THE USE OF SOME NON CONVENTIONAL CONTAINERS FOR REARING CLARIAS GARIEP1NUS IN SECONDARY SCHOOLS.

By

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DECLARATION

I declare that the work in the Thesis entitled 'The use of some non- conventional containers for rearing *Clarias gariepinus* in secondary schools' has been performed by me in the Department of Biological Sciences under the supervision of Drs. P. A. Audu, S. A. Abdullahi, and (Mrs.) P. N. Chiezey. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university.

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CERTIFICATION

This Thesis entitled "THE USE OF SOME NON CONVENTIONAL CONTAINERS FOR REARING *CLARIAS GARIEPINUS* IN SECONDARY SCHOOLS" by Dada, Abigail Omolola Idowu (Mrs.) meets the regulations governing the award of the degree of Master of Science in Educational Biology of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This Thesis is dedicated to my late parents Chief James Owolabi Fabunmi who slept in the Lord on 28th January, 2001 and Chief (Mrs.) Ruth Wuraola Fabunmi who slept in the Lord on 28th December, 2001.

May your soul rest in perfect peace.

ABSTRACT

The growth performance of Clarias garicpinus fingcrlings cultured in different experimental containers were investigated. One hundred and fifty fingcrlings obtained from the Ahmadu Bcllo University reservoir were used for the study. The fingcrlings were led with the same experimental diet in live different experimental containers namely clay pots, plastic baths, aluminium pots, water baths and glass aquaria. The glass aquaria served as the control. The experiment was carried out in the laboratory in 30 litres of dechlorinated tap water in each experimental container for eight weeks. Water quality parameters such as temperature, pH, dissolved oxygen and total hardness were monitored. Low mortality rale was observed during the experimental period. Growth and nutrient utilization indices viz Mean Weight Gain (MWG), Specific Growth Rate (SGR%), Feed Conversion Ratio (FCR) and Protein Efficiency Ratio (PER), Feed Efficiency (FE), Apparent Net Protein Ulilizatioin (ANPU), Nitrogen Metabolism (NM), were calculated. The initial mean body weights of 0.7Sg to l.08g were fed 5% of the body weights in the different experimental containers. The llngerlings had significantly (P<0.05) high increase in mean weight in all the five containers as Clay pots (2.43g), Plastic baths (2.28g), Aluminium pots (2.94g), Water baths (2.l4g) , Glass aquaria (2.84g). The best growth and nutrient utilization were observed in the fingcrlings cultured in the experimental container C, aluminum pots with significantly higher values (P<0.05) for Mean Weight Gain (MWG) and Specific Growth Rale. (SGR). The fish cultured in experimental container D, water baths had the least Mean Weight Gain (MWG) and Specific Growth Rale (SGR). The results, suggest thai any of these containers may be used for culturing fish in the school laboratories.

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CHAPTER ONE

1.0 INTRODUCTION

Fishes are cold blooded aquatic vertebrates belonging to either of the two classes Chondricthyes (Cartilaginous fish) or Osteichthyes (bony fish) which together comprise over 30,000 species occurring worldwide in seas and fresh waters (Macmillan Encyclopedia, 1981).

Fish are of major importance as a source of food, their other products and for sport. Fish are consumed as human food but provide many other by-products, including fish meal, fish oils, glues, pharmaceuticals, shells, pearls and others (Macmillan Encyclopedia, 1981).

Socio economically, fisheries make significant contribution to the improvement of Nigerian economy in terms of income, employment opportunities (in cottage industries involved in the processing of fish products, fish oil, in fish market), foreign exchange earnings and making significant contribution to the gross national products. Financial analysis revealed that fish marketing business is highly profitable in Nigeria (Eyo *et al., 1991*).

For many years, researchers have focused more on fish nutrition, nutrient utilization and growth performance with little attention to how best to rear fish for teaching purposes.

One of the major constraint militating against effective teaching and learning of science in the secondary schools is inadequate laboratory facilities and specimens. Many secondary schools in Nigeria lack ponds/aquaria, which makes effective teaching and learning of fisheries very difficult. Ultimately, the teaching of subjects like Biology, Agricultural science and Integrated science are negatively affected.

The major objectives of the Junior and Senior Secondary School Agricultural Education amongst other things include

Stimulate and sustain students' interest in Agriculture,

Acquisition of basic knowledge and practical skills in Agriculture/fish culture,

Prepare students for further studies in Agriculture,

Prepare students for occupation in Agriculture (FME, 1985).

- On the other hand, Biology syllabus focuses on equipping student with,

adequate laboratory and field skills in Biology;

Meaningful and relevant knowledge in Biology;

Ability to apply scientific knowledge to everyday life in matters of personal and community health and Agriculture;

Reasonable and functional scientific attitudes (FME, 1985).

Teachers have been teaching these students theoretically which has not been helping the students to acquire the practical skills and learning is not permanent.

An old adage says:

"what I see I know

what I hear I forget

what I do I understand"

It is hoped that the current study would identify methods of raising fish using locally available resources.

1.1 Justification

One of the aims of secondary education is to prepare the child for useful living within the society. In both Junior and Senior Secondary Agricultural Science syllabi, fisheries is an important topic. For instance in the Junior Secondary Agricultural Science syllabus fisheries is a major topic which focuses on Fisheries, classification, uses, fishing, fish processing and preservation. (FME, 1985). The performance objectives are:

Identify fish types and different aquatic macro organisms;

State the uses of fish and fish products;

Identify fishing equipment;

State the various methods of preserving fish (FME, 1985).

While in the senior secondary schools Agricultural science syllabus, fish farming and fishery regulations are major topics and performance objectives are:

State the conditions necessary for siting a fish pond;

Establish and maintain a fishpond or an aquarium;

State the basic laws and regulations on fishing. (FME, 1985).

Apart from this, Biology syllabus will not be complete without fish. Fish is an important specimen in National Examinations Council (NECO) and West African Examinations Council (WAEC) examinations. In view of the importance of fisheries as stated above, in schools, little or no attention is paid to fisheries. During NECO/WAEC examinations Biology and Agricultural science teachers run helter-skelter to get fish as required by the examination bodies.

In recent years i.e. 2003 and 2004, WAEC and NECO have set questions on fish i.e. bony fish (Tilapia), fish scales, gills (fresh ones) and West African Senior School Certificate Examination (WASSCE) NOV/DEC question 7b1 was on fish. In WASSCE 2003 Agricultural science practical specimen B was fish. In National Examinations Council (NECO) Senior School Certificates (SSCE) 2003 Biology practical specimen I was gill (fresh ones). In WASSCE 2006 Agricultural science practical specimen O was Catfish, specimen P was Tilapia spp, specimen R was hook and line. (fishing equipment) Similarly, in NECO SSCE 2006 Agricultural science practical specimen C was fishing net and specimen D was Tilapia fish (fresh).

The present study was undertaken to determine how live fish could be reared using locally available resources for effective teaching and learning in secondary schools.

Most secondary schools in Nigeria, lack ponds/aquaria as teaching aids for students. A study of this nature is vital in providing basic requirements for the rearing of fish in secondary schools for the teaching of Biology, Agricultural science and Integrated science, etc. This will

make the study of fisheries interesting to the students, and further forms the basis for a career in fish farming which will ultimately address the problems of unemployment/poverty in the society.

1.2 Statement of research hypotheses

For this study, the null (Ho) and Alternate (H_1) hypotheses are postulated on the growth performance of *Clarias gariepinus* reared in non conventional containers and ascertain the containers in which growth of fish is best.

H_0 There is no difference between the growth performance of *Clarias gariepinus* fingerlings cultured in different experimental containers in the laboratory.

H_1 There is difference between the growth performances of *Clarias gariepinus* fingerlings cultured in different experimental containers in the laboratory.

Ho Fish can be reared in non-conventional aquaria in the laboratory.

Hi Fish can not be reared in non conventional aquaria in the laboratory.

1.3 Aim of study

This study was focused on the use of some non conventional containers for rearing *Clarias gariepinus* in secondary schools for the purpose of teaching.

1.4 Objectives

The study was therefore designed with the following specific objectives:

1) To determine the growth performance of *Clarias gariepinus* reared in some non conventional containers in the laboratory.
2) To ascertain in which of the easily available and affordable containers the growth of the fish is best.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Distribution of cat fishes

Cat fishes are bony fishes. Most of them are freshwater fishes, but a few live in the sea. There are over 1200 different marine and freshwater Catfish of which only few freshwater species are important to commercial farmers. Catfish are found all over the world, in many different types of home. There are cave catfishes and those which live in torrential streams. There is electric cat fish, and an African cat fish which swims about upside down. (Landau, 1992).

In Hungary and Yugoslavia, the culture of the European catfish – sheatfish, or wels (*Silurus glanis*) is fairly well developed. These tasty and fast growing fish may exceed 2m in length. Two catfish of the family *Clariidae*, *Clarias batrachus* and *C. macrocephalus* are raised in Thailand, Vietnam, India, Pakistan and Malaya. These fish are very hardy, rapidly growing animals. *Clarias* is a good air breather (therefore easily transported when kept moist and cool). (Landau, 1992).

Catfish belonging to the family Pangasiidae in particular Pangasius are cultured in Thailand, Veitnam, Laos and Cambodia. These fish are usually grown in floating cages and fed)trash fish, aquatic vegetation, rice bran and other plant products. (Landau, 1992)

All catfish cultured in the United States belong to a family of Ictaluridae. Some farmers ;row the blue catfish, *Ictalurus furcatus,* or the white catfish, *Ictalurus catus*, but by far the most ommonly cultured species is the channel cat fish *Ictalurus punctatus*.

Bull head cat fish are considered a pest by most catfish farmer; bull heads or mud ıtsfish, includes: the speckled bullhead, I. *Nebulosus marmoratus*, brown bullhead, *I.nebulosus*, ack bull head, *I.melas* and yellow head, *I.natalis*. (Landau 1992).

2.2 Geographical distribution of Africa catfish

The African mudfish is widely distributed throughout Africa. It has an almost Pan-African distribution, ranging from the Nile to West Africa and from Algeria to Southern Africa. It also occurs in Asia Minor (Israel, Syria and South of Turkey) it inhabits tropical swamps, lakes and rivers, some of which are subject to seasonal drying (Veveen *et al.*, 1986).

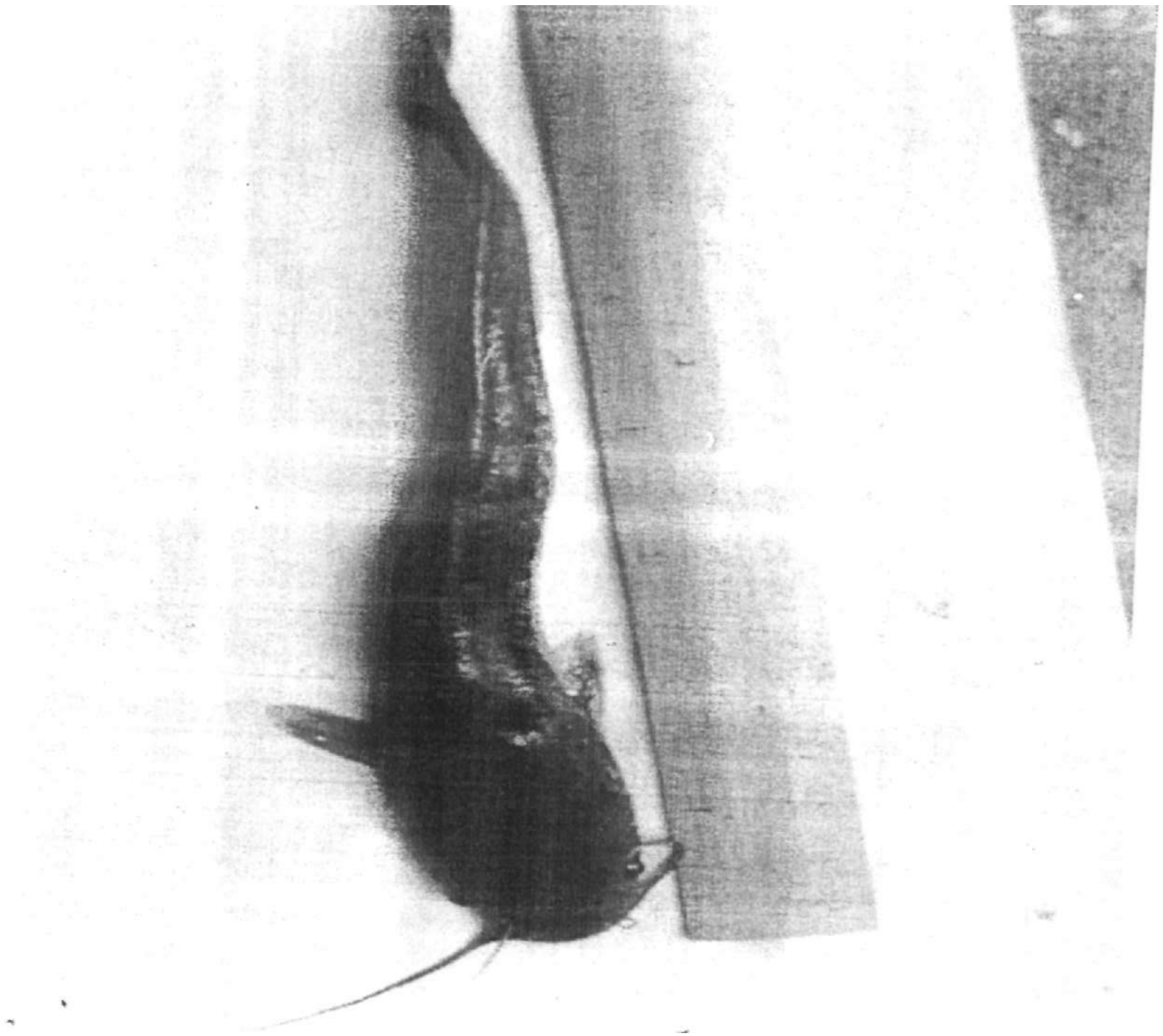
2.3 Biological description

The taxonomic status of C*larias gariepinus* is illustrated below:

Taxanomic status

KINGDOM	Animal
PHYLLUM:	Chordata
SUB-PHYLLUM:	Vertebrata
SUPER CLASS:	Pisces
CLASS:	Osteichthyes
SUB-CLASS:	Actinopterygii (ray-finned fishes)
ORDER:	Siluriformes (catfish)
FAMILY:	Clariidae (Airbreathing catfishes)
GENUS:	Clarias
SPECIES:	*gariepinus*
COMMON NAME:	African Mudfish

Clarias gariepinus has a scale less slimy skin, which is generally dark, grayish-black above and creamy-white below: the fish turns lighter in colour when exposed to light. During stress it will show a mosaic-like pattern of dark and light spots (Plate I). It possesses a fairly distinct black longitudinal band on each of the ventral surface of the head. The young (less than



9cm long) has a similar colour pattern except that the black bands on the head are absent. The head is large, depressed, and heavily boned. The mouth is quite large and sub-terminal (Skeleton, 1993). The upper surface of the head is coarsely granulate in adult fishes, and smooth in the young (Van Oijen, 1995). It possesses a wide mouth with eight barbels (nasal, maxillary, outer mandibular and inner mandibular). With the wide mouth it has the ability to feed on a variety of food items, ranging from minute zooplankton to fish. Close to the nasal barbels, two olfactory organs are located.

