with forceps, after which 5g of hepatopancreas, gill, gonad and muscle organ were remove and preserved in refrigerator at-21^{0}C. The organs were digested using 25ml of freshly prepared concentrated Nitric acid (HNO_3) and Hydrochloric acid (HCl) mixture in ratio 1:1, digestion was carried out on electric cooker in a fume cupboard while the temperature gradually rose up to a maximum of 160'C. Heating process was sustained for about 2 hrs, while reducing the volume in the beaker to about 5ml. After the beaker and its contents cooled, the content was transferred into a 50ml volumetric flask using aWhatman filter paper (filtration) and topped up with distilled water to 50ml mark. The biplots of metal concentration in the crab organs, shows different type of connections at the tip of ellipses between the mid-lagoon and other stations. This indicates that metal uptake patterns vary in organs of *C. amnicola*. The presence of organic matter, type of grain size can potentially increase metal concentrations in sediment by adsorption of metals from surrounding environment unto organic material which influence the metal uptake in the organs.

Keywords: Lagos lagoon, Heavy Metals, Pollution, and Blue crab.

Introduction
The increase in Heavy metal pollution in the aquatic environment including Lagos lagoon has been due to release or dumping of untreated waste including industrial effluent, solid waste, sewage, agricultural waste and so on. This is due to higher level of civilization and industrialization in Lagos metropolis (Olakolu and Chukwuka, 2014). Lagos have been reported to account for larger percentage of industries in Nigeria (Akinsanya, 2003 and Oketola and Osibanjo, 2009a) and most of these industries discharge untreated effluent directly or indirectly through drainages and canals into the Lagos lagoon complex thereby polluting the nursery ground of both fin-fishes and crustaceans (Oyewo, 1998 and Adebayo *et al*., 2007). Documentations from several authors give the daily disposal of effluent into the lagoon to be about 10,000m^3. (Oyewo, 1998 and Oketola, and Osibanjo, 2009b).

The Lagos lagoon, while serving as a receptacle for pollution, also serves as an ecosystem for a vast diversity of aquatic organisms. Regular disposal of untreated waste (domestic, sewage, saw-mill, industrial effluent, oil pollution and so on) in the Lagos lagoon has contributed immensely to decline in species richness and distribution of aquatic organism (Akinsanya, 2003 and Kamaldeen and Wahab, 2011).

Fish, shell fish, benthic organisms and other living resources have been affected by the pollution status and used greatly by toxicologist for biomonitoring studies. Majority of the coastal dwellers consumed shell fish including crab for food as a source of protein, therefore crab state of health is vital to public health (Adebayo *et al*., 2007).

The presence of a particular pollutants in the environment, does not show that the pollutants bio-accumulate in biological system and conclusions on the pollutant effects on the system cannot be made based on the result of chemical analyses (Wright and Welbourne 2002). However, the aim of this study is to measure heavy metals concentration in the organs of the blue crab C*allinectes amnicola* from the Lagos lagoon and determine the relationship in their uptake pattern in different organs of various stations.

Materials and Methodology
Sample Collection: Blue crab (*Callinectes amnicola*) samples were collected at six stations from Lagos lagoon; Makoko (N06^{0}29.721; E003^{0}23.986), Okobaba (N06^{0}28''.004; E003^{0}23''.353) (site of saw-mill industry and waste), Iddo (N06 ^{0}28''.044; E003^{0}22''.595) (receiving untreated sewage site), Ajah (N06^{0}28''178; E003^{0}32''558), Ikoyi (N06^{0}26''.180; E003^{0}27''. 052) and Mid-lagoon (N06^{0}31''.541; E003^{0}25''.575). (control) from a crab fisherman that was employed for crab fishing monthly for 24 months. Crabs (n=750; circular lift nets 50-76mm) were sampled within the ranges of each sampling stations and transported alive to the laboratory.

Dissection and preservation of crab organs*:* Crab sample were dissected using forcept to remove the selected organs according to the method of Harriet (2001) and preserved at -21^{0}c in a refrigerator, for further analysis.

Heavy Metal Analysis:
Digestion of Crab Sample: The crab organs (hepatopancreas, gills, gonad and muscles) were allowed to thaw, after which 5g of hepatopancreas, gills, gonad and muscles of crab were weighed on a sensitive weighing balance

into different 100ml beakers and digested with 25ml of freshly prepared concentrated Nitric acid (HNO_3) and Hydrochloric acid (HCl) mixture in ratio 1:1 (FAO/SIDA, 2003).

Digestion of Sediment Sample:
The bottom sediment samples from each study station were dried in open air and subsequently sieved with a 200mm mesh screen. 5g of the sediment wastaken into 100 mL conical flasks and digested with 25ml of freshly prepared concentrated Nitric acid (HNO_3) and Hydrochloric acid (HCl) mixture at a ratio of 1:1.

Digestion was carried out on electric cooker in a fume cupboard while the temperature gradually rose up to a maximum of 160'C. Heating process was sustained for about 2 hrs, while reducing the volume in the beaker to about 5ml. After the beaker and its contents cooled, the content was transferred into a 50ml volumetric flask using a Whatman filter paper (filtration) and topped up with distilled water to 50ml mark (FAO/SIDA, 2003)

The digested samples were then analyzed in the Central Laboratory of NIOMR using a Flame Atomic Absorption Spectrophotometer model Varian SpectAA 400 plus AAS with aqueous calibration standard prepared from the stock standard solutions of the respective elements. (APHA-AWWA-WEF, 2005).The results obtained were compared with the NESREA and WHO standard limit.

Data analysis:
All data were recorded as Mean and Standard Deviation (Mean±SD). The SPSS version 20.0 was used for analysis. Discriminant function analysis (DFA) was used to check the relationship between the stations and heavy metal concentration in the organs

Result
The uptake Pattern of Heavy Metals Concentration by Organs of *C amnicola* in Relation to the Sample Stations was determined using the biplots in the discriminant analysis; The biplots of metal concentration in Hepatopancreas (Figure 1), shows a close connection contacting at the tip of ellipses between the mid-lagoon and other stations. This indicates that metal uptake patterns in Hepatopancreas of *C. amnicola* from mid-lagoon may not be as distinct from uptake pattern found in the Hepatopancreas of *C. amnicola* from other stations.

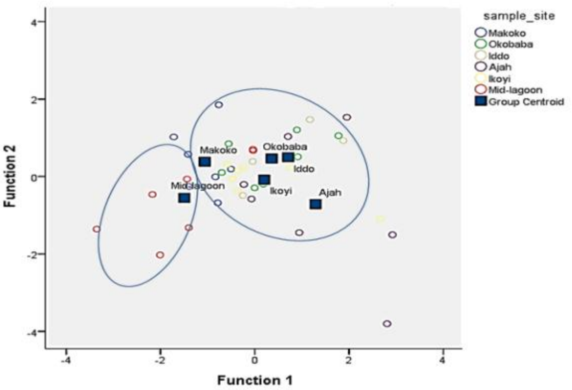

Fig 1: Discriminant Analysis for Heavy metal in Hepatopancreas across the stations

The discriminant ballot for metals in gills shows two distinct ellipses, in near contact. This biplots depicts that metal uptake patterns in crab gills around the mid-lagoon was slightly distinct from metal uptake patterns in gills of crabs from other stations (Figure 2).

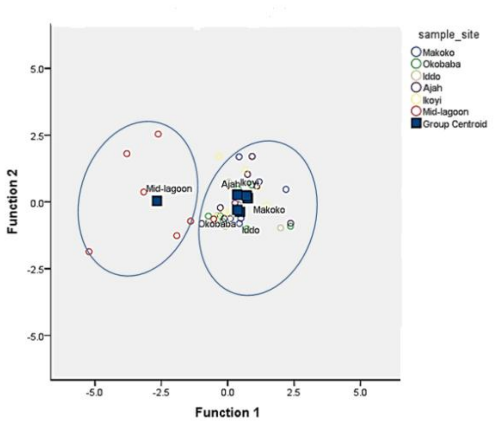

Fig 2: Discriminant Analysis for Heavy metal in gill in all the stations

Similarly, Figure 3 shows the distinct ellipse between the mid-lagoon cluster and cluster of other stations combined also depicts differences in uptake patterns of metals in gonads of crabs from Mid-lagoon compared with uptake patterns in gonads of crab from all other station.

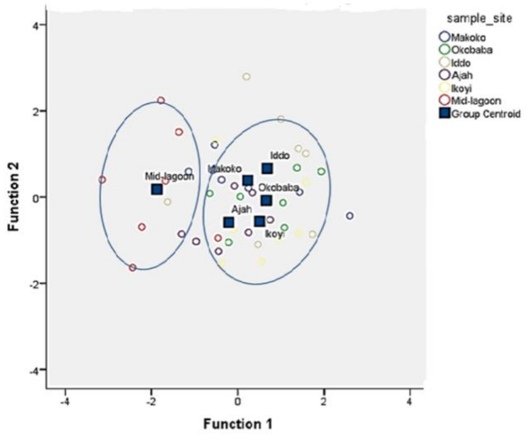

Fig 3: Discriminant Analysis for Heavy metal in gonad tissue across the station

The biplots of metal concentration in crab muscle (Figure 4) showed an overlap in ellipses between the mid-lagoon cluster and the cluster of other stations. This indicates that levels of metals in muscle may not be distinctly different crab muscles from Mid-lagoon and crab muscles from all other sampling stations.

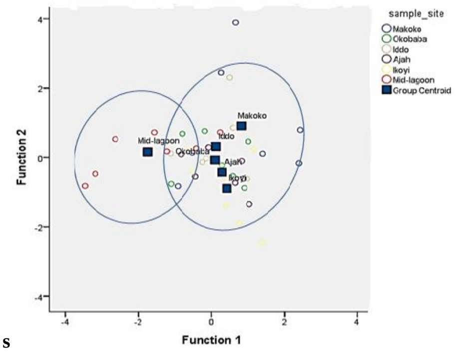

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Fig 4: Discriminant Analysis for Heavy metal in muscle across the station

Analysis of variance shows the variations in concentration of Cadmium, Lead and Zinc, were not significantly difference at 95% ($p>0.05$), however, Cu concentration in the organs shows a significant difference at 95% ($p<0.05$) between the sample stations.

Discussion

The biplots of metal concentration in hepatopancreas which is closely connected at the tip of ellipses of the Mid-lagoon and other station and the biplots of metal concentration in gill and gonad of *C. amnicola* which are distinct ellipse indicate that the uptake patterns of metals in hepatopancreas, gill and gonad of *C. amnicola* from mid-lagoon was different from uptake patterns of metals in hepatopancreas gill and gonad of crabs from other stations.

The distinct uptake patterns of heavy metals observed in hepatopancreas, gill and gonad of crab from Mid-lagoon and other stations may be attributed to the sediment texture and composition including grain size, organic matter content. Distribution of grain sizes has been reported to influence trace metal levels and uptake in coastal environments (Luoma, 2000). Reports have demonstrated that trace metals reside mostly in the silt/clay matrices of sediment, i.e. particles with size <0.063 mm (Krumgalz *et al.,* 1992). Also, the organic matter content of sediments increase as the sediment texture becomes finer (Williamson & Wilcock, 1994; Denton *et al*., 2001). The presence of organic matter can potentially increase metal concentrations in sediment by adsorption of metals from surrounding environment unto organic material (Loomb, 2001).

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Toxicity of Lime Fruit Juice to an African Leech (*Hemiclepsis quardrata*) and Its Haematophagous Potential.

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Abstract

The potential of lime fruit juice from *Citrus aurantifolia* plant as an effective water sanitizer against an African leech called *Hemiclepsis quardrata* and pattern of blood consumption were investigated. *H. quardrata* were exposed to lime fruit juice at concentrations of 0.00, 0.94, 2.07 and 4.55 ml/L under laboratory conditions for 48 hours and 96 hours, respectively. The LC_{50} values of 1.55ml/L and 0.67ml/L at 48-hr and 96-hr, respectively, were obtained through graphic and probit analyses. Blood from three organisms (*Clarias gariepinus, Heteroclarias* and man) was used during the feeding trial in three days; using 2.0 meals of blood per source per test tube. Each treatment was replicated thrice to accommodate a total sample of nine (9). The investigation was repeated thrice. Data was analyzed using descriptive statistics. A decreasing order of blood consumption (g) ranked preference for the blood of man (1.34), *Clarias gariepinus* (0.95), and Heteroclarias (0.76) in three (3) days. Lime fruit juice is effective in controlling the population of African leech but a direct skin contact with the parasitic insect should be avoided by fish farmers.

Introduction

Leeches are segmented worms and belong to the phylum annelida (Buchsbaun *et al*., i987; Wikipedia, 2019). The majority of leeches live in freshwater environment although some species can be terrestrial (Fogden and Proctor, 1985). Some leeches are haematophagous because they feed on vertebrate blood as well as invertebrate haemolymph (Sawyer et al., 1981; Agbowei and Ezekiel, 2011). However, majority of leech species are predatory because they feed on many invertebrates by swallowing. These preys for the leech include amphibians, reptiles, water fowl, fish and ma (mammals. Indeed, about 700 species of leeches are presently recognized where 100 are marine, 90 terrestrial and more than 200 belong to freshwater taxa (Sket and Trontalj, 2008).

It is a required practice of a good aquaculture production to prevent an invasion of pond by unwanted organism. These unwanted organisms include predators (hibernating fish, frogs, alligators, and leeches}, excessive phytoplankton, water snails and some other aquatic insects (Tiwari *et al*., 2003; Adesina, 2008 ; Ajibade *et al*., 2017). Hence, an adequate sanitation of ponds, especially earthen and concrete ponds being fed by water from reservoirs, sluggish streams and rivers, is important before fry or juveniles can be stocked in ponds. This practice will boost the survival and adequate growth rate of the economic and cultivable species in a periodically reclaimed pond (Ajibade, 2016).

The influence of toxic agents on aquatic organism in relation to cellular, individual, population and community level is known as aquatic toxicology (Solbe, 1995; Odiete, 1999). There are three major types of toxicity relative to exposure period: acute toxicity (4 days of exposure), sub-lethal toxicity (about 28 days of exposure) and chronic toxicity (56 days of exposure) (FAO, 1977; Solbe, 1995; Ajibade, 2016). *Citrus aurantifolia* (Rutaceae) is a popular food and medicine. It also serves as a therapeutic agent against many diseases (Adepoju and Adeyemi, 2010). These uses may be associated with its toxic or acidic properties. The juice from the citrus fruit has cytotoxic ability (Xu et al., 2003), and antimicrobial against respiratory tract bacterial pathogens (Adepoju and Adeyemi, 2010). It is also useful in preventing prolificacy of lymphoblastoid cell line (tumour cells) as reported by Adeleye and Opiah (2003) and Gharagozloo et al., 2002). Its bioactive compounds also prevents infections, inflammations and cancer (So et al., 1996; Rooprai et al., 2001; Adepoju and Adeyemi, 2010). This present study, therefore, applied acute toxicity which support the evaluation of the concentration of lime juice that kill 50% of the targeted population of *H. quardrata* as a means of control, conservation and fairness through the median lethal concentration (LC_{50}). The ability of the freshwater insect to feed on blood and preference was also evaluated.

Methodology

Identification of organisms

Organism was observed under an electronic microscope (Olympus) and identified according to description and re-description of Moore (1939 and 1987). Diagnostic features include a depress body at rest, lack of distinct division of anterior and posterior regions, a narrower head than the body, three annuli per segment in the mid body region and eyes found in the head. Hence, the name batracobdella species (Gossipholidae). Further, discovery of detailed features led to reclassification into a genus called Hemiclepsis as *Hemiclesis quardrata*.

These features include a dilated head region, three pairs of eyes, ten pairs of caeca and possession of small genital atria (Oosthuizen, 1984).

Collection and acclimation of organisms.
One hundred and twenty leeches (*H. quardrata*) were harvested from inactive earthen fish ponds of Oyo State College of Agriculture and Technology, Igboora, Oyo state, Nigeria. Sweep-netting method for the invertebrates was used (Manson, 1977; Sutherland, 1997; Ajibade, 2016). The leech recorded an average length (cm) and weight (g) of 4.24 and 0.4. However, dissolved nutrients in the pond water which served as former habitat was added daily to the conditioning plastic chamber (height x πr^2= 2.3* 13.7*3.142) without a definite feeding to enhance a partial starvation and check fitness of health before targeted tests.

Range finding and definitive tests. A trial test was first carried out for 24-hour using 10.0ml/L, 15.0 ml/L, 20.0ml/L as freshly prepared concentrations of lime juice which served as treatment. Experimental chamber was a one (1) litre capacity glass jar. Each trial treatment was duplicated. However, randomly picked population from the stock were initially starved for 24 hours by allotment into glass jars with freshwater from a borehole (zero-feeding} for adequate response to lime juice during exposure. The definitive test used a spacing factor of 2.2 and seven leeches in each glass jar as described by Solbe (1995) and Odiete (1999). Four (4) treatments (0.00 ml/L, 0.94 ml/L, 2.07 ml/L, and 4.55 ml/L) were applied and each treatment in triplicates (Representative 1, 2 and 3).The definitive test period was 96 hours. Static non-renewal method as described by Solbe (1995) was applied which helped in reducing external stress and chemical variation. Mortality per treatment was observed and recorded every four (4) hours. Selected physicochemical parameters were measured and analysed by the method of A.P.H.A (1988); pH-meter (water acidity), mercury in glass thermometer (water temperature), and titration method for dissolved oxygen (Boyde, 1981).

Blood consumption by the African leech (*H. quardrata*) was rated by feeding with three different types of blood from three sources, separately. Blood offered were sourced fresh from *Clarias gariepinus*, Heteroclarias and man (O +ve and genotype AA).These trials were carried out per blood over a period of three days in test tubes guided by rack and covering nets to disallow escape but supported oxygenation in the laboratory. Fish blood was obtained from the network of blood capillaries along the vertebral column using needle and syringe. 2.0 mls of blood was allotted to each test tube which housed one African leech (*H. quardrata*). A triplicate arrangement per diet was used during investigation to give a total of three representatives per source of blood. The experimental period was seventy-two hours and investigations were repeated thrice to increase precision of values. Blood consumption by the leech was estimated by deducting the initial weight of each test tube from the total weight of blood and tube at 24 –hr, 48-hr and 72 hr. The experimental design was a complete randomized design (CRD) with the model Yij = U + Ti + eij (u= universal mean, Ti = treatment, eit = random error). Descriptive statistics (mean, percentages and graphs) were used in describing the blood consumption pattern of the African leech. Also, probit analysis (a regression model) was used to relate lime fruit juice and mortality of *H. quardrata.*

Results And Discussion:
The selected water quality parameters of the experimental units agreed with the range of values reported by Kumar (1992) and Ajani et al. (2011). However, the water acidity (pH) values were progressively reduced with increase in concentration of lime fruit juice because of its richness in acidity (Table 1). Data from the present study also shows that lime juice is toxic to adult African leech (H. quardrata). The mass mortality recorded as the concentration was increased agreed with the report of Xu et al. (2003) and Adepoju and Adeyemi (2010) that observed cytotoxic ability of lime juice against microbes. Also, the present study recorded high yield of extract using hot extraction method. Behaviorally, the leech under exposure showed signs of distress on application of lime fruit juice to the 1 litre capacity glass jars containing water and seven (7) leeches each. The organisms were restless and looking for comfort zones without the juice. These actions were evident through a running habit to the brim of glass jars from the bottom area; an attempt to escape a toxic water environment. However, escape of H. quardrata was prevented by covering of glass jars with net and total filling of jars with the solution (water plus lime juice). Loss of aggregation at a locus (bottom of jars) was thus observed during the initial hours in high concentrations (4.55ml/L) or at latter days of exposure in low concentrations (0.94 ml/L and 2.07 ml/L). Similarly, this restlessness and attempt to jump or swim out of toxic solutions were observed in fish exposed to different kinds of toxic agents by researchers (Ajibade and Omitoyin, 2011; Omitoyin and Ajibade, 2014; Ajibade, 2016). The median lethal concentration (LC_{50}) value of 1.55 ml/L and 0.67ml/L were obtained at 48-hour and 96-hour, respectively. This means that 50.0% of the sampled population could be killed in a short-run (48-hour) or long-run (96-hour). This agreed with the rule of toxicology where fairness to target population and conservation of species were advised. That is an avoidance of total destruction of biodiversity (Solbe, 1995; Odiete, 1999). That is managers of aquaculture ponds targeting the leech would get a faster response by applying 1.55ml/L of pond water after a partial draining of pond water. However, a slower response but fairer treatment would result if smaller quantity of lime juice (0.67ml/L) is applied because of the longer time of death (96-hour).

Table 1: Water quality parameters of experimental set-up

Parameters	Observed values	Standards
Dissolved oxygen (mg/l)	5.80	> 4.0
Temperature (0^oC)	26.00	26.0 -30.0
Water acidity (pH)	05.60	6.0 – 9.0

Table 2: Mortality of *Hemiclepsis quardrata* exposed to various concentrations of lime fruit juice at 48-hour.

