DWINDLING FISH PRODUCTION: FISHERIES RESEARCH TO THE RESCUE

BY

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Distinguished Ladies and Gentlemen

1.0 Preamble

Let me start by giving thanks to Jehovah God for his protection over me and my family, and the grace to be here this afternoon to deliver this lecture. This is the first inaugural lecture to be delivered in the Department of Forestry, Wildlife and Fisheries and the 13th in the College of Agricultural Sciences.

I will start by telling you the story of how I became a Fisheries Scientist. My friends know that I like telling stories or in common parlance "gisting" and as a matter of fact my wife thinks I gist too much. I grew up in an environment that was highly vegetated and had an orchard that contained all sorts of fruits, because my father was an Agriculturist. In addition, the compound harboured all sorts of animals including snakes, squirrels, monkeys, chameleons (now endangered). As a young boy, I was fascinated by these animals although sometimes frightened. These early years experiences aroused in me the interest in animals. I therefore tinkered with the idea of pursuing a career in a field related to the study of animals. However, an elderly lady advised me not to pursue such a career as she put it, I may not be able to maintain my family. I thereafter decided to pursue a career in Medicine, but for some inexplicable reasons I went back to my first love which is Zoology and later Fisheries Science. The rest as they say is history. I stand before you this afternoon to talk about some of my contributions to the science of fisheries.

Inaugural lectures can be classified into three categories: the sublime, prophetic and the familiar (Temple, 1954). I intend this afternoon to follow the familiar path, where I will talk about a topic encompassing my research interests/activities and hopefully convince the audience of their relevance to increased food production.

I shall begin my lecture on the status of fisheries in Nigeria, then fisheries research in Nigeria, and finally on my humble scholarly contributions in this regard.

2.0 Introduction

Mr Vice Chancellor Sir, the importance and relevance of the fisheries subsector to national economies cannot be over-emphasised. Fisheries is divided into three categories:

(1) Capture Fisheries (2) Culture Fisheries (3) Post-harvest Fisheries

Capture Fisheries entails the harvesting of fish from marine, brackish and freshwaters.

Culture Fisheries (Aquaculture) entails the exploitation and improvement of all aquatic food resources both flora and fauna, from freshwater, brackish and marine environments related directly or indirectly to human consumption.

Post-harvest Fisheries

Post harvest fisheries comprise the activities that take place from the time the fish is landed or harvested until it is consumed. It embraces the cultural, environmental, economic, institutional, social, technical and marketing aspects of the supply, demand, preservation and processing and distribution of fish and fish products.

The relatively low success achieved in fisheries development particularly in developing countries compared to its potential high socio-economic benefits has been a major concern to national fisheries resource managers.

3.0 Status of fisheries and aquaculture in Nigeria

Mr Vice Chancellor Sir, Nigeria is endowed with a long coastline of about 960km, a large area of inshore waters, and a vast inland water system comprising natural and man-made lakes, rivers, creeks, lagoons and wet lands all of which support a good variety of fisheries.

Fishery contributes significantly to the economy of Nigeria, to food and nutrition security, providės jobs particularly in the coastal areas where the poorest and most vulnerable reside. Fish represents the major source of protein available to most Nigerians, with an estimated per caput fish consumption of 13.3kg in 2013(FAO,2018). The total fisheries production in 2015 was estimated at 1,027,000 metric tonnes to which marine catches contributed 36%, inland waters catches 33% and aquaculture 31%. Fishery sector contributed 0.5% of national GDP in 2015 (Table 1).

Table 1: Fisheries statistics – Federal Republic of Nigeria

	1980	1990	2000	2010	2014	2015	2016
Employment (thousands)	469.07	490.00	1177.31	1519.64	1477.65	1565.36	1190.50
Aquaculture	......	.....	....	200.54	313.23	316.73	....
Capture (t)	469.07	490.00	1177.31	1519.63	1477.65	1565.36	1190.50
Inland (t)	....	....	716.62	831.54	713.04	782.75	652.60
Marine (t)	469.07	490.00	460.00	688.08	764.62	782.61	537.90

Adapted sources: FDF 2015, FAO 2018.

Artisanal fisheries provide employment for over 400,000 people and is responsible for about 80% of total domestic production from coastal, inshore, creeks of the Niger Delta, lagoons, inland rivers and lakes(FDF,1997; FAO, 2018). The fishery is dominated by the small migratory bonga (*Ethmalosa fimbriata*), while *Sardinella* is the main species caught in the marine waters.

