FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

AFRICAN CATFISH:
A NATURAL PROTEINUOUS CHOICE

By

Prof. Shaba Mohammed Tsadu
BSc. Ed. (UDUS), MSc. (Jos), PhD (Minna)
Professor of Water Resources, Aquaculture and Fisheries Technology

INAUGURAL LECTURE SERIES 73

8TH AUGUST, 2019

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

AFRICAN CATFISH:
A NATURAL PROTEINUOUS CHOICE

By

Prof. Shaba Mohammed Tsadu

BSc. Ed. (UDUS), MSc. (Jos), PhD (Minna)

Professor of Water Resources, Aquaculture and Fisheries Technology

INAUGURAL LECTURE SERIES 73

8TH AUGUST, 2019

University Seminar and Colloquium Committee

This 73rd Inaugural Lecture was delivered under
the Distinguished Chairmanship of:

Professor Abdullahi Bala, FSSSN,
Vice-Chancellor
Federal University of Technology, Minna

ISSN 2550 - 7087

Published by:
University Seminar and Colloquium Committee
Federal University of Technology, Minna.

8th August, 2019

Design + Print:
Global Links Communications, Nigeria
✆: 08056074844, 07036446818

Professor Shaba Mohammed Tsadu

BSc. Ed. (UDUS), MSc. (Jos), PhD (Minna)

Professor of Water Resources, Aquaculture and Fisheries Technology

AFRICAN CATFISH *(CLARIAS GARIEPINUS)*: A NATURAL SELECTION TO SOLVE AFRICA'S FOOD PROTEIN DEFICIENCY PROBLEM

1.0 INTRODUCTION

1.1 WHAT IS FISH?

Fish is an aquatic vertebrate possessing some unique features such as gills for breathing and fins for locomotion in water which is its medium of life. The word "fish" is loosely used in fisheries and aquaculture to include both fin fish and other aquatic animals. Thus in a non literary definition, fish is all aquatic organisms exploited by man for any of their beneficial uses. This includes all aquatic vertebrate and invertebrate, shell and non-shell fishes such as Octopus, Oysters, Starfishes, Shrimps, Mollusks etc. (Lagler *et al.* 1977; Balogun 2015). Fish exist in various sizes from the smallest such as Philippine Goby (*Eviota*) whose maximum size is just about 12 mm (1.2 cm) to the largest animal on earth, the Whale shark or Berlin whale (*Rhincodon typus*) which can reach a length of 12.65 m (41.5 ft) and weight of 21.5 MT or more. Fishes are the most numerous vertebrate having between 20000 – 40000 species (Lagler *et al.* 1977).

1.2 ORIGIN OF FISH

Evolution is a gradual process of transformation of lines of descent from a common ancestor to a different more advanced stage. Evolution is a continuous process that is still in operation in life and hereditary modifications provide the bases for evolution (Lagler *et al.*, 1977).

From evolutionary point of view and phylogenetic relationship between different animal groups based on evidence from comparative anatomy, embryology and fossil records, fishes evolved from invertebrate chordates called Protochordates which are the beginning of the Phylum Chordata. They comprise of the Subphylum Hemichordata: the Acornworm (*Balanoglosus*) with notochord restricted to the proboscis; Subphylum Urochordata: the Sea Squirts (*Tunicata*) having notochord during its larval stage only; Subphylum Cephalochordata: the fishlike *Amphioxus* with notochord extending the whole length of the body. Protochordates evolved from Mollusks (*Molluscs*) and mollusks evolved from *Annelids*. (see phylogenetic tree).

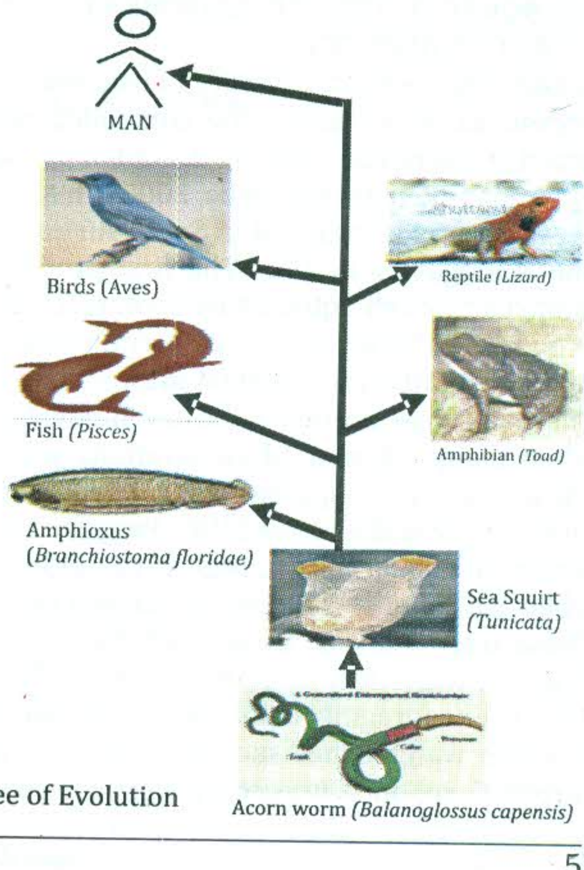

Fig 1: Phylogenetic Tree of Evolution

The appearance of fish on earth predates man's ape-like ancestors for about 500 million years. Many life features and body structure of man already existed for many years in ancestral fishes. These include the ground plan of animal body and the ten organ systems. Thus fish have a distant place in the ancestry of man (Lagler *et al.*1977). According to Ernst Haeckel (1834 - 1919) during embryological development, an organism repeats its ancestral history, "Ontogeny recapitulates phylogeny". The presence of branchial grooves and segmental myotomes in human embryo similar to that of fish indicates fish ancestry since fish predates man on earth.

1.1 AQUACULTURE DEVELOPMENT IN AFRICA, PROGRESS AND PROSPECTS

Aquaculture is the husbandry of fish and other valuable aquatic organisms in an artificially controlled water enclosure. The practice started as early as 2500 B.C in China and 6000B.C in Australia (Ekelemu and Ogba, 2005). In Africa, Trout culture and breeding was introduced in South Africa in 1859 and in Kenya and Madagascar in 1920.The first production of *Oreochromis niloticus* through aquaculture took place in D R Congo in 1946 (Vincke, 1995). By 1950s, fish farming was introduced to many African countries by Colonial masters and it developed rapidly. There was high interest in the new innovation but by early 1960s when many colonial administrations were coming to an end aquaculture development slowed down and many ponds and farms became abandoned (like Panyam fish farm near Jos).The history of fish farming in Nigeria therefore dates back to 1950's when the colonial masters established experimental fish farms. These were Panyam freshwater fish farm in Jos Plateau and Brackish water fish farm in Buguma, Delta State (Bardach *et al* 1972). Encouraging result was obtained from Buguma with brackish water fishes such as *Tillapia melanopleura, Cyprinus carpio* (Carp) and *Chrysichthys nigrodigitatus*. Panyam farm was established mainly to culture *Tillapia* but this became non-viable due to prolific breeding and overpopulation of *Tillapia*. Emphasis was therefore placed on culture of Carp but as *Tillapia* could not be eradicated and became enemies of Carp, introduction of piscivorous species *Lates niloticus* and *Gymnarchus niloticus* became necessary. Both did well but *Lates niloticus* proved more suitable for pond culture. The development slowed down by the end of colonial era but pick up again by late 1960s through increased technical assistance and finance from international donors (Machena Moehl, 2001; Vincke, 1995). Rapid aquaculture development took place in Africa between 1970s and 1980s and by the year 2000 it has become well established in many countries including Nigeria (Machena and Moehl, 2001). Nigeria, Uganda, Cote d-Ivoure, Zimbabwe, Kenya, Ghana and South Africa are the major producers. Catfish was the highest produced, 64% while Tilapia and others was 36%.

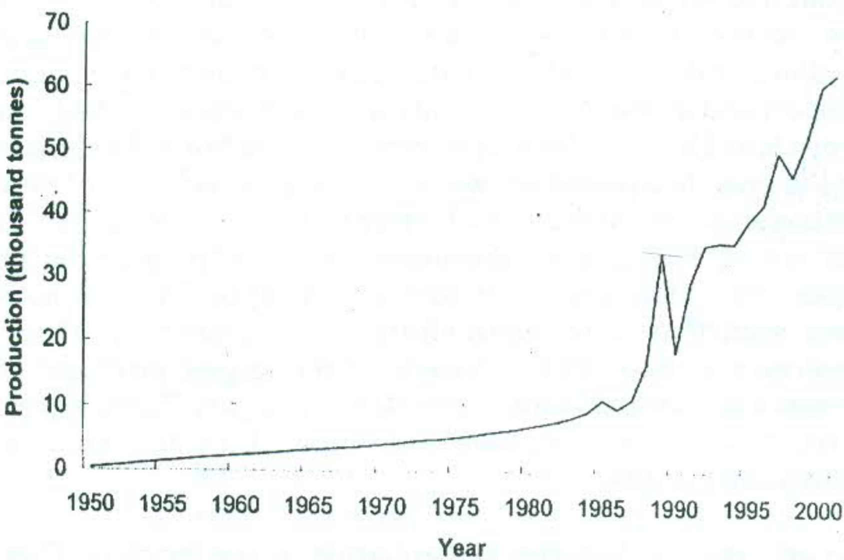

Fig 2. Evolution of Aquaculture in Sub-Sahara Africa 1950 – 2000.

FAO committee for Inland Fisheries of Africa (CIFA/R1, 1973) identified aquaculture as a priority area for development of Africa. Following this, FAO in 1975 organized the First Africa Regional Workshop on Aquaculture recognizing the importance attached to it by Government. It was observed that failure of some poorly planned aquaculture in the past was the constraints to further development as farmers were hardly convinced of its economic viability, coupled with lack of basic requirements for aquaculture and inadequate Government support. The workshop renewed interest in aquaculture and most African countries launched donor-supported aquaculture programmes. The production results however still remained below expectation.

The contribution of Africa to global aquaculture production is still not significant though it is increasing (Ben Satia, 2010). From 1998 to 2018, production has increased from about 43000 MT to about 8 M MT, with an average yearly growth of 14.45% due to the emergence and intensification of private sector small and medium scale aquaculture enterprises, stimulated by public support and inflow of foreign aids such as World Bank Assisted projects and loans, FADAMA projects and some NGOs. Awareness and interest in aquaculture was also raised by the effort of New Partnership for Africa Development (NEPAD) "Fish for all Summit" in 2005 and implementation of Special programme for Aquaculture Development in Africa (SPADA) by FAO. All these have contributed to aquaculture development in Africa. According to FAO (2013), Nigeria is the largest producer of African catfish in the World. Netherlands, Hungary, Kenya, Egypt, Syria, Brazil, Cameroón, Mali and South Africa also produce significant quantity.