Sample size	Ttreatment (ml/l)	Number of survivors	Actual Mortality	Mortality (%)	Probit-value
21	0.00	21.00	0.00	0.00	0.00
21	0.94	15.00	6.00	28.57	4.45
21	2.07	06.00	15.00	71.43	5.55
21	4.55	00.00	21.00	100.00	7.33

Table 3: Mortality of *Hemiclepsis quardrata* exposed to various concentrations of lime fruit juice at 96-hour

Sample size (ml/L)	Ttreatment (ml/L) (%)	Number of survivors	Actual Mortality	Mortality	Probit-value
21.0	0.00	21.00	0.00	0.00	0.00
21.0	0.94	3.00	18.00	85.71	6.08
21.0	2.07	0.00	21.00	100.00	7.33
21.0	4.55	0.00	21.00	100.00	7.33

Table4: The average consumption of blood per day by an African leech (*Hemiclepsis quardrata*)

Source of blood	Quantity of blood consumed per day (g)		
	Day 1	Day 2	Day 3
Clarias gariepinus	0.13	0.58	0.24
Heteroclarias	0.12	0.52	0.12
Human (o +ve)	0.34	0.75	0.25

The average blood consumption by the African leech, in ascending order, was 0.76g, 0.95g and 1.29g in three days sourced from Heteroclarias , Clarias gariepinus and man (O +ve and AA genotype), respectively. Hence, human blood was mostly preferred by *H. quardrata* in the present study because it recorded the highest rate of consumption. Futhermore, coagulation of blood was prevented throughout the experimental period of three days by the introduced leeches in the test-tubes before 2.0 meals of blood was allotted into each tube. This anti-coagulating ability was already reported and attributed to a substance called 'Hirudin' (Yantis *et al*., 2009; Bennett-Marsden, 2014); although some species of leeches would prevent blood clotting for only ten (10) hours. Also, the inability of *H. quardrata* to survive more than seventy-two hours in the blood contained in the test-tubes, evident through death, was caused by overfeeding in a space which disallowed freedom and disengagement from feeding in the current study. This agreed with the findings of Oosthuizen (1987) who reported that the ability of the leech to detach from the host after having its fill and rest on a substrate helped it to digest the meal before the next meal which facilitate survival. Hence, the inability to fall off and digest food was prevented causing overfeeding and death during latter hours of third day in the present study. Therefore, lime fruit juice is effective in controlling the population of African leech but a direct skin contact with the insect should be avoided by fish farmers because of its parasitic nature. Also, wastage of lime juice should be avoided by taking cognizance of the median lethal concentrations as a means of conservation for other uses of man. It could also serve as an alternative to the application of synthetic chemicals for the control of invasive insects such as the African leech in aquaculture.

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Nano-Clay Based Filter For Treatment of Fish Pond Wastewater

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Abstract
In this study, Sedimentation technique was used to produce clay particles of less than 2 μm hydrodynamic diameter. After the characterization was done for the various clay samples, Afuze clay was selected and activated for the production of nano-clay. X-ray diffraction (XRD), scanning electron microscope (SEM) techniques were used for the characterization of raw and beneficiated clay samples. The developed nano-clay was used for continuous removal of dissolved solids, bacteria and heavy metals from fish pond wastewater. In order to improve the adsorption properties of the activated nano-clay, the sample was blended with magnetite nanoparticles. The magnetite nanoparticles was produced by green synthesis co-precipitation method using Fe^{2+} and Fe^{3+} as precursors and mango leaves aqueous extract as reducing agent. The nano-clay-magnetite composite was prepared in a single step. Standard water analysis procedure was followed to determine the level of pollutant removal while the heavy metals was analysed using Atomic Absorption Spectrophotometer (AAS). The data generated was analysed using analysis of variance (ANOVA) to determine the significant difference, the result was compared using T-test while means of significant differences were separated using Duncan's multiple range test. The percentage removal efficiency of the heavy metals was in the order: Cu 48 %, Zn 89 %, Fe 98 %, Mn 100 % and Total bacteria count (TBC) 95 %. The ceramic water filter produced was able to successfully remove the colour, odour, and dissolved solids in the raw fish pond wastewater. It can be inferred from the various analysis conducted on the raw and treated fish pond wastewater sample that the developed nano-clay based filter in a single purification process are suitable for fish pond wastewater treatment.

Introduction
Numerous economic and scientific facts revealed that shortage of water or its pollution can cause severe decrease in productivity and death of living species (UNICEF, 2008). Access to clean water and its sources are insufficient and these can be attributed to population explosion, climate change, industrial and agricultural activities, (Campelo *et al.*, 2017). As the demand for clean, safe and sustainable water increases, and drinking water shortage, a great emphasis or demand has been placed on wastewater treatment and recycling (Wang *et al.*, 2018). The World Health Organization (WHO, 2016) estimates that 6.3 % of all deaths are caused by limited access to safe drinking water, hygiene practices, improved sanitation facilities and water management practices. It was reported that about 780 million people predominantly in Africa and Asia do not have access to clean and safe drinking water (UNICEF and WHO, 2015). Increase in agriculture and agricultural activities play an important role in the economic and industrial development of every country which in turns, contribute largely to improving domestic products and improved standard of living (FAO, 2015). However, these growing agricultural activities especially fish farming and aquaculture cause an increase in discharge of polluted water into surrounding environment. Despite an increase awareness on the negative impact of such discharge of polluted water, indiscriminate discharge of wastewater still persist resulting to pollution and unpleasant odour emanating from the environment where the wastewater was released into. It has been estimated that 70 % of industrial and agricultural water in all developing countries were discharged into waterways without treatment. (Leao *et al.*, 2017). Wastewater discharge influences the quality of surface water, which in turn affects the health of humans and the ecosystem.

Water contaminants may be organic, inorganic and biological. Some are toxic, carcinogenic and have deleterious effects on humans and ecosystem (Ali, 2012). The major pollutants of surface and underground water include heavy metals, inorganic salts, organic compounds, pathogenic microorganism and acids (Burakov *et al.*, 2018). Heavy metals like iron, copper, lead, manganese, zinc, mercury pose a serious threat to public and human health. Their occurrence has a harmful consequence on the physiology and biological systems of humans if the tolerance levels are exceeded (WHO, 2017). Due to in-accessibility to clean water, a high emphasis will be placed on wastewater treatment and recycling. In particular, it will be necessary to treat water and make it fit for reuse and for a particular purpose (Emir *et al*., 2018). The most important methods used in wastewater purification include screening, bio-filtration, micro and ultrafiltration, crystallization, sedimentation, gravity separation, floatation, precipitation, oxidation, adsorption, neutralization. (Ali, 2012). The above methods can be combined depending on the type of polluted water and the purpose of its use. The convectional wastewater treatment methods involves physical, chemical and biological processes which results can be limited because of high cost or due to poor treatment efficiency (Qu *et al*.,2012). Therefore, in view of the various problems associated with the conventional wastewater treatment methods, there is need to develop an efficient, practical and sustainable techniques to remove toxic organic and inorganic pollutants from water and make it reusable.

Nanotechnology as defined by the U.S National Nanotechnology Initiative (NNI, 2001) as *"Understanding and control of matter at dimensions of roughly 1 to 100nm where unique phenomena enable novel applications"*. (Ashraf *et al*., 2014) define nanotechnology as the study, design, creation, synthesis, manipulation and application of functional materials, devices and systems through control of matter at the nanometre scale ($1 x 10^{-9}$). Current research in nanotechnology offers the possibility of developing technically and economically viable alternative materials for wastewater treatment (Emir *et al*., 2018). One of the practical techniques used in nanotechnology application for the treatment of wastewater is adsorption. It has been identified as one of the most efficient treatment technique for the removal of organic, inorganic and microbial pollutants in wastewater (Jiancheng *et al*., 2017). Adsorption technology offers significant low cost, application simplicity, availability and efficiency benefit (Zhou *et al*., 2018).

Materials and Methods

Raw clay samples collected from four different locations were subjected to beneficiation to produce nano-clay. The green synthesis of magnetite nanoparticle was conducted using Fe^{2+} and Fe^{3+} salts as metal precussors while *Magnifera indica* extract was used as the reducing agent. The nano-clay-magnetite composite was fired at 700 ^{o}C for removal of heavy metals. The nano-clay produced was tested in a single filtration process for the removal of colour, odour, bacteria and heavy metals from fish pond wastewater. The wastewater sample was collected form a commercial earthen pond fish farm, which was then analysed. Total bacteria count was done by using elevated temperature fermentation method and the heavy metals like iron, manganese, copper and zinc were determine using atomic absorption spectrophotometry.

Result and Discussion

The result shows the analysis of variance for some heavy metals at different flow rates. The Iron (Fe) content of RAW is the highest (0.363±0.03) and is significantly ($p<0.05$) different from other treatments, flow rate of 10 mL/min had the lowest value (0.237±0.02) of Fe but was not significant ($p>0.05$) from 15 mL/min. The flow rate of the raw wastewater recorded a significantly ($p<0.05$) higher (0.126±0.008) Copper (Cu) than other treatments while 10 mL/min was the lowest (0.054±0.003). The manganese (Mn) content of the raw pond wastewater is the highest (0.042±0.003) and is significantly ($p<0.05$) different from other treatments. The flow rate of 15 mL/min has the lowest value (0.007±0.001) of Mn and was significant ($p<0.05$) from both the flow rate of 5 mL/min and 10 mL/min. Also the Zinc (Zn) content of raw is highest (3.20±0.22) and is significantly ($p<0.05$) different from other treatments, with flow rate of 10 mL/min with the lowest value (0.49±0.03) and was very significant from the flow rate of 5 mL/min with (0.60±0.04) but not very significant ($p>0.05$) for flow rate of 15 mL/min. While the total bacteria count shows significant reduction from raw content (54.0±4.00) to 5 mL/min (11.0±1.00) which is significantly different from other treatment ($p<0.05$), flow rate of 10 mL/min (4.0±1.00) shows the best removal of bacteria from the water but not very significantly ($p>0.05$) different for flow rate of 15 mL/min.

In terms of heavy metals sorption, the iron level was significantly reduced in the table below. Adverse effect of iron includes carcinogenic, intestinal damage, irritation of respiratory tract, nausea, diarrhoea and death (Gautam *et al.*, 2014). The iron content of the wastewater falls within the permissible limit of 0.50 mg/L (EPA, 2012) at 5 cm of the adsorbent column height. Similarly, high level of copper in water could cause liver damage, irritation, insomnia, brain damage and diarrhoea (Barakat, 2011). The copper present in the wastewater was reduced when in contact with the filter, all the treatments effectively reduced the copper content to permissible level of 1.0 mg/L (EPA, 2012).Moreover, manganese causes liver damage, pneumonitis, inflammation, neurotoxicity, and birth defects when it is present in water in excess of 0.50 mg/L (Gautam *et al.*, 2014). The clay filter effectively removed manganese 100 % in the wastewater. Nevertheless, high concentration of zinc (> 2.0 mg/L) in water causes depression, lethargy, neurological signs, cancer, nausea and zinc toxicosis (Barakat, 2011). The raw wastewater contain 3.49 mg/L of zinc and it decreased to 0.63 mg/L using the clay filter .Overall, the clay filter shows an effective removal capacity and abilities for the treatment of fish pond wastewater so as to remove pollutants from it.

Heavy metals analysis and total bacteria count result for the flow rate

Treatment	Fe	Cu	Mn	Zn	TBC
RAW	0.363 ± 0.03^{a}	0.126 ± 0.008^{a}	0.042 ± 0.003^{a}	3.20 ± 0.22^{a}	54.0 ± 4.00^{a}
5 mL/min	0.295 ± 0.02^{b}	0.121 ± 0.008^{ab}	0.013 ± 0.001^{b}	0.60 ± 0.04^{b}	11.0 ± 1.00^{b}
10 mL/min	0.237 ± 0.02^{c}	0.054 ± 0.008^{c}	$0.012 \pm 0.001^{\mathbf{b}}$	0.49 ± 0.03^{c}	4.0 ± 1.00^{c}
15 mL/min	0.241 ± 0.02^{c}	0.113 ± 0.008^{b}	0.007 ± 0.001^{c}	0.51 ± 0.03^{c}	6.0 ± 1.00^{c}

Mean with different superscript are significantly ($p<0.05$) different from each other (column wise)

Conclusion

In conclusion, the development of the magnetite nano-clay for the removal of dissolved solids, odour, colour and heavy metals was studied. For the clay filter, raw samples collected were subjected to beneficiation to produce nano-clay. The green synthesis of magnetite nanoparticle was conducted using Fe^{2+} and Fe^{3+} salts as metal precussors while *Magnifera indica* extract was used as the reducing agent. The nano-clay-magnetite composite was fired at 700 ºC for removal of heavy metals. The nano-clay produced and the silver doped multiwall carbon nanotube was tested in a single filtration process for the removal of effluents and heavy metals from fish pond wastewater.

The clay filter was subjected to performance evaluation for bacteria and heavy metals removal in pond wastewater. Percentage reduction for heavy metals shows 98 % removal for iron, 48 % for copper, 89 % for zinc and 100 % removal for manganese. The total bacteria count reduction was 95 %. The clay filter and the adsorbent application shows reduction in the water quality indicators with DO increasing from 3.07 to 8.00, COD reduced from 124.20 (mg/L) to 80 (mg/L), pH from 6.91 to 7.01. Consequently, conductivity reduced from 464 µS/cm to 332 µS/cm, alkalinity from 119 (mg/L) to 77(mg/L), magnesium from 7 (mg/L) to 0.54 (mg/L), phosphate from 1.58 (mg/L) to 0.39 (mg/L) and total dissolved solids from 0.78 (mg/L) to o.46 (mg/L). Overall, the nano-clay filter and the adsorbent have the ability to treat and remove effluents from fish pond wastewater and it can be applied to other environmental pollutants.

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Acute Toxicity of Water Accommodated Fractions (WAFs) of Three Nigerian Crude Oils to Black Jaw Tilapia, *Sarotherodon melanotheron*

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Abstract

Oil industry activities such as exploration, transportation, storage, use and disposal, as well as oil spills are sources of major contamination problems in Niger Delta, which have significant deleterious effects on aquatic organisms. The objective of this study was to report LC_{50} values obtained from acute toxicity tests on the Black jaw tilapia (*S. melanotheron*) exposed to Water Accommodated Fraction (WAF) –heavy (Ebok), light (Meji) and medium (Erha) crude oils. Acute toxicity concentrations WAFs for Ebok: 0%, 2%, 4%, 6% and 8%, Erha: 0%, 15%, 30%, 45% and 60% and MEJI: 0%, 5%, 10%, 15% and 40% were used on *S. melanotheron* to determine the 96h Lethal Concentration (LC_{50}) of heavy, light and medium crude oils respectively. The analysis of variance (ANOVA) showed that there was a significant ($p<0.05$) differences in the quantal response of *S. melanotheron* to different concentrations of the various crude oil types at 24, 48, 72 and 96 hours exposure. These results showed that $96LC_{50}$ values for heavy, light and medium crude oils on *S. melanotheron* were 0.09 mg TPH/l, 0.04 mg TPH/l and 0.12 mg TPH/l respectively. The $96LC_{50}$ of WAF showed that the light crude oil was two times more toxic than heavy and three times more toxic than medium and on toxicity categorization, the heavy, light and medium crude oils were very highly toxic, very highly toxic and highly toxic on *S. melanotheron* respectively. Based on the acute toxicity tests, light crude oil with high API (>31.1^{0}C) gravity was more toxic than both heavy and medium crude oils on *S. melanotheron*. All crude oils are toxic to aquatic organisms especially the fish; their discharge into the water bodies during crude oil exploration, transportation, storage and even sabotage should be discouraged to protect the environment.

Keywords: Acute Toxicity, Crude oils, Water Accommodated Fraction, *S. melanotheron*, API gravity.

Introduction

Spill of crude oil and its refined products occur on a frequent basis during routine operations of extraction, transportation, storage, refining and distribution (Zhu *et al.,* 2001). In Nigeria, studies have shown that the quantity of oil spilled over 50 years was 9-13 million barrels, which is equivalent to 50 Exxon Valdez spills (FME, *et al.*, 2006). However, the oil spills occurring in the Niger Delta have received less attention in global media, despite significantly higher impacts on human health and the local ecology (UNEP 2011). Oil exploration and exploitation activities produce environmental hazards that are chronic in nature, in that they often take months and years to cause disease and death (WHO, 2003). This is unlike the contamination of water, food, and the environment with micro-organisms, which immediately results in ill health (WHO, 2003). The covert and slow action of the hazards created by oil exploration and exploitation make it difficult to fully appreciate their contribution to the disease burden in Nigeria, especially in the oil-bearing communities, even with the emergence of non-communicable diseases as major causes of ill health in Nigeria (WHO, 2005). The aim of this study was to carry-out acute toxicity bioassay ($96LC_{50}$) using Water Accommodated Fraction (WAF) prepared from the three Nigerian crude oils heavy (Ebok), light (Meji) and medium (Erha) on *S. melanotheron*.

Materials and Methods

Selected Crude Oils:

Crude oils selected for the purpose of this study were Ebok crude oil, Meji crude oil and Erha crude oil. The selection was based on the American Petroleum Institute gravity (API) and the sulfur content of the cru de oil.

Source of Crude Oils:

Meji, Erha and Ebok crude oils were provided by Chevron, ExxonMobil and Oriental respectively. They all supplied through their loading stations in Port Harcourt. All the crude oils were gotten through the assistance of the Department of Petroleum Resources (DPR) located in Lagos, Nigeria.

Animal Acclimation:

Fry of Tilapia, *S. melanotheron* were supplied by Aquaculture unit, Department of Marine Sciences, University of Lagos following the procedures of (OECD, 2000).

Preliminary Ranging Test:

Groups of ten *S. melanotheron* in three replicate were exposed to several concentrations for 96 hours following the procedures of (Solbe, 1995, Rahman *et al*, 2002).

Preparation of Water Accommodated Fraction (WAF):

The water accommodated fraction is a solution free of particles of bulk material (i.e., droplets > 1 µm diameter) derived from mixing (no vortex) test material and water (USEPA, 2010; Singer et al., 2000).

Semi-Static Acute Toxicity with WAFs Crude Oils:
WAFs acute toxicity bioassay was performed for 96 hours (USEPA, 2002) on *S. melanotheron* with ten species of Tilapia in three replicates at different concentrations. On the three oils, the percentages of WAFs for Ebok: 0%, 2%, 4%, 6% and 8%, Erha: 0%, 15%, 30%, 45% and 60% and MEJI: 0%, 5%, 10%, 15% and 40% were used for *S. melanotheron*. For acute toxicity test, the concentrations were converted into a logarithm and the corresponding percentage (%) mortality was transformed into probit values (Sprague, J.B., 1964 and Finney, D.J. 1971).

Statistical Analysis:
All values were expressed as mean + SD and analyzed by SPSS for Win 20.0 software. Acute toxicity tests were determined according to the method described by Finney (1971). The concentrations were converted into a logarithm and the corresponding percentage (%) mortality was transformed into probit values (Sprague, J.B., 1964 and Finney, D.J. 1971). The indices of toxicity measurement and their 95 confidence limit (CL) derived from this analysis were:

LC50 = Lethal concentration that causes 50% mortality (response) of exposed organism.
LC95 = Lethal concentration that causes 95% mortality (response) of exposed organism.
LC5 = Lethal concentration that causes 5% mortality (response) of exposed organism.