The median fins consist of a dorsal (61-80 soft rays), a caudal, and an anal fin (45-65 soft rays), while the paired fins consist of the pectoral and ventral fins. It has a strong pectoral fin with spines that are serrated on the outer side (Teugels, 1986). The sharp spines are not poisonous. The eyes are small. The urogenital opening is situated at a papilla just behind the anus, the male possessing an elongated form of this papilla. According to IGFA (2001), the maximum size that it can attain is 1.7m (total length) while the maximum published weight is 60.0kg (Robins *et a.l*, 1991). The maximum reported age in the wild is eight years. It is a freshwater fish that can live in a depth range of 0-80m.

The African mudfish lives in a variety of freshwater environments, i.e. it occurs mainly in quiet waters, lakes and pools but is also very prominent in flowing rivers, rapids and around dams (Teugels, 1986). It is widely tolerant of extreme environmental conditions and can live in a pH range of 6.5-8.0. It is able to live in very turbid waters and can tolerate temperatures of 8-35°C. Their optimal temperature for growth is 28-30°C (Teugels, 1986). Verreth and Den Bieman (1987) specifically recommended 28°C as the optimum temperature for *Clarias gariepinus* larval rearing. The presence of an accessory breathing organ enables this species to breath air when very active or under very dry conditions. It is also able to secrete mucous to prevent drying and burrow in the muddy substrate of a drying body of water (Skelton, 1993). It remains in the muddy substrates of ponds (benthopelagic) and occasionally gulps air through the

mouth (de Moor, 1988). As a result of being capable of atmospheric respiration it may exist in mud during the dry season. It is potamodromous, which it can migrate between streams and rivers (Teugels, 1986). It can leave the water at night using its strong pectoral fins and spines in search of land-based food or can move into breeding areas through very shallow pathways (Burgess, 1989).

It is a bottom feeder, which is also capable of feeding at the surface (Teugels, 1986). It is an omnivore. It is not specific in its food requirements. In its natural state, it is known to feed on insects, plankton, snails, crabs, shrimps, and other invertebrates (Burgess, 1989). It is also capable of eating dead or rotting animals - birds, reptiles, amphibians, small mammals, other fishes, eggs, and plant matter such as fruit and seeds (de Moor, 1988). Because it is mobile on land, it is able to predate on terrestrial organisms. This species may also hunt in packs on occasion by herding and trapping smaller fish. It is also referred to as sharp tooth catfish because of its fine, pointed bands of teeth (Skelton, 1993). This species can live in very poorly oxygenated waters. Since the fish can tolerate low dissolved oxygen levels in the water, it is very suitable for fish culture. In nature, it matures after 2-3 years. Under pond conditions however, mudfish mature at 7-10months (Viveen *et al.*, 1986).

The knowledge of the culture and increased survival rates of catfish is still insufficient to alleviate the difficulties encountered in its rearing. *Clarias* have been known to exhibit high mortality rate at its early stage of development (Faturoti *et al.*, 1988) which may be due to its nutritional requirement. Oresegun and Ayinla (2001) reported that *Clarias spp* are predators and that the most popular cultural system is its combination with *Tilapia spp* which is a prolific breeder. *Clarias* are bottom dwellers and are generally dorsal ventrally compressed and have streamline shape. They feed on mud, detritus, worms, algae etc

2.4 Sexual differences

Sex of a fish can very seldom be determined from external characters. In *Clarias*, the females are characterized by a flat, rounded genital opening, a wide abdomen, and a small head. A large rounded belly and soft ovaries are characteristics of a good spawner. Male *Clarias* has a nipple like genital papilla, a wide head, and a relatively thin abdomen. The characteristics of a male brooder are darkening under the body and a protruded genital papilla (Landau, 1992).

2.5 Suitability of *Clarias* in aquaculture

The *Clarias* exhibit many qualities which make them suitable for culture. These include ability to withstand stress, disease resistance, fast growth rate, high yield potential, high fecundity as well as high palatability (Eroundu *et al.*, 1993,Nwadukwe., 1993). They can also withstand low oxygen and pH levels (Huisman and Richter, 1987; Fagbenro and Sydenham, 1988). These qualities make C*larias gariepinus* suitable for this study.

2.6 Food, feeding habits and feeding regimes of *Clarias* under experimental conditions

Clarias spp is describe as omnivorous with a high propensity for being carnivorous (Reed *et al.*, 1976). They live mostly at the bottom of rivers, swamps and muddy places (hence the name mud-fish) where they feed on a wide variety of food ranging from decomposing organic matter, plankton, weeds other small fishes, insects and their larvae, crustaceans, worms, snail, etc. (Bakare, 1968). *Clarias* can therefore be described as an opportunistic feeder, feeding on virtually everything that comes its way. *Clarias* can survive under all kinds of conditions and can be raised under restricted environment.

Madu, *et al. (1987)* reported that 40% crude protein meet the dietary requirement of *Clarias gariepinus* fingerlings of about 2-5 months old. The experiment he conducted yielded 2.065g per day as the mean weight increases in the fingerlings using 40% crude protein feed. A similar 40% crude protein level gave similar weight increase (Faturoti *et al.*, 1986). Using different feeding levels and feeding frequencies in the culture of *Clarias gariepinus* fingerlings, Hogendoorn .

(1980) found out that a body weight of about 10g could be achieved within two months after first feeding taking into consideration that one month was used to raise the fry up to fingerlings of 0.5 to 1g. On feeding frequency Hogendoorn, (1980) also found out that continuous feeding for 24 hours a day gave he fastest growth followed by continuous feeding for 12 hours at night. On feeding regimes, (Faturoti, 2003) recommended that fingerlings be fed twice a day, morning and evening between 8-8.30 am and 5-5.30pm respectively at 3-5% body weight per day. Once a while the container's bottom should be checked for food remnants about 30 minutes after feeding. If any food remnants have accumulated the quantity of food fed should be reduced.

Faturoti, (2003) sums it up "the last guide for the aquaculturist is to place the feed, where it can be obtained by the fish. Offer it so that it will be immediately eaten and present it so that all the fish will receive their share.

QL
638.C6
Dad

2.7 Nutrient requirement of *Clarias*

Several works have been carried out to show the inevitability of some basic nutrients of some of our indigenous fish such as *Clarias*, Tilapia, Carp etc.

Fish like any other animals require a well balanced diet to meet the physiological needs of energy supply, promotion of growth, body maintenance and reproduction. Supplementary diet is needed to meet all its nutritional requirements for better and faster growth especially when reared under closed confinement and at high stocking density. In intensive culture system, the growth of fish depends primarily on the quality and quantity of feed supplied by the farmer (Chan and Tang, 1978).

According to Lovell (1989), nutrient requirements for any animal species can be defined using several criteria, and the requirement for a given nutrient may vary with the criterion used. Growth, reproduction, behaviour patterns, nutrient storage, enzyme activity, gross and histological appearance of tissues and their content of nucleic acid and proteins are the major criteria used to assess the nutritional adequacy of diets. Falaye (1988) stated that fish require

protein, fat, carbohydrates, minerals and vitamins which must be available to enhance fast growth and optimum harvest of healthy fish.

2.7.1 Protein and amino acid requirements

In aquaculture, the protein requirement of the fish species being reared has to be satisfied. Proteins are composed of long chains of amino acids. Although proteins may be metabolized for energy, one goal in aquaculture is to utilize as much of the dietary protein as possible for growth, allowing the carbohydrates and lipids to provide metabolic energy. Proteins are the flesh-forming principles present in most foods. They are also known as 'proteids', 'albuminoids', or 'nitrogenous principle', the latter name being used on account of the presence in them of nitrogen. Proteins have in addition to carbon, hydrogen and oxygen, nitrogen and usually sulphur and sometimes phosphorous (William and Geoffrey, 1967).

The nutritional importance of dietary protein is due to its amino acid content. Fish require certain amino acids ("essential") in proteins for growth, tissue repairs, general health and reproduction. Fish cannot make the essential amino acids, and they must be provided in the diet. Protein is the most significant and the most expensive single nutrient in fish diet preparation. According to Reay (1979), the gross digestible protein requirement for a number of farmed fish species fall within 20-25% of total dietary weight. It will therefore be of advantage to increase protein efficiency ratio without negative effect on food conservation ratio which consequently ensure that expensive dietary protein is utilized for fish growth and spared as a source of energy.

According to Faturoti *et al.*, (1986) 40% crude protein level was optimum for growth and food utilization in *Clarias lazera*. Madu and Tsumba (1988) also reported that the best growth performance and food utilization parameters for the mud fish *Clarias anguilaris* were attained at 40% crude protein level when the fish was fed with different level of protein diet. Degani *et al.* (1987) also reported that 40% protein level was best for growth ratio for *Clarias gariepinus*

when fed different levels of proteins. On the other hand if too much protein is supplied in the diet, that which is not utilized will be broken down to produce energy (Lovell 1989). and Hilton (1983) reported that earthworm meal contains most of the amino acids needed for fish growth.

However, that there is amino acid deficiency in earthworm meal. Lovell (1994) reported that the biological value of protein source does not only depend on its amino acid profile but also on its digestibility.

The quality of protein in any diet is principally based on the amount of essential amino acids present. Amino acids are the substances derived from the ultimate products of digestion. There are about twenty naturally available amino acids; arginine, histidine, isoleucine, leucine, methionine, phenylalanine, threonine, tryptophan, valine, alanine, aspartic acid, asparagines, cystine, glutamic acid, glutamine, glycine, proline, serine, tyrosine (Hardy, 1990) but only the first ten are essential for fish growth because they are not synthesized in fish and so must be provided in the feed. As such, they are referred to as "essential" or "indispensable" (Norris, 2005). Most species of fish require a dietary source of at least one sulfur-bearing amino acid, although when the required one is available in sufficient quantity, other sulfur-bearing amino acids can be synthesized from it (Stickney, 1979). Methionine, cysteine and cystine contain sulphur and supply as the raw material for all the sulphur-containing compounds used in the body, such as glutathione, taurine, the thiosulphates and the thiocyanates. A particularly important amino acid for growth is lysine. Proteins rich in lysine can be obtained from legumes, fish meal, blood meal, or meat and bone meal. Tryptophan is very important for growth of all cells and normal development. It is used in cell proliferation. Arginine and histidine play an important role in maintaining a normal and healthy bloodstream and has other complex functions (William and Geoffrey, 1967). Animals, fish inclusive are able to synthesize some of their amino acids (non-essential amino acids) from carbohydrates and lipids, and other nitrogen compounds, but generally from other non-essential amino acids. Any diet deficient in any of these essential

amino acids will cause depressed appetite and growth rate of fish (Ayinla, 1991). Due to a shortage of an economic source of animal protein, plant protein is increasingly being resorted to in spite of the fact that the best quality of proteins come from fishmeal (Lovell, 1981). Fishmeal is not deficient in any of the essential amino acids. In fact, it contains an excess of those which are deficient in any most plant protein. This makes fish meal a valuable complement to fish diets containing large amounts of plant ingredients. Feedstuffs of vegetable origin on the other hand, are as a whole lower in protein content when compared with fish meal. In addition, the presence of high amounts of carbohydrates, fibre and other organic molecules such as glycosides, phytates, and cyclopropenes in these sources present the nutritionist with problems that are generally not encountered with the former. Despite these problems, feedstuffs like soya bean, cotton seed meal and sunflower meal are being used to some extent in commercial aquaculture diets. None, however, perform as well as fish meal on a protein equivalent basis. These feedstuffs contain protein in amounts ranging from about 15 to 50 percent and so fall within the range of the protein requirements for optimum growth of several species of fish. However, proteins derived from vegetable sources are somewhat deficient in several key amino acids such as lysine, methionine, and tryptophan (Hardy, 1990).

Soya bean is one of the most abundant plant protein available for fish feed today in most parts of the world, Nigeria inclusive. Therefore, a considerable amount of work has been done for its use in fish diets (Eyo, 1989). It contains all the essential amino acids which are required by fish (Lovell, 1985; Eyo, 1989). Soya bean meal is therefore the highest quality (best balanced in essential amino acids) plant protein available. However, its use in fish feeds competes with other uses to which it is put. For instance, it is incorporated in livestock and poultry feeds. Man also uses it as food and other effect of all these is an ever increasing cost due to its demand.

The essential amino acids cannot be synthesized by the fish and hence must be supplied in the diet. The ten essential amino acids needed for growth are arginine, lysine, leucine,

isoleucine, histidine, methionine, valine, phenylalanine, threonine and tryptophan. These amino acids must be in the diet in near balanced amounts to furnish an acceptable amino acid this pattern before fish flesh can be formed. A deficiency in one more of these essential nutrients result in reduced growth rate, depressed appetite disease or even death (NRC, 1993).