Opportunities in fisheries and aquaculture are limitless. They exist for everyone whether or not they are professional aquaculturists or fisheries scientists. Today many people engage in fish culture either as part time job, post retirement job, hobby, as homestead pond for feeding the family, as part of other major farms or integrated farming. Many do attempt a small scale or medium scale commercial fish farming. Many of them are just fish culturists but not real fish farmers and as many go into it so also there are many failures due to lack of knowledge, lack of expertise and lack of experience.

Commercial capture fisheries has been the business of riverine communities since ancient times but it is evident now that production from capture fisheries can no longer satisfy the fish demand as particularly observed in Nigeria. This is due to over exploitation, lack of conservation and population explosion. Though marine and inland capture fisheries contribute to African economies, it has become unsustainable as the resources are fully or even overexploited and is dwindling and even increasing fishing effort does not increase fish yield or catch (NEPAD, 2003).

Aquaculture has become one of the fastest growing food producing sub-sector of agriculture today and has become the major supplier of fish worldwide (Subasinghe, 2003; FAO, 2014). About 85% of world aquaculture production comes from developing countries especially in Asia but Sub-Saharan Africa still contribute less than 1% of the total world production (FAO, 2003).African aquaculture is still mostly a secondary and part time activity taking place in small farms with small to medium scale production only. This is still the situation in Nigeria today.

1.0 AFRICAN CATFISH *(CLARIAS GARIEPINUS)*: A NATURAL SELECTION FOR AFRICA

Natural selection is an evolutionary process which accounts for adaptation of organisms to their environment and the basis of selection is the genotype. Carriers of different genotypes in a population contribute differently to the gene pool of the succeeding generation and some genotypes contribute more than others in the same environment. The ability of the carrier to transmit its gene determines its adaptive value. Charles Darwin called this, the fitness of the organism i.e. **'The Survival of the Fittest'**. Natural selection makes the gradually changing organism become adapted to the condition they find themselves and under which they must exist. Adaptation through natural selection is important in a continuously evolving population of organisms (Lagler *et al.* 1977).

Throughout Africa, two fish families have become more adapted than all other fishes. These are the Family **Cichlidae** particularly the Genus *Tilapia* and *Oreochromis* and the family **Claridae** particularly the Genus *Clarias* and *Heterobranchus*.

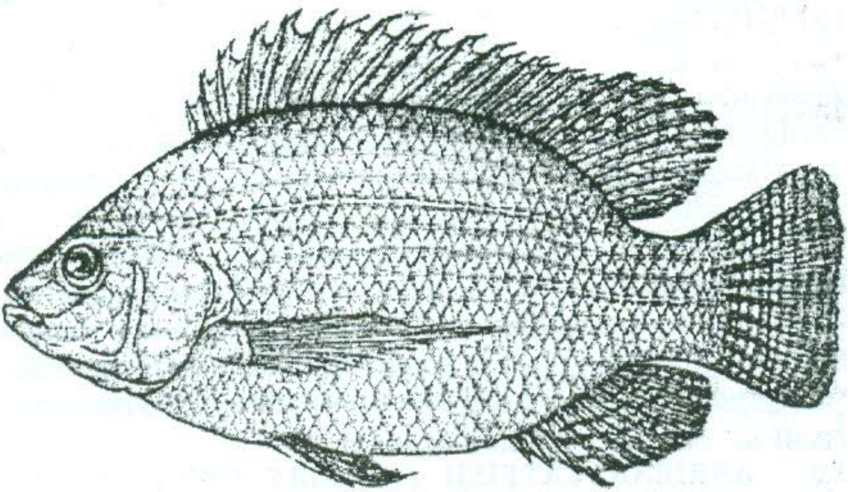

Plate 1: Oreochromis Niloticus

);

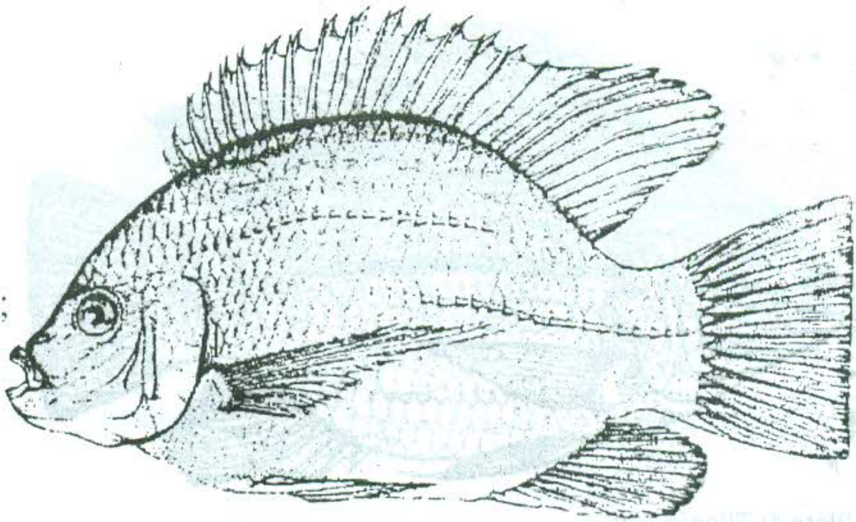

Plate 2: *Tilapia Galilaea*

Plates 1 & 2 The Family Cichlidae (*Oreochromis Niloticus* & *Tilapia Galilaea*)

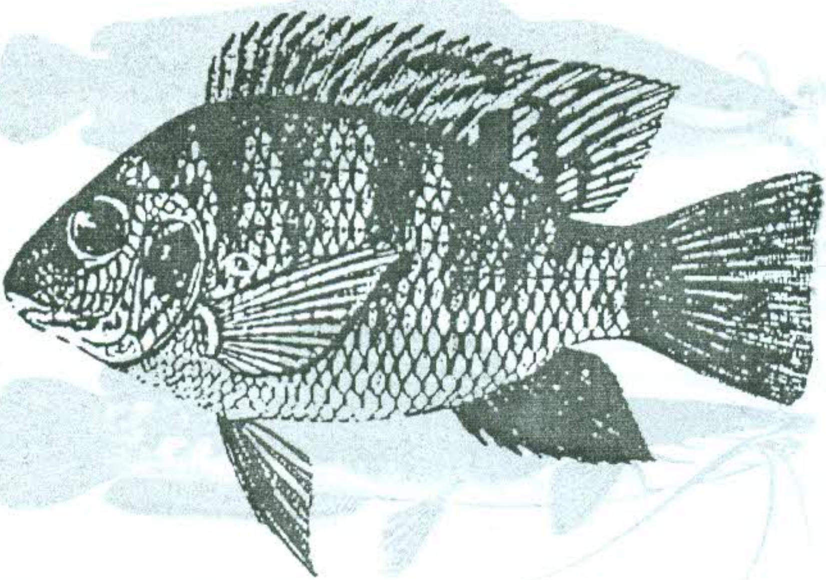

Plate 3: *Tilapia Guineensis*

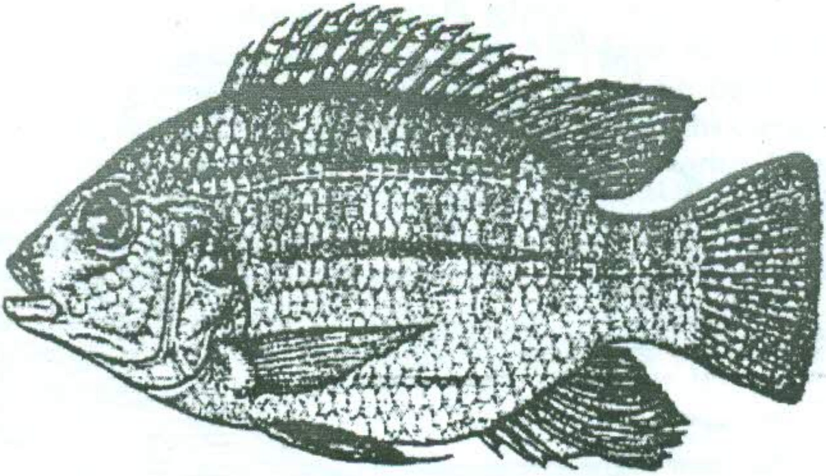

Plate 4: *Tilapia Zilli*

Plates 3 & 4: The Family Cichlidae *(Tilapia Guineenses* and *Tilapia Zilli*)

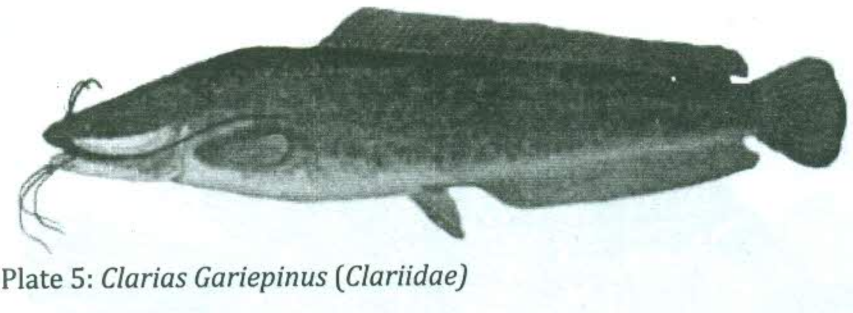

Plate 5: *Clarias Gariepinus* (*Clariidae)*

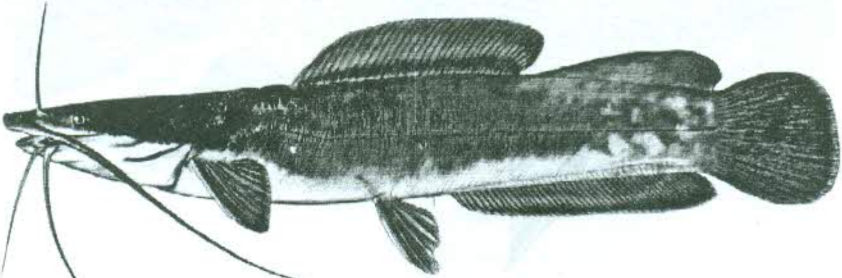

Plate 6: *Heterobranchus Longifilis* (*Clariidae*)

Plate 7: Heteroclarias (Hybrid of *C.Gariepinus* and *Heterobranchus*

Three common species of *Heterobranchus* are identified in Africa and also in Nigeria. These are *H. longifilis, H. bidosarlis* and *H. isopterus* (Olaosebikan and Raji, 2013). Tuegels (1986) identified about 14 Genera of *Clarias* in Africa. Olaosebikan and Raji (2013) identified 10 Species of *Clarias* in Nigeria of which 3: *Clarias gariepinus* (Sharptooth Clarias), *C. anguillaris* (Mudfish Clarias) and *C. lazera* are most common.