Nigeria is a net importer of fishery products, with total fish imports amounting to about USD 1.2 billion and exports valued at USD 284,390 million in 2013(FAO, 2018). In 2014, 713,036 were engaged in inland fisheries with 21% being women.

Nigeria is the largest aquaculture producer in sub-saharan Africa. The aquaculture sub-sector is mostly private sector driven, and its importance is increasing, with feed and fingerlings being provided by the private sector. The government has showed renewed interest in this sector through policy initiatives and political will. According to government reports, production increased from 217000 tonnes in 1999, to 316,700 tonnes in 2015 (FAO, 2018). The African catfish, *Clarias gariepinus* is commonly grown in concrete tanks and earthen ponds, and constitutes over half the total aquaculture production by volume.

In 2012, 13,627 people were reported as employed in aquaculture, with 2% being women (FAO, 2018).

4.0 State of fisheries research in Nigeria

A major factor in boosting fishery production is the application of research findings. Researches are aimed at making progress toward sustainable resource management and the realization of new opportunities. How can research bring about improvements?

Fisheries research is a scientific endeavour, performed by skilled individuals, rather than by institutions that employ them. Researches can be divided into the following categories: basic, applied and adaptive.

Literature is replete with information on various research findings on capture fisheries and aquaculture in Nigeria all aimed at increasing food production. These researches have been mainly funded by international agencies (World Bank, FAO etc.) particularly those that involve extensive data collection of marine resources.

Factors limiting the impact of fisheries research on fisheries livelihoods (FAO, 2002) include:

- Inadequate and erratic funding
- Poor infrastructure
- Inconsistent and inappropriate policies
- Inadequate number of skilled manpower
- Ineffective research-extension-farmer linkages
- Weak linkages with other service providers such as rural financial institutions.

Fisheries and aquaculture research is carried out by the Nigerian Institute for Oceanography and Marine

Research(NIOMR) Lagos and by the National Institute for Freshwater Fisheries Research(NIFFR) New Bussa, while aquaculture research is undertaken by the African Regional Aquaculture Centre (ARAC), Port Harcourt and a number of Nigerian universities. These are the major institutions involved in fisheries research.

Nigerian Institute for Oceanography and Marine Research (NIOMR)

Mr Vice Chancellor Sir, the core mandate of NIOMR is to conduct research into the resources and physical characteristics of the Nigerian territorial waters and the oceans, and to disseminate validated research findings of the Institute. Some of the research findings have been beneficial to end users in the areas of:

- Fish smoking; processing and utilisation technologies using the NIOMR smoking kilns
- Fish canning of the African catfish
- Use of by-catches and trash fish in producing value added fish product.
- Post-harvest management of fish resources
- Fishing technology

However a major constraint to its mandate has been funding of research and dissemination of research findings.

National Institute of Freshwater Fisheries Research (NIFFR)

The inland waters of Nigeria comprising ponds, rivers, streams, flood plains, lakes (approximately 149, 919km^3, Ita, 1994) have enormous fishery potential to meet the nutritional needs of communities, and provide jobs. NIFFR has as its core mandate, conducting research on the management and rational exploitation of these inland water resources.

African Regional Aquaculture Centre

The mandate of the African Regional Aquaculture Centre is to develop aquaculture with the introduction of new species for the brackish water environments. In Ogun State, the Eriwe Fish Farm is the largest fish farm estate in Nigeria. It has over six thousand registered farmers with an annual production of about 2500 metric tonnes and generates an income of about one billion naira annually. The major fish cultured is the African catfish , *C. gariepinus* (FMARD, 2018).

Research activities of universities and international organisations

Other institutions involved in inland, brackish and marine fisheries research include the Universities and some International Organizations. These institutions have contributed immensely to increased food production through research findings over the years.

However, they are faced with a number of constraints which include

- Unenforceable moderations in policy regulation, the major actor in policy formulation being the government represented often by administrators who seldom advance the relevance of scientific research in developing new technologies.
- Funding: funds release schedules often lag behind meaningful research work plan profiles.
- Inadequate capacity building for research personnel.
- Research- extension linkages weakened by widespread rural illiteracy especially among fishers.
- Inadequate extension personnel provisions.
- Conflicting interactions between policy management schedules of governments and research/ extension institutions.

Key factors influencing the performance of research providers

The important factors include:

- Funding resource initiatives
- Infrastructure/ Networking priorities
- Policy management
- Human resources development
- Socio-economic research analyses

I will not digress further.