Fagbenro *et al*. (2000) reported the estimated essential amino acid requirements in (g/kg protein) of *Clarias gariepinus* as, arginine (445), histidine (21.5), isoleucine (30.6), leucine (52.2), lysine (57), methionine (18.3), Phenylalanine (27.3), threonine (31.6) and valine (29.0). Eyo (2001) work on fish feeds and reported that cereals, palm kernel cake and groundnut cake were low in lysine and methionine. Cotton seed cake and soybean meal were low in methionine. Blood meal has been reported to have the least isoleucine content.

The requirement of *Clarias bactrachus* for protein in a practical type diet was suggested by Cruz L. (1976) as 35.69 – 37.72% while Garling W. (1976) recommended 32 – 36% for channel catfish. Halver (1978) reported from his work in feeding fry, fingerlings and yearling fish have shown that gross protein requirements are highest in initial feeding fry and that they decrease as fish size increases. To grow at the maximum rate, fry must have a diet in which nearly half (50%) of the digestible ingredient consists of balanced protein. At 6-8 weeks, this requirement is decreased to about 40% of the diet for salmon and trout and to about 35% of the diet for yearling salmonids raised at Standard Environment Temperature (SET).

Chakroborty (1981), studied the growth performance of Catfish *Heteropneustes fossilis* fry reared in laboratory aquaria on three fish feeds prepared from indigenous materials as frog meal, mustard cake meal, rice bran, aroid leaves and table salt. He concluded that a good feed must contain 40% or more of good quality protein. Faturoti *et al*. (1988) when working with artificial microencapsulated egg diet containing 48.8% crude protein concluded that 40% crude protein diet among the other alternative diets used was optimum for growth and utilization of

Clarias lazera. The microencapsulated diet with its high protein content did not add any special nutritional benefit on the growth and nutrient utilization of the fish.

Ayinla and Akande (1988), while working on the growth response of *Clarias gariepinus* fed silage based diet concluded from their result that *Clarias gariepinus* fingerlings and juveniles require 31-34% crude protein while the adult requires 40% crude protein. Faturoti *et al.* (1988) also recommended 40% for *Clarias gariepinus*, Madu (1992) also recommended 40% crude protein for *Clarias anguillaris* and 40 – 42.5% was recommended for *Heterobranchus bidorsalis* (Fagbenro *et al.*, 1992)

2.7.2 Effect of age or fish size on protein requirement

The effect of age or size of fish on dietary protein requirement showed a general decrease in protein requirement with increasing fish age or size. For example channel catfish fry require a minimum of 40% protein decreasing to 30 – 36 percent protein for fingerlings and 25 – 30 percent protein for fish weighing more than 114g. (NRC, 1977and Andrews; 1977). Andrew (1977) further demonstrated that the higher protein concentration in the two ranges, produce better growth of channel catfish fingerlings and juveniles. Whereas the lower protein concentration provide better protein conversion.

Bolarin and Haller (1982) reported that *Tilapia* of less than 1g require 35 to 50 percent protein, 1 – 5g fish require 30 – 40 percent protein, 5 – 25g fish require 25 – 30 percent protein and *Tilapia* weighing more than 25g require 20 – 25 percent protein. Goldfish require about 40 percent protein during the initial feeding stage of fry (Mohanta *et al.*, 2002) and 29 percent at fingerling stage (Lochman R. *et al.*, 1994)

2.7.3 Carbohydrate requirement

Buhler and Halver (1961) reported that relatively high levels of carbohydrates are tolerable by carnivorous fish and that dietary carbohydrate levels of around 20% may be optimal. The carbohydrate based feedstuffs are usually the cheapest source of energy for cultured fish

because of their natural abundance. A ration poor in carbohydrate entails the use of either lipid or protein to provide the necessary calories (Cowey and Sargent, 1972). In addition to energy, carbohydrates have the physical functions of texturing manufactured feeds and acting as a binder in the formation of both compressed and expanded pellets. Energy is another nutritional component for the aquaculture of animals. Failure to include adequate quantity of energy in the diet result in reduced growth, whereas excessive quantities of energy result in undesirable fat deposition or reduced feed consumption (NRC, 1993).

2.7.4 Fats requirement

Fats are dietary source of essential fatty acids, which are required for the normal functioning of the body. Catacutan (1991), revealed that homoeothermic animals have dietary requirements for Essential Fatty Acids. From the stand point of practical fish culture, dietary lipids are an important source of energy and the only source of Essential Fatty Acids (EFA) in fish and are different from species to species and from age and size (Shepherd and Bromage, 1992).

Lipids are often neglected in fish feed preparation. Cowey and Sargent (1972) recommended that they should not be present at excessive levels in the diet of fish. They are non-protein calorie sources and are generally more digestible than some carbohydrates (Hilton, 1982).

2.7.5 Mineral requirements

Mineral requirement of fish is similar to those of terrestrial animals. Fish have a requirement for calcium, phosphorous, potassium, chlorides, magnesium, iron, manganese, zinc, copper, iodine, cobalt, and fluoride. Fish require large amount of calcium and phosphorous. Fish can absorb some of the minerals in the water and this reduces their requirement (Lall, 1991). Aduku (1993) reported that blood meal, bone meal, fish meal, lime stone etc are natural sources of macro and micro minerals used in feed formulation for animals. Bone meal supplies to

minerals to the fish and can be prepared simply by burning cow bone. It is added to the diet at 0.5% of the ration. The mineral requirement of channel catfish have been reported by Lim and Dominy (1989) to be as follows: calcium <0.1%, Phosphorus 0.4%, Magnesium 0.04%, iron 30mg/kg, copper 5mg/kg, manganese 2.4mg/kg, zinc 20mg/kg and selenium 0.25mg/kg. Mineral are major elements needed in the fish diet for the adequate maintenance of their body activities. Minerals are required in the body for teeth, bones, scales and tissue fluids. They serve as variety of supporting functions in body chemistry. For example iron in the haemoglobin molecule enables blood to carry oxygen to the cells, calcium and phosphorus are the major minerals most likely to be lacking in the diet of fish. Some are needed in large quantities such as calcium, phosphorus, magnesium, sodium and potassium while some are required in very minute quantities such as iron, iodine, manganese, copper etc. According to Gallagher (1993), in some fishes mineral uptake in the water may be sufficient but in others, dietary supplementation is necessary.

2.7.6 Vitamin requirement of fish.

Vitamins are organic compounds that serve as catalyst for many biochemical reactions in the body tissues. Vitamins are also required in the diet in relatively small quantities for proper growth, health and function in fish and generally in other animals. Lovell and Lim Shurau (1982) showed that *Oreochromis niloticus* produce vitamin B 12 in the intestinal tract through bacterial synthesis and not require much of the vitamin in the diet. Deficiency of almost any vitamins can result in increased susceptibility to diseases and retarded growth (Woodward 1994; Kaushik *et al.*, 1997). These studies shows clearly that the supply of all vitamins at their minimal requirement levels as per the (NRC,1993) is sufficient to support rapid and minimal weight gain for diverse species of fresh water fish like catfish. Vitamins present in natural food are sufficient for fish.

However in an intensive culture system, where limited natural food organizations are present, vitamins are supplemented through commercial feeds. Vitamins are usually used as premixes in the diet of fish. They are usually introduced at 1 or 2% of the feed. Lovell (1989) reported that it is possible to formulate a fish feed from commercial ingredients that is adequate in essential vitamins except vitamin C. Lall (1991) gave the summary of vitamin requirements of diet for the growth of channel catfish as follows: vitamin A 5,500-iu; D, 500-4, 000iu;E50-100iu; vitamin k 10iu, thiamine 1-20mg; Riboflavin, 9-20mg; pyridoxine 3-20mg; pantothenic acid 10-50mg; Niacin 14mg; folic acid 5mg; B_{12} 0.02mg; Choline 400, Inositol, not required; (N.R), C(N.R) or 100mg.

2.7.7 Energy requirement

Fish need energy to maintain basic metabolic activities and to support growth, reproduction activity, and good health. Proteins, carbohydrates and lipids can all be used for energy. Lipids contain about twice as much calories per gram as proteins or carbohydrates (Lochman, 2001).

According to Lovell (1989) fish have a lower energy requirement because they do not maintain a constant body temperature and they exert relatively little energy to maintain position and to move in the water than and do mammals and birds on land and in air respectively.

Fish tend to adjust their feed intake in accordance with their energy requirements (Smith, 1989), and there was no evidence of differential feed intake of fish fed different diets.

2. 8 Water quality requirement

The composition, digestibility and physical characteristics of feeds may have a significant effect on water quality. The excretion of indigestible matter can be reduced by the manipulation of diet composition. Ingredients containing high concentrations of ash, fibers, chitin and indigestible carbohydrate result in an increase in the excretion of suspended solids, ammonia and phosphorus. These substances cause eutrophication consequently leading to oxygen deficits in

ponds or the receiving water (Ketola, 1985; Sumari 1986). Diet containing a high level of protein or a poor quality protein with a low level of energy supplied from lipid result in increased oxidation of protein causing high rate of ammonia excretion from the gills and high faecal nitrogen content. The phosphorus output from fish farm can be controlled by reducing the phosphorus level in the diet increasing feed efficiency and limiting the use of feed and limiting the use of feed ingredient, supplying excessive levels of phosphorus (Ketola, 1985; Sumari 1986). Excessive carbohydrate particularly starch stimulates the growth of fungi. Furthermore, feeds containing lipids which are not properly retained in the pellet may leach out thus producing a thin film on the water surface and possibly affecting the fishes gills.

According to Guidice, *et al* (1982), iron at 0.5ppm begins to coat the gills of fish causing impaired respiration. Sand filters may be used with aeration to remove irons from incoming water. Less common problems are the presence of hydrogen sulphide or ammonia in well water. Hydrogen sulphide leaves the water as a gas after aeration (Guidice *et al*: 1982). Amine *et al* (1994) reported that artificial feeds change the relationship, which exist between the animals and its environment. The deterioration of water quality and tank cleanness due to the use of formulated feeds may also affect the survival and growth rate of fish larvae in their early stage (Amine *et al.*, 1994). Windell *et al.* (1978) showed that improper collection of faeces such as allowing faeces to remain in the fish tank too long, caused serious over estimation of digestion coefficients.

2.8.1 Temperature

Temperature is next to dissolved oxygen as the single most important factor affecting the welfare of cultured fish are poikilothermic and water temperature plays a tremendous role in their feeding. This parameter affects the metabolic activities, feeding potential, growth, survival, reproduction in all fishes (Dupree and Hunner, 1984) and efficiency of food conversion (Martinez-Palacios *et al.* 1993). It has been reported that a 5°C sudden change in temperature

will stress or even kill fish and this has formed the basis of the acclimatization of fish (Adeniji and Ovie, 1990). Temperature has a pronounced effect on the rate of chemical and biological processes in water. For instance, fish require twice as much oxygen at 30° C than at 20° C (Adeniji and Ovie, 1990). Increment of the water level may therefore be necessary at higher temperatures. Temperature also affects the dominance and distribution of phytoplanktons in water. It is recommended that fish in the tropics be kept in water whose temperature range is between 25°C and 30°C (Auta,1993). Commercial production of aquatic organisms is often limited by water temperature and/or the length of the growing season. The body temperature of an aquatic organism is approximately the same with the water temperature that affects its activity and growth. The level of temperature that promotes growth differs among different types of aquatic animals. For example goldfish and trout require lower water temperature than Channel Cat fish. Temperature below the optimal levels, prolong time required to raise an aquatic organism to market size and consequently, raise production cost. Temperature above the optimal level for growth will stress the aquatic organism and result to disease and often death (Louis, 1997). Water temperature in fish pond varies from 27°c in the morning to 31°c in the later afternoon.

2.8.2 Hydrogen ion concentration (pH)

The pH of water is a measure of how acidic or alkaline it is on a scale of 0 to 14 with 7 being neutral. In fish ponds, the time of day that a sample is taken often will influence the pH because of variations in the carbon dioxide concentration. As plants in the water remove carbon dioxide for photosynthesis, the pH will increase. At night, the pH will decrease as carbon dioxide accumulates. Increasing the total alkalinity concentration in water helps buffer against pH changes. The pH of the pond water varies from 6.9 to 10.3, increasing in the afternoon and decreasing at night (Anonymous; 1994)

Chronic pH levels may reduce fish reproduction and are associated with fish die-offs (Stone and Thomforde, 2006). Adeniji and Ovie (1990) noted that acid and alkaline death points are approximately at pH 4 and 11 respectively and that water with pH values ranging from 6.5 to 9 were observed to be the most suitable for fish production. Dupree and Hunner (1984) also observed that high pH increased the toxicity of sulphides. Also, Auta (1993) stated that the desirable pH range for fish is 6.7 to 9.0.

2.8.3 Total Dissolved Solids (TDS)

The term "Total Dissolved Solids" (TDS) refers mainly to the inorganic substances that are dissolved in water. These substances can include carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions and other ions. A certain level of these ions in water is necessary for aquatic life (Stone and Thomforde, 2006) TDS (in mg/l or ppm)are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers).

Changes in TDS concentrations can be harmful because the density of the water determines the flow of water into and out of an organism's cells. Therefore, if TDS concentrations are too high or too low, the growth of fish can be limited, and death may occur. Similarly, total suspended solids (TSS), high concentrations of TDS may also reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature (Murphy,2005).

2.8.4 Electrical Conductivity (EC)

Electrical conductivity (EC) is a measure of how well a solution conducts electricity and is correlated with salt content. Conductivity is typically reported in units of (μ Siemens/cm (microsiemen per centimeter). Freshwater fish generally thrive over a wide range of electrical conductivity. Electrical conductivity (EC) also can be used to give a rough estimate of the total amount of dissolved solids (TDS) or the total amount of dissolved ions in water. Typically, the

TDS value in mg/l is about half of the EC (µSiemens/cm). High conductivity is an indication of the presence of large amounts of dissolved salts which may be detrimental to fish. The desirable range is 100-2,000. µ Siemens/cm and the acceptable range is 30 - 5000 µ Siemens/cm (Stone and Thomforde, 2006).