3.0 HISTORICAL ACCOUNTS OF THE GENUS *CLARIAS*

The genus *Clarias* belongs to the group of fishes called Catfish. The term Clarias was derived from Greek word "Chlaros" meaning lively, referring to the ability of the fish to live for long time out of water (Wikipedia). They are called various names such as Airbreathing catfish, Walking catfish, Broadhead catfish, Sharptooth, Sawtooth and Mudfish catfish. The name Catfish is a nickname for scaleless fishes. All scaleless fishes are also characterized by possession of circumoral barbells which looks like the whiskers of cats and mousses, hence the name catfish. Barbels have gustatory as well as tactile functions.

The first description of the Genus *Clarias* was by Belon (1655) in his work on River Nile and he called it *Clarias nilotica*. Russel (1756) described the same species from Orontes River in Syria (Aleppe River) and gave it a vernacular name "Simariil assouad" meaning black fish. Hasselquist (1757) in his description of Nilotic species called it *Silurus charmuth niloticus*. Linnaeus in 1758 gave it a binomial nomencleture *Silurus anguillaris*. Gronovius in 1763 gave a detailed description of the morphology of the species from Orontes River as characterized by anguilli form body, flattened head and long dorsal fin and gave it the name *Clarias*. Lacepede in 1803 also from his work on Genus and Species from the Nile called the species *Macropteronotus charmuth* a name enphasising the long dorsal fin. Burchell (1822) called the species *Silurus gariepinus*. His description of *Silurus* is synonymous to what is now known as *Heterobranchus*. Curvier and Valenccennes in 1840 classified the genus into three species, *Clarias lazera, Clarias capensis* and *Clarias syriacus*. Peters in 1852 described the species and called it *Clarias mosambicus*. Gunther in 1864 classified *Clarias* into the family *Siluridae* and three subfamilies *Clariinae, Plotosina* and *Chaçina*. He recognized three species which are *Clarias orontis, Clarias macracanthus* and *Clarias xenodon*. Within the subfamily *Clariinae* he identified two Genera: Genus *Clarias* and Genus *Heterobranchus* (Tuegels, 1986). Boulenger in 1911 reported about 60 species of *Clarias* but recognized 33 as the most valid (Tuegels, 1986). Olaosebikan and Raji (2013) documented 10 species of *Clarias* from Nigerian freshwaters. These are *C. gariepinus, C. anguillaris, C. jaensis, C. macromystax, C. albopunctatus, C. agboyensis, C. buthupogon, C. ebriensis, C. pachynema* and *C. cameruensis*.

Identification The Genus *Clarias* are easily identified from other Catfish Genus by two important features. 1. A characteristic dark line band on both sides of the lower surface of the lower jaws on the head region. 2. The number of gill rakers on the first branchial arch (Gill arch) which ranges from 24 in small size fish to 110 in large size fish. *Clarias anguillaris* of equal size will only have between 16 to 40 gill rakers on the first branchial arch. There is a high correlation between standard length and gill raker number.

Clarias gariepinus also known as African Sharp-tooth is closely related to *Clarias anguillaris*, known as African Mud-fish (Linneus, 1758). They occur sympatrically together and have almost Pan African distribution. Their identification can only be achieved by gill raker count and shape of pharyngeal tooth plate (the vomarine teeth) which is conical and crescent shaped in *C. gariepinus* while it is pointed or V-shaped in *C. anguillaris.*

Ecology and Geographic Distribution of *Clarias*

Clarias mostly inhabit quiet and calm waters but may also be found in fast flowing rivers (rapids). They inhabit wide range of inland waters including streams, rivers, lakes, pools and impoundments. They thrive well in turbid waters and lakes but are more successful in clear river waters. They have Pan African distribution except areas such as Maghreb, Upper and Lower Guinea, the Cape and Nogal Provinces where they do not occur naturally (Tuegels, 1986). They have wide distribution due to their hardiness and adaptability to different environmental conditions. This is partly due to possession of suprabranchial organ that enable them to utilize atmospheric air when out of water or water with low dissolved oxygen. Apart from their Pan African distribution and origin, they have worldwide distribution including Europe, Asia and Americas (FAO, 2012). Cambray (2005), reported that Africa's *Clarias gariepinus* appears in rivers in Brazil and is spreading worldwide due to aquaculture, angling and natural conservationists. They thrive well in both temperate and tropical environments (Coppens International, 2006). They are the fresh water fish with the widest latitudinal range in the world (70° Latitude). They have wide temperature tolerance range of between 8°C to 40°C for survival and optimum temperature for growth of between 20°C to 30°C and salinity tolerance range of 0 to 12ppt (Lamai, 2011). According to Coppens International (2006), from the biological perspective, African catfish *Clarias gariepinus* is one of the most ideal aquaculture species in the world because they are hardy, has fast growth rate, efficient feed utilization and feed conversion rate, has high fecundity and is easily bred under captivity.

Etymology - *Clarias gariepinus* is named after its locality of origin, the Gariep River, a Hottentot name for Orange River in South Africa (Teugels, 1986).

4.0 **FISH DEMAND AND SUPPLY IN NIGERIA**

Fish is the cheapest source of protein in the diet of large percentage of Nigerians. Its nutritional quality and affordability is greater than that of beef and other protein sources. Despite the enormous water resources in Nigeria she is yet to meet her domestic fish demand and spends huge amount of money in fish importation. Out of the total annual fish demand of over 3.6 Million Metric Tonnes (3.6 MMT) for the year 2018 only about 1.1 Million Metric Tonnes was supplied domestically from all sources including aquaculture, artisanal and industrial fishing sectors leaving a demand gap of about 2.1 MMT for importation (Minister of State for Agriculture, Mr. Heineken Lokpobiri: *thisdaylive.com* May 2018). Lokpobiri said fish production in Nigeria has increased by 600000 MT in the last three years due to Government restriction of food importation.

Table 1: Nigeria Fish Demand and Supply, 1997 – 2018.

YEAR	FISH DEMAND (MMT)	FISH SUPPLY (MMT)	FISH IMPORTATION (MMT)
1997	1.27	0.7	0.57
2010	3.02	849026.00	768745.00
2011	3.11	893099.00	762508.40
2012	3.21	968283	758619.00
2013	3.32	1083507.00	770802.59
2014	3.42	1113011.00	776552.00
2015	3.53	1027058.00	806000.00
2016	3.65	1.12	1.88
2017	3.76	1.10	1.90
2018	3.61	1.1	2.1

Source: FDF Abj.

The dwindling supply from capture fisheries (both artisanal and industrial) is due to over exploitation, lack of conservation strategies, lack of responsible fisheries and environmental degradation. Clariid fishes (*C. gariepinus, C. anguillaris* and *Heterobranchus*) are the most cultured catfishes in Nigeria and have become the model fish for aquaculture. Their choice is due to their economic importance and desirable aquaculture characteristics such as hardiness, omnivorous feeding, high fecundity, fast growth rate, large size, disease resistance, adaptability to poor environmental conditions (Agbabe *et al* 2013). Nigeria is second after Malysia in world catfish production (FAO, 2017).

According to Faturoti (2017), aquaculture in Nigeria has greatly assisted in bridging the gap between fish demand and supply in the past two decades as production from aquaculture increased from 70000 metric tons to over 350000 metric tons and 90% of this is from Catfish farming. He also observed that the benefit of catfish include supply of Omega-3-fatty acid which is known to reduce coronary heart diseases, lowering of cholesterol, reduction of body swellings and pains, lowering risk of age related muscular degeneration. Vitamins D and B2 and some micronutrients such as calcium, phosphorus, iodine, iron, zinc, magnesium and potassium that are essential for healthy living are abundant in catfish. Catfish is therefore actually selected nutritious choice for Africa.

5.0 FISH IMPORTATION IN NIGERIA

Despite the high level of fish production (Table 1), Nigeria is still ranked as the highest sea food importer in Africa. About 0.72 MMT of frozen fish, worth of about $500 m was imported by Nigeria in 2012 (Attanda, 2012) and about 1.9 MMT was imported in 2017 (NAN, 2017).From the ongoing Federal Government effort to diversify the nation's economy, it was observed that Nigeria spends over N288bn ($800m) on fish importation annually (Obatola, *thisdaylive.com* May 2018). This can be saved if the nation's water resources are properly developed and harnessed. Imported frozen fish from Europe are mostly obtained by interception of migratory anadromous fishes such as Salmon, Trout and Stripped basses. In anadromous fishes the adults live, feed and grow in the sea but migrate to freshwaters to breed. In catadromous fishes the adults live, feed and grow in freshwaters but migrate to the sea to breed e.g. Eels (*Anguilla Anguilla*).

6.0 FISH MIGRATION

The pattern of fish migration is important in fishing industry. The term Diadromous (dia = through and dromous = running) is a Greek term referring to fish migration between the sea and freshwater. Thus anadromy and catadromy are two kinds of diadromy. The Pacific salmon and Trout are well known anadromous fishes. They spawn and hatch in freshwater streams and their hatchlings utilize their yolk sac and later the carcass of their spent parents that die automatically or naturally after spawning. The young elvers then migrate to the sea to feed, grow and mature. When matured after two to six years they return to the same stream where they were hatched to spawn (this is called Salmon run).

Intercepting and harvesting the migrating fishes is the best way of utilizing them because they will not return after spawning. During the run they no longer feed and their intestines degenerate. The remaining energy in the body is only used for running to arrive at their spawning destination. This is why most if not all the ice fish imported do carry eggs. Their harvest is of economic importance to Europe. It is even supported by U.S Environmental Protection Agency by supporting research to ensure good water quality of the streams for the returning salmon population.

