# EFFECTS OF STOCKING DENSITY ON PRODUCTION *OF CLARIAS GARIEPINUS* (TUEGELS) JUVENILES IN FLOATING BAMBOO CAGES AT KUBANNI RESERVIOR, ZARIA, NIGERIA

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**FEBURARY 2011**

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**A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA IN PARTIAL FULFILMENT FOR THE AWARD OF MASTERS OF SCIENCE DEGREE IN FISHERIES**

**DEPARTMENT OF BIOLOGICAL SCIENCES, FACULTY OF SCIENCE, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA**

**FEBURARY 2011**

# DECLARATION

I declare that the work in the thesis entitled Effects of Stocking Density on Production *of Clarias gariepinus* (Tuegels) juveniles in Floating Bamboo Cages at Kubanni Reservoir, Zaria, Nigeria has been performed by me in the Department of Biological Sciences under the supervision of Prof. J. Auta and Prof. S. J. Oniye. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree at any university.

| **Name of Student** | **Signature** | **Date** |
|---|---|---|

## CERTIFICATION

This thesis entitled "EFFECTS OF STOCKING DENSITY ON PRODUCTION *OF CLARIAS GARIEPINUS* (TUEGELS) JUVENILES IN FLOATING BAMBOO CAGES AT KUBANNI RESERVOIR, ZARIA, NIGERIA" by Dasuki Awawu meets the regulations governing the award of the degree of Masters of Science of Ahmadu Bello University**,** and is approved for its contribution to knowledge and literary presentation.

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## DEDICATION

This work is dedicated to Allah (SWT) with whom all things are possible.

## ACKNOWLEDGEMENT

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# ABSTRACT

The African Catfish (*Clarias gariepinus,* Teugels) were reared at three different stocking densities in bamboo-net cages to evaluate the effects of stocking density on growth, survival rate and food conversion ratio. 300 fish weighing 1.8Kg were stocked at 25, 50 and 75 fish/ $m^3$ cage in a Bi-factorial experimental design with a mean weight of 5.6±0.23g, 5.9±0.23g and 6.3±0.23 g/$m^3$ respectively. The growth trial lasted for 150 days (May 2009 to October 2009). 20% of the total biomass (weights) of fish in each cage was weighed monthly and the bulk weights, considering any mortality were recorded monthly. The final mean weights (±S.E) of the fish stocked at densities of 25, 50 and 75 fish/$m^3$ cage were 828.0±1.83g, 774.0±20.18g and 693.0±34.20g. The corresponding mean values of Specific Growth Rate were 3.33, 3.25 and 3.43. Temperatures ranged between 24.5$^0$C - 32.6$^0$C while salinity ranged between 24 - 95ppm. The Feed Conversion Ratio (FCR) was 4.99, 4.73, and 3.43, and cumulative survival rates were calculated as 99.84, 99.66 and 99.50% respectively. The results revealed that stocking density had a significant effect on growth and survival rates of *Clarias gariepinus*. Fish held at the highest stocking density exhibited the lowest growth and survival rate. Cages with 50fish/$m^3$ had the best production economic returns in terms of final weight (38.67Kg), production cost (□19,940.95) and profit index (3.27) compared to the other treatments.

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# CHAPTER ONE

## 3.0 INTRODUCTION

## 1.1 BACKGROUND INFORMATION

Aquaculture is the rearing of fish and other aquatic organisms in man- made ponds, reservoirs, cages or other enclosures in lakes and coastal waters (Essien, 1981). Fish can be cultured in one of four culture systems-ponds, raceways, recirculation systems, or cages. Rearing of fish in enclosure (suspended cage in reservoirs) is a practice that is relatively new in the Northern part of Nigeria as compared to the Southern parts of Nigeria. Data derived from the summary report of the 13-year International Biological Programme (IBP) illustrates that between temperate (23°N–67°S) and tropical (23°N–23°S) zones, there is a considerable increase in the range of production values of fish catch and thus tropical water bodies offer better opportunities for extensive and semi-intensive cage and pen culture (Le Cren and Lowe-McConnell, 1980). One of the limiting factors of aquaculture development apart from high temperature is the non suitable soil in the Northern parts of Nigeria. Many water bodies in the northern parts of the country have the potential to serve in a multiuse capacity. In addition to traditional uses, such as livestock watering, irrigation and recreational fishing, such waters can be integrated for aquaculture through the use of cage culture. Fish grown in cages can improve the food budget by providing a cheap source of protein for personal consumption or may supplement a farmer's income through direct sales.