5.0 My Scholarly Contributions

Mr Vice Chancellor Sir, some of my contributions to fisheries research towards improving dwindling fish production will be discussed under the following headings: Fish ecology, Reproductive biology, Fish nutrition, Fish toxicology and Fish pathogens/parasites.

Fish Ecology

My foray into research began with my Ph.D programme at the University of Ibadan in 1985 under the supervision of Prof. S. O. Fagade. At this time, the research team was interested in the biology and ecology of fish populations in fresh water bodies. Under the federal government water projects scheme at the time, dams were being created to provide potable water, hydroelectric power and reservoirs which had a huge potential for fish production. There was a need to study such water bodies with a view to determining the pre-impoundment flora and fauna, in order to be able to monitor subsequent changes. I was assigned to investigate the ecology of the fishes of Oyan lake which was one of such new impoundments for my Ph.D project. Oyan lake situated in south-west, was formed as a result of the dam located 20km north-west of Abeokuta on the Oyan river. The lake which has a maximum length of 27km, a maximum width of 6km and a maximum depth of 63m, covers an area of 40sq km.

Twenty six species of fish belonging to 14 families were caught in the lake with the cichlids being the dominant family. The fish fauna of Oyan lake followed the pattern in some man-made lakes in Africa e.g. Lake Volta in Ghana, Lake Kainji in Nigeria, Lake Kariba in Zimbabwe, where the Cichlidae and the Bagridae are the dominant families, with Tilapias dominating the fishery (Table 2). An investigation into their feeding relationships revealed food overlap among some of the species, suggesting possible competition (Olurin and Fagade, 1994; Olurin and Fagade, 1998).

Table 2: Fish specimens caught from Oyan Lake

FISH FAMILY	GENERIC AND SPECIES NAME
Mormyridae	*Gnaththonemus niger*
	Hyperopisus bebe
	Mormyrops deliciosus
	Mormyrus rume
	Marcusenius senegalensis
Characidae	*Alestes macrolepidotus*
	Alestes longipinus
	Hydrocynus forskahlii
Hepsetidae	*Herpsetus odoe*
Icthyoboridae	*Phago loricalus*
Cyprinidae	*Labeo oguensis*
Bagridae	*Chrischythys nigrodigitatus*
Schillbeidae	*Schilbe mystus*
Claridae	*Clarias gariepinus*
	Heterobranchus bidorsalis
Malapteruridae	*Malapterus electricus*
Mochokidae	*Synodontis schall*
Centropomidae	*Lates niloticus*
Cichlidae	*Sarotherodon galilaeus*
	Tilapia zilli
	Tilapia mariae
	Oreochromis niloticus
	Hemichromis fasciatus
	Chromidatilapia guntheri
Channidae	*Channa obscura*
Anabantidae	*Ctenopoma kingsleyae*

Pre-impoundment studies were also conducted on Owa stream south-west, Nigeria, and the cichlids were also found to be the dominant species(Table 3). Feeding interrelationships revealed both opportunistic feeding and stenophagy (Olurin and Sotubo, 1989;Olurin and Awolesi, 1991).

Table 3: Percentage composition of fish species by weight and number in Owa stream

Family	Total No.	% by No.	% by weight
Notopteridae			
Xenomysutus nigri	12	5.83	4.09
Papyrocranus afer	9	4.37	6.51
Malapteruridae			
Malapterus electricus	2	0.97	4.06
Cichlidae			
Tilapia mariae	45	21.84	30.21
Tilapia zillii	5	2.43	1.92
Chromotilapia guntheri	92	44.66	38.62
Hemichromis fasciatus	38	18.44	12.85
Channidae			
Channa obscura	1	0.49	0.89
Anabantidae			
Ctenopa kingsleyae	2	0.97	4.06

Fafioye, Olurin and Sowunmi (2005), also studied the physico-chemical properties of River Omi, with a view to determining its water quality. Results revealed that the water is suitable for aquaculture. We also investigated the food and feeding habits of *Synodontis nigrita* from Osun River, near Epe, Lagos (Olojo *et al.,* 2003). The diet covered a wide spectrum, with a seasonal variation. It was concluded that the species is an omnivore.

Reproductive biology

The reproductive biology of a community of fish provides information on their spawning cycle, fecundity, egg size and sexual maturity, which helps in determining the recruitment patterns in such habitats.

Investigations were conducted on the reproductive biology of some fishes in a number of water bodies. These include those of the fishes of Owa stream (Olurin and Odeyemi, 2010).Of the species examined, only *Hemichromis fasciatus* differed significantly from the 1:1 sex ratio (Table 4). Size at maturity varied among the species. The gonado-somatic indices increased with gonadal stages of development, and the values for males were lower than those of the females of corresponding stages of development.