7.0 CATFISH BREEDING AND FINGERLING PRODUCTION

Biomanipulation / Biotechnology in Aquaculture

One major aim of aquaculture is to increase production by all means above the level that would be produced naturally. Desirable fish species are therefore stocked in controlled culture environment and all the appropriate care, feeding and biomanipulations are done to increase production. Aquaculture scientists try to improve culture species and their production through crossbreeding, hybridization, gynogenesis, genetic engineering, selection, induced breeding and artificial incubation and hatching. The knowledge of the biology of cultureable species, endocrinology and genetics have contributed largely to the development of aquaculture through manipulation of fish reproductive characteristics and culture environment.

Hatchery Management and Catfish Breeding

Fish hatchery management is the skillful mass production of fish fingerlings through series of breeding activities. This involves two major activities which are:

a. Induced spawning and hatching of eggs.
b. Nursery management of the hatchlings up to fingerling stage.

Induced Spawning and Hatching of Eggs

When fish is in its natural environment, the gonads develops up to final stage of maturity and then turn into a "resting or dormant" phase until favourable conditions for spawning occurs (Harvy and Hoar, 1979; Delince *et al*, 1987). Such conditions include:

(a) Good spawning ground. This varies according to species, for catfish this includes inundated shallow edges of water with submerged vegetation. This is because catfishes are substrate spawners attaching their eggs to submerged aquatic vegetations in shallow waters.

(b) Good water quality. This is water with optimum water quality parameters such as Temperature (27 – 30°C), pH (6.5 – 7.5), Dissolved Oxygen (DO) (>5mgL⁻1).

(c) Rising water level or flood (inundation) or water movement (current).

(d) Presence of suitable mating partner.

(e) Absence of predators.

During the resting stage, sensory cues of the environmental factors are received by the brain (hypothalamus) (Fig. 3). When the sensory cues reach certain threshold level, the fish becomes aware that the environmental factors are now favourable. The hypothalamus then release Gonadotrophin hormone releasing hormone (GHRH). This goes to the pituitary gland at the base of the brain (brain hypohpysis). The pituitary gland then releases the Gonadotrophic hormone (GH) which goes via the blood to the gonads (Ovary or Testes). The gonads in turn produce other sex hormones (Ovarian steroids) including Androgens and Estrogens (Estrogen C-19 and Estrogen C-21) which trigger off other endocrine actions leading to final maturation of eggs or sperms, ovulation and spawning. Estrogen C-21 induces maturation of primary oocytes which involves vitellogenesis (first stage of egg development). Estrogens are also involved in the development of secondary sexual characteristics. Gonadotrophin also induces follicle tissues to produce Prostaglandin and Catecholamine steroids which stimulate maturation of eggs (secondary oocytes) and ovulation. Injection of Progesterone and 17-α-hydroxy-20-β-dihydroprogesterone has been found to induce ovulation (Delince *et al* 1987).

Under captivity in artificial environment, favourable conditions for natural breeding may be inadequate or unavailable and release of hormones and hence ovulation or spermiation may not take place. Thus the resting or dormant phase eventually degenerate into follicular putrifaction or egg / sperm reabsorption and the fish does not breed (Harvey and Hoar, 1979). Also according to Bruton (1979), during the resting or non breeding phase, the gonadotrophin content of the pituitary and the gonad steroid hormones become reduced. This is where the artificially induced breeding becomes necessary.

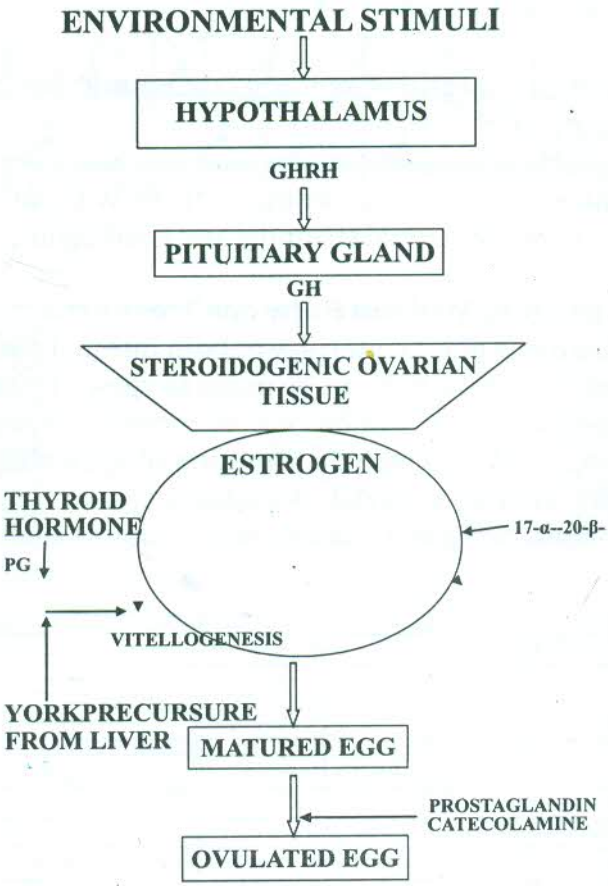

Fig 3: Endocrinological Links in Fish body during Induced Breeding

8.0 INDUCED ARTIFICIAL FISH BREEDING

Induced breeding intervene against egg/sperm reabsorption and shorten the resting stage. This is done by either simulating the external conditions (simulating natural environmental conditions in ponds) or by hormone treatment (hypophysation or use of synthesized hormones). Thus artificial fish breeding or fish seed production involves three major practices or methods.

1. Induced natural breeding/spawning without hormone treatment.

2. Induced natural breeding/spawning by hormone treatment.

3. Induced breeding/spawning with or without hormone treatment by manual stripping and fertilization.

Induced Spawning Without Hormone Treatment

As reproduction is due to interplay of both internal and external environmental factors, fish can be made to spawn by simulating natural environmental conditions in ponds. Depending on species concerned, this include provision of spawning surfaces such as nest building materials, kakabans, sponges, receptacles or hollow pipes, rising water levels, inundation of shallow areas,

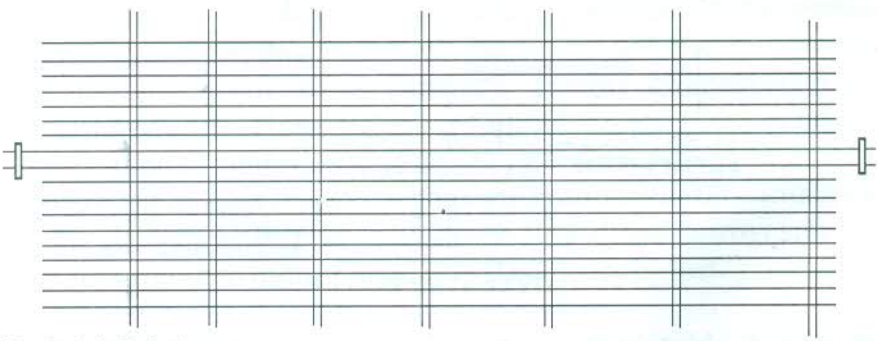

Fig 4. (a) Kakaban

deep and shallow areas in breeding ponds (Hoffer and Dubisch pond types) (Fig 4), control of water temperature, photoperiod and provision of reproduction partner with appropriate sex combination ratio (Woynarovitch and Hovarth, 1980). This can raise the natural threshold level that would trigger off natural spawning.

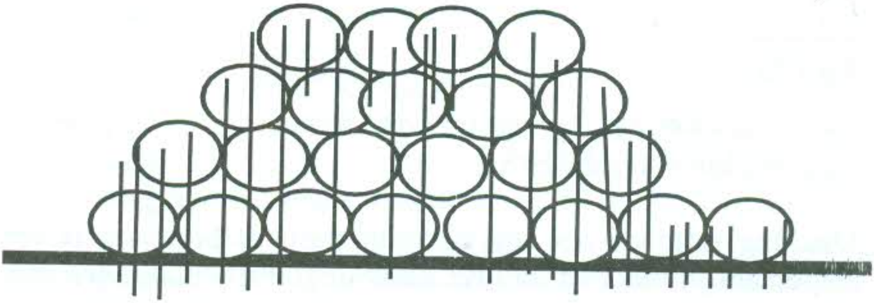

Fig 4. (b) Sponge

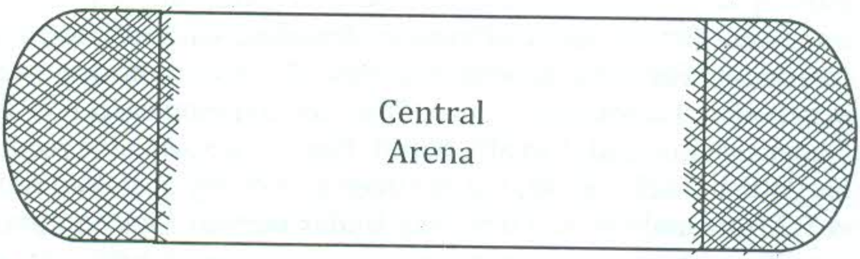

Fig 4. (c) Arena receptacle

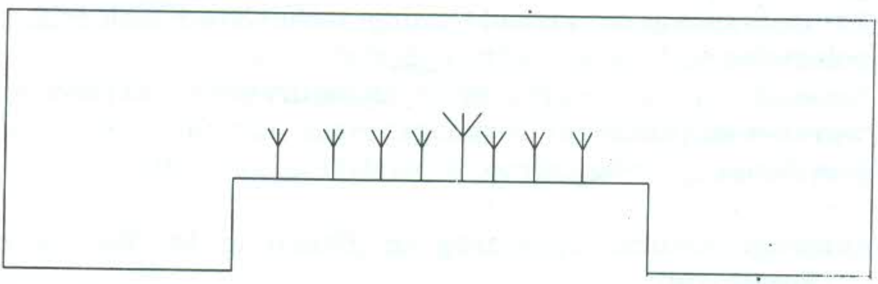

Fig 4. (d) Hoffer

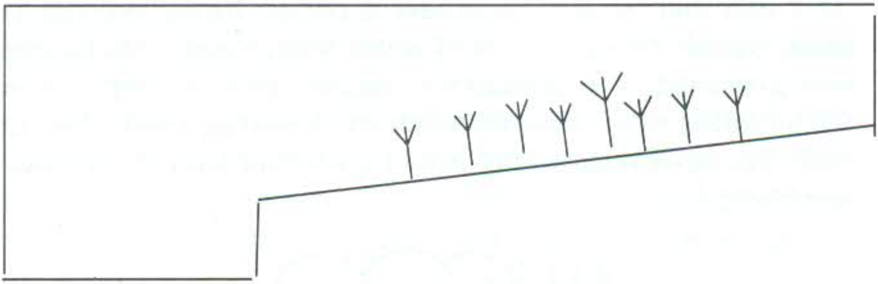

Fig 4. (e) Dubisch

Fig 4: (a) Kakaban (b) Sponge (c) Arena receptacle/Hollow pipe (d) Hoffer (e) Dubisch

Stocking ratio or sex combination ratio of breeders is very important in induced natural spawning. If the males are more they will fight due to mating aggression and on the other hand if the females are more, some would be isolated and would not participate in mating and breeding. Thus optimum sex ratio is important for efficiency of induced breeding without hormone treatment. For *Oriochromis niloticus,* the optimum sex ratio observed is 1:3 (Madu and Ita, 1988); for common carp, it is 1:2 (Woynarovitch and Horvath, 1980). There is no available record for Catfish (Madu, 1989) but the most commonly observed ratio is 1:2 (one male to two females). Under normal environmental condition, good water quality and sex ratio, courtship would take place and spawning and fertilization would take place naturally. Catfishes such as *Clarias* and *Heterobranchus* attach their eggs to substrates such as submerged vegetations in shallow edges of the water. This can be simulated by laying dry grasses or leaves or woven mats (Kakaban) or sponges made from fibers of jute or polythene bags or bagco-bags in ponds (Figs 4 a and b).