The toxicity factor 1 (TF1) for different crude oils was determined using the formula described by Odiete (1999) while the toxicity factor 2 (TF2) was gotten using Zinc Sulphate as reference toxicant on C. gariepinus (Ololade and Oginini, 2009).

$$\text{TF1 = Toxicity Factor 1} = \frac{\text{LC50 of Test Compound at 24 hours}}{\text{LC50 of Test Compound at others hours (48, 72, 96 hours)}}$$

$$\text{TF2 = Toxicity Factor 2} = \frac{\text{LC50 of Test Compound at 96 Hours}}{\text{LC50 of Reference Compound (Zinc Sulphate) at 96 hours}}$$

Results
The relative toxicity values (LC50, LC5 and LC95, probit equations and toxicity factors) for Water Accommodated Fraction (WAF)-Ebok, Meji and Erha in *S.melanotheron* were reported in Table 1. The 96LC50 values of WAF-Ebok, WAF-Meji and WAF-Erha were found to be 0.091, 0.041 and 0.117mg TPH/l respectively when tested against *S.melanotheron*. This showed that meji crude oil was most toxic followed by Ebok crude oil while Erha was least toxic on *S.melanotheron.*

Table 1: Relative Toxicity Factor of WAF-Ebok, Meji And Erha Crude Oils (%) against *S. melanotheron*

Exposure Time (h)	LC_{50} (95%LC) (ml/L)	LC_5 (95%LC) (ml/L)	LC_{95} (95%LC) (ml/L)	Slope S.E	Probit lineEquation	TF1	TF2
WAF-EBOK							
24	1.099 (0.00-0.00)	0.003 (0.00-0.00)	31.254 (0.00-0.00)	0.88±0.53	y = -0.036+0.881x	1.00	
48	0.133 (0.00-0.00)	0.00 (0.00-0.00)	99.732 (0.00-0.00)	0.44±0.509	y = 0.391+0.446x	8.26	
72	0.192 (0.000 - 0.325)	0.002 (0.000 - 0.024)	2.47 (1.010 - 2.6X10)^{6}	1.15±0.523	y = 0.828+1.154x	5.72	
96	0.091(0.00-0.00)	0(0.00-0.00)	1.933 (0.00-0.00)	0.97±0.55	y = 1.005+0.965x	12.07	2.10
WAF-MEJI							
24	0.656 (0.00-0.00)	0.054 (0.00-0.00)	2.595(0.00-0.00)	2.14±1.15	y = -0.393+2.146x	1.00	
48	0.320 (0.195 - 6.970)	0.012 (0.000 - 0.034)	1.961 (0.578 - 1.2X10$^{4)}$	1.63±0.63	y = 0.805+1.628x	2.05	
72	0.130 (0.101 - 0.177)	0.012 (0.001 - 0.027)	0.471 (0.287 - 1.835)	2.29±0.57	y = 2.029+2.287x	5.05	
96	0.041(0.010 - 0.062)	0.002 (0.000 - 0.010)	0.193 (0.134 - 0.592)	1.89±0.58	y = 2.634+1.895x	16.00	
WAF-ERHA							
24	0.841(0.841–3.5x10^{5})	0.154 (0.00 - 0.276)	6.916 1.694 – 0.00	2.18±1.11	y = -551+2.183x	1.00	
48	0.514 (0.325 – 21.748)	0.005 (0.000 - 0.038)	6.600 (1.567 - 5.9X10$^{9)}$	1.15±0.53	y = 0.334+1.156x	3.48	
72	0.170 (0.032 - 0.060)	0.004 (0.000 - 0.027)	1.262 (0.664 - 38.441)	1.47±0.53	y = 1.133+1.470x	10.52	
96	0.117(0.020 - 0.185)	0.00 (0.00 – 0.26)	0.644 (0.427 – 2.946)	1.73±0.57	y = 1.612+1.732x	15.29	2.66

LC = Lethal Concentration, CL = Confident Limit, TF = Toxicity Factor, WAF = Water

Toxicity Categorization

USEPA's $96LC_{50}$ aquatic toxicity scale for laboratory-generated aquatic toxicity data was used to determine the toxicity category of the three crude oils. Toxicity levels of WAF-Ebok, Meji and Erha on *S.melanotheron* were very highly toxic, highly toxic and highly toxic respectively (Table 2 and 3).

Table 2: USEPA's $96LC_{50}$ Aquatic Toxicity Scale

$96LC_{50}$	**Toxicity Category**
<0.1mg/l	Very highly toxic
0.1 – 1 mg/l	Highly toxic
1 – 10 mg/l	Moderately toxic
10-100 mg/l	Slightly toxic
>100mg	Practically non-toxic

Source: USEPA, 2002

Table 3: Toxicity Category of the Three Nigerian Crudes on *S. melanotheron* Based on USEPA Toxicity Scale.

Type of Crude	**$96LC_{50}$**	**95CL**	**Toxicity Category**
WAF-EBOK	0.09	------------	Very highly toxic
WAF-MEJI	0.04	0.01 – 0.06	Very Highly toxic
WAF-ERHA	0.12	0.02 – 0.19	Highly toxic

Discussion

The $96LC_{50}$ of WAF-Meji was lower than the $96LC_{50}$ of WAF-Ebok and WAF-Erha which supported the findings of Dupuis and Ucan-Marin, (2015) that said, light crude oil are generally considered to be more toxic than heavy crude oils. Also, the light crude oil toxicity is immediate and reduces as the exposure time increases. According to NRC, (2003) and Murakami, (2008) the increased toxicity of light crude oils is primarily caused by two factors: (1) light crude oils often have higher concentrations of aromatic hydrocarbons, and (2) light crude oils are usually less viscous than heavy one thus requiring less mixing energy for toxic concentrations to be mixed into the water. The light oils are rich in aromatic hydrocarbons, these are known to be readily soluble and toxic (Neff *et al.*, 2000). This result agreed with the study of Olaifa (2005) who studied the toxicity of Nigerian Qua Iboe Light crude oil to *S.melanotheron*. It also agreed with the findings of Sogbanmu and Otitoloju (2014), they also studied the toxicity of Forcados Light Crude Oil to the same species of fish. It also supports the findings Ayoola and Alajabo (2012) of acute toxicity of engine oil on Black jaw Tilipia *S.melanotheron*. It is also in line with the results of Rhoton *et al*., (2001) on Alaska North Slope and Prudhoe Bay using Inland Silverside (Menidia beryllina).

On the toxicity USEPA's scale, very highly toxic, very highly toxic and highly toxic recorded for the Ebok, Meji and Erha were different from the findings of Reátegui-Zirena *et al*., (2013) of moderately toxic of Water Accommodated Fractions (WAFs) of Peruvian crude on red pacu (*Piaractus brachypomus*) and Fathead minnow *Pimephales promelas.* It also contradicts the findings of Artin and Thomas, (2011) on Louisiana sweet crude (LSC) who reported non-toxic effects of inland silverside fish using USEPA toxicity scales.

Several abnormal behaviour such as incessant jumping and gulping of air, restlessness, surface to bottom movement, sudden quick movement, resting at the bottom were similar to the observations of Omoniyi *et al.* (2002), Rahman *et al.* (2002) and Aguigwo (2002).

Conclusion

Meji crude oil is more toxic than other two Nigerian crude oils on *S. melanotheron*, this is due to higher concentrations of aromatic hydrocarbons and the less viscosity than the heavy crude oil. Therefore a lot of factors have to put into consideration to draw out a conclusion on the toxicity of a chemicals, these includes; physical and chemical properties of a toxicant, exposure duration, preparation of exposure media, exposure method, species and species habitat which indicate more research work has to be done on this particular species using the same crude oils. Bioassays are an important tool used to provide background information for risk assessment of chemicals. This study gives baseline information on the three Nigerian crude oils based on their different American Petroleum Institute (API) gravity.

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Assessment of Heavy Metals in E-waste Leachates: A Case Study of E-waste Dumpsites in Lagos and Osun States, Southwest Nigeria

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Abstract

The levels of some selected heavy metals lead (Pb), copper (Cu), cadmium (Cd), iron (Fe), chromium (Cr), mercury (Hg) and arsenic (As) were investigated in raw leachates from electronic waste (e-waste) dumpsites found in two major electronic sales markets (Alaba and Ajegunle) in Lagos and Osun states, Southwest Nigeria. Physico-chemical parameters were measured quarterly in leachate samples collected from the dumpsites using standard methods while heavy metals were digested and analyzed using Pye Unicam model 969 Atomic Absorption Spectrophotometer (AAS). Mercury was extracted from samples using the cold vapour method and the levels determined by Inductive Coupling Plasma (ICP) AAS. Turbidity was particularly high in both states which was attributed to the particulate matters from the e- waste in the dumpsites Levels of Fe, Pb, Cr, Cd, Hg from Alaba leachates were found to be higher than the levels in Ajegunle except for that of Cu (94.50/ 81.96 mg/l). This could be attributed to the volume and composition of the waste stream. Generally higher levels above the USEPA and Nigerian Environmental Standard and Regulation Agency (NESREA) environmental health and safety standards were recorded for all the metals. The concentrations of the metals are as follows in descending order: Fe 188/220mg/l > Cu 94.5/81.96mg/l > Cr 0.05/0.07mg/l > Pb 0.048/0.068> Hg 0.04/0.05mg/l > Cd 0.03/0.04 in the respective dumpsites. The results from the present study show that the indiscriminate and uncontrolled dumping of e-wastes in developing countries need to be addressed urgently considering the potential risks associated with the accumulation in wildlife and human food webs in these ecosystems and attendant health implications .

Keywords: E-waste, heavy metals, leachates, dumpsites, ecosystem

Introduction

Waste electrical and electronic equipment (WEEE) is composed of approximately 60% metals, 20% organic compounds, and 20% residual materials such as wood or glass (Schlummer *et al.* 2014). These complex mix of substances often released during recycling and disposal of e-waste are chemically and physically different from other types of municipal and industrial wastes because they contain precious and semi-precious metals such as copper (Cu), manganese (Mn), iron (Fe), and platinum (Pt), as well as toxic heavy metals like lead (Pb), mercury (Hg), cadmium (Cd) and nickel (Ni) among other persistent organic chemicals which can all be hazardous to human health and the environment.

Generation of e-waste in West African countries is highest in Nigeria (BAN/STVC, 2002). Southwest of Nigeria is the home of the two largest seaports which serve as major trade portals for not only Nigeria, but for the rest of West Africa. Rainfall, over e-waste mounds where these products have been indiscriminately dumped near waterways, result in the formation of leachate.

This flow-through contains high concentrations of hazardous organic and inorganic chemicals including heavy metals and POPs (Jang *et al*., 2011). Contamination of aquatic ecosystems with these chemicals are documented (Osibanjo *et al*., 2011; Okunola *et al.*, 2012). Recent studies have recognized and demonstrated extreme toxicities and dangers posed by these hazardous substances at recycling sites in developing states. Hence, they are of global and scientific concern (Osibanjo *et al.,* 2011; Okunola, *et al*, 2012; Baker *et al*.,2013).

Based on the above background, this study was designed to measure the physico- chemical parameters as well as assess the levels of some selected heavy metals in leachate from e-waste dumpsites Lagos and Osun States in Southwestern Nigeria.

Materials and Methods

Study area:

South-West Nigeria lies between latitude N09^{0}4'55.1964"and longitude E08^{0}40'30.9972". Intensive 24 months sampling (July 2012-July 2014) was performed in electronic waste dumpsites located in Alaba and Ajegunle markets (Figure 1) in Lagos and Osun states respectively. They major used electronic markets in the two States with longitude N06^{0}27'40.5"and latitude E003^{0}11'32.4"(Alaba)and longitude N07^{0}46'51.5"and latitude E004^{0}33'11.6" (Ajegunle).

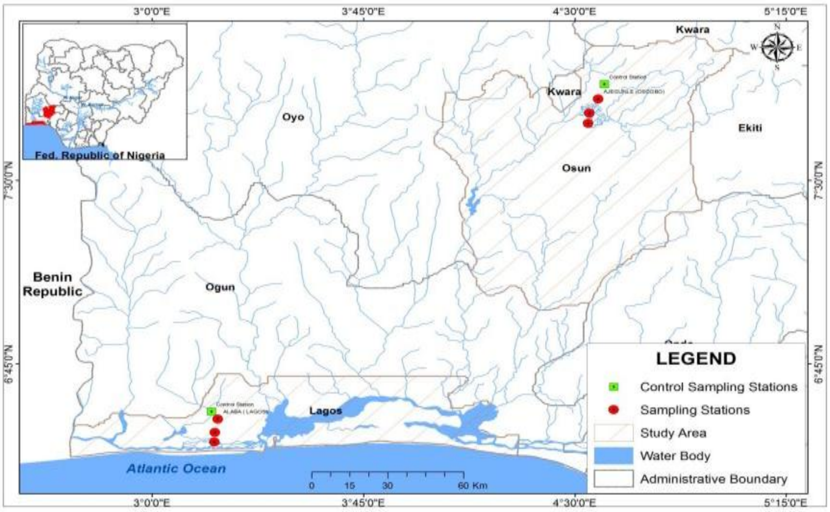

Figure 1: Map Showing Lagos and Osun Study Sites

Collection of Leachate Samples

Leachates samples were collected from 10 different points around the dumpsites with a 1dm^3 water sampler and, and filtered using 15 cm whatman filter paper (Okunola *et al*., 2012). Both samples were stored in 1litre water bottle each with a screw cap, transported to the laboratory for further analysis. Temperature and pH were measured *in situ*. The control was about 1000 km away from each of the dumpsites were no history of electronic waste dissembling has been recorded.

The samples were analyzed for a number of standard physico-chemical properties, including (pH, conductivity, salinity, alkalinity and biological oxygen demand (BOD) according to American Public Health Association (APHA, 1998). This was done with a Horiba-U-10 multi meter water checker. Other parameterts such as nitrate, phosphate, and sulphate were analysed using LaMotte spectrophotometer RMN2 6624 according to United States Environmental Protection Agency (USEPA, 2006).

Heavy Metals Analysis of the Leachate:

Heavy metals were analyzed in the samples according to the United States Environmental Protection Agency (USEPA 1998) and APHA (1998). 100 ml of each leachate samples were digested by heating on a hot plate with concentrated HNO_3 /H_2O_2 (1:1, v/v), until the volume was reduced to 3–5 ml. It was made up to 25ml with distilled water. Concentrations of the metals were estimated by using Pye Unicam model 969 Atomic Absorption Spectrophotometer. Hg and As were analysed using vapour method and Inductive Coupling Plasma (ICP) Atomic Absorption spectrophotometer

Data Analysis:

Descriptive statistics (mean values) were used and analysis of variance was performed on all experimental data and means were compared using SPSS version 20.0 software.

Results

Physico-chemical Parameters of Leachates from Lagos and Osun:

The physicochemical parameters of leachate from e-wastes dumpsites in Lagos and Osun are presented in Table 1. The leachate was found to be dark brown in colour. In Lagos, turbidity, alkalinity, dissolved oxygen levels in leachate were significantly different ($p<0.05$) from the control while in Osun conductivity, turbidity, dissolved oxygen level of water and leachate also showed significance difference from the control. Turbidity was particularly high and it was attributed to the particulate matters from the e- waste in the dumpsites.

Table 1: Physicochemical Parameters of Leachates (mg/L) in Lagos and Osun States

	Lagos Leachate		**Control**	**Osun Leachate**		**Control**	**USEPA (2009)**	**NESREA (2009)**
Physio-Chemical Characteristics	Mean±SE	t-stat.(p-alue)	Mean±SE	Mean±SE	t-stat.(p-value)	Mean±SE		
Air Temperature	27.25±0.56	0.286(0.776)	26.38±1.46	26.06±0.40	0.542(0.592)	27.59 ±0.41	n.a	n.a
Leachate Temperature	28.69±0.62	0.754(0.457)	27.44±1.56	25.69±2.00	0.579(0.567)	27.76 ±0.54	n.a	n.a
Salinity	0.52±0.20	0.414(0.682)	0.42±0.20	0.09±0.04	0.135(0.894)	0.12 ±0.05	n.a	n.a
pH	6.05±0.20	1.971(0.058)	7.54±0.15	6.50±0.22	488(0.629)	7.73 ±0.08	6.5 - 8.5	6 - 9
Conductivity	2.35±0.10	0.494(0.625)	3.21±1.31	1.21±0.22	2.434*(0.021)	1.19 ±0.15	n.a	n.a
Turbidity	68.00±22.21	3.60*(0.001)	10.50±1.77	65.1713.56	2.956*(0.006)	30.50 ±8.12	n.a	n.a
Alkalinity	92.13±10.95	4.304*(0.000)	10.56±0.72	92.00±20.25	3.908*(0.000)	22.13 ±5.91	20	150
Dissolved Oxygen	1.96±1.37	1.78*(0.085)	6.78±1.35	2.82±1.80	1.269*(0.214)	4.75 ±0.94	n.a	n.a
BOD	1.85±0.55	1.65(0.110)	0.55±0.14	1.45±0.32	1.175(0.249)	0.21 ±0.17	250	50
Silicate	59.000±5.19	5.58(0.00)	0.51±0.23	23.67±2.69	2.514*(0.018)	11.76 ±3.42	n.a	n.a
Nitrate	1.84±0.65	2.26(0.031)	0.11±0.05	0.64±0.36	1.759(0.089)	0.47 ±0.14	10	10
Phosphate	20.11±4.24	0.461(0.648)	0.15±0.08	20.03±2.82	0.733(0.469)	5.19 ±2.61	5	2
Sulphate	28.13±10.73	4.11*(0.00)	0.08±0.02	17.00±6.00	4.427(0.77)	38.16 ±12.12	n.a	n.a

*significant level at p<0.05.. n.a: data not available. Units are in mg/L except conductivity (µS/cm), salinity (ppm) Temperature (0^c) and pH which has no unit. BOD-biological oxygen demand. NESREA- National Environmental Standards Regulation and Enforcement Agency.

Heavy Metal Levels in Leachates Lagos and Osun:

The results of the analysis revealed higher heavy metal burdens in Lagos than in Osun presented as follows: Fe 188/220mg/l > Cu 94.5/81.96mg/l > Cr 0.05/0.07mg/l > Pb 0.048/0.068> Hg 0.04/0.05mg/l > Cd 0.03/0.04. The levels of Pb, Cd, Cr and Hg exceeded the USEPA (2003) and NESREA (2009) maximum permissible limit standards.

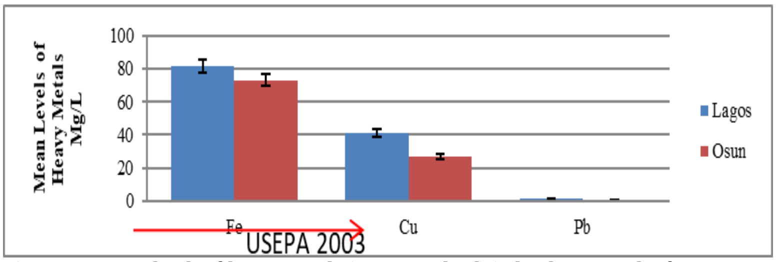

Figure 2a: Mean levels of heavy metals (Fe, Cu and Cd) in leachate samples from Lagos and Osun State. (n = 8)

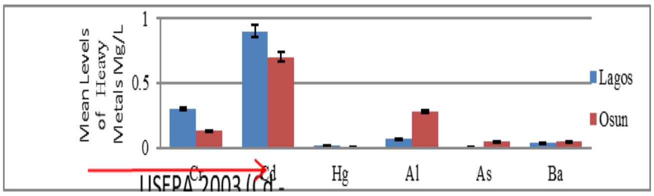

Figure 2b: Mean levels of heavy metals (Cr, Cd, Hg, Al, As and Ba) in leachate from Lagos and Osun States (n = 8).

Discussion

The dark brown colour of the leachate was mainly attributed to the oxidation of ferrous to ferric form and the formation of ferric hydroxide colloids and complexes with fulvic/ humic substances (Boalt *et al*., 2012). The leaching of heavy metals in electronic wastes have been documented in recent literatures (Stankovic *et al*., 2012). The higher heavy metal concentrations investigated in Lagos dumpsite could be attributed to a higher density market as well as higher anthropogenic activities which resulted to higher volumes of wastes (Puckett *et al*., 2010). The high concentration of Fe could be attributed to its abundance in the environment (Chukwu, 2006). The source of copper in the e-wastes dumpsite is from copper wires and the high concentration is attributed to the composition of the wastes stream. The metals Pb, Cr, Cd and Hg had lower levels compared to Fe and Cu but with concentrations exceeding that of the NESREA and USEPA permissible limits in both states. According to Jang, (2008) they are zenobiotics and exert toxic effects at any level of exposure. They therefore constitute a significant potential threat to both occupational and environmental health.

Conclusion

This study revealed the presence of toxic metals in e-waste leachates**.** This could impact on the development of exposed aquatic organisms as well as have detrimental effects on the surrounding environments. Taken together, this study suggests that the problem of indiscriminate and illegal dumping of e-waste as well as crude dismantling should be addressed urgently in Nigeria as contaminated organisms from this environments could pose as important exposure pathways for humans, leading to potential health consequences.

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Bioaccumulalation of some heavy metals in selected fish species in Shiroro Lake, Niger state, Nigeria.

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Abstract
The main purpose of this study was to determine heavy metals accumulation in the body tissue (gill, liver and tissue muscle) of the selected four fish species, *Clarias gariepinus, Bagrus bayad, Tilapia zilli and Lates niloticus* that are of commercial importance from Shiroro Lake, Niger State, Nigeria. Water samples were taken from five (5) stations in the lake, stations selected based on the entry points of effluent. The fish samples were bought from the landing site, Kwata Zumba monthly for 12 months (October 2018-September 2019).The weight of the fish species was recorded. One (1g) of the target organs (gill, liver and muscle tissue) of each sample were dissected out and digested, heavy metal concentration in them and that of water were determined using Atomic Absorption Spectrophotometer (AAS). The results showed that heavy metal concentrations in both water and fish tissues descended as follows Fe>Zn>Mn>Cu>Pb.Clarias gariepinus liver recorded the highest concentration of Fe (13.76 mg/l) .while in March (peak of dry season) the mean value of Fe in water was 3.99 mg/l (the highest).The lowest mean values,0.80mg/l were recorded in September. There were significant difference ($P<0.05$) between dry and wet seasons mean values of heavy metals in both fish organs and water. The results showed presence of some heavy metals in the organs of the selected commercially important fish species found in Shiroro Lake. Muscle tissue of all the selected species accumulated less metals compared to their gills and livers.

Keywords: Bioaccumulation, heavy metals, fish species, Shiroro Lake.

Introduction
Occurrence of heavy metals in the aquatic environment is of major ecological and public health concern because of their toxicity at certain concentration, translocation through food chains, non-biodegradability and threat to life and the environment (Eneji *et al*., 2012).Aquatic environments are being polluted due to increasing natural and anthropogenic activities.(Ojutiku *et.al.,2017*).