Table 4: Sex ratio of fishes in Owa stream

Species	No. of males	No. of females	Sex ratio	X^2 value	Significance P=0.05
Xenomystus nigri	5	7	1:1.4	0.16	n.s
Papyrocranus afer	--	4	--	–	
Clarias gariepinus	--	1	--	–	
Chromidotilapia guntheri	86	119	1:1.38	2.65	n.s
Tilapia mariae	36	35	1:0.9	0.007	n.s
Hemichromis fasciatus	33	12	2:5.1	4.35	0
Channa obscura	---	4	---	–	
Ctenopoma kingsleyae	2	9	1:4.5	2.23	n.s

Olurin and Savage (2011) also investigated the reproductive biology of the African snake head, *Parachana obscura* in River Osun. More males were caught. Eggs ranged in size between 0.88 and 0.11mm while fecundity estimates ranged between 1711 and 4000. No seasonal pattern of breeding was observed. (Table 5)

Table 5: Monthly occurrence of stages of gonadal development in *P. obscura*

Months	N	I		II		III		IV	
		M	F	M	F	M	F	M	F
August	3		1		1		1		
September	10		10						
October	17	3	12		2				
January	17			5	10		2		
February	28			3	11	2	11	1	

N- number; F-female; M-male

Olojo *et al.* (2012) investigated aspects of the reproductive biology of *S.nigrita* from River Oshun to determine its suitability for aquaculture. Size at maturity were 95mm and 115mm for males and females respectively; while fecundity varied between 216 and 9620 eggs. *S. nigrita* is a multiple spawner, spawning all year round.

Fish Nutrition

Mr Vice Chancellor Sir, a major constraint to fish production is feeds for fish culture. Feed is the most expensive item in the culture of fish. The cost of commercial feeds in fish culture in the tropics and developing world is high, and various attempts are being made at partially or wholly replacing these feeds with cheaper substitutes to reduce the cost of production. My colleagues and I carried out a series of studies to find alternative feeds for common aquaculture species e.g. *Tilapia and Clarias*. In the first series of such studies, we investigated the growth performance of *Clarias gariepinus* fed different levels of maggot (*Musca domestica*) as partial substitute for artificial feed. Fish fed 75% maggot, and 25% pelleted commercial diet had the highest mean growth rate (Olurin and Soyege,1999), (Table 6).

Table 6: Growth performance of fish fed different levels of fly maggots as partial substitute for commercial diets in a four-week trial.

Parameter	Treatment			
	Control: pelleted commercial Diet (PCD)	75% maggot:25%PCD	50% maggot:50% PCD	LSD 0.05
Average initial weight(g)	0.74±0.10^{a}	1.02±0.02^{a}	1.89±1.09^{a}	1.26
Average final weight (g)	0.99±0.27^{b}	1.91±0.07^{ab}	2.38±1.08^{a}	1.29
Average gain in weight (g)	0.25±0.16^{b}	0.89±0.04^{a}	0.49±0.06^{b}	0.25
Average growth rate (mg/g/day)	9.84±5.84^{b}	21.63±0.59^{a}	9.59±4.41^{b}	8.47

Values followed by the same letter in a row are not significantly different ($P>0.05$)

It was concluded that maggots could be included in the diet of *C. gariepinus*. However, this type of studies using maggots has been discouraged because of the possibility of zoonoses (i.e. the transfer of disease from animals to man) and ethical issues. In recent times, technology has advanced new techniques for the utilization of these sources without adverse effects.

The use of maggots was meant to assist resource poor fish farmers, feed being the single most expensive component of fish rearing. Investigations were also carried out on growth performance of *C.gariepinus* fry fed on different protein sources (Olojo *et al.*, 2005).

Mr Vice Chancellor Sir, the results showed that fish meal can be substituted completely with other protein sources such as blood meal, soya bean or palm kernel cake. This finding is important as this will considerably decrease the cost of fish production that depends mainly on fish meal as major source of protein.

Still on efforts geared towards reducing cost of fish production, we investigated (Olurin *et al,* 2006) the use of cassava meal as a replacement of maize meal in the diet of *C.gariepinus.* The major source of metabolisable energy in most compounded diets for fish and livestock is maize. However, the increasing prohibitive cost of this commodity as a result of many competing uses, especially in developing African countries has made it necessary to evaluate other ingredients to replace maize with cheaper carbohydrates.