Induced Natural Spawning or Breeding by Hormone Treatment

This is hormone injection technique but after injection the fish is released to spawn naturally (Induced natural spawning). Hormones are injected to speed up the endocrine reactions in the fish body and this in turn speeds up ovulation and spawning. The hormones are either natural hormones obtained from the endocrine centers of the animal or synthetic hormones synthesized from the natural hormones. The natural hormones are called First Generation Compounds while those synthesized from them or from some chemical compounds are called Second Generation Compounds. The first hormone injection technique discovered or practiced is "Hypophysation". This is the extraction of the pituitary gland of the fish and injecting it into another fish. This is based on the idea that pituitary gland is the master gland controlling all endocrine reactions in the body. The gland is extracted from the base of the fish brain (Hypothalamus) and is either macerated in saline solution or pure or distilled water and injected immediately or preserved by freezing or in alcohol or acetone or glycerine for future use.

Hypophysation was first described by Jacobi in 1765 but was not recognized until 1842 when it began to be experimented. The first documented experiment of the technique was by Housy (1931) in Agentina and by 1937 it became practiced at commercial level in Germany and Europe. The dosage and frequency of injection depends on the maturity stage of the brood fish. The general rule is to use pituitary from fish of equal size or weight and of the same species, this is called Homoplastic hypophysation. Pituitary gland of different species does not work on one another except that of Carp that was discovered to be universal donor but not universal recipient. The homogenized pituitary can be administered at once if the fish is ripe and about to spawn or divided into two and given as a priming dose to speed up maturation of eggs and resolving dose to cause ovulation and spawning. The pituitary gland can be refined to use its active ingredients instead of the crude pituitary. This include purified gonadotrophic hormone (GtH), Follicle stimulating hormone (FSH), Luteinizing hormone (LH), Interstitial cell stimulating hormone (ICSH), Prolactin, etc. Other natural hormones used nowadays include Human chorionic gonadotrophin HCG (Ovaprim) from pregnant woman urine, Luteinizing hormone releasing hormone (LHRH) from hypothalamus, prostaglandin from prostate gland, cortisone, progesterone, testosterone, dopamine antagonist, etc.

Second generation compounds are derivatives of first generation compounds found to be equally effective. These include Deoxicorticosterone acetate (DOCA), Luteinizing hormone releasing hormone analogue (LHRH-a), Gonadotrophin hormone releasing hormone analogue (GnRH-a), A-yerst 2525, 17-methyl testosterone (17Mt), 17-α-hydroxy-20-β-dihydroprogesterone, Dopamine antagonist drugs such as Clomiphene, Tamexifene, Damperone, etc.

Induced Breeding by Hormone Treatment and Manual Stripping and Fertilization of Eggs

Brood Fish Selection

Brood fish for inducement are selected by some criteria and body characteristics. The first criterion is to ensure that brood fish are collected from reliable sources free from diseases, well nourished and if possible age and weight should be known. The next criterion is to observe some body characteristics for signs of maturity, ovulation or spermiation. Gravid females show distended abdomen due to swollen ovary filled with eggs, (Plates 8 & 9) the genital orifice is slightly swollen and reddish infused with blood. If eggs are ovulated, they ooze out of the genital pore when the belly is gently pressed. Ripe eggs are greenish yellow or golden brown in color and uniform in size. For males, the anal papilla becomes turgid and vascularised (Plate 10). The tip of the papilla becomes slightly reddish, infused with blood also.

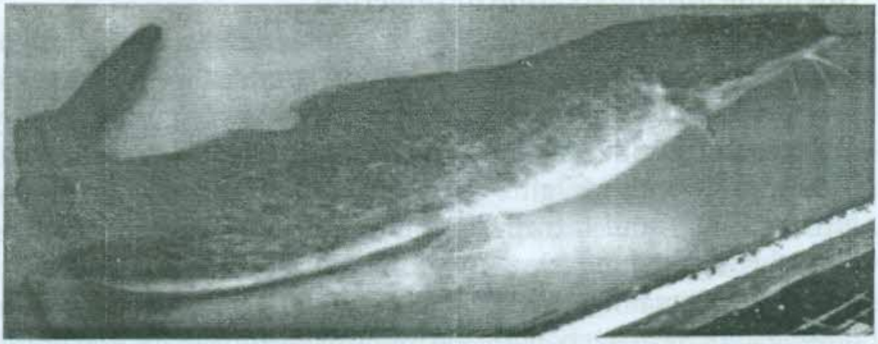
Plate 8: Gravid Female *Clarias Gariepinus* (Full Body)

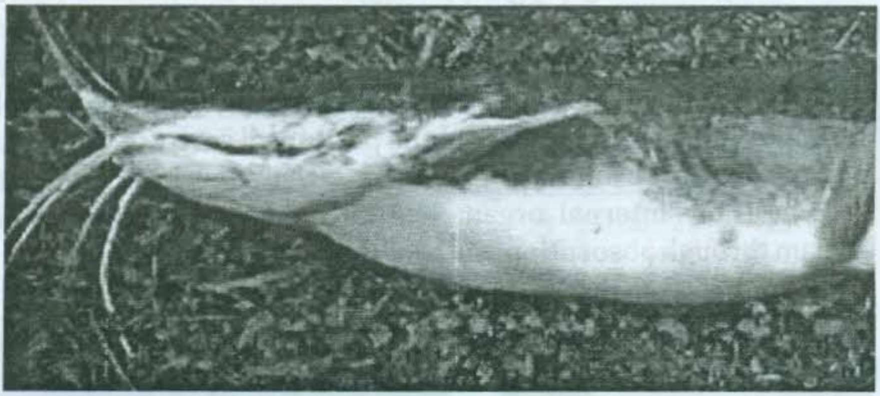
Plate 9: Gravid Female *Clarias Gariepinus* (Half Body)


Plate 10: Ripe Male Catfish

Hormone Administration or Injection

In induced artificial fish breeding, the quickest method of administering the hormone is by injection using needle and syringe. The dosage is determined by weight or level of maturity of the brood fish (see induced breeding). For Ovaprim hormone it is 0.5mg/Kg body weight. There are two methods of injection: Intramuscular and Intraperitonium. Intramuscular injection is done through the muscle at the dorsolateral part of the body just below the dorsal fin (Plate 11). The needle is inserted into the muscle 2 – 2.5 cm deep, pointing towards the posterior end or tail of the body at an angle of $30 - 45^{\circ}$ to allow the hormone to enter the blood stream and follow the single blood circulation system of fish. Care should be taken not to hit any bone or organ with the needle. Intraperitonial injection is done by raising the pectoral fin and inserting the needle into the peritoneal cavity of the body and release the hormone into the cavity. Care should be taken not to injure any internal organ. The hormone enters the blood stream through absorption. Both methods are effective.

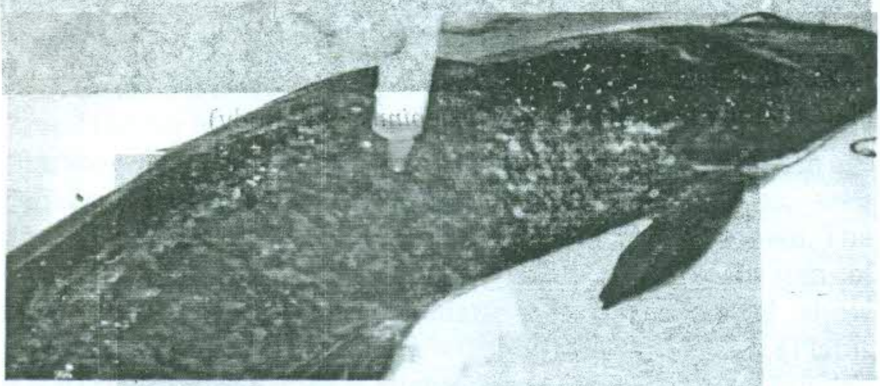

Plate 11: Demonstration of Intramuscular Injection methods

Latency Period after Injection

After injection the fish is kept isolated in a separate pond or container and given a latency period of 8–10 hrs (for tropical climate) depending on the level of maturity before injection and water temperature. The range worldwide is 7–21 hours depending on regional climate (Table 2). Latency period is the period during which ovulation takes place. The follicle cell of the egg breaks to release the ovum (egg) into the lumen of the ovary. The breeder should have accurate measure of temperature and check the fish regularly. If you keep away for too long the fish may release the eggs into the water and fertilization will no longer be possible. The brood fish should not be fed during latency period or even 36 hours before egg stripping (Ajana *et al*, 2006). This is to empty their stomach before stripping otherwise the content of the digestive system and excreta will flow along with the eggs during stripping and spoil the eggs.

Table 2: Water Temperature and Estimated Latency Period

Water Temp. (°C)	20	21	22	23	24	25	26	27	28	29	30
Latency Period (Hrs)	21	18	15.5	13.3	12	11	10	9	8	7.5	7

Source: Coppens International (2006); Ajana et al, (2006)

Egg Stripping

Egg stripping is easily carried out and safe with female African catfish. The fish is brought out of water, held gently and water or any moisture is wiped out from the body. The fish should be made comfortable, so it is held with wet towel and if possible aneathetised. Two people are required to hold the fish for stripping. The person to strip holds the head region covering the head with a towel while the other person holds the tail region. The belly is then tilted towards the container (a dry stainless or plastic container) and the abdomen is pressed gently towards the genital pore. Ovulated eggs easily flow out even on slight pressure (Plate 12). Stop stripping when blood start to appear. Don't allow water or blood to touch the eggs in the container before fertilization is done.