2.9 By-product of plant and animal origin used in the feed of *Clarias Gariepinus*

2.9.1 By-product of animal origin

The use of animal proteins in the diet of *Clarias gariepinus* have been reported by many fish nutritionists. Fish meal is used extensively as a source of protein in fish feed because of its unrivalled nutritive value. It has the highest biological value, higher in digestible energy, rich in lysine and methionine, minerals, vitamins and perhaps, unidentified growth factors required by fish (Lovell, 1981). However, Akinwande *et al.* (2002) reported that maggot meal could be successfully used to replace up to 50% fishmeal in the diet of *Clarias gariepinus* fingerlings, with optimal growth and nutrient utilization achieved. Blood meal is another animal protein source, which have been incorporated into diet of fish for improved growth. Although it has a high crude protein, its inclusion in the diet of *Clarias anguilaris* beyond 50% (Eyo, 1991) was found to cause a reduced growth rate of the fish. This may be due to the deficiency of isoleucine and methione. Earthworm is a cheap source of protein that was included in the diet of *Clarias gariepinus* fingerlings. The use of earthworm meal though seasonal will drastically reduce the cost of production in aquaculture operations. Tacon (1994) reported that fishmeal could be replaced with earthworm in fish feed without any adverse effect on the growth performance of the fish species. Toad is not edible to human beings because of its poisonous gland but Annune (1990) fed *Clarias gariepinus* dry toad meal diets for 70 days. He recommended the inclusion of skinned dry toad meals as a good replacement for compounded feed since fish fed this diet have better growth response than those fed either whole dry toad meal or compounded feed.

With the emergence of large scale poultry industries in Nigeria, there is the availability of enormous poultry waste that can be used in fish feed formulation. Chicken feather and offal were tried by Faturoti (2000) and gross profit and profit index were best at 75% and 100% inclusions of chicken offal in the diet fed to *Clarias gariepinus*. Live maggot, has a crude protein of 43.8, crude lipid 1.9, and 14.3 crude fibre (Madu and Ufodike, 2003) it has also been used in the diets of *Clarias gariepinus* fingerlings. The result indicated that live maggot utilization by *Clarias gariepinus* is of better economic value as compared to the costly compounded fish feed. *Clarias gariepinus* fingerlings were able to convert the protein present in the maggot more efficiently than the compounded feed (Sogbesan, 1998).

2.9.2 By products of plant origin

A lot of work has been done by aquaculturist on the possibility of replacing animal sources of protein with their plant counterparts in the diet of fish because of high cost of the animal proteins. Soybean has been identified as possible alternative to fishmeal in fish feeds due to its abundant protein. It contains all the essential amino acids and can be used in combination with other plants proteins to improve their nutritive value. The low methionine levels in soybean meal can be augmented by the addition of synthetic methionine in the diet (Eyo and Olatunde, 1998).

Groundnut cake is another conventional feed of plant origin used in the diet of fish. Eyo (1994) substituted soybean meal with different levels of groundnut cake in the diet of *Clarias anguillaris* and the growth performance and food utilization was observed to be highest at 50% inclusion level. Banyigi *et al* (2001) reported that diets containing Bambara groundnut meals fed to *Oreochromis niloticus* and *Clarias gariepinus* was highly digested by the fish, with highest value obtained in the fish diet that was traditionally toasted. This indicated that the Bambara groundnut has potential of being used in feed formulation if appropriate processing methods are used.

Palm kernel meal/cake is another proven feedstuff with results of several studies showing high potentials for use in feed manufacture. When Omoregie (2001) used palm kernel meal for the juveniles of *Labeo* senegalensis, 10% inclusion level of it compared favorably well with the control diet. The protein productive values were not significantly different. Wingkeong and Chen M. (2002) also reported no significant different in the growth performance of hybrid Asian catfish fed up to 20% palm kernel meal.

2.9.3 Aquatic by products

Aquatic weeds has been used extensively in feeding directly or processed and incorporated into fish feeds (Haustein et al. 1987). In a catfish feeding trials, mean percentage weight gain shows that the diet with 15% duck weeds had the best weight gain which was even higher than the control, 94.24g versus 93.83g respectively (Burke and Waldrop, 1978). Jeje (1992) reported the use of cultured natural zooplankton to aid better growth performance of *Clarias gariepinus.*

2.9.4 Food and health benefits of fish

Freshwater fish constitute 69.6% of the total fish supply available to Nigeria (FOS,1990). This represents a major source of animal protein supply to Nigeria, which has a low per capita protein consumption (Afolabi *et al.*, 1984). Fresh water Catfish or Mudfish constitute an important part of fish distribution in Africa and the marketing trends predict an increase in consumer demands. The families C*laridae* and Mochokidae have very good preservation qualities after salting, sun drying and even smoking (Madu *et al.*, 1984).

Apart from food value fish parts have served medicinally, such as the positive effect of fish oils consumption on cardiovascular problems by reducing the serum cholesterol (Conigilo, 1992). Dietary responses to short term diets of fish and the positive effects on protein-calory malnutrition, asthma, arthritis, auto-immunity, coronary heart disease, and athereoselerosis have been independently and unanimously reported (Gerhard *et al.*, 1991; Cobiac *et al.*, 1991).

Some individuals infected with HIV do not develop AIDS for over 10 years while others lo, in a short period of time. These variations have been traced to inadequacy of dietary nutrients uch as amino acids, folic acid, vitamins A, E, B6 and zinc (Retherford, 1994; Ward and Semba, 994). Despite the lack of information on the health benefits from long-term intake of fish ndshell fish, there is no obvious draw back in the opportunity to enjoy healthy living, prolonged ife and good diet of fish species (Ackman, 1992; Sharkey *et al.*, 1992).

2.9.5 Types of ponds

A pond, according to Chamber's Mini Dictionary, is a small lake or pond of water. When ish is raised in this enclosure, it is called a fish pond. But when a fish is located at the backyard of the farmer's home, and it is on a small scale, from a few metres (2-100m^2) to a few fractions of an hectare (01-1ha)^2 then it is a homestead pond. Homestead ponds can be of 3 main types;

(i) Earthen

(ii) Concrete

(iii) Make-shift containers, e.g., fibre-glass, bathroom tubs, abandoned dug-out or plank canoes, plastic container, earthen pot, etc. (Oyin Olakunle 2000)

Depending on the site, different fish ponds might be constructed; diversion or barrage onds.

I) Diversion ponds: are made by bringing water from another source to the pond. There are lifferent types of diversion ponds:

(A) Embankment ponds: The dikes of an embankment pond are built above a ground level. A disadvantage of this type of pond is that you may need a pump to fill the pond.

(B) Excavated ponds: An excavated pond is dug out of the soil. The disadvantage of this type is that one needs a pump to drain the pond.

(C) Partially excavated ponds with low dikes: Soil from digging out the pond is used to build the low dikes of the pond (NSPFS 2005)..

Different types of diversion ponds are;

A: embankment pond; B: excavated pond; C: partially excavated pond.

(II) Barrage ponds: are made by building a dike across a natural stream. The ponds are therefore like small conservation dams. The advantage of a barrage pond is that it is easy to construct. However, it is very difficult to control this system: It is difficult to keep wild fish out and a lot of food added to the pond will be lost because of the current.

A properly built barrage pond (with overflow) overflows only under unusual circumstances.(NSPFS 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental fish

The Fingerlings of *Clarias gariepinus* were used for the experiment. During the experiment, the same feed was given to the fish.

3.1.1 Experimental design.

One hundred and fifty fingerlings of *Clarias gariepinus* of unknown parental stock were obtained from the Ahmadu Bello University Dam Reservoir and were immediately conveyed in plastic buckets filled with water to the laboratory. The fingerlings were acclimatized in water bath for two weeks. During this period of acclimatization the fingerlings were fed with formulated diet, containing 35% crude protein, while the water parameters (Temperature, pH and Dissolved Oxygen) (D.O) were monitored weekly. At the end of two weeks of acclimatization the fish were weighed and randomly distributed into five different types of containers. These were three mud pots, water baths, plastic baths, aluminum containers and three glass aquaria measuring 60cm x 30cm x 30cm which served as control. These unconventional containers were of different shapes as shown in plate II. Before the fingerlings were stocked, the containers were filled with 30 litres of dechlorinated tap water each. The water used was collected from the tap and stored in large plastic basins and aluminum containers for 24 to 48 hours before being used.

Faecal matters from fish in each of the experimental containers were siphoned daily in the morning by using a flexible rubber tube and the volume of water replaced by adding fresh water from the stored water to each of the experimental containers before the fish were fed. This is to prevent contamination of food and accumulation of waste which can cause Oxygen depletion.

3.1.2 Weighing of fish

The weights of the fish were determined immediately after acclimatization by the means of Electronic Mettler sensitive top loading balance and recorded as initial weight.

There after, the weighing was done forth nightly and the final weight of the fish taken at the termination of experiment.

3.1.3 Stocking of fish

A total of one hundred and fifty *Clarias gariepinus* fingerlings were used.

The fish were randomly stocked in the different containers at the stocking rate of ten fish per 30 litres of dechlorinated water.

There were five treatments and two replicates for each treatment. The water in each container was changed every other day to remove the faeces and the left over feed to prevent contermination.

3.2.1 Feed stuffs,

The cow blood meal and fish meal and groundnut cake were used as animal and plant protein source respectively. Maize and sorghum were used as source of Carbohydrate and garri as a binder. Others were vitamin premix, salt, palm oil and bone meal as source of calcium were purchased at Samaru Market Zaria.

3.2.2 Feed formulations and preparation

Formulation of the feeds was based on a standard which was 35% crude protein level for *Clarias gariepinus* in the experimental diets. Pearson square method was used to obtain the quantity of the feed ingredients to be compounded. The quantities of each feed ingredient in the experimental diet for *Clarias gariepinus* are shown in table 3.1.

The experimental diet was prepared for the experimental fish. The ground feed stuffs were thoroughly mixed and the palm oil, vitamin/mineral premixes were added. After the

mixing, the diet was stirred in boiled water (manually) and was pelleted manually using locally made pelleting machine after which it was allowed to sun dry.