In Nigeria as well as other parts of the world, due to rapid urbanization, industrialization and high population pressure, we now experience increased domestic and waste disposal into nearby water courses as well as pollution from agricultural activities, hence aquatic environment are being polluted with heavy metals (Yusufu, 2015).

The consumption of fish worldwide has increased speedily in recent years particularly with the awareness of its nutritional and therapeutic benefits (Baruwo *et.al. 2018*). Fish serves as one of the major sources of protein that is low in saturated fat and contains sufficient omega 3 fatty acids (*Ojutiku et al.,2017*).The American Heart Association recommended consumption of fish at least twice per week in order to reach the daily intake of omega-3 fatty acid .However, fish normally accumulate heavy metals from food, water, and sediments and this is a good indicator of heavy metals contamination in water (*Baruwo et al.*,2018).

Bio-accumulation refers to an increase in the concentration of a metal in a biological organism over time, compared to the normal concentration in the environment. The presence of toxic heavy metals in fish can invalidate their beneficial effects and pose potential threat to both the environment and human health like, renal failure, liver damage, cardiovascular diseases or even death (Baruwo *et al., 2018*).

Shiroro Lake was primarily dammed for hydro-electric power generation, but with secondary objectives in Fisheries and Agriculture. Recently, anthropogenic activities near the lake for economic development have intensified continually and rapidly. This study therefore examined the bioaccumulation of some heavy metals in water and fish from Shiroro Lake, Niger State, Nigeria.

MATERIALS AND METHODS
Study Area
Shiroro Lake is a man-made hydro-electric power generation dam constructed on River Kaduna in Shiroro Gorge in Niger State. It is located on latitude 9°57´N Longitude 6°13´E.

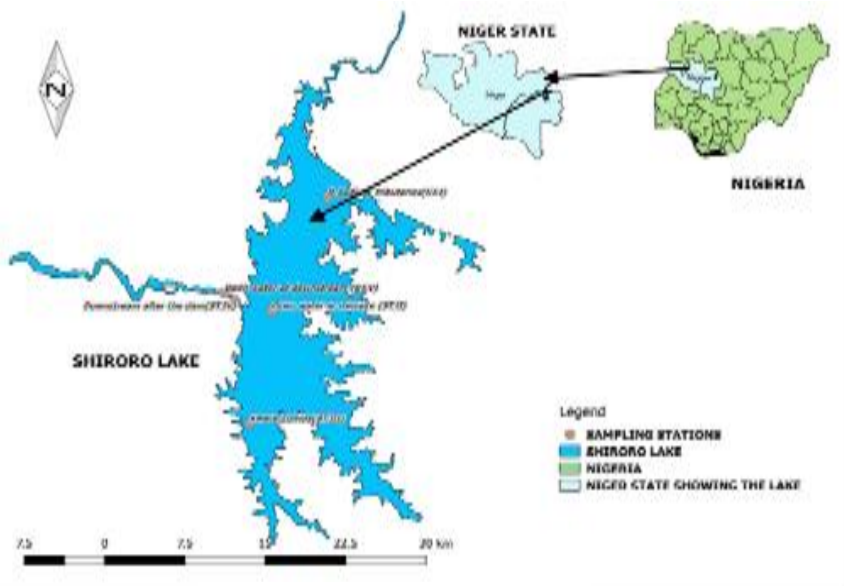

FIGURE 1: STUDY AREA

Sampling stations and collection

Water samples were collected from five stations, I, II, III, IV and V. Station I is on River Kaduna entry point (tributary), station II, on open water at the dam site, station III on point near the Zumba market (Kwata Zumba) where market activities take place, station IV on downstream (immediately after the dam) and station V, open water of the downstream, Water and fish samples were taken monthly for 12 months, three(3) water samples were taken from each sampling station as well as three samples of the selected fish species (October 2018 to September, 2019). Niger State Ministry of Animal and Fisheries surveillance boat was engaged in accessing sampling stations. Four fish species (*Clarias gariepinus, Bagrus bayad, Tilapia zilli and Lates niloticus)* were selected and bought from the Fishermen at the landing sites. The fish samples were transported in ice chests to the Water Resources, Aquaculture and Fisheries Technology Laboratory of the Federal University of Technology, Minna, Niger State.

Digestion of water sample:

Wet method of digestion was used to carry out this analysis (APHA,2005).10 ml was measured from lake water sample, 10 ml of nitric acid was added to it in a conical flask then digested on a hot plate at temperature of 150 ^{0}C till it reached a boiling point. The solutions were allowed to cool and distilled water added to make the volume up to 100ml then it was transferred into the pre-cleaned sample bottle and taken for further Atomic Absorption Spectrophotometer (AAS) analysis.

Digestion of fish samples:

Wet method of digestion was used to carry out these analyses (APHA, 2005). The fishes were dissected into separate organs, flesh, gills and liver using stainless steel dissecting instrument. 1g of the gills, flesh tissue and liver was each weighed from various fish species.20 ml of nitric acid was added to each sample and digested on hot plate at 150^{0}C till sample fully dissolved. To the digested sample, 100ml distilled water was added and poured in a sample bottled appropriately labelled for further analysis.

Metal Extraction:

Bulk scientific Atomic Absorption Spectrophotometer (AAS), model Accusy 211; manufactured in USA was used for determining the bio-accumulation factors of the heavy metals examined.

Statistical Analysis: One-way statistical analysis of variance (ANOVA) was used to determine the significant difference ($P<0.05$) in the concentration of the metals both in the water and the fish at ($P\leq 0.05$) probability using SPSS package.

RESULTS

The concentration of Iron (Fe), Copper (Cu), Zinc (Zn), Manganese (Mn), Lead (Pb) and Cadmium and fish tissue (gills, liver and muscle) from Shiroro Lake were as presented in tables 1-6

Water sample:

Heavy metals were found to decrease in the following order Fe> Zn>Mn>Cu>Cd>Pb. There was significant difference (P<0.05) in the metals among the months for Cu and Fe with highest value of 3.99 mg/L for Fe in March. Results also showed significant difference (P<0.05) between the metals except in the months of June – September.

Season: Mean season variation in heavy metal concentration in Shiroro lake water is as indicated in table 2. . Results showed significant difference (P<0.05) between the dry (November –April) and wet season (May-October).The average concentration of heavy metals is higher during the dry season which could be as a result of high temperature and concentration effect .The decreasing value is as follows Fe>Zn>Mn>Cu>Pb.

Table 3 showed the mean concentration of heavy metals in the gills of the experimental fish species, result showed that *Clarias gariepinus* gills had the highest concentration of Fe, 8.18 mg/l while least concentration of Cu, 0.02 mg/l was found in both *Bagrus niloticus* and *Tilapia zilli gills*. Among the gills of the selected species with the heavy metals, only Clarias gill with Zn and Lates gills with Cu had significant difference (P<0.05).

Table 4 showed mean concentration of heavy metals in the liver of the experimental fish species in Shiroro Lake. The results obtained revealed that *Clarias gariepinus* liver accumulated the highest concentration of Fe,13.76 mg/100g compared with the liver of other species which is far above the permissible limit recommended by the WHO .The least concentration of Pb was found in the liver of *Clarias gariepinus*.

Table 5 showed mean concentration of heavy metals in the muscles of the experimental fish species showing *Clarias gariepinus* recording the highest mean value of 4.39 which is below the permissible level. All the experimental fish recorded zero or not detected level of both Pb and Cd.

Table 6 showed all the experimental fish studied with the level of heavy metals accumulated by the gills, liver and the muscle tissue .The results showed that Clarias gariepinus liver recorded the highest value For Fe, 13.76 mg/l which exceed the maximum permissible limit recommended (WHO, 2011).The level of accumulation in target organs is in the following descending order Liver > Gills >Muscle. This variation is in line with previous studies by (Eneji et. al., 2012, Ojutiku et. al., 2017).

Table 1: Monthly mean variation of heavy metal concentration in water samples.

Months	Fe(mg/l)	Cu(mg/l)	Zn(mg/l)	Mn(mg/l)	Pb(mg/l)	Cd(mg/l)
October	2.47c	0.01ab	0.13e	0.04de	0.00	0.01b
November	2.41c	0.01ab	0.13e	0.05e	0.00	0.01b
December	3.27d	0.01ab	0.10d	0.04d	0.00	0.00a
January	2.97d	0.01b	0.09d	0.03c	0.00	0.00a
February	2.43c	0.01ab	0.07c	0.04d	0.00	0.00a
March	3.99e	0.02c	0.07c	0.05e	0.00	0.01c
April	3.06d	0.01ab	0.03b	0.01b	0.00	0.00a
May	2.19c	0.00a	0.01a	0.00ab	0.00	0.00a
June	1.75b	0.01b	0.01a	0.01ab	0.00	0.00a
July	1.51b	0.01b	0.01a	0.00aab	0.00	0.00a
August	1.41b	0.01b	0.01a	0.00a	0.00	0.00a
September	0.80a	0.00a	0.01a	0.00a	0.00	0.00a
WHO (2011)	-	2	-	0.4	0.01	
±S.E	0.07	0.00	0.00	0.00	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 2: Mean season variation of heavy metal concentration in water samples

Season	Fe(mg/l)	Cu(mg/l)	Zn(mg/l)	Mn(mg/l)	Pb(mg/l)
Dry	3.02a	0.01a	0.08a	0.03a	0.00a
Wet	1.69b	0.01b	0.03b	0.01b	0.00b
±S.E	0.97	0.01	0.05	0.02	0.01

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 3: Mean concentration of heavy metals in the gills of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CG	8.18b	0.31a	1.13b	0.39ab	0.00a	0.00a
TG	6.00a	0.20a	0.77a	0.41ab	0.00a	0.00b
BG	6.84ab	0.20a	0.69a	0.36a	0.00a	0.00ab
LG	6.40a	0.83b	0.82a	0.46b	0.00a	0.00ab
Permissible limit (FAO/WHO, 2011)	10	3	10	2-9	0.05	0.05
±S.E	0.27	0.06	0.05	0.01	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 4: Mean concentration of heavy metals in the liver of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CL	13.76b	0.75a	2.46b	0.80ab	0.01b	0.00a
TL	12.47ab	0.33a	1.22a	0.70ab	0.00a	0.01ab
BL	12.61ab	0.36a	2.35b	0.56a	0.00ab	0.01b
LL	9.68a	1.99b	2.48b	0.96b	0.00a	0.00a
Permissible limit (FAO/WHO,2014)	10	3	10	2-9	0.05	0.05
±S.E	0.66	0.12	0.15	0.06	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 5: Mean concentration of heavy metals in the muscles of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CM	4.39b	0.25a	0.77b	0.37bc	0.00a	0.00a
TM	3.71ab	0.13a	0.34a	0.25a	0.00a	0.00a
BM	3.39a	0.18a	0.84b	0.27ab	0.00a	0.00a
LM	3.41a	0.48b	0.67b	0.43c	0.00a	0.00a
Permissible limit (FAO/WHO,2011)	10	3	10	2-9	0.05	0.05
±S.E	0.14	0.03	0.04	0.02	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 6: Mean concentration of heavy metals in the gills, liver, and muscle tissue of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CG	8.18de	0.31a	1.13b	0.39ab	0.00a	0.00a
CL	13.76f	0.75bc	2.46c	0.80de	0.01b	0.00a
CM	4.39abc	0.25a	0.77ab	0.37ab	0.00a	0.00a
TG	6.00	0.20a	0.77ab	0.41ab	0.00a	0.00a
TL	12.47f	0.33ab	1.22b	0.70cd	0.00a	0.01a
TM	3.71ab	0.13a	0.34a	0.25a	0.00a	0.00a
BG	6.84cd	0.20a	0.69ab	0.36ab	0.00a	0.00a
BL	12.61f	0.36ab	2.35c	0.56	0.00a	0.01b
BM	3.39a	0.18a	0.84ab	0.27a	0.00a	0.00a
LG	6.40cd	0.83c	0.82ab	0.46ab	0.00a	0.00a
LL	9.68e	1.99d	2.48c	0.96e	0.00a	0.00a
LM	3.41a	0.48abc	0.67ab	0.43ab	0.00a	0.00a
Permissible limit (FAO/WHO,2011)	10	3	10	2-9	0.05	0.05
±S.E	0.29	0.05	0.06	0.02	0.00	0.00

DISCUSSION

The gills liver and muscle of the selected fish species (Clarias gariepinus , Bagrus bayad, Tillapia zilli and Lates niloticus) from Shiroro lake accumulate heavy metals though not at the same rate. The concentration of iron, Fe both in the water and fish constituted the major portion of the total heavy metal ions determined while Pb concentration was the lowest. This is in line with other studies *(Abraham et..al., 2012, Ojutiku et. al., 2017* .,*Egbeja et.,al.,2019*).

The concentration of Fe in *Tilapia zilli* and *Bagrus bayad* liver were high above the recommended level by FAO/WHO.(2011).*Clarias zilli* gills also exhibited high level of metal accumulation but below the permissible limit. This is not surprising based on difference in feeding habit, habitat and the multiple uses of their gills. This is in line with previous studies by *Eneji et., al,2012* and *Egbeja et.,al.,2019).*The low level of metal accumulation in *Tillapia zilli* also confirmed this.

Seasonal variations in heavy metals both in water and fish tissues noticed, and their concentrations higher in dry season due to temperature increase and other physicochemical interactions.

CONCLUSION

This study examined the bioaccumulation of heavy metals in the gills, liver and muscle of the selected fish species from Shiroro lake and it was clear from the study that heavy metals especially iron,Fe in liver of both Tilapia zilli and *Bagrus bayad* were a little above the permissible limit , it was observed that Zn,Mn,Cu,Cd and Pb were within the permissible limits set by WHO for now, however this calls for effective management of this valuable resource.

RECOMMENDATION

It is therefore advised that proper and regular monitoring of heavy metals effluent in water and fish should be done to avoid excessive accumulation.

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Toxicity effects of sub-lethal concentrations of cadmium (Cd^{2+}) on haematological parameters of fingerlings and juveniles of freshwater fish, *Clarias gariepinus* (Burchell, 1822)

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Abstract
Intensive agricultural operations and industrial activities release enormous amount of heavy metals into aquatic ecosystem. The extensive use of cadmium in industries and the degree of its toxicity indeed pose an environmental problem. The objective of the present work is to study the haematological changes in the freshwater fish *(Clarias gariepinus)* fingerlings and juveniles treated with sub-lethal doses of cadmium (Cd^{2+}). The research was carried out in the Fisheries Laboratory, Department of Biology, Ahmadu Bello University (ABU), Zaria, Nigeria. The fingerlings stage of the fish were exposed to 0.41, 0.81 and 1.62 mg/L Cd^{2+} and control (0.00 mg/L), derived from 96 h LC_{50}, (8.12 mg/L Cd^{2+}), while the juveniles stage were exposed to 0.51, 1.02 and 2.03 mg/L Cd^{2+} and control (0.00 mg/L), derived from 96 h LC_{50} (10.15 mg/L Cd^{2+}) in triplicates for a period of 56 days respectively. Blood samples were collected from the exposed fish to Cd^{2+} and the control for assessing some hematological parameters at the end of experiment for comparison. The haematological alterations based on the examination of blood indices during the period of exposure showed that, Red Blood Cells Count (RBCC), Packed Cells Volume (PCV) and Haemoglobin (Hb) concentration decreased significantly ($p<0.05$) in both stages of the fish relative to controls. The decrease was concentration-dependent. However, there was elevation in White Blood Cells Count (WBCC) with increase in Cd^{2+} concentrations which was significant ($p<0.05$) at both the fingerling and juvenile stages of exposure. There was also a significant variation in Mean Corpuscular Volume (MCV) at the juvenile stage of the fish, while Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin concentration (MCHC) in both stages of the exposed group were comparable with the control group. There was also an increased in lymphocyte and decreased in neutrophils counts in Cadmium (Cd^{2+}) exposure of *C. gariepinus* fingerlings and juveniles. Findings of the present study revealed that Cadmium adversely affected fish health. The present basic information of the haematological parameters would serve as a useful tool for further ecological assessment and monitoring of these aquatic organisms, which is considered to be an important food source for human beings.

Keywords: Haematology, Cadmium, *Clarias gariepinus*, Sub-lethal concentrations, Exposure

Introduction

Heavy metals after reaching the aquatic habitats cause serious problem due to bioaccumulation, biomagnification in the food chain and toxicity to aquati organisms (Govind and Madhuri, 2014; Ahmed *et al*., 2015). The toxicity of heavy metals to aquatic organisms particularly on freshwater fishes is well documented (Asrar *et al.*, 2012; Srivastav *et al.*, 2013).Cadmium (Cd) is one of the biologically non-essential, most toxic heavy metal widely used in Ni-Cd batteries manufacture, metal and mining, dentistry etc. because of its non-corrosive nature (Shoba *et al*., 2007). The major sources of contamination include electroplating, paper, PVC manufactures, plastic, paint pigments, fumicides and ceramic industries (Gupta *et al*., 2003). It is also entering into aquatic bodies through sewage sludge and with runoff from agricultural fields, as it is one of the major components of the phosphate fertilizers (Cherian and Goyer, 1989). Haematological indices have been recognized as valuable tools for evaluation of fish physiological status, the changes of which depend on fish species, age, cycle of sexual maturity and diseases (Soundararajan *et al*., 2014; Mallesh *et al*., 2015). The objective of the present work is to study the haematological changes in the fresh water fish *Clarias gariepinus* fingerlings and juveniles treated with sub-lethal doses of cadmium (Cd^{2+}).

Materials and methods

Experimental Fish

Fingerlings of *Clarias gariepinus* of average mean weight 8.70±2.11g and standard length 9.53±0.92 cm, and juveniles of *Clarias gariepinus* of mean weight 15.00±00g and standard length 16.43±0.85 cm were obtained through artificial reproduction of *C. gariepinus (*brood stocks) according to De Graaf and Janssen (1996) method.

Preparation of Metal Test Solutions

Analytical grade Cadmium chloride ($CdCl_2.2.5H_2O$) was obtained from Kaduna central market (Merck Company, Darmstadt, Germany, Glaxo India Limited, Bombay, India (No. 17584) and used without further purification. A stock solution of 1000 mg/L (1g/L) of the cadmium was prepared by adding 2.0 g of cadmium chloride to 1litre of de-chlorinated tap water (Reish and Oshida, 1987).

Experimental Design

Completely randomized experimental design was used in this experiment, with the same fish species making for one fish level. A total of one hundred and twenty (120) fish each of *Clarias gariepinus* fingerlings and juveniles respectively were used for the experiment. The fish were randomly placed into each test plastic tank of size 30.5 x 30.5 x 46.25 cm containers at a stocking rate of ten (10) fish per tank with four treatment levels Cd and three replicates, this gives 12 experimental set- up as described by (Simeon *et al.*, 2013). Three different concentrations of the heavy metal Cd and a control for the sub-lethal bioassay were prepared based on the 96 h LC_{50} values of 8.12 mg/L and10.15 mg/L for fingerlings and juveniles of *C. gariepinus* respectively. The nominal concentrations of Cd were derived from a fraction of (1/5 of 96 h LC_{50} 8.12 mg/L) 0.41 mg/L, (1/10 of 96 h LC_{50} 8.12 mg/L) 0.81 mg/L, (1/20 of 96-h LC_{50} 8.12 mg/L) 1.62 mg/L and control (0.00) for the fingerlings of *Clarias gariepinus* and (1/5 of 96 h 10.15 mg/L) 0.51 mg/L, (1/10 of 96 h 10.15 mg/L) 1.02 mg/L, (1/20 of 96 h 10.15 mg/L) 2.03 mg/L for juveniles of *Clarias gariepinus* (Simeon *et al.,* 2013). Physico-chemical parameters such as pH, temperature, electrical conductivity and dissolved solids were measured with the help of a multi parameter HANNA instrument (Model: HI98129), while dissolved oxygen (DO) and water hardness were determined exsitu following the methods of APHA (2005). The fish were fed with commercial feed (2mm coppens) at 5% of their body weights.

Procedures for Haematological Studies of Fingerlings and Juveniles of *Clarias gariepinus* exposed to Sub-lethal Concentrations of Cadmium (Cd^{2+})

Fish blood collection and analysis

Five fish per replicate were sampled from the respective test mediums after 56 days for blood collection. Collection of blood from fish specimens was done following the procedure of Blaxhall and Daisely (1973). Blood specimens were transferred to the laboratory unit, Ahmadu Bello University (ABU) Teaching Hospital for heamatological analysis. Blood from the various treatments were analysed for the following haematological parameters: PCV, haemoglobin HB, RBCC, WBCC and differentials using standard haematological procedures (Blaxhall and Daisely, 1973).

Statistical Analysis

One way Analysis of Variance (ANOVA) was used to test for significant difference between means using IBM Statics Version 20.0 for Windows 8, statistical analysis software. Duncan Multiple Range Test (DMRT) was used to test for significant difference between treatments when (p<0.05).