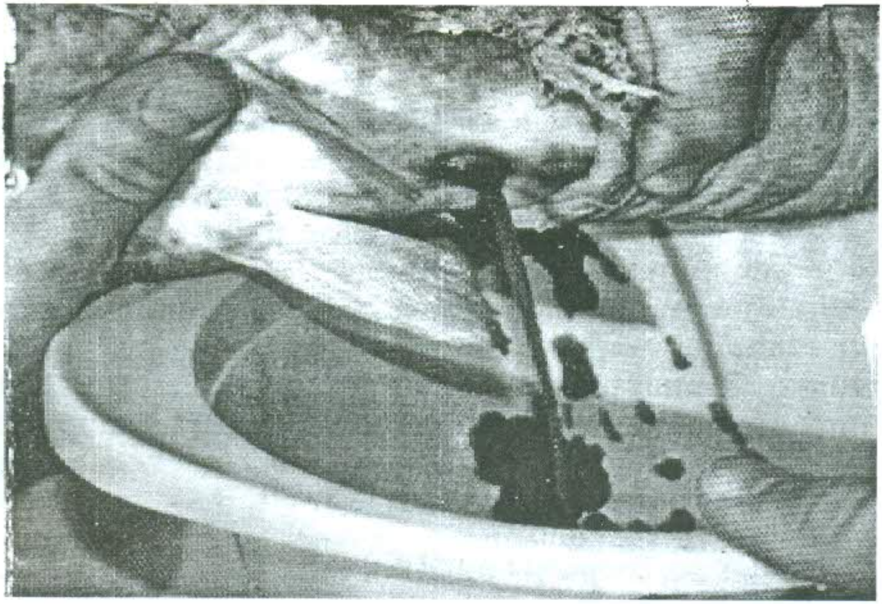

Plate 12: Egg stripping action

Obtaining the Milt from the Male Catfish

Milt is difficult to strip out from the male catfish because of the internal anatomy of the testis which are constricted or compartmentalized by epithelial membranes. Various techniques are therefore adopted to obtain the milt. The male is either injected with an overdose of hormone to ease the stripping or is killed to bring out the testis or an abdominal incision is done to ablate or cut out part of the testis or aspirate or siphon the milt and then stitch back the abdomen. The abdominal incision method or hormone overdose techniques are done to preserve a good variety of male for future breeding.

Artificial Fertilization of Eggs

After stripping the eggs and extraction of the testis or milt, fertilization should be done by mixing them together. This should be done immediately within five minutes of extraction. There are two techniques of artificial fertilization: Wet technique and Dry technique. In wet technique, the milt is mixed or diluted with saline solution and then sprinkled on the eggs while being stirred and mixed with a soft substance such as plastic spoon or feather. The saline solution serves as medium of fertilization. Milt diluted in saline solution or water should be used within one minute otherwise the sperm may lose motility and become unviable. Wet technique allows easy spread and contact between eggs and sperm giving high chance of fertilization. In dry technique the milt is not mixed or diluted in saline solution or any water medium, the testis is squeezed to drop the milt directly on the eggs while being stirred and mixed with a soft substance.

In both wet and dry techniques fertilization solution may be used to aid fertilization as the eggs may stick together due to sticky egg membrane or due to water activity. Many fertilization solutions are used including Saline solution itself and Cabamide solution. Cabamide solution is most preferred. This is made up of 30 g of Urea and 40 g of sodium chloride dissolved in 10 Liters of clean or distilled water (Delince *et al,* 1987; FAO, 1996). Some quantity of the solution is added to egg mass and stirred for 3 – 5 minutes during fertilization. After fertilization the eggs are transferred to the incubator for hatching.

Incubation and Hatching

Various types of incubators are used as a device for hatching the eggs. These include Glass or Fiber glass aquarium tanks, plastic tanks, zoug jars, aspersion chambers, shelf incubators, hapas and Small shallow concrete tanks. The essential requirement is that eggs should be immersed in shallow water and eggs should be either spread on a net platform in monolayer or attached to Kakabans or loose spongy material. A net hapa designed for this purpose serves best (Plate 13).

The time needed for hatching varies among species and water temperature (Table 3). In all cases they require warm water and good supply of well oxygenated clean water. The temperature requirement is between 27 - 30°C, this is not a problem in the tropic climate, this can however be maintained with the aid of Thermo-regulated water heater. The Dissolved Oxygen requirement is a minimum of $5mg^{L-1}$. This can be maintained by the use of Aerators or water flow through system. Under this optimum condition the eggs hatch within 24 hours.

Plate 13: Net Hapa for Incubation

Table 3: Water Temperature Level and Estimated Time of Incubation and Hatching

Water Temp. (°C)	20	21	22	23	24	25	26	27	28	29	30
Hatching Time (Hrs)	57	46	38	33	29	27	25	23	22	21	20

Source: Coppens International (2006); Ajana et al, (2006) The success of egg fertilization and hatching are observed during incubation. As soon as eggs are fertilized, embryonic development begins. Fertilized egg in this stage remain dark in color when transferred into the incubator while unfertilized egg turns whitish after one hour in the incubator. The proportion of eggs that turn whitish and those remaining dark indicates rate of fertilization. After hatching, the hatchlings drop to the bottom of the incubator leaving the egg cases attached to the net or Kakaban. Eggs that remain intact means they are unhatched, the proportion of which also indicates the rate of hatching.

9.0 HYBRIDIZATION OF CATFISH

This is the breeding or crossbreeding of two different species to produce an offspring with chromosome make up that is intermediate between the two species. It is selective crossbreeding of two different strains with special characteristics such as fast growth rate, attaining big body size, resistance to disease, tolerance of environmental changes. Many aquatic animals including fish hybridize readily and the technique have been adapted in aquaculture to improve fish production. The objective is to produce fish with better taxonomic and economic characteristics since one individual may not combine all the useful traits. Interspecific and intergeneric hybridization have been widely practiced in fisheries. Catfishes hybridize easily with each other. In intergeneric hybridization, a cross between male *Heterobranchus* and female *Clarias* will produce hybrid *Heteroclarias.* Name derived from the dominant sex, as male is dominant over the female it is called *Heteroclarias.* A cross between male *Clarias* and female *Heterobranchus* produces *Clariabranchus* (NIFFR, 1992). These crosses could be between *H. bidorsalis, H. longifilis* and *C. gariepinus* or *C. anguillaris.* *Heterobranchus* grows to a bigger size than *Clarias* but Clarias grows faster and male *Heterobrachus* even grows bigger than the female. So a cross between male *Heterobranchus bidorsalis* and female *Clarias gariepinus* produces hybrid *Heteroclarias* which combines both characters of fast growth rate of *Claias* and bigger body size of *Heterobranchus*. This is why hybrid catfish is most hunted for in aquaculture. The hybrid possesses a reduced adipose fin of *Heterobranchus* showing a sex linkage. However, though *Heteroclarias* grows faster and bigger, survival rate of their hatchlings is not usually as high as that of pure breeds of *Clarias* and *Heterobranchus*. NIFFR (1992) observed highest growth rate in *Heteroclarias* followed by pure breed *Heterobranchus bidorsalis* and *Clarias anguillaris* but *Clarias anguillaris* had the highest survival rate of the hatchlings. Another disadvantage of hybrids is that they are sterile and cannot reproduce. They always have to be produced by new

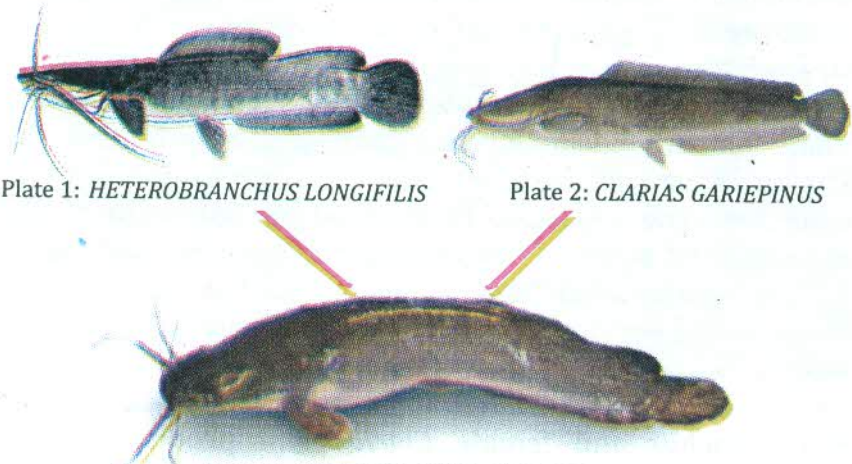

Plate 1: *HETEROBRANCHUS LONGIFILIS*

Plate 2: *CLARIAS GARIEPINUS*

Plate 3: *HETEROCLARIAS* (HYBRID)

Fig 5: Catfish Hybridization Crosses

10.0 ECONOMIC PERSPECTIVE OF CATFISH FINGERLING PRODUCTION

A catfish breeder can make a simple economic analysis to access cost effectiveness and income of fingerling production.

Estimation of Fingerling Production and Income

It is estimated that the proportion of ripe eggs in a ripe normal female catfish is between 15 – 20% of its total body weight. Given that a 2 Kg female catfish has 15 % body weight as ripe eggs. The following (Table 4) is an estimate of fingerling production and income in Naira from a 2 Kg female with 15 % body weight egg production.

Table 4: Estimated Fingerling Production and Income (Naira) from 2kg Ripe Female Catfish (*Clarias Gariepinus*)

15% of 200g	300g
Estimated No. of Eggs in 1g	1500
1500 Eggs 1g x 300g	450000 Eggs
Estimated % Fertilization	90 %
90 % of 450000	405000
Estimated % Hatching	90 %
90 % of 405000	364500 Hatchlings
Estimated % Survival after Yolk sac	80%
80 % of 364500	291600
Estimated % Survival after Weaning	70 %
70 % of 291600	204120 Hatchlings
Estimated % Survival to Fingerling stage	60 %
60 % of 204120	122472 Fingerlings
Estimated % Fingerling Mortality/Stunting/Rejection	10 %
10 % of 122472	12247.2
122472 minus 12247	110225 Fingerlings
110225 x N25.00	N2755625.00

11.0 MY CONTRIBUTIONS TO FISHERY DEVELOPMENT

1. Problem of Catfish Breeding in Minna (Low survival rate of hatchlings)

Upon my appointment in FUT Minna in 1992 to the present Department of Water Resources, Aquaculture and Fisheries, I discovered that fish breeding was never successful for more than 20% or even less in Bosso Campus. After successful breeding and hatching, the hatchlings will continue dying gradually until it remains very few hardy ones to survive. As a PhD candidate specializing in fish breeding and Departmental Farm manager, I took it upon myself to find out the reason. We went into catfish breeding research in 1999/2000 using all available water sources in Bosso Campus (Boreholes and municipal tap water) and we discovered that it was water quality problem. This was discovered when we used surface well water from a well that was newly dug near the farm. Our finding was that all the borehole waters in Bosso campus and in many parts of Minna are not suitable for fingerlings production.