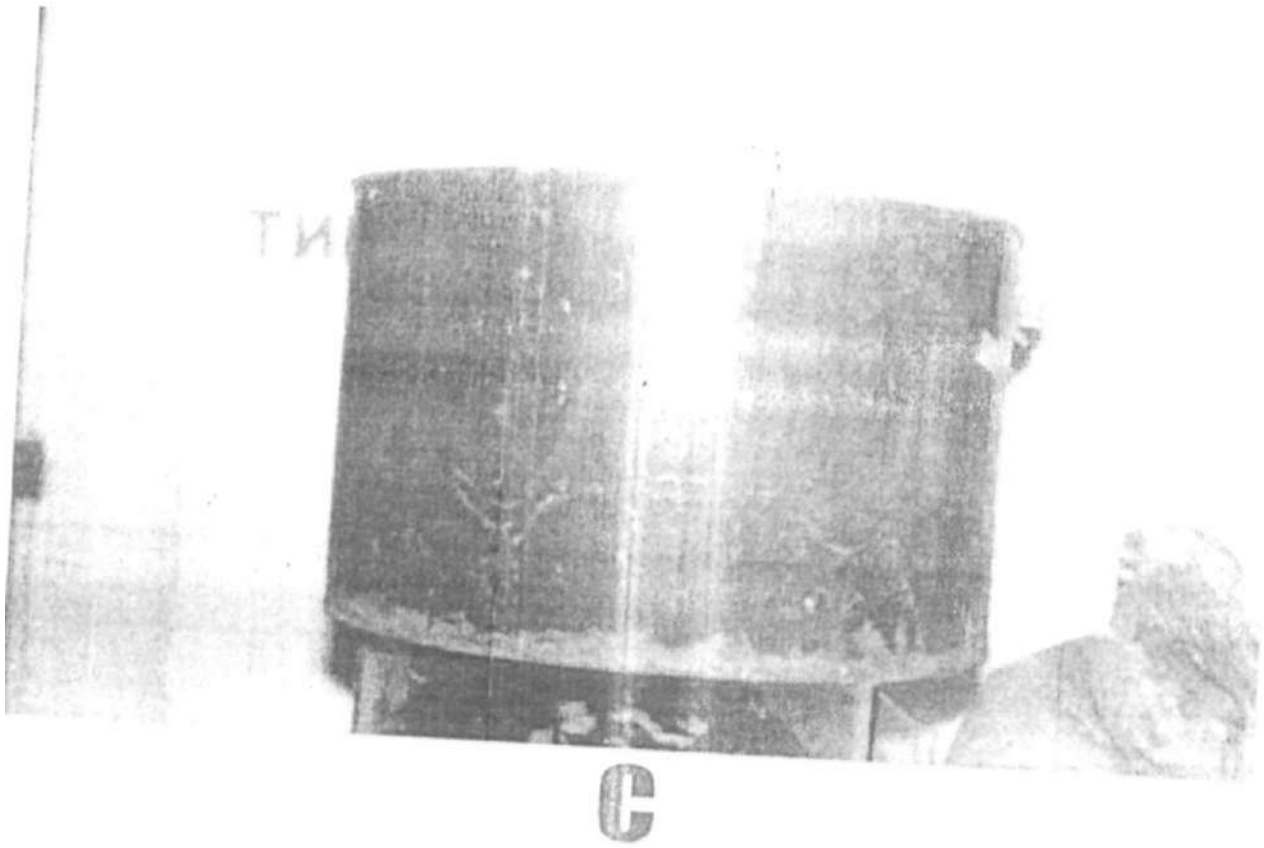
A

Plate 2: Experimental Clay Pot



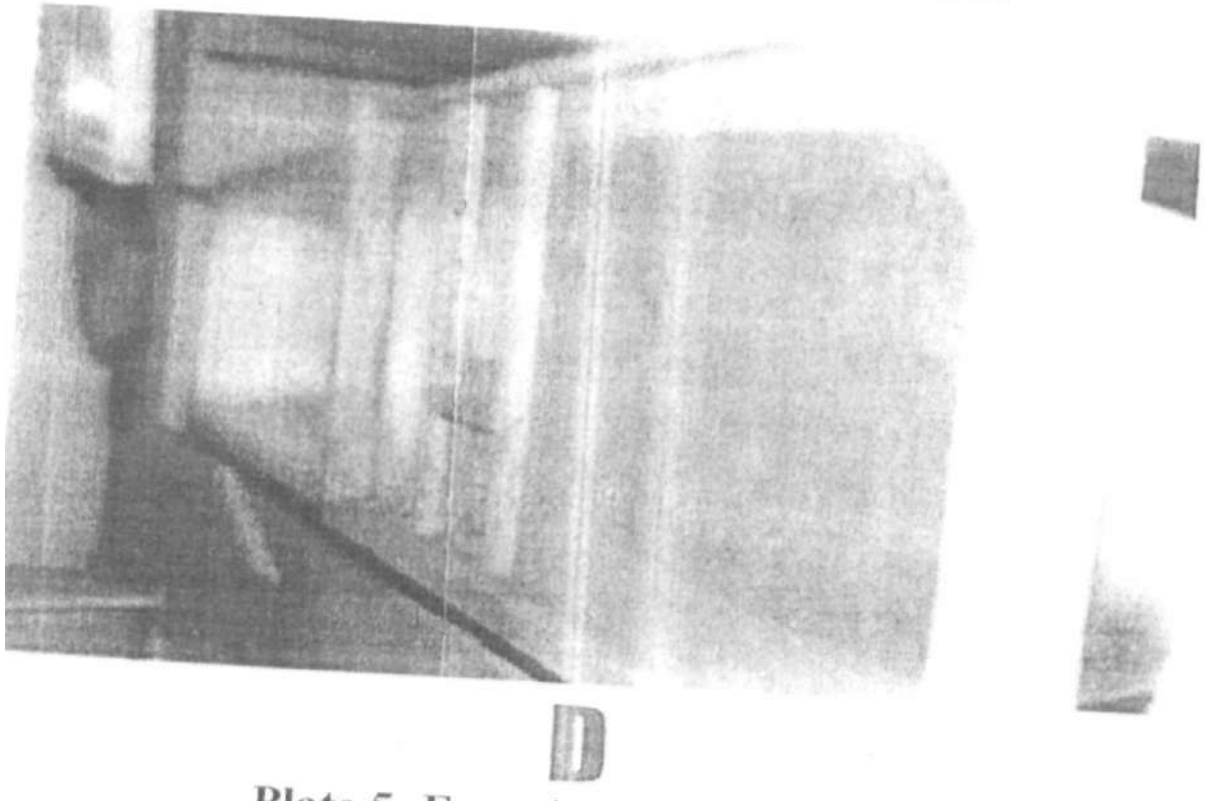
B

Plate 3: Experimental Plastic Bath



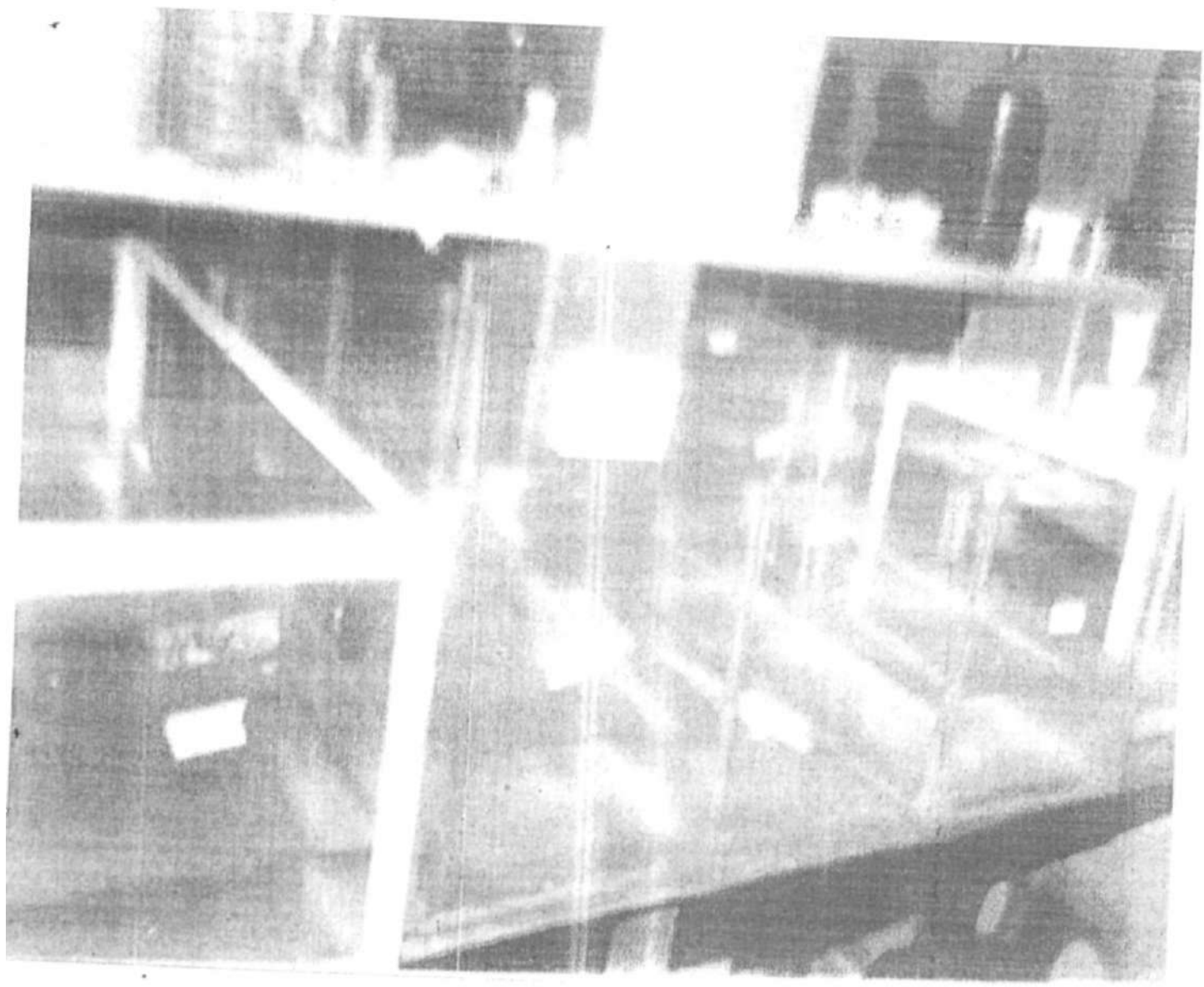
C

Plate 4: Experimental Aluminium Pot



D

Plate 5: Experimental Water Bath



E

Plate 6: Glass Aquarium, which served as control

QL
638.C6
Acd

3.3 Feeding

Feeding was carried out three times daily in three meals every five hours 8.00am, 1.00pm, and 6.00pm a quantity was equivalent to 5% of fish biomass. The feed was divided into three portions and one-third of the feed for a day was given to them in the morning, afternoon and evening. Fish were reweighed forth nightly and the feed adjusted to reflect the new body weight. The feeding process lasted for ten weeks.

3.4 Fish weight measurement

The weight gain of fish in each experimental container was obtained forthnightly. The fish were brought out one after the other and weighed using Electronic mettler Top loading balance. The total and the standard length were taken and recorded using measuring board. The average weight of fish in each experimental container was determined by adding the weight of each fish and divided by the number of fish in each of the experimental containers.

3.5 Determination of physico – chemical parameters of water

Water temperature, pH of water and Dissolved Oxygen (D.O) of water were determined.

3.5.1 Temperature

Water temperature was taken weekly with thermometer calibrated in ^{o}C. The thermometer was lowered into the water and rotated inside for about 2 - 4 minutes before recording.

3.5.2 pH

The pH was determined by using a pH meter. The meter was standardized with buffer solutions at pH 4.0, 7.0 and 9.0. The readings were taken weekly at a constant interval by lowering the pH meter into water sample collected inside the bottles. The pH meter was held inside the water for about 3 – 5 minutes before the readings were taken.

3.5.3 Dissolved Oxygen (D.O)

The dissolved oxygen was determined weekly by using oxygen meter calibrated in parts per million (ppm). Gallemkamp magnetic stirrer connected to electric source was used to stir the water while the oxygen meter was lowered into water samples collected inside the bottle and held inside for about 3 to 5 minutes before recording the readings.

3.6 Analysis of fish growth

The data collected were analysed for weight gain in order to establish the fish growth and feed utilization parameters.

3.6.1 Weight Gain (WG)

Weight gain was calculated as the difference between the initial and final body weights of the fish at the end of the experiment in gram.

Final weight - initial weight =WG.

3.6.2 Percentage Weight Gain (PWG)

The percentage weight gain was calculated as the difference between the initial and final weight divided by the initial weight expressed as percentage.

$$\text{Percentage Weight Gain} = \frac{W2 - W1}{W1} \times \frac{100}{1}$$

Where:

W1 = Initial fish weight (g)

W2 = Weight as a time t days (g)

3.6.3 Specific Growth Rate (SGR)

The specific growth rate was determined as described by Brown (1957)

$$SGR = \frac{Log_e^{W2} - Log_e^{W1}}{T - t}$$

Where W1 = Initial weight (g)

W2 = Final weight (g)

c = The base of natural log

T – t = Time interval between initial and final weight (days)

3.6.4 **Feed Conversion Ratio (FCR)**

Feed Conversion Ratio was calculated as described by (Hepher, (1988)

$$FCR = \frac{\text{Feed applied (g)}}{\text{Net weight fish Produced (g)}}$$

3.6.5 **Feed Conversion Efficiency (FCE)**

$$FCE = \frac{\text{Weight gained by fish}}{\text{Weight of food consumed}} \times \frac{100}{1}$$

3.6.6 Protein Efficiency Ratio (PER) (Hepher, (1988)

The protein efficiency ratio was calculated following Mazid *et al.* (1972) Methods

$$PER = \frac{\text{Weight gained}}{\text{Protein fed}}$$

Where:

$$\text{Protein fed} = \frac{\text{\% protein in diet x total diet consumed}}{100}$$

3..6.7 Feed Efficiency (FE)

Feed efficiency was computed as a ratio that express the fish weight gain to the quality of feed.

$$FE = \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}}$$

3.6.8 Apparent Net Protein Utilization (APPNPU)

Apparent net protein utilization was calculated using the following formula as described by Dabrowski (1979); Mazid *et al.* (1972)

$$\text{AppNPU} = \frac{\text{Fish protein gained} \times 100}{\text{Protein fed}}$$

Where:

Protein gain = final body protein – initial body protein

Protein consumed = total dietary protein fed

3.6.9 Nitrogen Metabolism (NM)

The value of NM were calculated with the formula of Dabrowski (1977)

$$\text{Nm} = \frac{(0.549)\,(b\text{-}a)h}{2}$$

where:

a= Initial weight of fish (g)

b= Final weight of fish (g)

h= Experimental period in days

3.6.10 Proximate Analysis

Proximate analyses of carcasses before and after the experiment were carried out. Similarly, analysis of experimental diet before and after the experiment were performed using the standard AOAC (1985) methods.

3.6.11 Statistical Analysis

At the end of the experiments, statistical analysis of the data were carried out using analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) Steel and Torrie (1981) to determine the best treatment. The overall fortnightly and periodical means and standard

deviations of water temperature and pH were calculated following the established statistical procedure (Miller and Miller 1986).

3.6.12 Limitations to the study.

1. The fish were not readily available and were of unknown parental stock.
2. Lack of constant supply of water in the laboratory. The water when supplied was heavily chlorinated and hence can not be used directly to the fish.
3. Electricity supply was another limiting factor. Delay in weighing the fish was encountered on weighing days when there was no electricity to weigh the fish and the feeds.

Table 3.1 Percentage Composition of Experiment Diet.

Ingredient	Percentage composition
Maize	16.0
Sorghum	14.0
Garri	2.0
Groundnut cake	27.0
Fish meal	13.5
Blood meal	13.5
Bone meal	2.5
Palm oil	3.0
Salt	2.5
Vitamin Premix	6.0
Total	100.0

Vitamin premix providing vitamins and minerals per gram of diet (or per 100g) vitamin A, 4500 I.U., Vitamin D_3, 1125 IU.; Vitamin E 7I.U; Vitamin K_3 2mg; vitamin B_{12}, 0.015mg; Panthothermic acid, 5 mg; nicotinic acid, 14mg; folic acid, 0.4mg; biotin, 0.04mg; choline, 150gm; Cobalt, 0.2mg; Copper; iodine 0.6mg; Selenium, 22mg; Zinc, 20mg antixidant, 2mg.

CHAPTER FOUR

4.0 RESULTS

4.1 Physico - chemical parameters of the water.

4.1.1 Temperature

Table 4.1 shows the record of temperature on weekly basis for *Clarias gariepinus* for eight weeks. The water temperature of all the different containers were between 23.4^{0}C and 26.6^{0}C. Record of water temperature on weekly basis showed that at week eight, the highest record of about 26.6^{0}C was observed.

Table 4.1 Mean variations of temperature readings on the growth experiment of *Clarias gariepinus* reared in different containers.