Results

Physico-chemical parameters of diluting water monitored during the sub-lethal exposure of fingerlings and juveniles of *Clarias gariepenus* to cadmium (Cd^{2+}) for 56 days

The physicochemical parameters of the test water measured daily during sub-lethal toxicity bioassay with cadmium concentrations are presented in Table 1 and 2. The Temperature (T) (°C) range was between 19.10 to 25.70 °C, Hydrogen ion Concentration (pH) was between 6.70 to 8.20, Electrical Conductivity (EC) (µS/cm) was between 121 to 403 µS/cm, Total Dissolved Solids (TDS) (mg/L) was between 60 to 199 mg/L and Dissolved Oxygen (DO) (mg/L) was between 3.50 to 5.20 mg/L. The slight differences in these parameters are not believed to have influenced the responses of the fish recorded in the course of the study.

Table 1: Physico-chemical parameters of diluting water monitored during the sub-lethal exposure of fingerlings *Clarias gariepenus* to cadmium (Cd^{2+}) for 56 days

Parameters	Range	Mean± S.E
Temperature(T) (°C)	24.80 – 25.70	25.23±0.08
Hydrogen ion Concentration (pH)	7.52 – 7.90	7.72±0.05
Electrical Conductivity (EC) (µS/cm)	141– 235	187.42±10.41
Total Dissolved Solids (TDS) (mg/L)	70 –117	93.33±5.22
Dissolved Oxygen (DO) (mg/L)	3.50 – 4.50	3.98±0.09

Table 2: **Physico-chemical parameters of diluting water monitored during the sublethal exposure of juveniles of *Clarias gariepenus* to Cadmium (Cd^{2+}) for 56 days**

Parameters	**Range**	**Mean± S.E**
Temperature(T) (°C)	19.10 – 24.70	21.78±0.58
Hydrogen ion Concentration (pH)	6.70 – 8.20	7.38±0.16
Electrical Conductivity (EC) (µS/cm)	121– 403	211.00±32.19
Total Dissolved Solids (TDS) (mg/L)	60 – 199	105.17±15.94
Dissolved Oxygen (DO) (mg/L)	4.00 – 5.20	4.46±0.12

Haematological Parameters due to Sub-lethal Exposure of *C. gariepinus* Fingerlings to Cadmium (Cd^{2+})

Results of haematological parameters of *C. gariepinus* fingerlings exposed to sublethal concentrations of cadmium (Cd^{2+}) are presented in Table 3. Fish exposed to sub-lethal doses of cadmium (Cd^{2+}) after 56 days shows that, RBCC, HB and PVC values of control group were higher than the exposed group. Similarly, the same values of RBCC, HB and PCV values decreased with increase in concentrations. In a reversed manner, WBCC of exposed group to cadmium concentrations were significantly higher ($p < 0.05$) compared to control fish at 1.62 mg/L Cd. MCV, MCH and MCHC of control fish were comparable with fish exposed to sub-lethal concentrations of cadmium. Percentage neutrophils in the control group were higher than those of the exposed group to the toxicant. Percentage neutrophils decreased with increased in concentrations and it was dose-dependent. However, percentage lymphocytes of the control fish were lower than the exposed group, but the values were also comparable.

Table 3: Effect of sub-lethal nominal doses of (Cd^{2+}) on some haematological parameters of *C. gariepinus* fingerlings for 56 days of exposure

Treatment(mg/L)	**0.00**	**0.41**	**0.81**	**1.62**
Parameters				
RBC (x10^{12}L	$5.20{\pm}0.38^{a}$	$4.78{\pm}032^{ab}$	$3.82{\pm}0.30^{b}$	$3.72{\pm}0.26^{b}$
WBCC (x10^{9}L)	$5.37{\pm}0.67^{a}$	$6.03{\pm}0.38^{a}$	$6.29{\pm}0.51^{a}$	$7.43{\pm}0.44^{b}$
HB (g/100ml)	$14.37{\pm}0.07^{a}$	$11.78{\pm}0.51^{b}$	$10.65{\pm}0.54^{b}$	$9.21{\pm}0.24^{c}$
PVC (%)	$43.00{\pm}1.04^{a}$	$32.07{\pm}3.39^{ab}$	$30.50{\pm}4.80^{ab}$	$26.57{\pm}4.38^{b}$
MCV (x10^{6}Pgcell)	$83.30{\pm}4.28^{a}$	$68.01{\pm}9.92^{a}$	$79.80{\pm}9.80^{a}$	$71.47{\pm}10.28^{a}$
MCH (x10^{6}Pgcell)	$27.90{\pm}1.82^{a}$	$24.96{\pm}2.44^{a}$	$28.05{\pm}1.30^{a}$	$20.67{\pm}3.04^{a}$
MCHC (g/100ml)	$29.75{\pm}2.93^{a}$	$26.21{\pm}3.07^{a}$	$28.54{\pm}0.84^{a}$	$21.72{\pm}3.66^{a}$
Neutrophils (%)	$54.90{\pm}1.82^{a}$	$46.67{\pm}1.18^{ab}$	$45.57{\pm}5.07^{ab}$	$40.17{\pm}0.42^{b}$
Lymphocytes (%)	$50.01{\pm}4.49^{a}$	$54.02{\pm}4.27^{a}$	$55.36{\pm}4.35^{a}$	$59.70{\pm}4.44^{a}$

Means with the same superscript along rows are not significantly different ($P \leq 0.05$) (Mean values ±SE) n=3 Red blood cell = RBC, White blood cell = WBC, Haemoglobin = Hb, Pack cell volume = PCV, Mean cell volume = MCV, Mean cell haemoglobin = MCH, Mean cell haemoglobin concentration = MCHC.

Haematological Parameters due to Sublethal Exposure of *C. gariepinus* Juveniles to Cadmium (Cd^{2+})

Haematological parameters of *C. gariepinus* juveniles exposed to sub-lethal concentrations of cadmium (Cd^{2+}) are shown in Table 4. Fish exposed to sub-lethal doses of cadmium (Cd^{2+}) after 56 days shows that, RBCC, HB and PVC values of 0.5mg/L group were higher compared to those exposed to 1.02 and 2.03 mg/L group. Similarly, RBCC, HB and PCV values decreased with increase in concentrations. However, WBCC of exposed group to cadmium concentrations were higher compared to the control fish. Mean corpuscular haemoglobin (MCH) and MCHC of control fish were not significant with fish exposed to sub-lethal concentrations of cadmium. Percentage values of neutrophils decreased with increased in concentrations and it was dose-dependent. However, percentage lymphocytes of the control fish were lower than the exposed group, but the values were comparable.

Table 4: Effect of sub-lethal nominal doses of (Cd^{2+}) on some haematological parameters of *C. gariepinus* juveniles 56 days of exposure

Treatment(mg/L)	0.00	0.51	1.02	2.03
Parameters				
RBC ($x10^{12}$L	5.30 ± 0.12^a	4.90 ± 0.15^{ab}	4.63 ± 0.13^b	4.37 ± 0.23^b
WBCC ($x10^9$L)	4.60 ± 0.06^a	5.67 ± 0.09^b	6.30 ± 0.15^b	7.47 ± 0.42^c
HB (g/100ml)	15.35 ± 0.41^a	13.97 ± 0.37^{ab}	12.40 ± 0.72^b	10.60 ± 0.36^c
PVC (%)	45.80 ± 0.96^a	39.80 ± 0.36^b	34.50 ± 0.29^c	31.30 ± 0.70^d
MCV ($x10^6$Pgcell)	86.42 ± 0.70^a	81.37 ± 2.55^a	74.55 ± 1.59^b	71.53 ± 2.18^b
MCH ($x10^6$Pgcell)	28.98 ± 0.91^a	28.57 ± 1.24^a	26.80 ± 1.73^a	24.42 ± 1.67^a
MCHC (g/100ml)	33.52 ± 0.79^a	35.12 ± 1.26^a	35.93 ± 1.96^a	33.92 ± 1.63^a
Neutrophils (%)	60.10 ± 2.06^a	59.10 ± 0.90^a	52.33 ± 2.67^b	46.87 ± 1.99^b
Lymphocytes (%)	52.79 ± 3.82^a	56.05 ± 4.42^a	57.94 ± 2.92^a	63.24 ± 3.39^a

Means with the same superscript along rows are not significantly different ($P\leq0.05$) (Mean values ±SE) n=3. Red blood cell = RBC, White blood cell = WBC, Haemoglobin = Hb, Pack cell volume = PCV, Mean cell volume = MCV, Mean cell haemoglobin = MCH, Mean cell haemoglobin concentration = MCHC.

Discussion

This study elicited various changes in the heamatological parameters in the test organisms after 56 days of sub-lethal exposure to Cadmium (Cd^{2+}). The results of hematological parameters showed marked significant difference between control tanks and the treatments tanks, which is an indication of the deleterious effects of the chemical pollutant to the body fluid of *Clarias gariepinus*. Anaemic condition of *Clarias gariepinus* exposed to Cadmium (Cd^{2+}) is observed with reduction in the red blood cells (RBC) as a result of increase in the sub-lethal concentration of Cadmium (Cd^{2+}), the same goes for the packed cell volume (PCV) during the trials which results in the low level of haemoglobin (Hb) in the test organisms. Inhibition of erythropoiesis due to Cadmium (Cd^{2+}) toxicity by its action on erythrocytes cell membrane may be another possible reason (erythropoiesis is the formation and production of the red blood cells resulting in the release of matured red blood cells erythrocytes into circulation). Decrease in numbers of RBC in fish due to toxicant exposure has also been reported by Debasmita *et al*. (2016) in fresh water cat fish, *Clarias gariepinus* with (average length of 24 to 26 cm and weight of 100g) exposed to sub-lethal concentrations of Cadmium. Similar findings were reported by Azi *et al*. (2019) on haematological studies of *Clarias gariepinus* and *Oreochromis niloticus* juveniles exposed to cadmium chloride. The observed decrease in RBC in the present investigation resulted from inhibition of RBC production or Hb synthesis by the toxicant. This may be as a result of toxic effects of Cadmium which interrupted the synthetic pathway by distressing the enzymes involved in haemoglobin synthesis. It might also be due to accumulation of Cadmium (Cd^{2+}) in the gill region which may have damaged the structure of the gill resulting in haemolysis (rupturing (lysis) of the red blood cells and the release of their content (cytoplasm) into surrounding fluid). This investigation reports that there was significant ($p < 0.05$) decrease in PCV, RBC, neutrophil and increase in the white blood cells and the lymphocytes during the exposure. This reverse response by the WBC and Neutrophils indicates some defensive action to protect the fish from further severe injuries. The increase in WBC counts suggests the incidence of leucocytosis, (a condition where more WBC is released in the blood system for adaptive immune response to Cadmium (Cd^{2+}). It is well known that the changes in Neutrophils counts after exposure to pollution may be associated with a decrease in non-specific immunity of the fish. Leucocytes and neutrophil (neutrophils are the first line of host cellular defense against attack or injuries) are involved in the regulation of immunological function in many organisms; also increase in WBC in stressed animals indicates a protective response to stress. Debasmita *et al*. (2016) reported significant increase in WBC count in *C. gariepinus* exposed to sub lethal concentrations of Cadmium and attributed to a stimulation of the immune system in response to tissue damage caused by Cadmium. There are also significant increases in WBC during Cadmium (Cd^{2+}) treatment, which might have resulted in the stimulation of the immune system by the Cadmium (Cd^{2+}) and for protection of the fish against toxicity. The increase in WBC count during this study may be due to extended toxic effect of the Cadmium (Cd^{2+}) on the liver tissues, which are the primary sites of haematopoiesis, provoking immunosuppression. Moraes (2007) stated that, one of the most elementary ways to assess the immune system is to explore changes in the WBC count. Another possible reason may be due to elevation of white blood cells maturation and the release from tissues reservoirs by the action of Cadmium (Cd^{2+}) to combat the stressor. Significant increase in WBC values has been reported in *Clarias gariepinus* and *Oreochromis niloticus* juveniles exposed to Cadmium (Azi *et al*., 2019). Insignificant changes in MCH and MCHC values observed in Cadmium exposed groups with reference to the control suggest normochromic anaemia while the significant elevation in MCV values of Cadmium exposed fish in 0.81 mg/L Cd at the fingerlings stage indicates macrocytic anaemia which probably was induced by Cadmium toxicant. Similar findings were reported by El-Boshy *et al*. (2014) in catfish (*Clarias gariepinus*) exposed to sublethal concentrations of Cadmium for 3 weeks and attributed it to presence of normocytic and normochromic anemia in the Cadmium exposed groups. Red cell indices (MCV, MCH and MCHC) are important indicators of anaemic conditions Iheanacho *et al*. (2018), providing useful information regarding the type of anaemia found in animals (Eldibary *et al*., 1999). Alterations in MCV, MCH and MCHC clearly indicated that the fish are under chemical stress, which lead to pathological condition in the tissues (Bujjamma and Padmavathi, 2018). Anemia was documented in *Oreochromis mossambicus* and *Channa punctatus* intoxicated with different doses of cadmium (Karuppasamy *et al*., 2005; Wu *et al*., 2006) respectively. In the same line anemia after exposed to heavy metals was recorded in *Leporinus obtusidens, Hypentelium nigricans*, *Hoplias malabaricus* and *Channa punctatus* by (Tyagi and Srivastava, 2005; Oliveira *et al*. 2006; Gioda *et al*., 2007; Schmitt *et al*., 2007).

Conclusion

The present study has shown that the exposure of fish *C. gariepinus* fingerling and juveniles to cadmium can inflict alterations in the haematological indices which could induce unfavourable physiological changes in the target organism ultimately leading to death. The study showed that intentional and unintentional release of heavy metals into the aquatic environment could threaten fish survival. This study could therefore be used as a tool to assess the effects of cadmium to fish in the course of the monitoring of waters in Nigeria.

Recommendations

It is recommended that treatment of all kinds of wastewaters sewage and Agricultural waste must be conducted before discharge into the aquatic system. Also, enforcement of all articles of laws and legislations regarding the protection of aquatic environments must be taken into considerations.

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Seasonal variations in the occurrence and distribution of pharmaceuticals in the Odo-Iya Alaro river, Lagos state Southwest Nigeria

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Abstract
Pharmaceuticals are indispensable to human health although their usage and discharge into the aquatic environment may lead to ecological problems and antibiotic resistance. The occurrence and seasonal variations of 37 pharmaceuticals belonging to 19 therapeutic classes in a sewage treatment plant Alausa Sewage Treatment Plant (Alausa STP)and surface water in Lagos, Southwest Nigeria was investigated. Water samples were collected quarterly from April 2017 to January 2018. Among the targeted analytes, 26 compounds were detected. The highest concentrations was observed for antibiotic and analgesic: sulfamethoxazole (129474 ngL^{-1}) had the highest maximum concentration followed by paracetamol (111374 ngL^{-1}). Over all, paracetamol had the highest mean concentration (18178 ngL^{-1}) while sulfamethoxazole had the second highest mean concentration (11160 ngL^{-1}). Cimetidine had the third highest maximum concentration of (95689 ngL^{-1}) and mean concentration (10458 ngL^{-1}). There were no specific spatial trends observed in this investigation and concentrations of pharmaceuticals in the study locations were high throughout the catchment revealing that there are potentially many contributing sites. There were statistically significant differences between the different site categories (Pharmaceutical manufacturing sites (PME), Alausa STP site (Sewage Effluents-SE), Semi- Urban and Urban sites (GLM: χ^2 (3) = 883.32, p <0.001). There are seasonal variations in the number of analytes detected in each sampling station. This investigation showed that pharmaceutical pollution of the aquatic environment will continue to be a major challenge in Nigeria and management efforts are needed to address this issue.

Keywords: Pharmaceuticals; Rivers; Water quality; Pollution; Sewage

Introduction

Pharmaceutical presence in the aquatic environment was first detected in the 1970's (Tabak and Bunch, 1970; Norpoth et al., 1973). Numerous studies had been carried out on occurrence of pharmaceuticals in the aquatic environment, but these have mostly been undertaken in Europe and North America (K'Oreje et al., 2012; Hughes et al., 2013). Fewer studies have been carried out in the developing countries of Africa, Asia, South America and the Middle East (Hughes et al., 2013; Madikizela et al., 2017). Some relatively high concentrations have, however, been found in countries such as China and India where treatment/regulation is less stringent than in the West. A similar situation exists in Africa, where high concentrations of pharmaceuticals are likely due to many regions suffering from little or no treatment of sewage before discharge to surface waters, particularly in rural areas and even in big cities. Even where sewage treatment plants (STP) exist many pharmaceuticals are not entirely removed by existing wastewater treatment methods (Gracia-Lor, 2010; Van Ginneken et al., 2017; Ortiz de Garcia et al., 2013).

In the past six (6) years, publications on occurrence and fate of pharmaceuticals in Africa aquatic system have been on the increase, however, very limited information are available for Nigeria (only three publications to date). For example, Olarinmoye et al. (2016), using LC-MS/MS for quantification reported pharmaceutical residues in wastewater impacted surface waters and sewage sludge from Lagos, Nigeria, for the surface water, ibuprofen showed the highest concentrations up to 8.8 μg/L, while diclofenac was more abundant in sewage sludge with concentrations up to 1100 μg/kg dry weight. Olaitan et al. (2014) also reported the detection of pharmaceutical compounds in surface and groundwater samples collected from an irrigation canal and several wells in a pharmaceutical industrial area of Sango Ota, Ogun State, Nigeria.

Agunbiade and Moodley (2015) investigated the occurrence and distribution of eight acidic pharmaceuticals in South Africa and found that all were present in sediments, wastewater, and surface water samples. Wood et al. (2015) surveyed the occurrence of anti-retroviral compounds used for HIV treatment in South African surface waters and found average concentrations between 27 and 430 ngL^{-1}.

Madikizela et al. (2017) reviewed the status of pharmaceuticals in African (Kenya, South Africa and Tanzania) water bodies, finding that NSAIDs, antimicrobial and antimalarial compounds are the most common drugs in the aqueous environment and that concentrations in wastewater exceed the levels found in developed countries. K'Oreje et al. (2018) studied the occurrence, fate and removal of pharmaceuticals, personal care products and pesticides in wastewater stabilization ponds and receiving rivers in the Nzoia basin of Kenya. Paraben concentration was up to 1 μgL $^{-1}$, antiretroviral and antibiotics were most prevalent measuring up to 100 μgL^{-1}, and low concentrations of pesticides was also detected.

In Nigeria, analgesics, antibiotics, antacid, antihistamines, anticonvulsants, steroids, antimalarial and antihypertensive are among the most consumed classes of compounds and are routinely purchased without a prescription (Odusanya, 2005). However, the statistics available on the usage of pharmaceuticals are not reliable because of the activities of unregistered pharmacies in some cities (e.g., Lagos) (Akande and Ologe, 2007; Oshikoya and Ojo, 2007; Nwolisa et al., 2006; Odusanya, 2005).

Here the first detailed/comprehensive study of pharmaceutical occurrence in Nigerian river is presented, covering more detected compounds than existing work in Nigeria and other African nations. The main objectives were: (i) to understand the extent to which 37 drugs belonging to different therapeutic classes are found in the river, (ii) to quantify spatial patterns of pharmaceutical contamination and, (iii) to determine seasonal dynamics of contamination.

Materials and Methods

Study area and sample collection

Study compounds

Benchmarking of high use pharmaceuticals was conducted according to Hughes et al., 2013 to identify different therapeutic classes.

Study catchment: Lagos State, Nigeria

Lagos State is a low-lying coastal region occupying 187 km of Nigeria's coastline. It is situated between latitudes 6° 22'N to 6° 42'N and longitudes 2° 42'E to 4°20'E. Twenty-two (22) sampling stations along the river (Figure 3.1.2) were chosen.

Sample collection

At each sampling station, three 50 mL water samples were collected into amber vials with Teflon® lined caps (Fisher Scientific, UK) and then homogenised into a single 150 mL composite sample of which 20 mL was taken. Sampling was undertaken on a quarterly basis to incorporate both the wet (April and July 2017) and dry seasons (October 2017 and January 2018). Sampling vials were rinsed with 100% methanol once and deionised water three times to remove potential contamination before sampling. Samples were collected at the same time of day and in the same location, checked using a Global Positioning System (GPS).

Sample preparation

A 10 mL aliquot of each composite sample was filtered on site at the points of collection using the procedure of Wilde et al. (2004) through a Whatman GFF (0.7 µm pore size) glass microfiber syringe filters into a 20 mL amber glass vial with a Teflon-lined screw cap. The filtered samples were frozen immediately on site with dry ice before shipping within 24 hrs to the University of York Centre of Excellence in Mass Spectrometry, York, United Kingdom for analysis.

Analytical procedure and method validation

Quantification was achieved using HPLC-MS/MS with a Thermo Scientific TSQ Endura Mass spectrometer coupled with an UltiMate 3000 liquid chromatograph. The method employed was adapted from Furlong et al. (2014) and validated for this purpose at the University of York Centre of Excellence in Mass Spectrometry (Burns et al., 2018).

Analysis was conducted by direct injection of 100 µL of respective samples onto a Phenomenex Eclipse Plus C18 chromatography column using a Phenomenex C18 (ODS, Octadecyl) 4 mm x 3 mm ID guard column. Mobile phase A was HPLC-grade water with 0.01 M formic acid and 0.01 M ammonium formate while mobile phase B was 100 % HPLC-grade methanol, flow rate of 0.45 mL min^{-1} was used with a gradient starting at 10 % B which then increased to 40 % at 5 min, 60 % at 10 min, 100 % at 15 min, and remaining 100 % B until 23 min then dropping to 10 % at 23 min prior to a re-equilibration. The autosampler temperature was kept at 4°C and the HPLC column compartment at 40°C. The collision gas was argon at a pressure of 2 mTorr.