Cage culture originated from Kampuchea, Southeast Asia (Pantalu, 1979) where fishermen in and around Tonle□ Sap (The Great Lake) hold their fish catches (*Clarias* species and other commercial catches) alive for short periods of time in bamboo or rattan

cages and baskets until they were transported to markets. The intentional confinement of fish in cages to increase their size is a technology dating back to the early 1900s and is now wide spread through the lower Mekong area (Ling, 1977) and in recent years to Viet Nam, Thailand and other Indo-Chinese countries.

In Mundung Lake Jambi, Indonesia, fry of *Leptobarbus heoveni* captured from the wild according to Reksale-gora (1979) has been grown in floating bamboo cages since 1922 while Vass and Sachlan (1954) reported that capture and enclosure of Carps in submerged bamboo cages has been practice since 1940's where the carps were fed and grew on organic materials and benthic organisms carried in the drift. In recent years cage culture has spread throughout the world to more than 35 counties in Europe, Asia, Africa and America and by 1977 more than 70 species of fresh water fish have been experimentally grown in cages (Coche, 1977). Today cage culture is practiced in many regions of the world, and is a thriving industry in some areas (Beveridge, 1987).

Cage culturing makes it possible to grow fish in bodies of water where draining and seining would be difficult or impossible. Cages are for instance utilized in lakes, large reservoirs and rivers. They are also a good alternative for estuaries and coastal bays, and have been successfully used for farming tilapia in cooling water discharge Canals (Luchini, and Quiros, 1990). Cages are used to produce high quality protein cheaply as it requires a low capital outlay and makes use of simple technology. The cages consist of mesh in order to let the water circulate freely and they are best located in the open water of a pond or lake where the prevailing winds allow water movement through the cages. Even slight breezes can cause wave and current action that can assist in water movement through a cage,

bringing in oxygenated waters and helping to remove metabolic and food wastes (Schmittou, 1991). Harvesting is simplified and less cost effective.

Cages are constructed using materials such as nylon, plastic, polyethylene and steel nets (more expensive although, permit better water exchange), wood and bamboo. Most cage designs are of the floating type and, rely on a buoyant collar usually constructed from locally available materials such as bamboo, steel or plastic pipes suspended in a synthetic fiber net, oil drums or Styrofoam (Coche, 1982) and are usually floated in rafts either anchored to the bottom of the water body or connected ashore by a walkway. In China and the Philippines, fixed cages are used in shallow water (□8m) with muddy bottom (FAO, 1983), where synthetic fiber net bags are attached to post driven into the substrate. These types of cages are cheaper, simpler and poorly constructed thereby susceptible to adverse weather conditions as witnessed at Lake Buhi, Bicol region of the Philippines in July, 1983 when Typhoon *Bebeng* destroyed most of the fixed cages; but most floating cages survived (Beveridge, 1984). Buoyant collars according to IDRC/ SEAFDEC (1979) accounts for more than 50% of the capital outlay in cage construction. Cage culture system maximizes the use of feeds and allows higher stocking densities as compared to the unit area of the net-hapa. This system also permits better management, which results in high production potentials and low mortality of fish (Okoye *et al.,* 2007). In Nigeria, aquaculture practices are still in the extensive and semi intensive levels (Adikwu, 1999) and recently intensive re-circulatory system (Bolorunduro, 2006).