Fingerlings were subjected to five treatments in which maize was replaced by cassava at 0%,(control), 25%, 50% and 100% levels. Growth parameters were not significantly different among diet treatments. It was concluded that cassava flour can be included in the diet of the African catfish.

Roles of fish oil in diet

A major component of fish feeds is fish oil, which serves as a veritable source of essential fatty acids (EFAs) and energy. A dietary deficiency in those essential fatty acids result in slow growth and various pathologies (Karapanaglottidis,2002; Sargent *et al.,* 1999). Fish oil which is mostly obtained from marine fish is however becoming limiting and expensive, and therefore the need to find alternative sources of EFAs.

Olurin *et al.,* (2004) investigated the use of palm oil in the diet of the African catfish, as an alternative to fish oil. Fish oil was substituted with palm oil at 0% (control), 25%, 50% and 100%. Growth performance was not significantly affected by diet. It was concluded that palm oil can be substituted for fish oil in the diet of *C. gariepinus* (Table 7).

Table 7: Effect of different levels of inclusion of palm oil on growth and feed utilization by *C. gariepinus* fingerlings

Parameter	Diet 1	Diet 2	Diet 3	Diet 4
Mean weight gained (g)	0.95	1.45	1.65	1.75
Feed conversion efficiency	20	25	23	17
Specific growth rate	0.9	0.85	0.9	1.1

In the course of our investigations, we examined the nutrient profile of various earthworms and their suitability as alternative protein sources in fish diet. In a study of the macromineral profile of four species of earthworm (Dedeke *et al.*, (2010a), we found that five macrominerals (Ca, Mg, K, Na, P) which are requirements of animals were adequately present in earthworms. Therefore, the use of meal prepared from these earthworms as mineral supplements in fish diet could be encouraged.

Also it was found that in the amino acid profile of four earthworm species from Nigeria (Dedeke *et al.,* 2010b), lysine and methionine which are limiting amino acids were present in all earthworms examined. These basic studies on the macro mineral and amino acid profiles of the earthworm encouraged us to conduct feeding trials using earthworm meal as a substitute for fish meal in the diet of *C.gariepinus* (Dedeke *et al.,*2013).

Fish meal protein was replaced by earthworm meal at 0%, 15%, 25%, 35%, and 50%. Growth indices showed optimal growth in fish fed D 25. It was concluded that fish meal can be substituted with earthworm meal up to 25% in the diet of *C.gariepinus* without adverse effects on growth and nutrient utilization.

Fish Toxicology

Mr Vice Chancellor Sir, fish production is hampered by pollutants which cause undesirable changes in the environment. These pollutants alter the physiological processes in the body which are detected early by histopathology, leading to decreased growth and ultimate death. These pollutants obtained from the aquatic environment and food cover a wide spectrum of gases, chemicals and solids. Most toxicological studies have been limited to the effects of lethal or acute doses of these pollutants (Huertas *et al.,* 2002, and Das *et al.,* 2004), whereas, subtle physiological disorders result with exposure to sub-lethal/low doses (Varo *et al.,* 2007).

We carried out a number of investigations on the effect of some of these pollutants in fish using histopathological techniques, because of the public health implications. It is common practice to dump old batteries into waters, thereby contaminating the environment with Pb. Olojo *et al.,* (2005) therefore conducted a study on the histopathology of the gill and liver tissues of the African catfish, exposed to lead. Fish fingerlings were exposed to sub-lethal concentrations of lead for a period of three weeks. Results showed that the degree of distortion of the gills and liver was proportional to the exposure periods and the concentration of the metal (Figs 1&2). The effect was found to be dose and time dependent.

Figure 1. Liver tissue showing deformities in the tissue 9 days after exposure to lead (Pb) treatment 0.006mg/L. Sinusoidal pole bearing blood vessels are well manifest with increase in density of fibre connective (T) radiating towards the central vein (V). Areas of lysed cells (D) are equally indicated. Mg. x 400.

Figure 2. Photomicrograph of gills showing the arrangement of the Primary (P) and Secondary (S) lamella. In the central core is amass of hyaline Cartilage (C) surrounded with darkly staining blood vessels and sinusoidal spaces. Mg x 400.

Similary, Olurin *et al.,* (2012) investigated the effect of Zn on haematological parameters of *C. gariepinus*. The result obtained from the study showed that zinc triggered haematological responses in *C.gariepinus*.