	WEEKS							
Containers	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week
A. Clay pots	23.4± 0.80	24.5± 0.65	24.5± 0.05	24.5± 0.06	24.3± 0.62	23.2± 0.65	24.6± 0.67	25.6± 0.72
B. Plastic baths	23.4± 0.71	24.6± 0.65	24.6± 0.75	24.6± 0.62	24.8± 0.55	24.6± 0.72	25.5± 0.70	26.5± 0.70
C. Aluminium pots	23.4± 0.60	24.6± 0.65	24.6± 0.45	24.6± 0.50	24.5± 0.56	24.4± 0.75	25.3± 0.65	25.9± 0.70
D. Water baths	23.4± 0.26	24.6± 0.75	24.6± 0.50	24.6± 0.65	24.5± 0.75	24.4± 0.80	25.5± 0.95	26.6± 0.80
E. Aquaria (Control)	23.4± 0.70	24.6± 0.80	24.6± 0.70	24.6± 0.65	24.6 ±0.78	24.5± 0.80	25.4± 0.80	26.3± 0.70

4.1.2 Hydrogen ion concentration

Table 4.2 shows the mean hydrogen ion concentration (pH) recorded on weekly basis.

The pH values ranged from 6.26 to 7.03. The variations of pH were clearly insignificant

Table 4.2: Mean variations in pH readings obtained from the growth experiment of *Clarias gariepinus* reared in different containers.

Containers	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week
A Clay pots	6.40± 1.01	6.40± 1.02	6.42± 0.02	6.40 ± 0.03	6.40 ± 0.05	6.40 ± 1.83	6.40 ± 1.03	6.42 ± 1.04
B Plastic baths	6.30 ±0.43	6.30± 0.45	6.26± 0.50	6.30 ± 0.25	6.30 ± 0.35	6.30 ± 0.45	6.30 ± 0.45	6.26 ± 0.35
C Aluminum pot	6.60± 1.02	6.60± 1.03	6.61 ± 1.01	6.60 ± 1.02	6.60 ± 1.03	6.60 ± 0.02	6.60 ± 1.01	6.61 ± 1.02
D water bath	7.0± 0.80	7.0± 0.05	6.90± 0.06	7.0 ± 0.05	7.0 ± 0.07	7.0 ± 1.06	7.0 ± 0.05	7.03 ± 0.04
E Aquaria	6.30± 1.32	6.30± 14.31	6.32± 1.25	6.30± 1.30	6.30± 1.15	6.300± 1.05	6.30 ± 1.01	6.32 ± 1.03

4.1.3 Dissolved oxygen

Table 4.3 shows the mean dissolved oxygen recorded on weekly basis. The dissolved oxygen of all the different experimental containers ranged between 5.4mg/L to 9.45mg/L.

Table 4.3 Mean variations of dissolved oxygen readings on the growth experiment of *Clarias gariepinus* reared in different containers

Containers	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week
Clay pots	7	6.9	7.5	7.5	7.3	7.8	7.6	7.5
Plastic baths	6.9	6.8	6.9	7	7.5	7.6	6.8	6.9
Aluminium pots	7.2	7.5	9.2	8.2	8.5	8.7	9.45	8.8
Water baths	6.8	5.4	6.5	6.6	7	6.9	6	6.5
Aquaria	7.1	7	8.2	8	8.2	8.4	8.5	8.4

Proximate composition of experimental diet

Table 4.4 Shows the data for the proximate analysis of the experimental diet. The moisture content of the experimental diet was 2.29%. The dry matter was 97.71%, the organic matter was 94.65%, Carbohydrate/fibre was 52.09%, the crude protein was 33.85%, the crude fat was 4.32%, Nitrogen free extract was 4.30% and the ash was 5.35%.

Table 4.4: Proximate composition of Experimental Diet

	Percentage dietary Protein level (%)
Composition	(35%) Protein level
Moisture (Dry weight)	2.29 ± 1.45
Dry matter (Dry weight)	97.71 ± 1.25
Total	100.00
Organic matter	94.65 ± 1.30
Ash	5.35 ± 1.25
Total	100.00
Carbohydrate/ fibre	52.09 ± 2.06
Crude Protein	33.85 ± 1.44
Crude fat	4.32 ± 1.06
Nitrogen free extract	4.30 ± 0.05

All the experimental fish fingerlings were fed with the same experimental diet.

4.2 Growth performance of *Clarias gariepinus* (fingerlings) reared in some unconventional containers for eight weeks

Table 4.5 : showed the growth performance of *Clarias gariepinus* fingerlings cultured in different unconventional containers for eight weeks.

Mean Weight Gain (MWG)

Fish weight increased with increase in age in the different experimental containers. For example in container A which was clay pots, the mean weight gain was (9.72g), in container B, plastic baths, the mean weight gain was (9.11g), in Container C, Aluminium pots, the mean weight gain was (11.74g), in container D, water bath, the mean weight gain was (8.57g) and in contain E aquaria which was the control experiment, the mean weight gain was (11.39g). Containers A, B and D clearly showed no significant difference ($P>0.05$) and containers C and E showed no significant difference ($P>0.05$).

Increase in Standard Length (SL)

The fish standard length increased with increase in the age of the fingerlings in the different containers. For example in container A the increase in standard length was 3.58cm, in container B, it was 1.67cm, in container C it was 2.72cm, in container D it was 2.77cm while in container E (aquaria) it was 3.01 cm .

Statistical analysis showed a significant difference ($P<0.05$) in standard length in all the fish in the different containers.

Increase in Total length (cm) (TL)

The results of the study clearly showed that the fish cultured in aluminum pots had the highest increase in total length of 3.82cm followed by 3.75cm observed in the fish cultured in the clay pots and the fish cultured in the water bath recorded the least total length of 2.13cm. Statistical analysis showed a significant difference ($P<0.05$) in total length in all the containers.

Specific Growth Rate (SGR)

The Specific Growth Rate of the fingerlings cultured in the different containers are as Follows; container A has 0.232, container B 0.201, container c 0.296, container D 0.148 and container E 0.256. The specific growth rate of fish cultured in container C aluminum pots was the highest followed by container E aquaria (control). The specific growth rate of the fish in containers A and B has no significant difference (P> 0.05). The lowest specific growth rate was obtained from the fish cultured in container D, water bath (0.148). There was no significant difference (P>0.05) between containers A, B, C and E however container D is significantly different from the other containers.

Feed conversion Ratio (FCR)

The fingerlings cultured in containers B plastic bath had the highest feed conversion ratio of 6.92 followed by container A clay pots 6.59 and container D water bath 6.37. Container C aluminium pots had the feed conversion ratio of 5.04 and container E had 5.33.

Protein Efficiency Ratio (PER)

The protein efficiency ratio of all the fingerlings in the different containers are as follows: Container A clay pots 0.434, container b, plastic baths 0.410, containers C aluminium pots 0.529, container D water bath 0.449 and container E aquaria (control) 0.536. The results showed no marked difference between all the containers. There is no significant difference between the protein efficiency ratio of all the containers.

Feed efficiency.

The feed efficiency of the experimental fingerlings in the different containers showed no significant difference. The feed efficiency of the fingerlings in the different experimental containers are as follows.

Container A (0.152), container B (0.145), container C (0.185), container D (0.157) and container E (0.188).

Percentage Weight Gain (PWG)

The calculated Percentage Weight Gain (PWG) as shown in table 4.4 indicated that the fingerlings cultured in the aquaria (control) (59.6) recorded the highest value followed by the fish cultured in container C aluminum pots (58.61). The fish cultured in container D water bath had 47.3, container A clays pots had (47.0) and container B plastic baths had the least value (44.97).

Apparent Net Protein Utilization (ANPU)

The apparent net protein utilization were determined as follows:

Container A (0.433), container B (0.169), container C (0.703), container D (0.089) and container E (0.670).

Nitrogen Metabolism (NM)

The nitrogen metabolism of all the fish cultured in different containers were as follows:

Container C had the highest value (180.47) followed be container E (175.9). Containers A and B (149.4) and (140.04) respectively while container D had the least value (131.74)

Percentage Survival (PS)

The percentage survival is shown on table 4.4 where little mortality was observed in all the treatments through out the period of the experiment.

Table 4.5 Summary of Growth indices, feed utilization and % survival rate of *Clarias gariepinus* fingerlings reared in non conventional containers for eight weeks

Parameters	Containers					
	A Clay pots	B Plastic pots	C Aluminium pots	D Water bath	E Aquarium	SEM
Mean initial body weight (g)	20.68 [a]	20.26 [a]	20.03 [a]	18.12[c]	19.11[b]	0.82
Mean final weight (g)	30.4[a]	29.37[b]	31.77[a]	26.68[b]	30.50[a]	1.38
Mean weight gain (g)	9.72[b]	9.11[b]	11.74[a]	8.57[b]	11.39[a]	1.17
Mean initial standard length (cm)	12.08[b]	13.53[a]	13.075[a]	11.83[b]	13.49[a]	0.68
Mean final standard length (cm)	15.66[a]	15.20[c]	15.79[a]	14.60[b]	16.50[a]	0.52
Increase in standard length (cm)	3.58[a]	1.67[c]	2.72[c]	2.77[b]	3.01[a]	0.44
Mean initial total length (cm)	13.75[c]	14.71[b]	13.71	14.72[b]	15.18[a]	0.55
Mean final length (cm)	17.49[a]	17.01[a]	17.53[a]	16.85[b]	18.40[a]	0.23
Increase in total length (cm)	3.75[a]	2.30[b]	3.82[a]	2.13[b]	3.22[a]	0.66
Specific Growth Rate (SGR)	0.232[a]	0.201[a]	0.296[a]	0.148[b]	0.256[a]	0.04
Percentage Weight Gain (PWG)	47.0[b]	44.965[b]	58.61[a]	47.28[b]	59.60[a]	6.07
Percentage survival (PS)	99.0[a]	99.0[a]	99.6[a]	97.6[a]	99.6[a]	0.74
Feed conversion Ratio (FCR)	6.59[a]	6.92[a]	5.40[b]	6.37[a]	5.33[b]	0.61
Protein Efficiency Ratio (PER)	0.434[b]	0.410[b]	0.529	0.448[b]	0.536[a]	0.05
Feed Efficiency (FE)	0.152[b]	0.145	0.185[a]	0.157[b]	0.188[a]	0.02
Apparent Net Protein Utilization (ANPU)	0.433[b]	0.169	0.703[a]	0.089	0.67[a]	0.23
Nitrogen Metabolism (NM)	149.42[b]	140.03[b]	180.47[a]	131.74	175.09[a]	14.0

Values with the same superscript on the same row are not significantly different ($p>0.05$) Duncan's test. Superscript [a] stands for highest value.

4.4 Bi monthly increase in weight of *Clarias gariepinus* cultured in experimental containers

Table 4.6 showed the bi monthly increase in weight of *Clarias gariepinus*. The results showed a general increase in weight in all the experimental containers. At two weeks container C gave the best weight gain of (1.8g) followed by container D (1.3g), container E (1.28) and container B (1.04) while container A had the least value (0.78g). There was a significant difference between container A and the other containers ($P < 0.05$). At the end of week four container E had the best weight (3.93g) followed by container B (3.61), container C (3.05g), container A (2.12g) and container D had the least weight (1.43g).

At the end of week six, container A had the best weight of (5.47g) followed by container C (3.4g), container B (3.14g), container D (3.02g) and container E had the least value (2.66g).

There was a significant difference between container A and the other experimental containers. At the end of week eight, container C had the best weight of (3.49g) followed by container E (3.52g), container D (2.81g), container A (1.35g) and container B (1. 32g) which was the least value.

Finally container C gave the best mean weight gain (2.94g) followed by container E (2.85g), container A (2.43g), container B (2.28g) and container D (2.14g) which was the least value.

4.5 Bi monthly increase in Total Length (TL) of *Clarias gariepinus*

Table 4.7 shows the data for bi monthly increase in total length of *Clarias gariepinus* fingerlings. There was a general increase in the total length of the fish cultured in all the experimental containers. At the end of two weeks container C had the greatest increase in total length (1.07)cm followed by container A which recorded (0.81cm), container E had (0.54cm), container B had (0.22cm) and the least was container D (0.15cm). At the end of week four container A had the highest record of (1.28cm) followed closely was container D (1.215cm),

container C (1.06cm), container E (0.75cm) and container B (0.7cm) which had the least increase in total length. At the end of six weeks container D had the highest total length increase of (0.765cm) followed by container B (0.67cm), container A (0.63cm), container C (0.54cm) and container E (0.27cm) which was the least total length increase.

At week eight container D had the highest total length increase of (1.76cm) followed by container E (1.66cm), container C (1.15cm), container B (0.65cm) which has the least increase in total length.

Container D had the highest mean increase in total length followed by container C (0.955cm), container A (0.935cm), container E (0.805cm) and container B (0.56).