2. In the year 2004/2005, to further improve on catfish fingerling production, we constructed net hapas for incubation of eggs instead of the traditional spreading of Kakaban or sponges directly on water to incubate eggs (Plate 13). This improved hatchability and survival of the hatchlings. The use of the net hapa in All-year Round breeding experiment of catfish was exhibited at National University Commission (NUC) research exhibition fair by Prof. S. O. E. Sadiku in December 2006 at Abuja and we won an award. We also used the net hapa in dry season breeding experiment of catfish in 2008 (Tsadu and Guis Dan. 2008).

3. In our quest to know the hereditary characteristics of hybrid *Clarias gariepinus* and *Heterobranchus bidosarlis*, we carried out

Hybridization of male *H. bidosarlis* and female *C. gariepinus* with observation of polygenic inheritance of the hybrid (*Heteroclrias*) (Tsadu, Lamai and Akilo; 2008). It was observed that the hybrid inherited ability to grow to bigger size than the normal *C. gariepinus* and also inherited adipose fin, though of much reduced size. Ability to grow to big size and possession of adipose fin are characteristics of the Genus *Heterobranchus*. Similar observation was made from hybrid crosses of male *H. longifilis* and female *C. gariepinus*, (Tsadu and Ayanwale, 2014). Small adipose fin is the genetic mark for easy identification of hybrid African catfish (See Fig. 5).

4. Biology and captivity of feral stocks of some African catfish *Bagrus bayad* and *Euchenoglanis occidentalis* were carried out with the aim of introducing them into aquaculture. Survival and growth in captivity in both concrete and earthen ponds and reproductive characteristics of *Bagrus bayad* was carried out by Tsadu, Lamai and Oladimejiin 1999/2000. The species performed well in captivity but could not be bred. Thus, to culture them, their fingerlings will have to be sourced from the wild. Similarly, *Euchenoglanis occidentalis* were kept in concrete ponds for captivity and their performance (survival, growth and feeding habit) was studied in both wild and captivity (Tsadu and Chukwuemeka, 2016). The species performed well in captivity but could not be bred.

5. Collection, preservation and utilization of freshwater zooplankton was carried out (Tsadu and Tukur, 2012) (Plate 14) as an attempt to find an indigenous alternative to imported *Artemia salina* for feeding fish hatchlings after induced breeding. A cocktail of freshwater zooplankton were cultured and used to feed catfish fingerlings and it gave an equally good result as the use of *Artemia salina*. The use of *Artemia* to feed our freshwater fish hatchlings is erroneous because *Artemia salina* are marine

zooplankton, packaged and imported to Africa for feeding the hatchlings after induced breeding. The zooplankton we collected and preserved (Plate 14) was exhibited during the February 2018 Convocation exhibition but the assessors could not understand or believe what they saw as an important thing in fish breeding. They were after difference in the cost price of imported *Artemia* and my local zooplankton while my emphasis was on the innovation of using our freshwater resources.

(A) IMPORTED *ARTEMIA SALINA* (B) FRESHWATER ZOOPLANKTON

Plate 14: Freshwater Zooplankton and Imported *Artemia* Package

6. My other contribution to catfish farming and aquaculture development in Nigeria and Niger State in particular is facilitation of a number of fish farming training programmes. These include:

(a) Fish farming training during refresher course for all Niger State Local Government Agriculture Staff, (March, 2001).

(b) Fish farming training for Entrepreneurship and

Agrobusiness Enterprise. 22nd to 31st October 2018. Organized by Minna Institute of Technology and Innovation (MITI).

(c) Fish farming training for Entrepreneurship and Agrobusiness Enterprise. 19th to 22nd November 2018. Organized by Federal University of Technology Minna Entrepreneurship Center, 2018.

7. Design of standard modern fish hatchery for FUT Minna, Department of Water Resources, Aquaculture and Fisheries Technology (WAFT). This was built as part of University Need Assessment in 2015.

12.0 **CONCLUSION**

African catfish (Genus: *Clarias* and *Heterobranchus*) are naturally best adapted to African climate and are most abundant there than other nations. They have the potential to supply all the food fish protein requirements of Africans and even worldwide if properly harnessed through intensive aquaculture. If properly harnessed African catfish can replace the imported ice fish for domestic supply and export. African catfish *Clarias gariepinus*, is one of the best aquaculture fish in the world. Aquaculture should be seen to have great potential to contribute significantly to food security, to increase per caput consumption of animal protein and eradicate poverty in sub-Saharan Africa. Food security is crucial to any nation's stability and development. Large percent of Africans derive high quality protein in their diet from fish at a low cost. Aquaculture and fisheries sector of food production is crucial to meeting FAO's goal of "a world without hunger and malnutrition" Aquaculture contributes to economic growth and fight against poverty. Many countries Government in Africa including Nigeria have adopted some policies and budgets for aquaculture development and have also developed framework, strategies and guidelines to implement the policies. Nigeria for example have in the past and present Government policies provided for credit facilities, loans, empowerments and input supply through World Bank Assistance, Agricultural Development Banks, Central Bank, Commercial Banks and FADAMA Development Grants. However, access to these loan facilities are still not easy for ordinary Nigerians. There is need to do more to reach out to really interested fish farmers.

13.0 **RECOMMENDATIONS**

Aquaculture is now well known in Africa and well established in many countries however its growth and development is still faced with many challenges which should be removed for it to reach to its full potential. Effort should be made to encourage adoption of new technologies to improve production from the existing producers and farmers.

There is population increase all over Africa and this justifies intensification and diversification of food production ventures. So aquaculture should be intensified as it has the potential to increase food and financial security of both rural and urban areas.

Success stories of some fish farming ventures often motivate people to invest in aquaculture but many do fail because they lack basic knowledge of aquaculture. There is therefore need for training and retraining of interested farmers. Government should provide an enabling environment to promote investment in aquaculture. Training of farmers, technicians, extension agents and other stakeholders is essential to the development of aquaculture. Government could organize and coordinate such trainings and enact policies that will promote development of aquaculture. Aquaculture training should be included in pre-retirement training of civil servants and other stakeholders.

Nigeria has a total of about 923768 Km^2 land area out of which about 13000 Km^2 is wet land comprising of rivers, lakes and reservoirs and 853 Km long coastline (Peter *et al.*, 2005) all suitable for fish production. Careful planning should be adopted to guide future development for proper utilization of available resources.

Non-Governmental Organizations (NGO) and donor nations should be encouraged to participate in aquaculture development through empowerment as they do in other sectors. Private sectors can play important role in production, marketing and extension service support. NGO's can serve as interface between Government and private entrepreneurs and farmers. They can empower farmers, reduce input cost and minimize market bottlenecks. They can foster efficient information exchange among stakeholders.

Research in the area of aquaculture development is insatiable. There are many commercially important aquatic organisms which are not yet in aquaculture. There should be continuous research to develop new technologies to increase production and better utilization of available natural resources.

Networking and information flow among stakeholders should be encouraged. Fish farmers associations should organize regular meetings to discuss trends and problems in their business and have a kind of monitoring and evaluation. Government and private sectors should also organize consultative forum for the stakeholders.

ACKNOWLEDGEMENTS

In the name of Allah, the Benevolent, the Beneficent, the Merciful. I say **Alhamdulillah, Alhamdulillah, Alhamdulillah.** I thank God for all he has done for me, sparing my life and guiding me through up till today and henceforth. I started fascinating the word Professor since my primary school days even though I did not know what it means. I respected all books I came across written by Professors. I even called all the great philosophers and scientists of those days 'Professors' such as Plato, Socrates, Jean-Jacques Rousseau, Charles Darwin, Linnaeus, Ernst Hekel, John Dewey, Alport, etc. I was also fascinated by the word 'Pedagogy' so any time I was asked of what I want to become, I said I want to be a Professor, I want to be a Pedagogy'. My thanks to God today is unquantifiable and beyond expression.

To my parents Alh. Isah Muhammad Magana (of blessed memory) and Hajiya Fatima Muhammad (still alive) whom God used to bring me to this world, I am very grateful to them. My father had 11(eleven) surviving children and decided to allow all of us to go to school. When asked he said he would not want to have anybody's blame if one way becomes better than the other. I am highly grateful and appreciative of my guardians Alh. Muhammad Tsadu Gogata (of blessed memory) and my aunt Hajiya Nnadzwa (still alive) for seeing through my early education. Alh. Tsadu was one of the powerful Primary School Headmasters of those days, 1960's and 1970's. I am highly appreciative of their love and care.

To my immediate family, my wife Malama Hawwau Abdulkadir

Mohammed Tsadu. Thank you for your love, care and support. My children Hafsatu (BA, MA English, ABU Zaria) (happily married with children), Hulaira (500L B.Tech IMT, FUT Minna), Fatima (300L Physics, ABU Zaria), Umar (100L ABU Zaria), Rahmat (100L BUK), Abdulaziz (Abu Turab Minna), Rafaatu (Abu Turab Minna) and Abba Abdulkadir (2018/2019 Headboy FUT Staff School), thank you for your patience support, love and kindness. Thank you for enduring and toiling through with me.

I wish to appreciate my primary school teachers, notably and worthy of mention is Alh. Salihu Yidan at Kudu Primary School Niger State. In those days it was one teacher per class to teach every subject except religion. I am highly grateful for his primary school mentorship. I wish to also extend my gratitude to my second guardian and former Principal of the famous Bida Teachers College, Alh. Muhammad Egba Enagi who saw to my admission to Bida Teachers College in 1971 where my pedagogical career began and also where I met my best friends in life (my classmates and schoolmates 1971 – 1975). Many of us are still together today as Old Boys of BTC. I am highly appreciative of their friendship and support.