Also a study of the effects of glyphosate (herbicide) on the gill and liver tissue of *C. gariepinus* revealed (Olurin *et al.,* 2006) marked alterations in the gill epithelia. There was fusion in adjacent secondary lamellae resulting in hyperplasia with profound oedaematons changes. In the liver, there was enlargement of the hepatocytes, and it was concluded that glyphosate has a deleterious effect on the organs of *C.gariepinus*

In a related study, we investigated the effect of phostoxin (Aluminium sulphate) on *C. gariepinus* juveniles(Olurin *et al.*, 2016). Phostoxin commonly called "trebor" is used by farmers to prevent weevil infestation in stored grains. Unfortunately most of these pesticides pose a health risk to man and the environment. Inadvertently, the tablets are ground with maize and end up in feeds consumed by fish. It has been reported by some poultry farmers that the spleen of chicken fed contaminated diet show pathological effects. In *C. gariepinus*, phostoxin caused significant alterations in the cyto-architecture of the gills and to a considerable extent the liver and the kidney(Figs. 3-5).

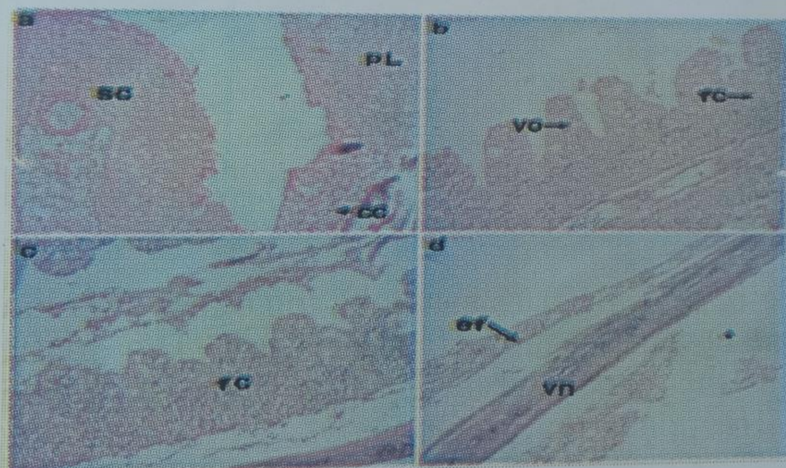

Figure 3. (**a-d**) Photomicrograph showing transverse section of gill filaments of *Clariasgariepinus*juveniles. (**a**) Control showing normal appearance of gill filaments, primary lamellae (pL), secondary lamellae (sc), chloride cell (cc) and polar cell (pc). (**b**) Gill of exposed at 0.125mg L-1 indicating mild hyperplasia with fused (fc) and un-fused secondary lamellar (vo). (**c**) Gill of exposed at 0.250mg L-1 indicating severe hyperplasia with complete fusion of secondary lamellae (fc). (**d**) Gill of exposed at 0. mg L-1 showing complete disintegration of secondary lamellae, epithelial lifting (ef) exposing central venous sinus (vn). Obj.40x.

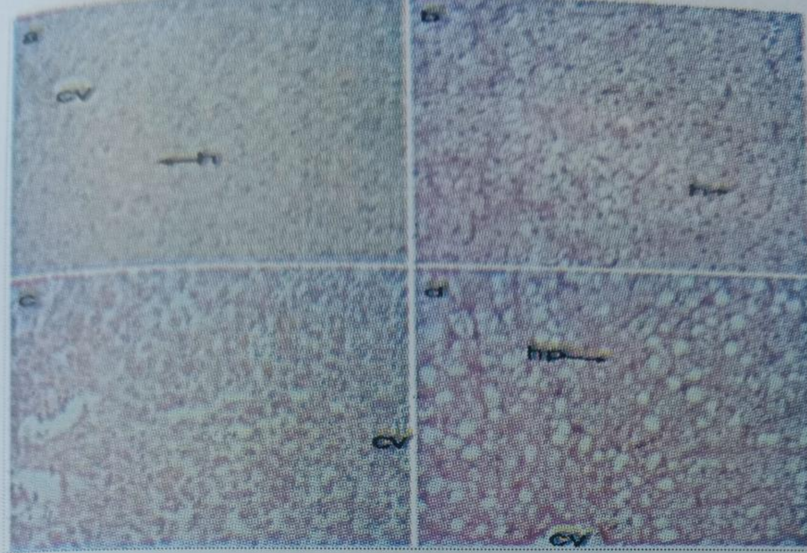

Figure 4. (a-d) Photomicrograph showing transverse section of hepatic tissue of *Clariasgariepinus*juveniles. (a) Control showing normal parenchyma indicating hepatocytes (h) and central vein (cv). (*b*) Exposure at 0.125 mg L-1 showing normal hepatocytes (h). (**c**) Hepatic tissue exposure at 0.250mg L-1 indicating slight leukocytes infiltration. (**d**) Exposure at 0.5mg L-1 indicating severe inflammatory changes with hydropic degeneration (hp). Obj.40x