There is no significant difference between the mean total length of the fish cultured in experimental containers D, C and A ($P > 0.05$). There is also a significant difference between containers B and E ($P < 0.05$)

Table 4.6: Bi monthly increase in weight (g) of *Clarias gariepinus* cultured in experimental containers for eight weeks

Experimental Containers	2 weeks	4 weeks	6 weeks	8 weeks	Mean
A clay pots	0.78	2.12	5.47	1.35	2.43
B Plastic baths	1.04	3.61	3.14	1.32	2.28
C Aluminium pots	1.8	3.05	3.4	3.49	2.94
D Water bath	1.3	1.43	3.02	2.81	2.14
E Aquaria	1.28	3.93	2.66	3.52	2.85

Fig.4. 1 BI MONTHLY INCREASE IN WEIGHT (G)

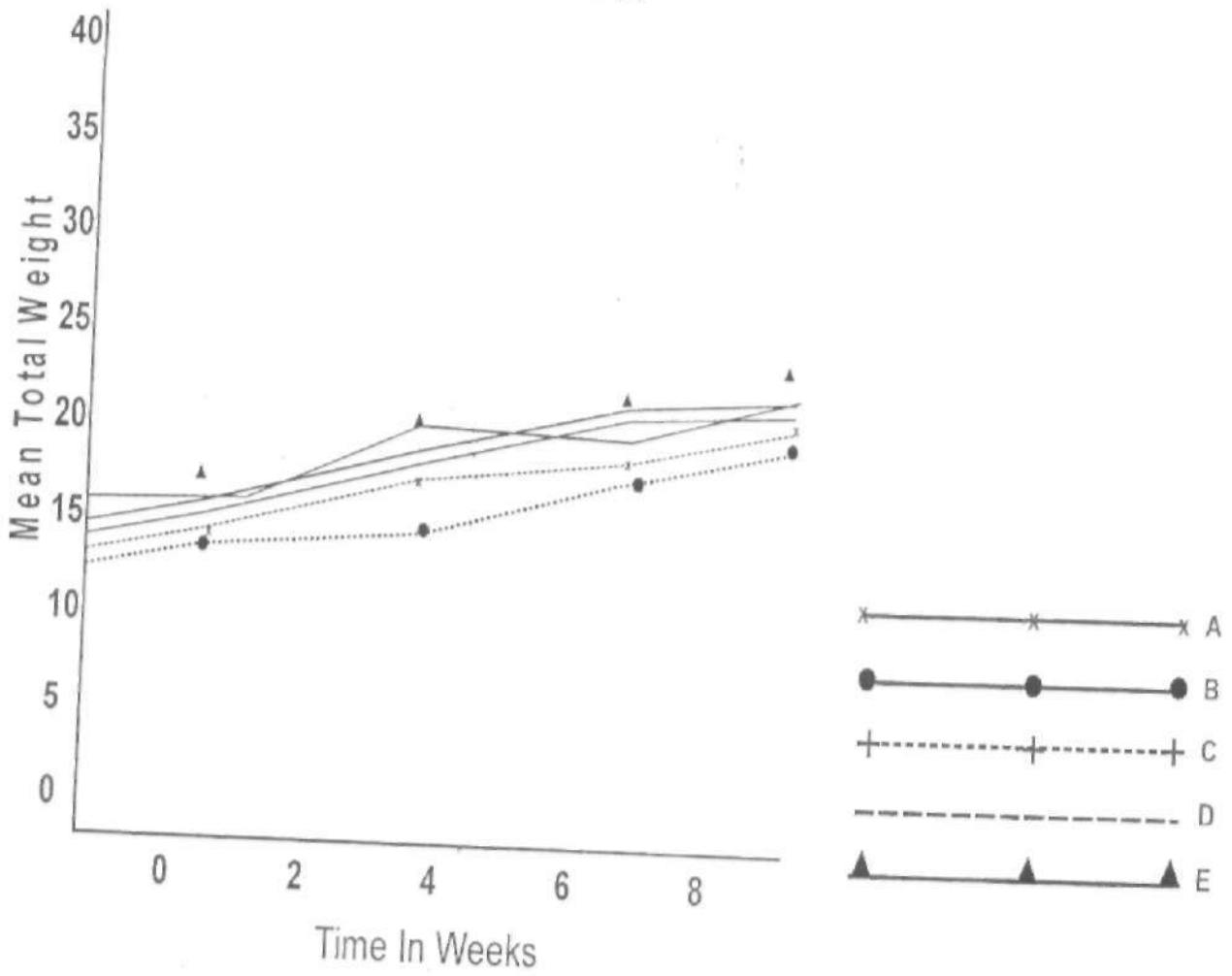
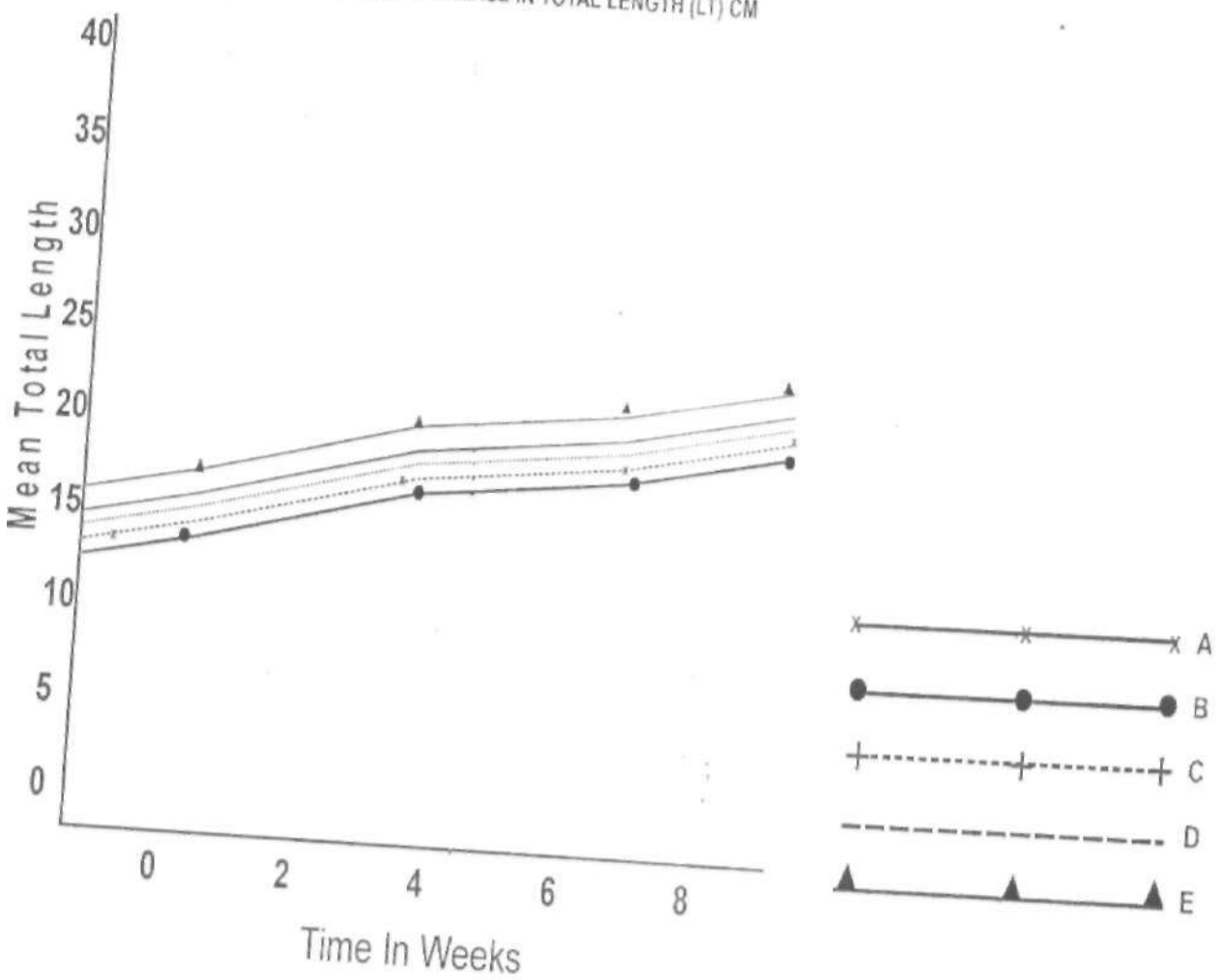


Table 4.7: Bi Monthly increase in total length (TL in CM) of *Clarias gariepinus* cultured in experimental containers for eight weeks

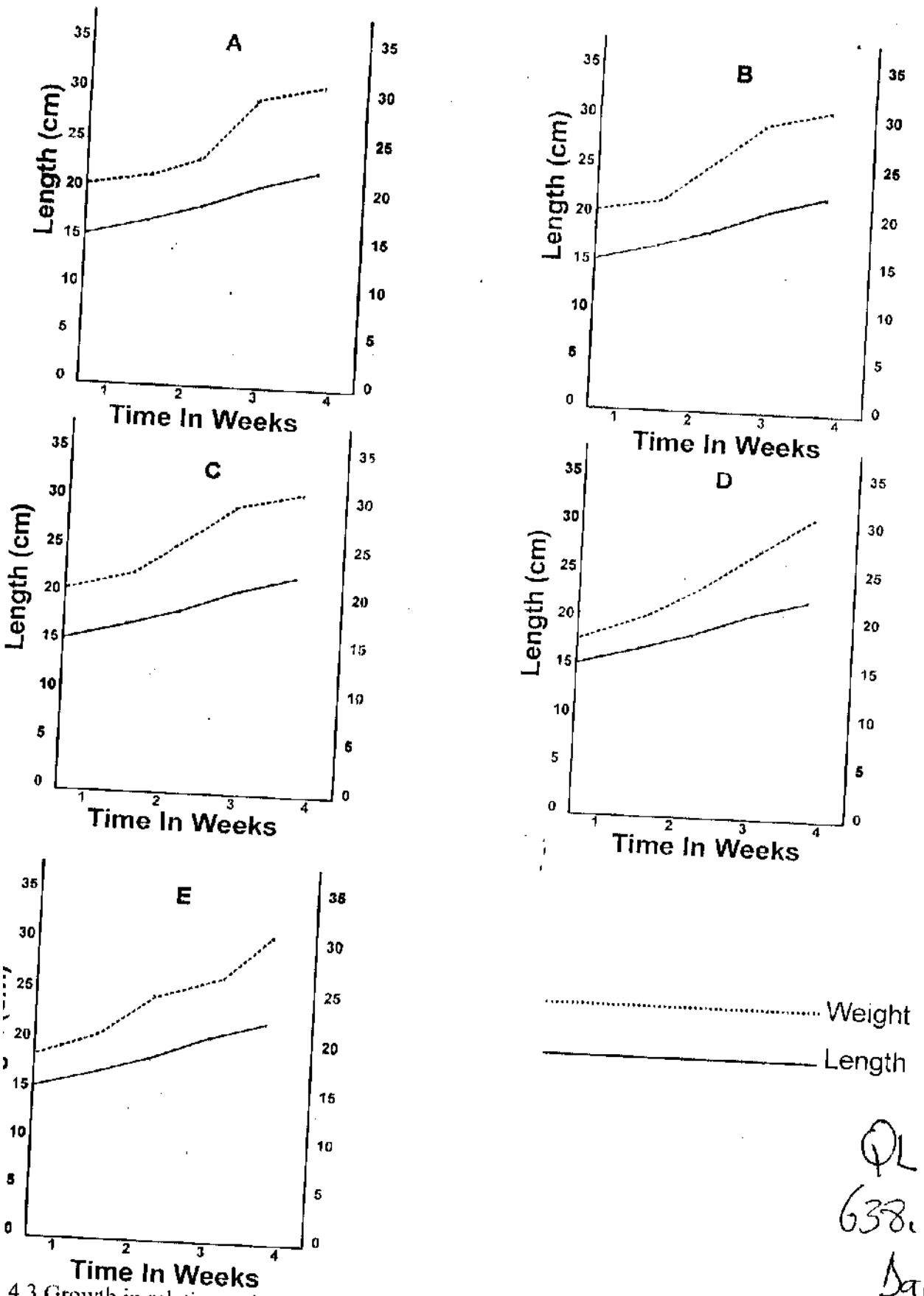
Experimental Containers	Initial	2 weeks	4 weeks	6 weeks	8 weeks	Mean
A clay pots		0.81	1.28	0.63	1.02	0.935
B plastic baths		0.22	0.70	0.67	0.65	0.56
C Aluminum baths		1.07	1.06	0.54	1.15	0.955
D Water bath		0.15	1.215	0.765	1.76	0.9725
E Aquaria		0.54	0.75	0.27	1.66	0.805

Fig.4.2. BI MONTHLY INCREASE IN TOTAL LENGTH (LT) CM



4.6 Growth in relation to length and weight

Fig 4.1 shows the relationship between length and weight of fish cultured in the experimental containers. As the weight increased there was a corresponding increase in length. The rate of growth was faster in weeks four and six. The increase in weight and length was faster in week eight.



4.3 Growth in relation to length and weight

QL
638.c6
Dad

4.7 Carcass composition of *Clarias gariepinus* before and after the experimental period

Table 4.7 shows the data for the proximate analysis of *Clarias gariepinus* fingerlings before and after the experiment. The moisture content of the carcass ranged from 6.29-9.00%, showing a narrow range. The results clearly showed that as the crude protein level increased, the moisture content decreased. The moisture content of the initial carcass is shown to be higher than the final in all the treatments. There was no significant difference ($p>0.05$) in all the treatments including the moisture content of the initial.

Crude protein content of the carcass are shown in Table 4.7.Container C, aluminum pots had 62.10%, container E had 60.70%, container A clay pots 56.20%, container B plastic baths 50.30%, and container D water bath 48.20%. The crude protein content of the initial carcass recorded 46.50%. Container D and initial had no significant difference ($p>0.05$). Similarly container C and E indicated no significant difference ($P>0.05$).

The organic matter content of the carcass are as follows:

Containers A 78.6%, B 73.7%, C 77.6%, D 75.10%, E 77%. There was no significant difference between the organic matter content of the carcass in all the experimental containers.

The crude fat content ranged from 9.29-12.00%. The highest value was observed in container B 12.00 which was not significantly different from the initial value while container E recorded the least value. Containers C and E were not significantly different ($P>0.05$).

The carbohydrate content of the carcass ranged from 1.14-5.12% which was significantly different from the initial value in all the experimental containers ($p>0.05$). The crude fibre content of the carcass before the experimental period was 5.63%. The crude fibre content ranged from 5.13 to 10.30%. the crude fibre content of the carcass was highest in container D which was 10.30% which was significantly different from the initial value ($P<0.05$) and container B had the least crude fibre (5.13%).The ash content of the carcass ranged from 21.40-28.50%. The highest ash content was observed in container B plastic baths 28.50% which was significantly different

from the initial crude fibre content of the carcass ($P<0.05$). Container A had 21.40%, C 22.40%, D 24.90% and E 23.00%.