I wish to appreciate my lecturers at undergraduate at Usumanu Dan Fodio University Sokoto 1982 – 1985. Notably among them are Dr. Attahiru Jega, Dr. Hyslop (English), Professor Hamid (Indian) and the most fascinating to me Dr. Mondoski (Polish) who said his degree is DSc. and not PhD. When asked he said to be a DSc means you have Masters and PhD in the three basic sciences, Physics, Chemistry and Biology. My sincere gratitude also goes to my lecturers and supervisors during my MSc. at University of Jos 1989/1990, Professor A. A. Adebisi (of blessed memory) and Professor P. C. Ofojekwu (also of blessed memory). May their souls rest in peace.

At this juncture I wish to express my sincere gratitude and appreciation to my PhD supervisors, mentors and colleagues, Professor S. L. Lamai and Professor A. A. Oladimeji. Thank you for your mature and fatherly guidance, support and advice. I wish to appreciate my friends and colleagues in my Department, WAFT notably Professor S. O. E. Sadiku. A rare heart that is a friend to everybody. A man of no enemy. All my colleagues in the Department: Prof. R. J. Kolo, Prof. J. O. Oyero, Prof. R. O. Ojutiku, Dr G. G. Bake, Dr. A. Orire, Dr. A. T. Yisa, Dr. S. U. Ibrahim, Dr. U. Y. Paiko, Dr. S. O. Olayimika, Mal. A. Ibrahim, Mal. J. Yusuf, Mr. Bulus B. M., Mal. Ndaman Mal. A. Kpotun, Mal. Isah Majiko, Mal. I. Wali, Miss Cecilia H., Mal. Maigari Ndako and Mr. Timothy A. Thank you all for your support and encouragement.

Finally, I would like to thank the University authority of Federal University of Technology Minna, the Vice Chancellor Prof. Abdullahi Balla, the Principal officers, all the Deans, HOD's and Professors in all the Schools, all academic and non-academic staff of the entire University. **THANK YOU ALL.**

REFERENCES

Agbabe, O. T., Ilabya, D. E. and Adebambo, A. O. (2013). Preliminary characterization of genetic strains in Clariid species *Clarias gariepinus* and *Heterobranchus bidosarlis* using microsatellite markers. *African Journal of Biotecnology*,12(4): 364 – 369.

Ajana, A. M., Adekoya, B. B., Olunuga, O. A. and Ayansanwo, T. O. (2006). *Practical Fish Farming.* ACT Pub. 88pp ISBN 978-2345-116

Attanda, A. N. (2012). Fish Species Diversification in Aquaculture for the Success of The Transformation Agenda, The Role of Tilapia Production. *Annual Public Lecture of Fisheries Society of Nigeria* (FISON) Lagos, Nigeria

Bardach, K. H., John, A. R. and William, O. M. (1972). Aquaculture. The Farming and Husbandary of Freshwater and Marine Organisms. John Wiley & Sons Inc. 244 – 255 pp

Balogun, J. K. (2015). *Basic Aquaculture.* ABU Press Ltd Zaria Pub. www.abupress.org 98pp

Ben Satia (2010). Aquaculture Development in Africa: Current Status and Future Prospects. *Environment and Sustainability*, 749 (Views)

Bruton, M. N. (1979). The breeding Biology and early development of *Clarias gariepinus* (Pisces, Clariidae) in Lake Sibaya, South Africa, with a review of breeding species of the Subgenus *Clarias* (*Clarias*). Trans. Zool. Soc. London, 35: 1 – 45

Cambray, J. A. (2005). Africa's *Clarias gariepinus* (Teleostei: Clariidae) appears in Rivers in Brazil. *African Journal of Aquatic Science 30: 201 - 202*

Coppens International (2006). *Manual on Catfish Reproduction*. Coppens International, P. O. Box 534, 5700 AM Helmond, The Netherlands. 19pp www.coppens.eu

David, B. O. and Raji, A. (2013). *Field Guide to Nigerian Freshwater Fishes* (Revised Ed.). 144 pp, Remi Thomas Press. Pub. ISBN 978-34-760-0-9

Delince, G. A., Campbell, D., Janssen, J. A. L. and Kutty, M. N. (1987). *Seed Production*. Working Paper: ARAC/87/13. Lectures presented at ARAC for Senior Aquaculturists Course. African Regional Aquaculture Centre, Aluu, Port Harcourt, Nigeria. July 1987. 114 pp

Ekelemu, J. K. and Ogba, O. (2005). Growth performance of *C. gariepinus* fed ration of maggot meals as replacement of fish meal. In: Fish for food and income generation in Nigeria. *Proceedings of the 20th Annual Conference of Fisheries Society of Nigeria*, Port Harcourt. 554 – 556

Faturoti, O. (2017). Fish demand in Nigeria. Keynote address Annual Conference of Fishery Society of Nigeria (FISON), Lagos 2017.

Federal Department of Fisheries (FDF) (2018).*Nigeria Fish Demand and Supply, 1997 – 2018* . FDF Federal Ministry of Agriculture Abuja Nigeria.

Food and Agricultural Organization (FAO) (1996). Artificial reproduction and pond rearing of the African catfish *C. gariepinus* in Sub-Sahara Africa. FAO Fisheries Technical Paper No. 362. 73pp www.fao.org

Food and Agricultural Organization (FAO) (2003a). *The Role of Aquaculture in Improving Food Security and Nutrition.* FAO Committee on World Food Security. www.fao.org

Food and Agricultural Organization (FAO) (2012). *Maximizing te Contribution of Fish to Human Nutrition.* FAO Nutrition and Food Security. www.fao.org

Food and Agricultural Organization (FAO) (2017). *The State of the World Fisheries and Aquaculture.* FAO Fisheries and Aquaculture Department. www.fao.org

Harvey, B. J. and Hoar, W. S. (1979). Theory and Practice of Induced Breeding in Fish. IDRC – TS 21, Ottawa, Ont. 48 p.

Lagler, K. F., Bardach, J. E., Miller, R. R. and May Pasino, D. R. (1977). Ichthyology. 2nd Edition. John Wiley & Sons. Pub. 1 – 8 p.

Lamai, S. L. (2011). 22nd Inaugural lecture, FUT Minna

Lokpobiri, H. (2017). Fish Demand and Supply in Nigeria. *Vanguard News*, August 19 2017.

Lokpobiri, H. (2018). Fish Demand and Supply in Nigeria: *thisdaylive.com*. May 2018

Machena, C. and Moehl, J. (2001). African Aquaculture: A Regional Summary with Emphasis on Sub-Saharan Africa.

Aquaculture in the Third Millennium. 341 – 355 pp. NACA, Bangkok and FAO, Rome.

NEPAD (New Partnership for Africa's Development), (2003). *Comprehensive Africa Agriculture Development Programme*. 220 p. South Africa.

National Institute for Freshwater Fisheries Research (NIFFR) (1992). Annual Report.

Obatola, P. O. (2018). Fish Importation in Nigeria. *Thisdaylive.com* 2018

Subasinghe, R. P. (2003). An Outlook for Aquaculture Development: Major Issues, Opportunities and Challenges. *Review of the State of World Aquaculture*. FAO, Rome www.fao.org

Teugels, G. (1986). A systematic revision of the African species of the Genus *Clarias* (Pisces: *Clariidae)*. Annals musec royal de I Afrique central, 247: 1 – 199.

Vincke, M. M. J. (1995). The present state of Development in Continental Aquaculture in Africa. *The Management of Integrated Freshwater Agro-Piscicultural Ecosystems in Tropical Areas.* (Eds: J. J. Symoens & J. C. Micha) pp 27 – 61. Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, the Netherlands

Woynarovich, E. and L Hovath, L. (1980). The Artificial propergation of warm water fin fishes. – a manual for extension. FAO fish. Tech. paper, 201: 147 pp.

A BRIEF PROFILE OF THE PRESENTER

Professor Shaba Mohammed Tsadu was born one Friday morning on 22nd November 1957 to the family of Alhaji Isah Muhammad Gana and Hajiya Fatima Muhammad at Edati-Lassagi, Edati Local Government Niger State. He was entrusted to the guardianship of Alhaji Muhammad Tsadu Gogata at about the age of 4 (four).

He started his early education from Infant Class (now called Nursery) in 1962 at infant class section of Lemu Primary School, Lemu Niger State. He completed the infant class and started primary one at Sabon Gida Primary School, Bida in 1963/1964. He completed his primary school at Kudu Primary, Kudu Niger State in 1970. He attended Bida Teachers College from 1971 to 1975 where he obtained Teachers Grade II Certificate. He then went to the Advanced Teachers College Minna (now College of Education) from 1976 to 1979 where he obtained Nigeria Certificate in Education (NCE). He went for National Youth Service Corp (NYSC) at Cross River State in 1979/1980. On return from NYSC in 1980, he took appointment with Niger State Government Ministry of Education as Master III and was posted to Government Vocational Training Center, Katcha.

He got admission to Usumanu Dan-Fodio University Sokoto in 1982 and finished BSc. Ed. Zoology in 1885. Thereafter he taught at various schools including Government Day Secondary School, Kutigi and Government Secondary School, Kontagora. From there he got admission to University of Jos where he read MSc. Hydrobiology and Fisheries in 1989/1990. After this he reported back to Niger State Ministry of Education and was posted to

Government Day Secondary School, Chanchaga Minna as Vice Principal Academic. He served in that capacity until March 1992 when he transferred his service to Federal University of Technology Minna.

Professor S. M. Tsadu took appointment with Federal University of Technology Minna on 5th March 1992 as Assistant Lecturer in the Department of Fisheries Technology. He registered for his PhD Degree in the Department in 1996/97 session under the supervision of Professor S. L. Lamai and Professor A. A. Oladimeji and completed in 2000/2001 session successfully. There he rose through all ranks until he became Professor of Water Resources, Aquaculture and Fisheries in the year 2014.

He has held many administrative responsibilities at Department, School and University levels. These include Departmental Examination officer, Field Trip Coordinator, Library officer and Farm Manager. School Examination officer, School Rep. to Senate, School Rep. to Student Disciplinary Committee. Senate Rep. to FUTMIN Venture Management Board. Deputy Director CCCFR, CDRMDS and CPES and Head of Department WAFT. He has served in many committees at Departmental, School and University levels. He has held many community services at State and National levels. He attended and presented papers in many national and international conferences. He has over 45 peer reviewed research publications in reputable journals and conference proceedings. He has supervised several undergraduate and postgraduate research projects including PGD, MTECH and PhD.

THANK YOU! THANK YOU! THANK YOU!

ISSN 2550 - 7087

global links communications
©: 08056074844, 07036446818