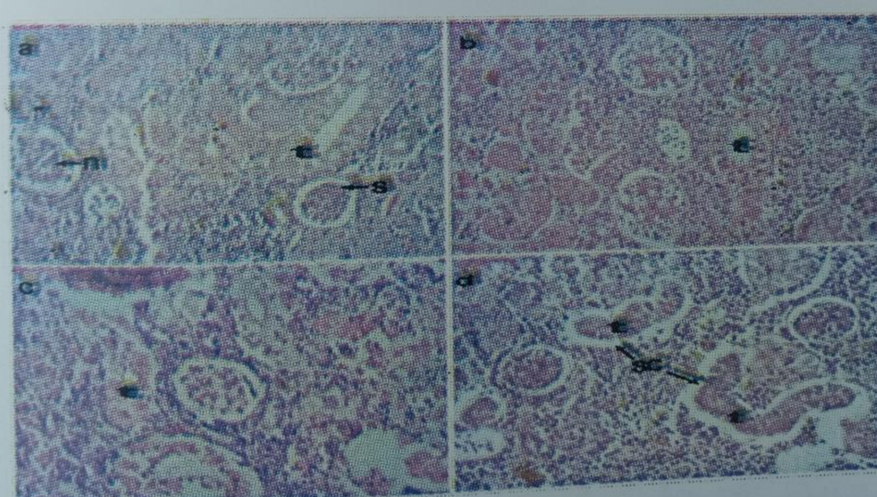

Figure 5. (a-d) Photomicrograph of transverse section of the renal tissue of *Clariasgariepinus*juveniles. (**a**) Control showing renal corpuscles (n), the Bowman's space (s) and the convoluted tubules (t). (**b**) Exposure at 0.125mg L-1 showing convoluted tubules (t). (**c**) Exposure at 0.250mg L-1 indicating convoluted tubules (t). (**d**) Exposure at 0.5mg L-1 showing mild inflammatory changes at the interstices with the convoluted tubules showing partial shrinkage surrounded by coalesced spaces (sc). Obj.40x.

Mr Vice Chancellor Sir, the lagoon systems in Nigeria are highly polluted, as a result of the dumping of industrial wastes (heavy metals). A study was conducted on the seasonal variation in the bioaccumulation of heavy metals in the tissue of *Oreochromis niloticus* and the silver catfish *Chrysichthys nigrodigitatus* (commercially important) in the Lagos lagoon (Olojo *et al.*, 2012). Metal concentration in *O.niloticus* occurred in the order: Fe>Zn>Mn>Cu>Pb>Co>Cd, while in *C. nigrodigitatus*, the order was Fe>Mn>Zn>Ca>Co> Ni> Pb>Cd.

In recent times, certain protein metabolites are being used as biomarkers for heavy metal pollution (Olojo *et al.,* 2012). In fish exposed to continuous sub-lethal concentrations of lead, certain proteins showed potential as biomarkers.

Fish pathogens

Bacterial pathogens

Mr Vice Chancellor Sir, bacterial infection is an economic limiting factor in intensive fish production (Okaeme and Ibitoye,1989).Continuous low level losses from either opportunistic or facultative bacterial disease outbreaks not only affect production but can also be economically devastating for rural farmers(Thompson and Crumlish, 2000). In water bodies with nutrient over enrichment, there is always the possibility of proliferation of bacteria, especially opportunistic pathogens.

There have been reported cases of fish deaths from bacterial infections (Kabata,1985). We conducted a number of investigations on the presence of bacteria in production ponds including bacteria from eutrophic concrete tanks and earthen ponds (Olurin *et al.,* 2006). The bacteria flora identified were *Escherichia coli*, *Klebsiella* spp., *Vibrio* spp., *Streptococcus* and *Enterococcus* spp. It was concluded that these fish rearing environments contained bacteria capable of causing fish mortality under stressful conditions. Similarly, Efuntoye *et al.,* (2012) investigated the antibiotic resistance of bacteria isolated from *C.gariepinus* from some farms *E.coli* strains were resistant to major antibiotics.

Fish parasites:

Studies were conducted on fish parasites with emphasis on the helminths (Olurin and Somorin, 2006; Olurin *et al.,* 2006, Olurin *et al.,* 2012). Helminths obtained include *Neoechinorhynchus rutilli* (Acanthocepha) and the metacercaria of *Clinostomium* in cichlids from Owa Stream, and River Oshun.