Table 4.8 **Proximate Analysis of *Clarias gariepinus* Carcass before and after the experimental period**

	Type of Container					
	Initial	A	B	C	D	E
% Moisture Content	9.21[a]	7.51[b]	9.00[a]	7.24[b]	7.82[b]	6.29[c]
% Ash Content	26.30[a]	21.40[c]	28.50[a]	22.40[c]	24.90[b]	23.00[b]
% Organic Matter	73.30[b]	78.6[a]	71.50[b]	77.60[a]	75.10[a]	77.00[a]
% Fat Content (other Extract)	12.21[a]	11.81[a]	12.00[a]	9.94[b]	11.49[a]	9.29[b]
% Crude Protein	46.50[c]	56.20[b]	50.30[b]	62.10[a]	48.20	60.70[a]
% Crude Fibre	5.63[b]	5.47[b]	5.13[b]	5.63[b]	10.30[a]	5.76[b]
% Carbohydrate	9.36[a]	5.12[b]	4.07[b]	1.14[c]	5.11[b]	1.25[c]

Values with the same superscript on the same row are not significantly different ($p>0.05$)

Duncan's test. Superscript [a] stands for highest value.

Key

Container A Clay pots

Container B Plastic baths

Container C Aluminium pots

Container D Water baths

Container E Aquaria

CHAPTER FIVE

5.0 DISCUSSION

The growth performance and feed utilization of *Clarias gariepinus* reared in some unconventional containers were observed and monitored for eight weeks. The result showed that fish cultured in container C aluminium pots had the highest mean weight gain, which could be attributed to high dissolved oxygen.

The result of the water parameters reported in this research work, were within the range of values recommended for the culture of *Clarias gariepinus* as defined for warm water fish species. The pH values (6.30 – 7.0) and the water temperature (23.4^{0}C – 26.6^{0}C) in this research work fall within the range that is adequate for fish growth. Boyd (1979) reported that pH (6.5 – 9.0) temperature (22^{0}C - 27^{0}C) and dissolved oxygen range of 6.3mg / L – 9.6 mg/L gives the best growth in cultured tropical fishes. Auta (1993) reported that temperature between 25^{0}Cand 30^{0}C, pH 6.7 to 9.0 would be adequate for freshwater fish culture. Similarly Kimura (1995) was also of the view that clupeid fishes generally initiate increment in body weight at temperature range of 24 ^{0}C to 29^{0}C. Balogun *et al.* (2004) also reported a temperature range of 23^{0}C – 27^{0}C, pH 6.3 – 7.8 and dissolved oxygen of 6.3mg/L – 9.6mg/L for the optimal growth and development of *Oreochromis niloticus* cultured under aquaria conditions.

The experimental fish were fed 35% crude protein and fingerlings had significantly high increase in mean weight in all the five containers as: A (2.43g), B(2.28g), C (2.94g),D (2.14g), E (2.84g),. The result of this study showed that 35% crude protein level produced the best growth response with respect to weight gain. This finding is similar to the work of (Shim and Chua 1986) who reported that 30 percent crude protein produced the best growth response in guppy (*Poecilia reticulata*). Wilson and Halver (1986) also suggest that crude protein value between (31 – 38%) produced the best growth in carp (*Cyprinus carpio*). Lochman R. *et al.* (1994) was also of the view that golden shiners and goldfish fed diet containing 29% protein

showed optimal performance in the absence of natural food. Dorman (1994) reported 32% crude protein for optimal growth of baitfish.

The result of this work also showed a general trend of an increase in the body protein of the fish which is due to efficient feed utilization despite the fact that the containers were not of the same size and shape. Ogino *et al.* (1979) reported the linear relationship between protein content of diet and the body protein of young carp using casein as the protein source, within the dietary protein levels from 4.6 to 38.2 percent.

The higher fish carcass protein at the end of the experiment than the initial carcass protein indicated that the fish growth recorded could be associated mainly to tissue protein synthesis (Ipinjolu, 2000). The percentage increase in weight at two weeks interval showed that the increase in weight was faster when the fish were young. The growth rate then decreased as the fish were growing older. This is supported by N R C (1973) when salmonids required about 50% protein during the initial feeding stage of fish and 40% protein at eight weeks with 35% crude protein for yearling. The specific growth showed a similar pattern with the body weight gain.

The specific growth rate was highest in aluminum pots which was 0.296 and least in water bath which was 0.148. However there was no significant difference ($P > 0.05$) in specific growth rate of the fish in the different experimental containers. Balogun *et al.* (2004) reported that weight gain and standard length increase are known to be the most important indices for measuring fish responses to experimental diets and reliable indicators of growth.

The feed conversion ratio is also a growth parameter used to measure the gross utilization of food for growth. Adikwu (2003) reported that lower of FCR implies efficient food utilization by fish. Container C aluminium pots with the lowest FCR recorded in this work had the best growth while the fish cultured in plastic bath had the highest value. However there was no

significant difference (P> 0.05) between the feed conversion ratio (FC,R) of fish cultured in the different experimental containers.

Shim and Chua (1986) explained that with the presence of protein in the diet, true growth could occur resulting in a lowering of the feed conversion values, however no significant difference (P>0.05) was observed among the feed conversion values of all the treatments. Despite the lack of any significant difference, container C (aluminum pots 5.04) and container E, (aquaria, 5.33) both had the least FCR values suggesting that feed was most efficiently utilized in these experimental containers.

Dada *et al.* (1999) was also of the view that the higher the specific growth rate, the better the feed while the smaller the feed conversion ratio, the better the feed in quality.

According to Adikwu (2003), the PER is not an accurate measure of growth and protein utilization in fish and other animals because PER implies that weight increase in fish and other animals is mainly due to growth, and growth is defined strictly as increase in total body protein.

However fat and water accumulation may result in weight increase in animals. The high level of growth indices recorded in Aluminium pots and aquaria could be as a result of accumulation of water and oil. The protein efficiency ratio (PER) feed efficiency (FE) Apparent Net protein utilization (ANPU) and Nitrogen Metabolism (NM) showed no significant difference in all the fish in the experimental containers.

The carcass proximate composition of the experimental fish showed a significant difference (P 0.05) in the crude protein content of the carcass of the fish cultured in all the experimental containers compared to the initial. This showed a reasonable level of protein retention due to optimal utilization of the protein for growth and development (Alegbeleye et al., 2004). The crude protein was highest in experimental container C, aluminium pots which showed that there was proper protein utilization by the fish.

Other factors that could be responsible for the low values recorded for the growth indices may be attributed to the source of the fish, which is of unknown parental stock, contaminated by hybridization. The ages and physiological status of the fish were also unknown (Pullin, 1983). The experimental container water was also replaced every other day and Absalom and Omanaihe, (2000) reported that the less the frequency of water replacement, the better the growth performance and survival rate of the fish.

Generally, the percentage survival in all the experimental containers which was between 97.6% and 99.6% might be attributed to availability of good aeration and good handling during the experiment.

In general, fish contain approximately 70 to 80 percent of water, extreme values ranging from 53 to 89.3 percent. This water content is higher than that of birds (About 70 percent) and mammals (about 75 percent) (Vinograder 1953). The moisture content of the fish before and after the experiment in this work range from 6.29 to 9.21 percent. The moisture content of fish was higher before the experiment than in any of the treatments after the experiment. All the five experimental containers had about the same moisture content ranging from 6.29 to 9.00 percent. Thus the five treatments did not affect the fish moisture content to any marked extent. This is in line with the results of Dabrowski (1977) who found no change in the body moisture content of grass carp (Ctenopharyngodon idellus) fry when the dietary protein level was varied.

The body ash level showed no significant difference in all the fish in the different experimental containers. Fish is a good source of calcium and phosphorus (Allen, 1970). The ash content ranged from 21.40 – 26.30 which was as a result of the requirement for minerals for the formation of bony structure as the increase in the meal taken by the fish.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The growth performances of one hundred and fifty Clarias gariepinus fingerlings of unknown parental stock were reared in some non-conventional containers for investigation in the laboratory. The highest percentage weight gain, increase in standard and total length, specific growth rate, lower feed conversion ratio and protein efficiency ratio showed that experimental container C aluminium pots and container E aquaria were the best containers for culturing fish with the optimum being the aluminium pots while the water bath had the least value.

The result and cost implication of these experimental containers suggest that any of these containers can be used for culturing fish in the school laboratories, however the better and cheaper was aluminium container.

6.2 Conclusion

The result obtained from this work indicated that the non conventional containers the clay pots, aluminium pots, plastic baths, water baths can be used successfully in culturing fish in schools. Based on the growth indices recorded, coupled with the financial implications, it can be concluded that the fish can be cultured in clay pots, aluminium pots and plastic baths that are much cheaper than the aquaria. It also showed that fish could be cultured using locally available containers in our secondary schools.

6.3 Recommendations

No much research work has been carried out on the culture of fish using non conventional containers. These locally available materials are in abundance in every part of the country. In the light of the findings in this study, the following suggestion/recommendations are made:

1. Any of these experimental containers can be used in the culturing of fish in the laboratory.
2. These locally available containers should be used in culturing fish outside the laboratory to determine if the fish will grow well.
3. It is also recommended that further studies be carried out using plastic containers of different colours and shapes and other locally available materials to culture fish.
4. All secondary schools should use any of these locally available containers to culture fish in their schools.

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APPENDIX I

ANALYSIS OF FISH GROWTH

a) Percentage weight gain

$$PWG = \frac{W_2 - W_1}{W_1} \times \frac{100}{1}$$

Where

W_1 = Initial fish weight (g)

W_2 = Final weight gain (g)

Thus PWG for fish cultured in experimental containers was calculated as follows:

A Clay pots $\frac{30.4 - 20.68}{20.68} \times \frac{100}{1} = 47.00$

B Plastic baths $\frac{29.37 - 20.26}{20.26} \times \frac{100}{1} = 44.97$

C Aluminium Pots $\frac{31.77 - 20.03}{20.03} \times \frac{100}{1} = 58.61$

D Water Bath $\frac{26.68 - 18.12}{18.12} \times \frac{100}{1} = 47.29$

E Aquaria (control) $\frac{30.50 - 19.11}{19.11} \times \frac{100}{1} = 59.60$

Specific Growth Rate SGR

$$SGR = \frac{\text{Loge } W_2 - \text{Loge } W_1}{T-t}$$

Where

W_1 = Initial weight (g)

W_2 = Final weight (g)

e = The base of natural Log

T-t = Time interval between initial and final weight

A Clay pots $\frac{30.4 - 20.68}{56} = \frac{20.90524324 - 7.908989311}{56} = 0.232142857$

B Plastic baths $\frac{29.37 - 20.26}{56} = \frac{18.85918381 - 7.583690845}{56} = 0.201428571$

C Aluminium Pots $\frac{31.77 - 20.03}{56} = \frac{23.97472139 - 7.411256551}{56} = 0.295892857$

D Water Bath $\frac{26.68 - 18.12}{56} = \frac{14.4111812 - 6.122680556}{56} = 0.148214285$

E Aquaria (control) $\frac{30.50 - 19.11}{56} = \frac{21.11534442 - 6.759845265}{56} = 0.25625$

Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Feed applied (g)}}{\text{Net fish produced (g)}}$$

A Clay pots $\frac{64.07}{9.72} = 6.591563786$

B Plastic baths $\frac{63.04}{9.11} = 6.919868277$

C Aluminium $\frac{63.4}{11.74} = 5.400340716$

D Water Bath $\frac{54.56}{8.57} = 6.366394399$

E Aquaria (control $\frac{60.71}{11.39} = 5.330114135$

PROTEIN EFFICIENCY RATIO (PER)

$$PER = \frac{\text{Weight gained}}{\text{Protein fed}}$$

Where

$$\text{Protein fed} = \frac{\text{\% Protein in diet x total diet consumed}}{100}$$

A Clay pots $\frac{35 \times 64.07}{100} = 22.4245$

B Plastic baths $\frac{35 \times 63.043}{100} = 22.2005$

C Aluminium $\frac{35 \times 63.4}{100} = 22.19$

D Water Bath $\frac{35 \times 54.56}{100} = 19.096$

E Aquaria (control $\frac{35 \times 60.71}{100} = 21.2485$

$$PER = \frac{\text{Weight gained}}{\text{Protein fed}}$$

A Clay pots $\frac{9.72}{22.4} = 0.433928571$

B Plastic baths $\frac{9.11}{22.2} = 0.41036036$

C Aluminium $\frac{11.74}{22.19} = 0529067147$

D Water Bath $\frac{8.57}{19.096} = 0.448785085$

E Aquaria (control $\frac{11.39}{21.25} = 0.536$

Feed Efficiency (FE)

$$FE = \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}}$$

A Clay pots $\frac{9.72\ g}{64.07g} = 0.152g$

B Plastic baths $\frac{9.11\ g}{63.043g} = 0.145g$

C Aluminium $\frac{11.74g}{63.4g} = 0.185g$

D Water Bath $\frac{8.57\ g}{54.56} = 0.157g$

E Aquaria (control $\frac{11.39g}{60.71g}$ 0.188g

$$APPNPU = \frac{\text{Fish protein gain}}{\text{Protein fed}} \times \frac{100}{1}$$

Where

Protein gain = Final body protein – initial body protein

Protein consumed = Total dietary protein fed

A Clay pots $\frac{56.2 - 46.50}{22.4} = 0.433035714$

B Plastic baths $\frac{50.30 - 46.50}{22.2} = 0,169642857$

C Aluminium Pots $\frac{62.10 - 46.50}{22.19} = 0.703019378$

D Water Bath $\frac{48.2 - 46.50}{19.096} = 0.089023879$

E Aquaria (control) $\frac{60.7 - 46.50}{21.25} = 0.668235294$

$$Nm = \frac{(0.549)(b-a)h}{2}$$

Where

a = Initial weight of fish (g)

b = Final weight of fish (g)

h = Experimental period in days

A Clay pots $\frac{(0.549)(9.72)56}{2} = 149.41584$

B Plastic baths $\frac{(0.549)(9.11)56}{2} = 140.03892$

C Aluminium Pots $\frac{(0.549)(11.74)56}{2} = 180.46728$

D Water Bath $\frac{(0.549)(8.57)56}{2} = 131.73804$

E Aquaria (control) $\frac{(0.549)(11.39)56}{2} = 175.08708$