Data on domestic fish production in Nigeria has shown a downward decline over the years: 1982 (920,484), 1990 (315,000) and 1996 (200,171) metric tons as reported by (FDF, 1990; FOS, 1997). In order to sustain the current average domestic production of 615,507

metric tons per annum, an effective delivery system has to be put in place (FDF, 2007). Nigeria is amongst the largest consumer of fish in Africa (FAO, 1999); its total available land for aquaculture development according to Fisheries statistics of Nigeria is about 1.7million hectares and existing pond area under cultivation is about 60,000 hectares with a domestic production of merely 0.62million metric tons while it has an aquaculture potential of producing about 2.5million tons. Nigeria's current domestic fish production from aquaculture is only about 85,087 tones and consumption was estimated to be over one million metric tons. In order to reduce importation of fish to Nigeria, there is need to develop local domestic fish production.

*Clarias gariepinus* is a highly appreciated fish in Nigeria due to its favourable food conversion ratio, resistance to disease, low technology farming system, excellent food meat quality, possibility for high stocking density and can tolerate wide ranges of environmental conditions (Fagbenro *et al*., 2003), and also they can grow to a large size of over 10kg (Reed *et al.,* 1967; Olaosebikan and Raji, 1999) which are attractive to consumers. Thus, *Clarias gariepinus* was chosen for this study because of its ready availability, economic and ecological advantages.

Artificial feeding should therefore have the benefits of promoting greater production in terms of yield per hectare and efficient growth of fish in an aquacultural system which depends on feeding the best feed at quantity not exceeding the dietary requirements (Banyigyi *et al.*, 2001). Feeds with floating capacity are best used in cage culture as it allows the farmer to observe the fish while feeding.

## 1.2 RESEARCH PROBLEM

With global population expansion, the demand for fish is steadily increasing and natural fish population have declined during the last decade due to environment degradation and overfishing. This has resulted in an increasing effort in the technology for more domestic production. A lot of people have gone into the fish farming at both subsistence and commercial level in North-Central Nigeria; however there has been low capacity production due to problems of knowing the right size of fish to stock, stocking at too high density and under-stocking of fish (Edward and Demaine, 1988). Apart from the non availability of good soil; constant supply of water, and availability of quality feeds, cage culture is an alternative means of aquaculture especially for land-less fish farmers and it is almost none existing in the North-Central part of the country. Nigeria is blessed with an abundance of scattered inland water mass (comprising of lakes, reservoirs, ponds, streams and rivers) of 12.5 million hectares (Ita *et al*., 1985)

The use of cages in an existing water body whether community or government owned, enhances aquaculture and enables rural and small-scale farmers to go into aquaculture for increased productivity in domestic fish production. The system is also particularly suited to the rural poor who do not have access to land for any other form of agricultural production.

## 1.3 JUSTIFICATION

The demand for fish as compared to other animal source of protein in recent years has been on the increase but this increase has not been met by supply. Fish are low in collagen content, have a nutrient profile superior to all other source of animal protein, it has a high digestibility; as almost every nutrient is absorbed (WHO/FAO, 1999). Fish protein

contains all the necessary amino acids - as high as 60% on dry matter basis (Alatise *et al.,* 2006) needed for man's physical and mental growth. Nigerians have been observed as the largest fish consumers in West Africa with some 1.3 million tons of fish consumed annually (Miller, 2003). However, Nigeria's fish production stands at only 450, 000 million tons of domestic production. A lot of farmers have been discouraged by incidence of high mortality in the present day practice in North-Central Nigeria. Cage culture is not new in Nigeria, the problem is that the practice has remained at the experimental level for over two decades (Okorie, 2003). There are encouraging studies (Otubusin. 1989; Otubusin and Olatunde, 1992) on the viability of cage culture in Nigeria, but these scientific contributions have not yet translated to large scale cage culture either at the subsistence or commercial levels. In other countries of similar socio-economic standards, cage culture has provided spectacular opportunities for creation of employment and large scale fish production. In Philippines, for instance, large scale tilapia/milk fish culture in cages is carried out in Lake Laguna (900 $km^2$ surface area) based on industrial and domestic effluents of over 6 million inhabitants of Manila the capital city. One of the likely reasons for the failure to popularize cage culture in Nigeria is that the idea has not been properly sold to potential farmers, especially in terms of economics of production.