Fish larval nutrition

Larval fish nutrition in aquaculture is predominantly dependent on the use of brine shrimps (*Artemia* spp.), particularly for first feedings. However, the cost of brine shrimp is prohibitive for resource poor farmers in the developing world, which has necessitated investigation into alternative feeds. Workers have used formulated feeds or combinations of formulated feeds and live feeds in feeding trials with different species of fish larvae (Yilmaz *et al.,* 2003; Panaglotis and Neofitou, 2004) In most studies, live foods (e.g. Artemia,rotifers, copepods) produced better results in terms of growth and survival than inert diets(Dabrowski, 1984).

We also made attempts at determining suitable live foods for post hatch larvae of *C.gariepinus*. Olurin and Oluwo (2010) determined the growth and survival of *C.gariepinus* larvae fed decapsulated *Artemia*,live Daphnia and commercial starter diet. It was concluded that feeds of animal origin are more suitable for first feeding than inert diets. Olurin *et al.*,(2012) also found that wild copepods could be used as alternative to decapsulated*Artemia* in the diet of fish larva.

Field Studies

Mr Vice Chancellor Sir, our work has not been restricted to laboratory studies. We have also carried out diagnostic surveys of fishery establishments in Ogun State as well as a sponsored study on the eradication of water hyacinth in Ere Channel in Ogun State. Diagnostic surveys are useful in determining the status of fisheries and to recommend future research and development interventions.

In Ere Channel, we were able to demonstrate the control of water hyacinth using herbicidal control. The studies which lasted over a year involved the aerial application of herbicides. Water hyacinth is an obnoxious plant that hinders navigation and fishery.

Mr Vice Chancellor Sir, contributions of fisheries research are expected to improve the livelihoods of fisheries communities on a sustainable basis.

The researches highlighted in this inaugural lecture have led to a better grasp/understanding of the conditions of fishing communities and improved technologies aimed at promoting sustainable fisheries livelihoods. It can be summarized as a rescue to dwindling conditions of fish production.

6.0 Recommendations

1. Government should devote a substantial portion of the annual budget to fisheries research, while researchers should engage in more intensive collaborations and multivariate networking with other researchers, policy managers, extentionists and industries.

2. Researchers need to aggressively market their findings with a view to commercializing them.

3. There should be productive linkages between researchers and policy managers in order to maintain sustainable fisheries development. In other words, research conducted must positively impact on the livelihood of farmers. These findings must be communicated through the extension system to the farmers aimed at improving their incomes and livelihoods on a sustainable basis.

4. Government should reinvigorate policy in order to strengthen research, extension farmers linkage system (PREFILS) for more definite and cohesive research and development options..

5. The establishment of private sector led fish farm estates is an important paradigm shift for introducing youths into sustainable agricultural livelihoods.

6. Government should discourage obnoxious practices in aquaculture, specifically on brood fish selection/ sourcing e.g. egg collection by fish mongers, indiscriminate use of antibiotics, gorilla sourcing of brood fish from the wild and use of growth hormone.

7.0 Conclusion

Mr Vice Chancellor Sir, in the course of this lecture, I have highlighted the major factors contributing to the dismal performance of the fisheries sub-sector, particularly to increased fish production aimed at improving the livelihoods of stakeholders. I have also highlighted some of my research contributions to fisheries research in the key areas of fish biology, fish nutrition and pollution studies, with emphasis on *Clarias gariepinus*, a major aquaculture species in Nigeria. It is hoped that some of the findings have been able to elucidate some of the problems confronting increased fish production.

While we have made modest progress in some of these areas, there is room for greater improvement in our research techniques aimed at demand driven researches that will appeal to all stakeholders, and further reduce the disconnect between researchers and policy managers and improve fish production. Our future research interest will focus on the production of local alternatives to the use of Artemia in fish breeding. Currently the country spends an enormous amount of money on the importation of Artemia cysts. Also research emphasis will be on the production of local efficient low cost feeds for aquaculture. Emphasis will also be on the search of additional fish species for aquaculture.

8.0 Acknowledgements

I will like to end this lecture by acknowledging the contributions of a number of individuals to my modest achievements to date.

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Finally to my younger colleagues, pursue your dreams and be mobile. Do excellent research and enjoy yourselves. Distinguished ladies and gentlemen, that is my story so far. Thank you for your attention and patience.

God bless you all.

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