Quantification was done with a 16-point calibration using deuterated internal standards (Burns et al., 2018) ranging from 1 to 32000 ngL^{-1}. Calibration r^2-values were consistently >0.95. Analytical limits of detection were calculated as described by Burns et al. (2018) and ranged from 0.9 ngL^{-1} (carbamazepine) to 12.4 ngL^{-1} (gabapentin). Quality control (QC) measures were used throughout the analysis.

Data analysis

Data were organised using Excel (Microsoft, 2013) and residuals of the data were checked for normal distribution using the Shapiro-Wilk normality test and homogeneity of variance using the Bartlett test of homogeneity of variances. R (R Development Core Team, 2008) was used to analyse the data and ggplot 2 to create figures (Barplot, Box-and-Whisker). Generalised linear model and Chi-square were used to find if there are differences between the sampling sites. Seasonal variations were analysed using one-way ANOVA where assumptions of normality and homogeneity were met followed by Tukey's post-hoc tests to determine if there is any variation in concentrations between the wet and the dry the seasons.

Results

Detection frequency

Out of the 37 targeted analytes 27 were detected at the Alausa STP (SE) (Figure 1A) and at the receiving river (Urban site category) (Figure 1B). 25 and 15 analytes were detected in receiving river (Semi-urban) and the pharmaceutical manufacturing effluents (PE) respectively. The ten most frequently detected compounds across the site categories were fexofenadine, carbamazepine, paracetamol, metformin, diazepam, cimetidine, codeine, sulfamethoxazole, atenolol and trimethoprim. Analytes not detected were venlafaxine (SE site category), triamterene (Urban site category), triamterene and venlafaxine (Semi-urban site category), gabapentin, hydrocodone, raloxifene, verapamil, diltiazem, oseltamivir, propranolol, sitagliptin, temazepam, triamterene, venlafaxine and tramadol (PE site category).

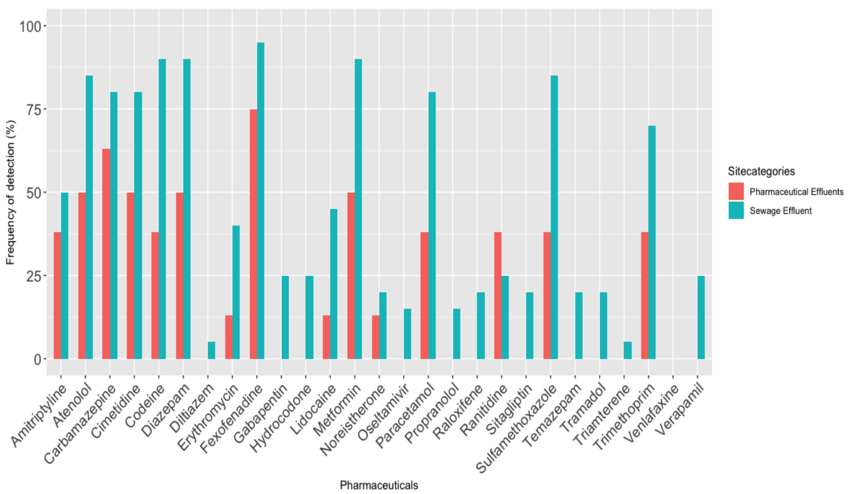

Figure 1A: Frequency of detection of pharmaceuticals in sewage effluents(SE) and pharmaceutical effluents (PE) in the Odo Iya Alaro river, Lagos, Southwest Nigeria.

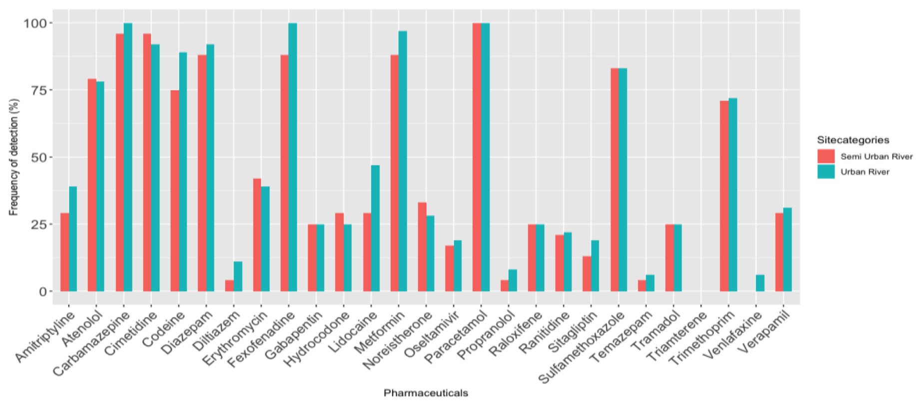

Figure 1B: Frequency of detection of pharmaceuticals in receiving river (Urban and Semi-urban site categories) in the Odo Iya Alaro river, Lagos, Southwest Nigeria.

Spatial distribution of pharmaceuticals in Odo Iya Alaro river

Pharmaceutical pollution was ubiquitous in the Odo Iya Alaro river with no obvious spatial patterns. Although there are diverse sources of pharmaceuticals into the river such as STPs, pharmaceutical manufacturing facilities, urban waste collection areas and vacuum truck operators who collect sewage from residential apartments and discharged to water course without treatments. There were statistically significant differences between the different site categories (Pharmaceutical manufacturing sites (PME), Alausa STP site (SE), Semi- Urban and Urban sites) (Figure 2) (GLM: χ^2 (3) = 883.32, p <0.001).

There are variations in the number of analytes detected in each site categories. For instance, 15 pharmaceuticals were detected at the pharmaceutical manufacturing site (PME) and the list detected analyte was noreistherone with mean concentration of 2.24 ngL^{-1} and peak concentrations of 17.91 ngL^{-1}. 26 analytes were detected in Alausa STP site (SE) and Urban receiving river. The list detected was oseltamivir with mean and peak concentrations of 0.69 ngL^{-1} and 5.52 ngL^{-1} respectively for Alausa STP site (SE) and venlafaxine with mean and peak concentrations of 0.24 ngL^{-1} and 4.75 ngL^{-1} respectively was the list analytes detected in the urban site. 25 analytes were detected in semi-urban location with sitagliptin detected at mean concentration of 0.45 ngL^{-1} and maximum concentration of 4.25 ngL^{-1} respectively.

Seasonal variations in pharmaceutical concentrations

There were statistically significant differences between the dry season, peak of dry season, the wet season and peak of the wet season ((GLM: χ^2 (3) = 8.63), p<0.001). More pharmaceuticals were detected in the peak of the wet season (22) than the other seasons. 17 analytes were each found in the wet and dry seasons while 16 pharmaceuticals were detected at the peak of the dry season. Although more pharmaceuticals were detected in the peak of wet season, there was distinct variation in concentrations of many pharmaceuticals which generally higher at the peak of the dry season (concentration level) (Figure 3). Fexofenadine for example, an antihistamine, has the highest mean and median concentrations (28272 ngL^{-1} and 22318 ngL^{-1}) respectively in the peak of the dry season (Table 2) compared to all other compounds and other seasons. The mean and median concentrations of fexofenadine are more than 500 times higher than the concentration in dry, peak of the wet or wet seasons. Carbamazepine, a psychotic drug has the second highest mean concentration (25654 ngL^{-1}) in the peak of the dry season and followed closely by paracetamol (24616 ngL^{-1}) in the same season. The mean concentration of paracetamol in the peak of the dry season was almost 1.5 times higher than the peak of the wet season. The median concentration was 9228 ngL^{-1}for peak of dry season, 8930 ngL^{-1} for dry season, 8940 ngL^{-1} for peak of wet season and 7130 ngL^{-1} for wet season. The mean and median concentrations of all the pharmaceuticals detected in the Odo-Iya Alaro river are extremely higher in the peak of the dry season than any other season except the following compounds that are either not detected in the peak of dry season or detected in low concentrations in other seasons: diltiazem 6 ngL^{-1} (peak of wet season), erythromycin 785 ngL^{-1}(dry season), gabapentin 97 ngL^{-1} (peak of the wet season), lidocaine 269 ngL^{-1} (dry season), noreistherone 18 ngL^{-1} (peak of wet season), oseltamivir 6 ngL^{-1} (peak of wet season), propranolol 2 ngL^{-1}(peak of wet season).

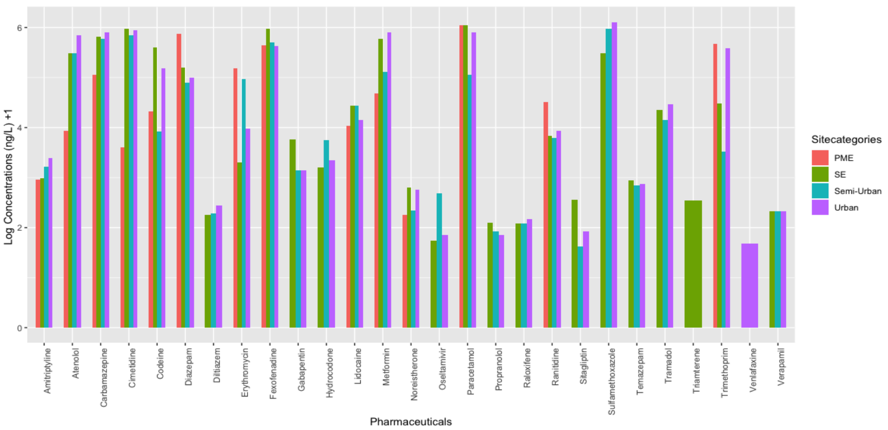

Figure 2: Log concentrations (ngL^{-1}) + 1 of pharmaceuticals detected at different locations: Pharmaceutical Manufacturing Effluents (PME), Sewage Effluents (SE) and receiving river (Semi-Urban and Urban) in the Odo Iya Alaro river, Lagos, Southwest Nigeria.

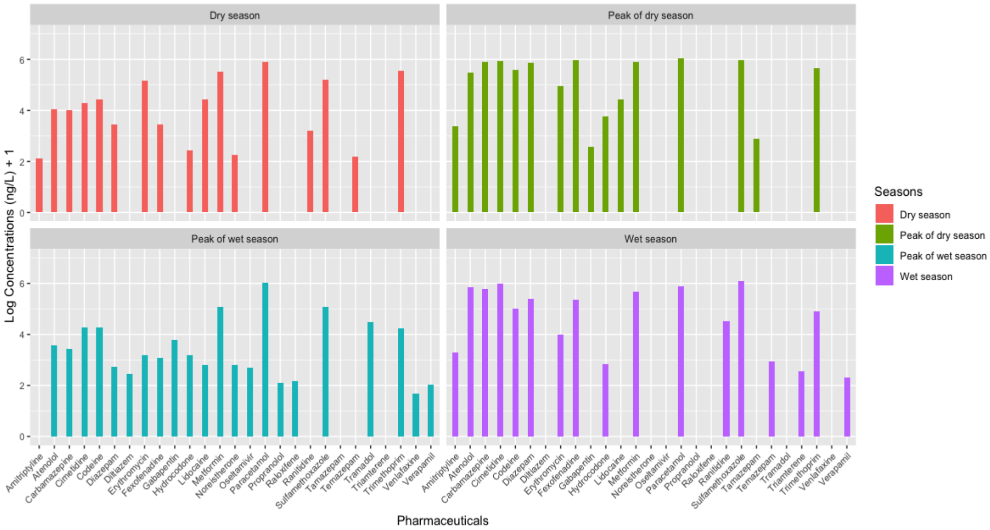

Figure 3: Barplots displaying log concentrations (ngL^{-1})+1 of seasonal variation of pharmaceuticals detected at Odo Iya Alaro river, Lagos, Southwest Nigeria.

Discussion

Pharmaceuticals are biologically active and pseudo-persistent, in the environment due to the continual input of wastewater effluent to rivers (Kay et al., 2017; Yamamoto et al., 2009). They, therefore, potentially pose a toxicological risk to non-target organisms (Boxall et al., 2002; Huang et al., 2012). The results presented in this work provide new information about the presence of pharmaceuticals in a Nigerian river, including frequency of occurrence, concentration ranges, spatial and temporal patterns and seasonal distribution. This work contributes significantly to the knowledge of pharmaceuticals in African rivers, which has wider relevance to developing countries worldwide.

The detection of 26 pharmaceuticals in the Odo Iya Alaro river has helped to confirm the presence of these substances in Nigerian watercourses including some that have not previously been observed in African rivers more widely. Pseudo persistence was observed, presumably due to continuous discharge of effluents to the river, similar to that found in other studies around the world (Burns et al., 2018; Hughes et al., 2013; Kay et al., 2017). Many of the substances found are the same as those in these other studies and certain substances are clearly used in great quantities around the world, including, for instance, fexofenadine, cimetidine, paracetamol, the sulphonamides and carbamazepine. Similarly, some substances appear to enter the aquatic environment in much lower amounts globally, e.g. propranolol. Furthermore, frequency of occurrence is higher in the receiving water than the STP and the pharmaceutical manufacturing effluents.

There were no specific spatial trends observed in this work and concentrations were high throughout the catchment revealing that there are potentially many contributing sites. Studies in Europe and the US have found that STP are the major source of pharmaceutical pollution (Hughes et al., 2013) but in the developing world it seems that there are a greater range of sources contributing to loads in rivers. These may include STPs, pharmaceutical manufacturing plants, urban waste collection areas and disposal of effluent by vacuum trucks. Similarly, pharmaceutical production facilities in Hyderabad, India have been found to be a key source in this developing country (Balakrishna et al., 2017: Fick et al., 2009; Larsson et al., 2007).

A number of studies have previously proposed a range of reasons for variation on concentrations of pharmaceuticals in river across the year, including seasonal usage and changes in environmental conditions (e.g. temperature and river flow) (Kolpin et al., 2014; Tewari et al., 2013). Typically, concentrations are highest during low flow conditions when sewage effluent makes up a greater proportion of river flow. As for spatial patterns though, seasonal trends in the data were complex with some compounds being found at extremely high concentrations in the peak of the dry season and conversely, some compounds such as atenolol, carbamazepine, cimetidine, codeine, diazepam, fexofenadine, metformin, paracetamol, sulfamethoxazole and trimethoprim are equally high during the wet period. Seasonal usage is unlikely to explain this as many compounds would be used equally over the year to treat persistent illnesses, e.g. carbamazepine and metformin. It may be that the multiple sources of pharmaceuticals in the catchment results in this complex picture with some that are associated with continuous effluent discharges (e.g. from STPs and manufacturing facilities) being diluted in the wet season but other sources (e.g. urban waste sites) which see pollutants mobilised in periods of rainfall.

Conclusion

This is the most detailed study to date of pharmaceuticals in African rivers and has highlighted their occurrence at high concentrations. Concentrations in Nigerian rivers appear to be several orders of magnitude higher than those reported for Europe and the US and, in some cases, even higher than the few existing values produced for other developing countries (e.g. Africa, China and India). Spatial and temporal patterns were complex and probably affected by a greater range of sources contributing to pharmaceutical loads than in many existing studies. This pose a particular issue for understanding and managing pharmaceutical pollution in African rivers. The scenario presented here has a strong likelihood of being replicated in other major African cities as well as megacities in other developing nations globally, where pharmaceuticals are available over the counter and where wastewater discharges to rivers proceed untreated. A key implication for the global research agenda on pharmaceutical effects in surface waters (e.g. ecotoxicological effects, antibiotic resistance) is that studies of pharmaceuticals in the environment should focus more on developing countries where contamination of water is likely much more significant.

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Distribution and composition of aquatic insects in relation to the physicochemical parameters of Awba reservoir, Ibadan

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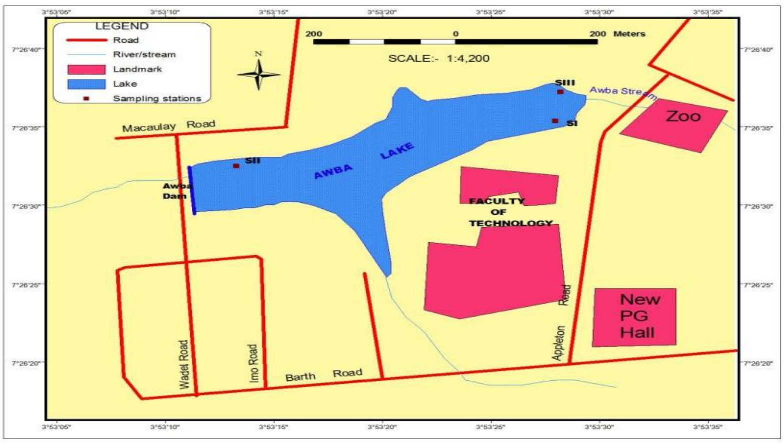
Abstract
The Species composition and diversity of insects from Awba reservoir, University of Ibadan, Oyo State were assessed; the influence of physical and chemical variables on their distribution was explored at three designated sampling points. A total of 1154 insect species belonging to 13 families were recorded. Water quality changes indicated significant difference ($P < 0.05$) in Dissolved oxygen and Phosphate- phosphorus within the points sampled. The families Chironomidae and Culicidae were the most abundant. These two families are indicators of poor water quality. The mean Shanon Weiner's index for the three stations (0.60) and Margalef index (1.63) were low, indicating poor water quality. The distinct taxa found in the sampled sites were indication of high organic input from the waste from the Zoological garden, hostels and the chemical laboratories which all empty into the reservoir.

Keywords: Aquatic Insects, Species, Diversity, Physico-chemical parameters

Aquatic insects are a group of arthropods that live or spend part of their life cycle in water bodies. Jain *et al* (2010). They are small-stream inhabiting creatures that are large enough to be seen with the naked eye, and spend all or part of their life cycle in or at the bottom of the water body (Mandeville, 2002). Some of them live near water or their life to some extent depends on water, these are the semi- aquatic insects. Immature aquatic insects are called either larvae or nymph They are of great importance in water bodies where they are found and their presence in water serve various purposes; some serve as food for fishes and other invertebrates, others acts as vectors through which disease pathogens are transmitted to both humans and animals (Chae *et al*.,2000). Most importantly, aquatic insects are very good indicators of water quality since they have various levels of tolerating environmental disturbances (Arimoro and Ikomi, 2008). This work was carried out to investigate the composition, diversity, and distribution of aquatic insects in relation to the changes in the physico - chemical properties of Awba stream and reservoir in University of Ibadan, in an attempt to evaluate their possible relevance as indicators of water quality stressors.

Materials and methods
The study area lies within Awba reservoir, located in the University of Ibadan, Oyo state, Nigeria. Geographically, the reservoir is located in the southwest area of the campus at an altitude of 185 metres above sea level.



Sample Collection
Water samples were collected fortnightly from each sampling points with plastic containers washed with nitric acid to remove any form of contaminants (Arimoro, 2007). The sampling period spanned from August through December 2008. The water samples collected were taken to the laboratory and analyzed immediately to ensure that the physical and chemical properties of the water were maintained.

Aquatic Insects sampling and identification

At each sampling point, insects were collected from water surface using a dip-net with Nytex® netting with 500-µm mesh. Adult insects and their nymph were also collected from the vegetation around the reservoir using a sweep net with a mesh size of 250-µm. The sweep net was passed over the area for at least two minutes. The contents collected were put into a sorting bucket and the net was properly checked for insects clinging to the mesh. Insects collected were preserved in 7% formalin in jars labeled according to site number, description, and collection date, according to Merritt *et al* (2008). A Van Veen Grab was used to collect benthic macro-fauna. The sediment collected was emptied into a labeled polythene bag. The samples collected were sieved through a net with mesh size of 0.5 mm to eliminate the excess sediments. Organisms were sorted from the detritus and stored in 10% formalin. In the laboratory, organisms were identified with the aid of a compound microscope, and were stored in individual vials containing 10% Formalin Solution.

Aquatic taxonomic keys (Needham *et al.*, 2000; Heckman, 2002) were used to identify the collected specimens to species, or at least genus level, except chironomids that were identified to family level.

Statistical Analysis

Analysis of variance (ANOVA) was used.

Results

Physico – Chemical Parameters.

The result of the physico-chemical parameters analyzed in Awba reservoir is presented in Table 1. The mean, minimum and maximum values and the standard deviation are also shown. The spatial trend in the pattern of each physical, chemical and heavy metal characteristic was similar along the stream. Temperature, pH, nitrate, velocity, zinc, copper, lead and cadmium were not significant (P>0.05) during the period of assessment however, phosphate and Dissolved oxygen were significant (P< 0.05) within the sampling points. Table I shows the variation in the physic- chemical parameters.

Table 1. Summary of the Mean values of Physico-chemical parameter analyzed in Awba Reservoir

Parameters	Point 1	Point 2	Point 3
Temperature (°C)	26.8^{a}	26.6^{a}	25.75^{a}
pH	6.69^{a}	6.81^{a}	6.75^{a}
Dissolved Oxygen (mg/l)	1.68^{b}	1.21^{b}	3.10^{a}
Alkalinity	88.5^{a}	85.63^{a}	81.75^{a}
Nitrate	0.03^{a}	0.02^{a}	0.025^{a}
Phosphate	0.046^{a}	0.02^{b}	0.025^{b}
Velocity (m/s)	0.03^{a}	0.018^{a}	0.021^{a}
Zinc	1.529^{a}	1.569^{a}	1.5056^{a}
Copper	0.513^{a}	$0.548^{a.}$	0.558^{a}
Lead	0.009^{a}	0.010^{a}	0.010^{a}
Cadmium	0.004^{a}	0.004^{a}	0.003^{a}

Note: means with different superscript in a row shows significant difference (P< 0.05) Indicated by Duncan Multiple Range Test.

Table 2: The overall composition and distribution of aquatic insects encountered in the sampling points, in Awba Reservoir

Species	Point 1	Point 2	Point 3	Total
Coleoptera				
Hydrophilic	02	03	-	05
Gyrinidae	07	04	12	23
Diptera (larvae)				
Chironomidae	418	254	34	709
Tabanidae	12	-	02	14
Cuicidae	35	52	07	94
Water flea	12	15	31	58
Odonata (nymphs)				
Lesticidae	-	01	01	02
Libellulidae	05	04	37	46
Aeschnidae	03	-	13	16
Hemiptera				
Belostomatidae	06	09	20	35
Gerridae	94	10	39	143
Neopla sp	02	-	05	07
Tricoptera				
Hydrosychidae	-	-	05	05
Total	596	352	206	1154

Table 3: Diversity and other indices of Aquatic Insects in the study Stations of Awba Reservoir

Variables	Point 1	Point 2	Point 3
No. of Taxa	11	09	12
No. of individuals	596	352	206
Taxa richness (d) Margalef index	1.56	1.27	2.06
Shannon Weiner index (H)	0.46	0.44	0.92
Evenness (E)	0.44	0.457	0.852
Simpson Dominance index (D)	0.52	0.54	0.42

Discussion

Water quality plays a vital role in the distribution, abundance and diversity of aquatic insects. The high abundance and distribution of pollution tolerant orders of aquatic insects in points 1 and 2 reflects the relative pollution of the reservoir. With special reference to Margalef's water quality index, values greater than 3 indicate clean conditions, values less than one (1) indicates heavy pollution of a stream while values between one to three (1-3) indicates moderately polluted conditions. Margalef index for point 1,2 and 3 indicates moderately polluted, thereby corroborating the evidence of the relative polluted nature of the reservoir and this showed that the various activities around the reservoir has brought about pollution.

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Evaluation of the transfer of heavy metals from pig manure to maggot, house fly larvae (*Musca domestica*)

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Abstract
A research was conducted in the research and fish farm of the department of fisheries and aquaculture, kogi state university Anyigba to evaluate the transfer of heavy metals from pig manure to maggot, house fly larvae (Musca domestica). The pig manure collected was divided into two parts: Pig manure before maggot culture and pig manure after maggot culture. The two samples were tested for heavy metals using Atomic Absorption spectrometer (AAS). The maggots produced were also tested for heavy metal using (AAS). The three samples were tested for five heavy metals: chromium (Cr) Cadmium (cd) Magnesium (Mg) Lead (Pb) and Zinc (Zn). The results were analyzed using SPSS Statistics version 19.0 soft ware for the ANOVA and the mean were separated with student test. The result recovered should significant difference in heavy metals content of the pig manure after and also in maggot produce (PC005). The content of pig manure after maggot culture had the lowest concentration of chromium (Cr) and cadmium (Cd). The results of this research showed that maggots are good bio-accumulators of heavy metals and would therefore be suitable for reducing the heavy metals content of pig manure making the manure suitable and less toxic as fertilizer in fish ponds and also reducing environmental pollution caused by disposal of pig manure. However, maggot produced can be used for feeding fish or in fish feed production. But caution should be take so that fish feed with maggot meal will not bio accumulate heavy metals.

Keyswords: Heavy metals, Pig manure, Maggot.

Introduction
The practice of animal production and husbandry is common in all parts of the world and as part of Agricultural production, became strongholds for the world economy as people need to feed, even with the advance in technology, the Agricultural sector still continues to grow globally. The practice of animal husbandry also comes with its disadvantages such as land pollution with the generation of manure. Livestock pollution generate approximately 14million tons of manure annually in the European union (Foged *et al*., 2012) and about 55Billion tons of manure are generated every year from animal feeding operations globally (Girotto *et al*., 2017). Manure management has become an essential part of environmental protection which widely employ technologies of manure management that includes fertilizer treatment, energization etc (Charlton *et al*., 2015). For example, in France animal manure are mainly use as organic fertilizer for agricultural production because of their abundant nutrient composition such as nitrogen (N), phosphorus (P) and potassium (K). However, several substances contain the manure that are harmful to human safety as well as ecosystems (heavy metals, antibiotics and pathogens) and this limit the development. Cang *et al*., 2004 detected high concentration of heavy metals like Zinc (Zn), copper (Cu), Chromium (Cd), Lead (Pb), Nickel (Ni) and arsenic (As) in swine manure, and the application of this manure as fertilizer to the soil without treatment can lead to eutrophication. A rapid cost effective treatment of manure is its conversion by insect. Many insects can reduce large quantities of the manure and turn into high quality fertilizer. The house fly (*Musca domestica*) is considered a good candidate for use in manure management and the non-pest black soldier fly (*Hermetra illucons* L.) (Diener *et al*., 2009) is used to substantially reduce organic waste in low and middle income countries. The increase in Aquaculture leads in growing demand for feed for culture organism and therefore increases prices of feed (Riddick 2014). Fish meal is becoming too expensive and less available and this has made the sales of insect protein helpful not only to replace fish meal but also contribute to cover the waste disposal cost as well as allowing innovative, small scale entrepreneurs to establish a profitable business niche. There has been a rising concern in the field of animal production as to how to effectively dispose animal manure in such a way that it is environmentally friendly and less injurious to man. The production of maggot, the larvae form of house fly (*Musca domestica*) from waste material either from plant or animal origin and food waste become popular as it competes as animal protein sauce with high nutrient value and also digest waste material making odor free "scum" (Michael and Sogbesan, 2015). In aquaculture, maggot is a form of unconventional feed for fish, in the process of using maggot cultured from pig manure to feed fish, the heavy metals accumulated by the maggot are transferred to the fish which can be harmful to the fish themselves and the consumers of the fish.

Materials and Methods
Study Location;-
The study was conducted in the fish research farm of the department of fisheries and aquaculture, faculty of agriculture of Kogi state university Ayingba, Dekina LGA Kogi State, Nigeria. Located on latitude $7^0 15$-$7^0 29$N and longitude $7^0 11$-$7^0 32$E

Collection of Pig Manure
Pig manure were collected from the pig farm of Kogi State university pig farm in a jute bag

Experimental Procedure

The pig manure collected were divided into two parts of 1kg each. One part was taken to the laboratory for heavy metal content analyses before maggot culture. The other portion were poured into a five litre plastic container after premixed with cow blood as fly attractant. The container was perforated at the through which a hose of ¼ diameter connects it with another 2littre plastic container which served as a maggot collector. Water was sprinkled on the manure device daily to keep it moist for three days until flies began to lay eggs. The eggs from the flies began to then develop into maggot within 5-6 days. The maggots so produced migrate through the hose and drop in the two liter container where they are harvested. The maggot harvested and the remnant of the pig manure after maggot production were taken to the laboratory for heavy metal content analyses of both samples.

Heavy Metal Analyses

The maggot samples were prepared using method used by Ozmen *et al.* (2004). Each maggot were weighed from different parts in two grams into each beaker and into each beaker 12ml of the mixture of aqua regia solution added as digestion procedure while manure sample were air dried sieved to normalized particle size and digested using the method provided by Agemian and Chau (1976). The samples in each beaker were digested to a clear colorless solution using hot plate at 80^0C. The digests were allowed to cool filtered through whatman No1 filter and then transferred to different 50ml volumetric flask and filled to 20ml mark with de-ionized water and kept read for atomic absorption spectrophotometer analysis. The prepared solution was aspirated into the instrument through capillary tube. The machine was connected to a computer and two gas cylinders one of which is filled with acetylene and the other with air, these gases kept the flame burning.

Bio Accumulation Factor (BAF)

The bio accumulation factor of the heavy metals for the maggot sample was calculated using the formula

$$BAF = \frac{\text{Concentration of heavy metals in maggot mg,kg-1}}{\text{Concentration of heavy metals in pig manure mg.kg-1}}$$ (Wong *et al*., 1992)

Statistical Analysis

Results are presented using students E-test and significant differences among mean value were tested using one way ANOVA (spss 19.0 software)

Result

Heavy metals in the sample of the pig manure before maggot culture as in table below showed that chromium and cadmium have the lowest concentration in pig manure with magnesium and zinc having high concentration. Heavy Metals Content of Pig Manure, (Before maggot production BMP), maggot, pig manure, (After maggot production AMP).

Heavy Metals (diluted Mg/L)

Samples	Pb	Cr	Mg	Zn	Cd	SEM
Maggot	0.03 ± 0.58^b	0.00±0.00	0.19 ± 0.46^a	0.6+0.61	0.00±0.00	0.87
Pig manure (BMP)	0.17±0.15	0.00±0.00	0.20 ± 0.005^b	0.90 ± 0.57^a	0.00±0.00	0.62
Pig manure (AMR)	0.01 ± 0.10^a	0.01 ± 0.02^b	0.14 ± 0.02^a	0.67 ± 0.38^a	0.00±0.00	0.24
BAC(maggot)	0.18	0.00	0.95	0.67	0.67	

All superscript with different letters are significantly different ($p<0.05$)
BMP (Before Maggot Production)
AMP (After Maggot Production)
BAC (Bio Accumulation Factor)

Discussion

Pig Manure carried high concentration of heavy metals in the study especially Zinc and magnesium. This could be as a result of the premix in the pig feed as highlight by Ampofo *et al*. 2017, who said that the premix used in pig feed always have concentration of Zinc and Magnesium. Chromium, Cadmium and lead concentration were not significant ($P > 0.05$) compared with magnesium and zinc. This result agreed with the research carried out by Wary *et al*., 2017; who traced heavy metals in some manure-maggot-chicken production chain. The concentration of heavy metals present in maggot are relatively higher than in pig manure before maggot culture. This showed the bioaccumulation characteristics of the cultured maggot. This which agreed with the research of Wang *et al*., 2017; who said that maggot have little ability to bio accumulate lead in manure and Diener *et al*. 2015 predicts that the concentrating lead in the larval exuviate is higher than the concentration of lead in their feed indicating that lead is sequestered in the exoskeleton of the black soldier fly (*Hermatia illucans*). Bioaccumulation characteristics of the culture maggots is relatively high for some heavy metals and are low in some. For example, it is very low in cadmium from this study.

Acknowledgement
With profound gratitude, I write to give glory to almighty for good health and enablement to embark on this study. I sincerely want to appreciate the support of Prof. Adeyemi S.O and Mr. Micah A.D. in every aspect of this work.

Conclusion
From this study, maggot can effectively transform the heavy metals in swine manure especially zinc, lead, chromium and cadmium in bioaccumulation characteristics and bioaccumulation factor of maggot indicated that the concentration of heavy metals in maggot was below the acceptable limit. Therefore, maggots can be used to reduce the concentration of the heavy metals in pig manure, making it safe for use as fertilizer in fish ponds.

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Assessment of Bioaccumulation Rate of Heavy Metals in Drill Cuttings by Mangrove Periwinkle (*Pachymelania aurita*) of the Lagos Lagoon.

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Abstract
The bioaccumulation of Zn, V and Pb from the oily drill cuttings by the Mangrove Periwinkles *Pachmelania aurita* of the Lagos lagoon was evaluated in the laboratory. Specimens (120) of *P. aurita* were collected from the edge of the Lagos lagoon at low tide, put in different holding tanks and aerated with a 220v air pump. Drill cuttings used were collected in two 20 litres plastic bucket from the main discharge point at the Shell Development Petroleum Corporation. Atomic absorption spectrometer technique was used for the heavy metal analysis. The exposure of these animals to sub-lethal concentration (1/100th and 1/10th of $96EC_{50}$) of drill cuttings showed that the animals bio-accumulated varying degrees of metals. *P. aurita* exposed to 1.024ml/L drill cuttings for 32 days have 1.27mg/kg, 0.15mg/kg and 0.004mg/kg overall net gain of Zn, V and Pb respectively. Organisms exposed to 10.024ml/L of drill cuttings have 1.5mg/kg, 0.007mg/kg and 0.008mg/kg overall net gain of Zn, V and Pb respectively. The significance of this result is the need to include bio-accumulators of heavy metals such as *P. aurita* in monitoring programme aimed at establishing the environmental levels of such pollutant as drill cuttings in aquatic ecosystems.

Keywords: Bioaccumulation, Drill cuttings, Lagos lagoon, Mangrove periwinkle

Introduction
Heavy metals of the onshore drill cuttings have been known to be capable of polluting the environment with the resultant effect on human health (Gbadebo *et al.*, 2010). Bioaccumulation is a process whereby an organism concentrates metals in its body from the surrounding medium or food either by absorption or ingestion. The in-organic pollutant heavy metal elements present in drill cuttings are barium, copper, cadmium, iron, lead, manganese, nickel, vanadium and zinc (Neff 1987). Trace elements such as copper, iron and zinc are essential to maintain the metabolism of the human beings. However heavy metals such as cadmium, chromium, mercury and lead pose a number of health hazards to humans. Humans are exposed to this by ingestion (drinking or eating). High concentrations of cadmium causes itai-itai disease. Chromium compound are toxins and are known human carcinogens. Mercury permanently damages the brain, kidney and developing foetus (Abiaobo *et al* 2017). Many aquatic organisms for example periwinkles have the ability to accumulate and bio-magnify contaminants like heavy metals, polycyclic aromatic hydrocarbon and PCB in the environment (Moslen *et. al*, 2017, Aigberua and Izah 2018). *Pachymelania aurita* is regarded as a dominant member of the faunal community of Lagos lagoon with a mean annual production rate that varied from 1.59g and 0.99g/0.5m/year (Brown 1991). The specie is edible and serves as a source of protein to local inhabitants.

Therefore, this present study is aimed at determining the bioaccumulation of selected heavy metals by *P. aurita* exposed to sub-lethal dosages of oily drill cuttings under laboratory conditions.

Materials and Methods
Test animals
The test animals used for this bioassay were periwinkles, *Pachymelania aurita* (Mollusca, Gastropoda, Mesogastropoda, Melanidae). *P. aurita* were collected from the mangrove flats of Lagos lagoon, Lat. 6^0 31 .188 E.

Test compound
The test compound used for this bioassay were oily drill cuttings.

Sublethal Test (Bioaccumulation Studies
Drill cuttings was tested against *P. aurita*: 1.22ml/L (0.01 of the 96hEC50), 12.22ml/L (0.1 of the 96hEC50) and untreated control

Analysis Of Metals In Tissues Samples
Analysis of metals in tissues samples was carried out by Atomic Absorption Spectrophotometer model of AAS machine.

Regression analysis
Regression analysis was carried out to determine correlation coefficient (r^2) between concentrations of test metals accumulated in the test animals or sediment with period of exposure.

Result

TABLE 1: The Accumulation of Heavy Metals (Zn, V And Pb) By *P. aurita* Exposed to Sublethal Concentrations of Drill Cuttings Over A 32-Day Period

TREATMENTS (ml/l)	**MEAN CONCENTRATIONS OF HEAVY METALS IN WHOLE ANIMAL TISSUES (mg/kg dry weight basis)**					**WHO Limits**
	Day 0	**Day 4**	**Day 8**	**Day 16**	**Day 32**	
Zinc (Zn)						
Control	8.11	8.15	8.15	10.78	13.16	3
1.22ml/l (1/100th EC_{50}-)	8.11	13.56	15.60	16.35	16. 85	
Net gain**		5.45	2.04	0.75	0.5	
Control	8.11	8.15	8.15	10.78	13.16	
12.22ml/l (1/10th EC_{50}-)	8.11	16.11	16.24	16. 26	16.85	
Net gain**		8.00	0.13	0.02	0.23	
Vanadium (V)						
Control	0.00	0.00	0.00	0.002	0.003	
1.22ml/l (1/100th EC_{50}-)	0.0	0.001	0.002	0.003	0.004	
Net gain*E		0.001	0.01	0.001	0.001	
Control	0.00	0.00	0.00	0.002	0.003	
12.22ml/l (1/10th EC_{50}-)	0.00	0.003	0.004	0.004	0.006	
Net gain**		0.003	0.01	0.00	0.002	
Lead (Pb)						
Control	0.00	0.00	0.001	0.003	0.002	
1.22ml/l (1/100th EC_{50}-)	0.0	0.00	0.001	0.004	0.005	0.01
Net gain**		0.00	0.001	0.003	0.001	
Control	0.00	0.00	0.001	0.003	0.002	
12.22ml/l (1/10th EC_{50}-)	0.00	0.003	0.004	0.006	0.0086	
Net gain**		0.003	0.001	0.002	0.002	

*Overall net gain = concentration in animal after 32days – concentration in animal at zero day
**Net gain – difference in concentration between the immediate preceding days of harvesting e.g. 4-0day, 8-4day etc.
*1/100th 96-h EC-$_{50}$ values of the drill cuttings in the test compounds
**1/10th 96-h EC_{50} values of the drill cuttings in the test compound

Bioaccumulation of Zinc by *P. aurita*

Post treatment analysis of whole body tissue of *P. aurita* showed that the animals exposed to (1.22ml/L and 12.22ml/L) sub-lethal concentration of drill cuttings accumulated higher quantities (1.28 and 1.25 times respectively higher) than the residual levels in animals in untreated control media over a 32-day period of observations (Table 1).Furthermore, at the end of the 32 day exposure period, there was an overall gain of 8.74mg/kg and 8.38mg/kg of Zn over respective initial amount of Zn in the animal tissues exposed to the sub-lethal concentration of (1.22ml/L and 12.22ml/L respectively) (Table 1).There were positive correlation between amounts of Zn accumulated by *P. aurita* with time of exposure. (r^2 = 0.8049 and 0.5336 for the 1.22ml/L and 12.22ml/L test media respectively (Fig 1).

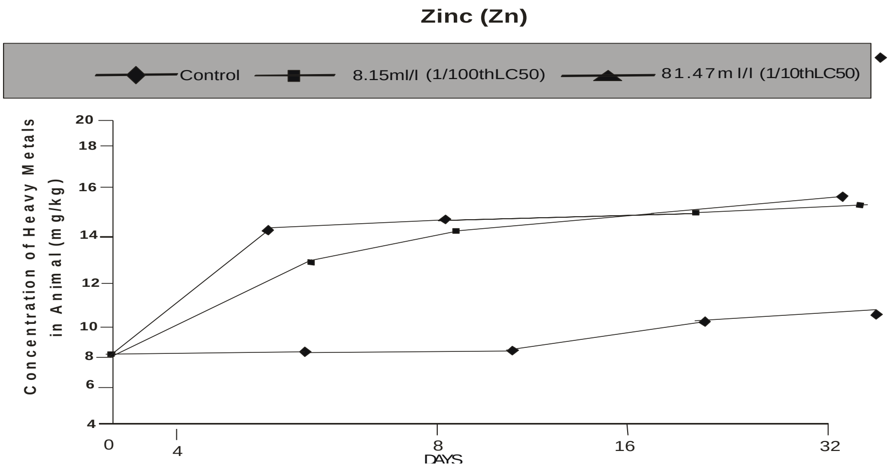

Fig 1: Profile of accumulation of Zinc (Zn) P.aurita Exposed to Varying Sublethal Concentration of Drillings Cuttings over a 32-period.

Bioaccumulation of Vanadium by *P. aurita*

Post treatment analysis of the whole body tissue of *P. aurita* showed that the animals exposed to (1.22ml/L and 12.22ml/L) sub-lethal concentrations of drill cuttings accumulated higher quantities (1.33 and 2 times respectively higher) than the residual levels in animals in untreated control media over a 32-day period of observations (Table 1). Furthermore, at the end of the 32 day exposure period, there was an overall gain of 0.004mg/kg and 0.006mg/kg of V over the respective initial amount of V in the animal tissues exposed to the sub-lethal concentration of (1.22ml/L and 12.22ml/l respectively) (Table 1).

Bioaccumulation of Lead by *P. aurita*

Post treatment analysis of whole body tissues of *P. aurita* showed that animals exposed to (1.22ml/L and 12.22ml/L) sub-lethal concentration of drill cuttings accumulated higher quantities of Pb (2.5 and 4 times higher) than the residual levels in animals in untreated control media over a 32 day period of observations (Table 1).Furthermore, at the end of the 32 day exposure period, there was an overall gain of 0.005mg/kg and 0.008mg/kg of Pb over the respective initial amounts of Pb in the animal tissues exposed to the sub-lethal concentration of (1.22ml/L and 12.22ml/L respectively) (Table 1). There were positive correlations between the amounts of Pb accumulated by *P. aurita* with time of exposure. (r^2 = 0.8909 and 0.981 for 1.22ml/L and 12.22ml/L test media respectively) (Fig 2;

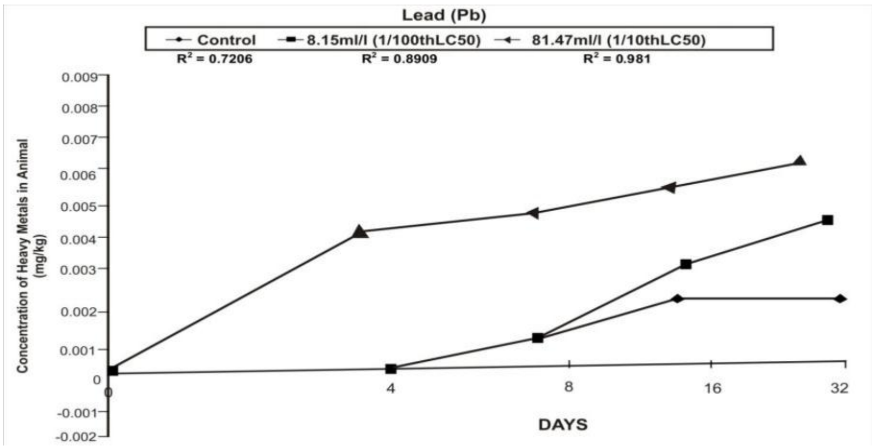

Fig 3: Profile of Accumulation of Lead (Pb) by P.*aurita* Exposed to Varying Sublethal Concentrations of Drill Cuttings over a 32-day Period

Discussion

The exposure of *P. aurita* to sublethal concentration of drill cuttings resulted in the accumulation of varied degree of metals (Zn, V and Pb) by the exposed organisms. The level of heavy metal accumulation in the animal was found to correlate positively with the concentration of drill cuttings in the test media and the duration of exposure. There was a positive correlation between the concentration of Zn accumulated by *P.aurita* and that of the sediment bioassay. Kiffney and Clement (1998) have also reported increase in concentration of Zn by about 2 to 3 fold over a period of one year in *Periphyton, Baetis, Archopysche* and *Rhyacopihla* species in a heavy metal station in the Arkanasas river. The amount of V accumulated by the animals increased with time of exposure and concentration of the metal in the test medium sediment. However a downward trend was observed between 8 and 16 day exposure period of *P.aurita* to sub-lethal concentration of 12.22ml/L. This could be as a result of individual organisms not accumulating at the same pace. The concentration of V in the body tissue of *P.aurita* exposed to 12.22ml/L of drill cuttings was found to be 2 times higher than the concentration detected in animals in the untreated media. The concentration of Pb in the body tissue of *P.aurta* exposed to 12.22ml/L sub-lethal concentrations of drill cuttings was found to be 4 times higher than the concentration detected in animals in the untreated media. Comparison between the concentration of heavy metals (Zn, V and Pb) in the body tissue of test organisms *P.aurita* and the sediment of the test media showed that there were positive correlation between the concentration of the metals in the sediment and that of the test organisms, as the concentration in the sediment increased, the concentration accumulated by the test animals also increased. This type of correlation was reported by Otitoloju and Don-Pedro (2002) when *Tympannotonus fuscatus* was exposed to sublethal concentration of Zn, Pb, Cu and Cd. The observation justifies the importance attached to periwinkles as useful group of organisms for assessing heavy metal toxicity and bioaccumulation in aquatic environment.

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Impact of some hydrological factors on biodiversity of fish in Agaie/Lapai dam reservoir of Niger State, Nigeria

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Abstract:
The effects of some hydrological factors (rainfall, inflow and depth of water) on fish biodiversity in Lapai dam reservoir were studied by monthly samplings and measurements taken from May, 2013 to October, 2014. This reservoir is situated at 9^0 39´ N latitudes and 6^0 33´ E longitudes located near Bakaje at the confluence of the Jatau River. Samples of fishes were collected from the fishermen in two chosen landing sites where they catch fishes using cast nets, seine nets and hooks and lines in designated locations of the reservoir. Eleven (11) fish families were identified during the study belonging to *Brigridae* with 2 species, *Characidae* with 2 species, *Schilbeidae* with 2 species, *Cichlidae* with 5 species, *Claridae* with 2 species *Cyprinidae* with 3 species, while *Chanidae*, *Hepsetidae*, *Malapteruridae*, *Mochokidae* and *Mormyridae* had 1 specie each respectively. The highest level of impact of rainfall was felt by the fish from the month of March to November. *Cichlidae* recorded the highest respond to the inflow of water from tributaries while other fish families showed no any increase or decrease in abundance to the changes of the flow-rates of water. The family of *Mochokidae* responded to the fall of water level (depth) while other families of fish were not significantly impacted by the factor.

Keywords: Confluence, Impact, Inflow-rate, Water level, Rainfall, Landing site.

INTRODUCTION

Niger State is blessed with numerous large water bodies including reservoirs, floodplain of River Niger and Kaduna, and several streams. Large number of the population derives their livelihood from the water bodies through artisanal fishing. Agaie/ Lapai dam is one of the medium earthen dams constructed by the Upper Niger River Basin Development Authority with a reservoir of estimated 13.5sq. meters and a maximum storage capacity of 38 million cubic meters (UNRBDA, 1978).

The water systems are interconnected; they host plant and animal life and both influence and interact with weather patterns. The physico-chemical parameters induce both vertical and horizontal migration of aquatic organisms. It affects the organism distribution, diversity and feeding. (Imam and Balarebe, 2012).

Biodiversity constitute part of the stabilization of ecosystem and protection of overall environmental wellbeing of all species of organisms on the planet (Saliu and Eruteya, 2006). Fish biodiversity of reservoirs essentially represents the fish faunal diversity and their abundance (Lawson and Modupe, 2010). Nigeria has potential fish culture, although it is still lacking to be fully exploited compared to the developed countries (Ikomi and Anyanwu, 2010). Fishes are the largest part of the living vertebrates that constitute more than half of the approximately 48,170 known vertebrate species in the world although diversity of freshwater organisms are much narrower than on land or in the sea. (Ikomi and Anyanwu, 2010). Many small lakes and reservoirs may be regarded as parts of river or stream systems in which the inflow of water has been impeded (Singh and Laura, 2012).

The magnitude of the influence of the inflow of water through a lake reservoir depends on the volume, the extent of its catchment area and the amount of rainfall (Shukla *et al*., 2009). The effects of inflow on population and structures of fish has been the interest of ecologists in the past (Lashkar and Gupta, 2009; Roeike *et al.*, 2010; Eldridge and Roelke, 2010 Singh and Laura, 2012).

An increasing depth negatively affects mean light intensity and so specific production of primary producers is predicted to decrease with depth. Increasing depth also negatively affects alga sinking loss rate within the mixed layer and enrichment with the limiting nutrient positively affects phytoplankton production. (Richardson and Schoeman, 2004). Depth negatively affects light availability but positively affect nutrient availability in the water column (Kunz, 2005).

MATERIALS AND METHODS

Study Area

Agaie/ Lapai dam is located adjacent to Bakajiba village at latitude 9^0 39'N and longitude 6^0 33'E southwest of Minna [Fig. 1]. It has a capacity of 38 million cubic meters and a crest length of 1.600 meters. Its average depth is about 10.8 meters and becomes progressively shallower towards the inflow part, where it measures less than 1.64 meters (Fig.2). The shore is not easily accessible during wet season. There are three tributaries and then one spillway on the side of the embankment of the dam. The northern end of the reservoir drains into a broad swampy area and gradually narrows to a small stream. The southern end is a small stream called Chemi River which flows directly into the reservoir. Other rivers are Jatau river coming from the eastern portion and river Jimada comes from the North-eastern part, bordered by fairly elevated flat land and covered by grasses and few scattered trees.

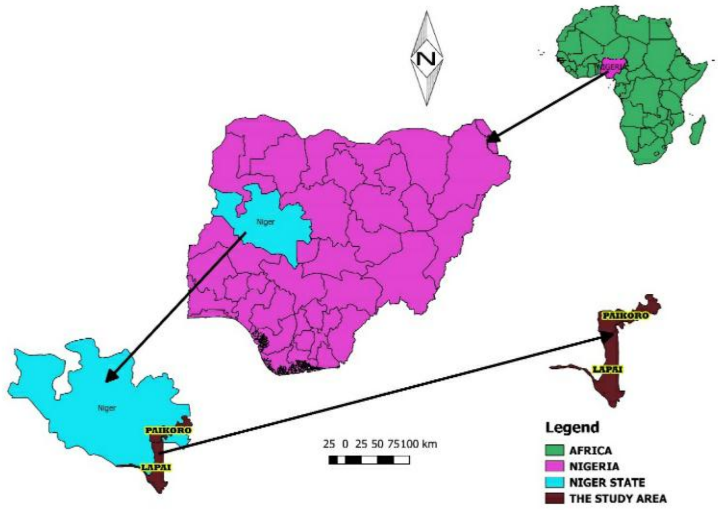

Figure 1: The location of Agaie-Lapai dam reservoir (inset map of Nigeria and Africa)

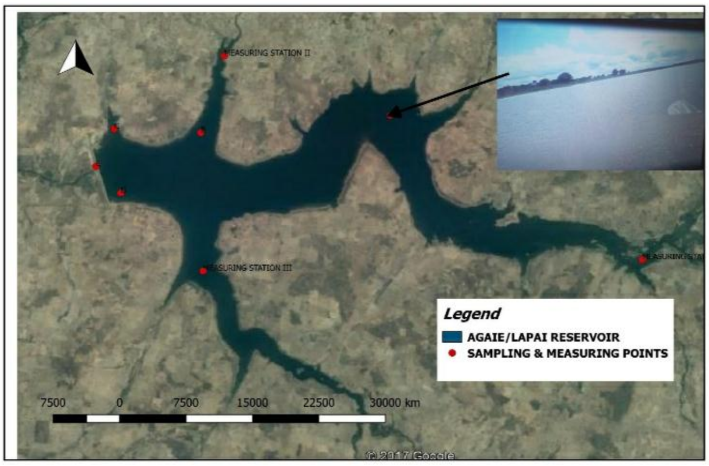

Figure 2 Agaie/Lapai Dam Reservoir showing the measuring and sampling points

Measurement of water level (depth) and rainfall

Depth of the water was measured by lowering a weighted, measuring tape to the bottom of the reservoir and then taking the value from the surface line of the water. Sample of physico-chemical parameters and plankton was taken from the surface of the water in all stations between 9.00am to11.30am. Daily rainfall measurement was taken using standard Rain gauge stationed at the dam site.

Measurement of Flow-rate (Cross Section Method).
The cross-section method was used to measure the flow-rate of the major rivers entering into the reservoir. It was done by choosing a point in the stream that acted as the cross-section of the river. The depth of the river was measured at equal intervals along the width of the river using a measuring tape. As the data was gathered, each depth was multiplied by the interval it was taken and the entire values were added. Then, a length of the river was decided typically longer than the width of the river. A floating object (an Orange) was released down the reservoir repeatedly. Using a stop watch the time it takes for the float to travel down the length of the stream was taken. This step was repeated four times and the mean value was calculated as the average velocity. The velocity obtained was multiplied by a friction correction factor in this case by 0.85 because of the rocky nature of the river beds. The corrected velocity was multiplied by the crosssectional areas to yield the flow rate in volume/ time (m^3/sec), (Graftman,2006).

Water Physical and Chemical parameters
Water physical and chemical parameters were measured following the methods described by the America Public Health Association (APHA, 2005).

Patterns of the hydrological factors in Agaie/ Lapai dam reservoir.
The pattern of local rainfall regimes in Lapai dam reservoir revealed the month of September with the high record value of 558.8mm of rainfall and at the end of November the value recorded dropped to 48.2mm signifying the close of the raining period of the season. In September the following year, the trend of local rainfall regimes changed where the record high of the rainfall value dropped to 508mm and the lowest value of 38.7mm was recorded at the beginning of the season in May (Figure 3). The water level (depth) of the reservoir had the record high value of 10.6m in the month of October and the lowest value of 6.2m in the month of April (Figure 3). The highest record value of 10.7 m water level (depth) of the two seasons was obtained in the month September. The flow-rate of water from the three major tributaries into the reservoir water showed the month of August had the highest flow-rate value of 234.4 m^3/ cm dropped to 48.2m^3/sec in November. In the following season 2014, the flow-rate record was first obtained in May with low value of 38.7 m^3/sec and the highest value of 241.2 m^3/sec in the month of August (Figure3)

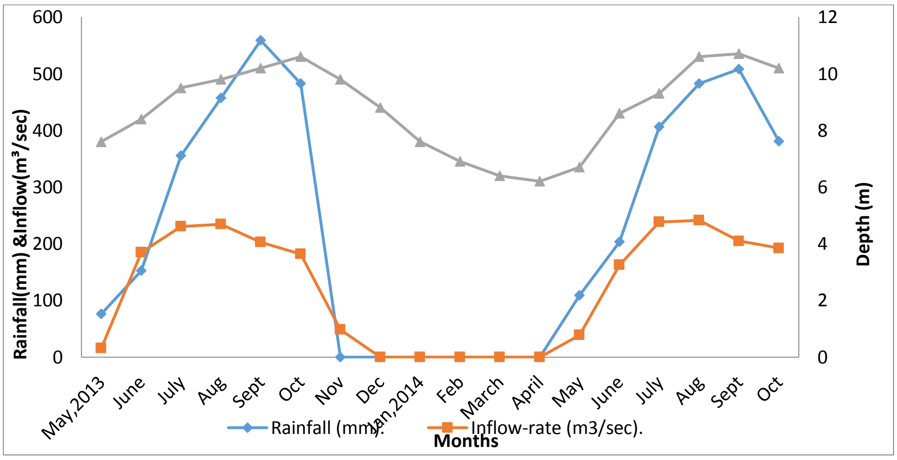

Figure 3: Patterns of the hydrological factors of Agaie/Lapai dam reservoir.

The impact of rainfall on the phytoplankton biodiversity and abundance of the dam reservoir
The impact of rainfall on the phytoplankton in the dam reservoir affected the abundance of phytoplankton (Figure 4.15). The highest values of 18 and 13cell/ml of Chlorophyta and Chrysophyta respectively were recorded when there was no rainfall within locality between the month of November and April. Other phytoplankton groups that were affected by the rainfall were the Bacillariophyta and Euglenophyta with lower values of 9 and 8 individuals' cell/ml respectively.

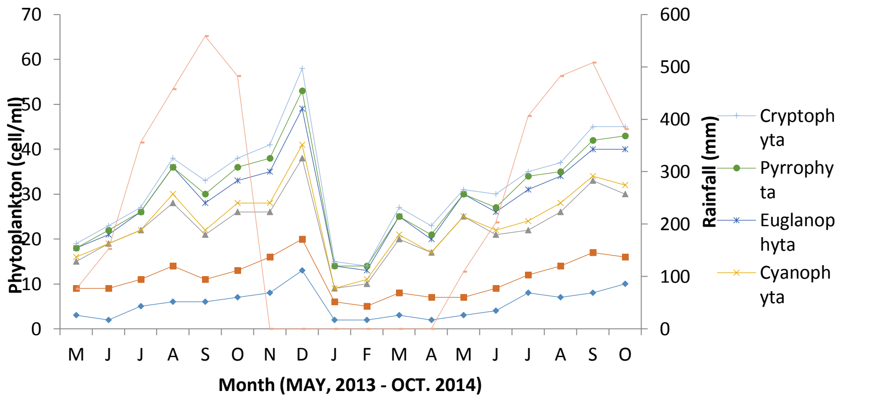

Figure 4: Impact of rainfall on the biodiversity and abundance of phytoplankton in the dam reservoir

The impact of inflow of water on phytoplankton biodiversity and abundance of the dam reservoir

The impact of flow-rates of water into the dam reservoir was pronounced on the phytoplankton groups. During two raining periods of the study, Chrysophyta and Bacillariophyta were not affected by the inflow-rates and the groups had 14 and 8 individuals cell/ml respectively at 234.4m^3/s (Figure 4.18). Similarly, the same groups of phytoplankton had 16 and 9 individuals cell/ml respectively at 204.7m^3/s. The Cryptophyta and Pyrrophyta were impacted by the inflow of water and they had 18 individuals and latter had 13 individuals at the peak of flow-rates.

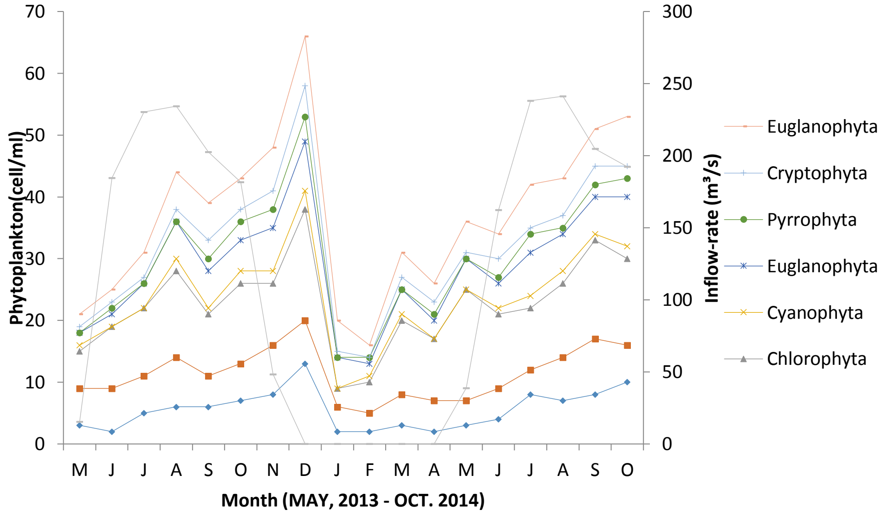

Figure 5: Impact of inflow-rate of water on biodiversity and abundance of phytoplankton in the dam reservoir

The water level (depth) on the biodiversity and abundance of phytoplankton of the dam reservoir.

The changes of water level (depth) of the dam reservoir showed the abundance of phytoplankton taxa of Chlorophyta and Chrysophyta were much affected when the water level was at the verge of falling (Figure 4.21). All of the groups fell sharply between the driest month of January and February. At the highest peak, Chlorophyta had 14 individuals cell/ml in August and Chrysophyta had 13 individuals cell/ml in December at the depth of 10.6m. The trend of variations continued in the proceeding season where Chlorophyta had 16 individuals cell/ml in September when the water level was 10.7m and Chrysophyta had 10 individuals cell/ml in October

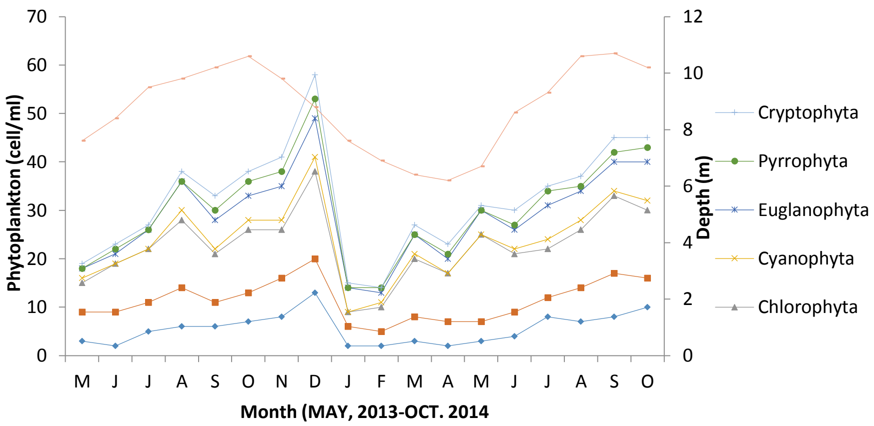

Figure 6: Impact of the water level on biodiversity and abundance of phytoplankton in the dam reservoir.

Discussion

In relation to the influence of the environmental variables, the peak of the total fish was between November and May. Magami, *et al*, (2015), reported October to concise with the raining season that the total number and abundance of the most species. Rainfall showed positive impact on the abundance of fish and reached its peak when the rain was about to stop (Lawson and Modupe 2010). Zarate-Hernandez, *et al.* (2012), supported the observation in the report that high occurrence of *Brevoortia gunteri* and *Menidia beryllina* species of fish showed positive correlation during dry season to trophic response associated with the proliferation of plankton. Rainfall increase tributaries discharge and freshwater runoff and, carries along large amount of allochthonous organic matter and dissolved nutrients into the aquatic system (Castillo-Rivera Manuel, 2013)

Conclusion

The environmental variable was found to influence the proliferation and abundance of the fish when the factors were at their peak about to decline or fall. Their multiplications and consequent abundance were brought to zero when the rainfall record stopped, the beginning of the dry season as the nutrients in the reservoir declined.

There are rich diverse culturable species of fish in Agaie/Lapai dam reservoir hence urgent need to protect the existing indigenous fish stocks and enhance their quality. These species are in numerous small other reservoirs across the state which should be incorporated into the value system of the society.

Recommendations

i. Fish stock assessment should be measured regularly.
ii. Conservation plan should be identified for effective monitoring.
iii. Preservation of the rich fish diversity of the reservoir should be intensified by regular restocking.

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