Studies have shown that cage culture is relatively new in the Northern parts of Nigeria as compared to its practice in the South-Western region. Otubusin (1989) reported that cage culture system can be used not only primarily for producing fish cheaply, but also for cleaning up eutrophic water bodies through the culture and harvesting of caged planktivorous fish species as practiced in Malaysia and Singapore. Cage culture in Nigeria according to the works of (Otubusin, 1989; Otubusin and Olaitan, 2001) has shown a drastic

reduction in the mortality rates of fish. The North-Central of Nigeria is a place blessed with abundant supply of scattered fresh-water bodies that can be used effectively to practice cage culture either at subsistent level or at a commercial level; thereby encouraging land-less farmers remain in the business, increasing fish production and reducing the level of poverty. Arable farming and aquaculture can go hand in hand. Aquaculture serves as the livelihoods of the poor in several ways as reported by Muir (1999) who considered its role in poverty alleviation; employment and income or securities which can be direct, indirect or general. In addition to fish, other aquatic organisms have been demonstrated to generate income in the rural communities. Many household do not own sufficient land to culture fish in a pond (land-based) system and the only option to culture fish may be a water based system such as cage or pen in large communal water bodies (lakes, reservoirs, and dam's etcetera) provided access to the water body can be achieved. Raising fish in cages can be quite challenging if the fish farmer stocks at a density too low or too high; also not using the right size of fish and number of fish that may be stocked will be limited by the "carrying capacity" of the water. Investment in terms of construction materials and its durability (lifespan) is relatively low when compared with (raising fish in open ponds) land based culture if an existing body of water is available depending, on location and type of culture being practiced; cage culture may be classified as extensive, semi-intensive or intensive on the basis of feeding. Harvest is generally simplified because the entire cage can be taken from the water and the fish removed. Otherwise, the fish are simply scooped out of the cage with a net. These harvest techniques eliminate the need for expensive harvesting equipment and labor. Fish are easier to observe for general health and feeding behavior. Cages also facilitate treatment of diseased fish and reduce fish losses to bird and other animal predation.

## 1.4 OBJECTIVES

a. To determine some physicochemical parameters of the reservoir during the period of the study.

b. To determine the effect of stocking density on growth and survival rate of *Clarias gariepinus* in bamboo net-cages.

c. To determine the economic analysis of the cage culture production system under the different stocking densities.

## 1.5 HYPOTHESIS

a. Some physicochemical parameter of the reservoir has no effect on the growth of the stocked fish.

b. There is no significant difference between the effects of stocking density on growth and survival rate of *Clarias gariepinus* in bamboo net-cages.

c. There is no significant difference between the economic analyses of the cage culture production systems under the different stocking densities.

# CHAPTER TWO

## 4.0 LITERATURE REVIEW

There have been different researches concerning different species of catfish the world over for aquaculture because of its high potentiality and preference. The stocking at best density still attract attention of researchers because these factors are aimed at yielding a higher profit for the farmer and getting good quality fish at a reasonably short period of time. The growth of *Clarias* species depends upon stocking density, dietary protein quality, energy content of feed, physiological status of fish (age, sex), environmental variables, farming conditions and food availability are some of the main factors that affect fish growth (Lovell, 1989). In terms of the fish production in cages, stocking density, which is related to the volume of water or surface area per fish is an important factor. Increase in stocking density results in increasing stress, which leads to higher energy requirements, causing a reduction in growth rate and food utilization. Contrarily, in case of low stocking densities fish may not form shoals and feel comfortable. Consequently, identifying the optimum stocking density for a species is a critical factor not only for designing an efficient culture system (Leatherland and Cho, 1985), but also for optimum husbandry practices. Controlling the fish size and production are the two important tasks to meet the market demands as, price of fish is determined by the market demand of supply (size and production), and that in turn depends on their growth. Increase in stocking density to produce more fish which increases fish intensification may not be the best way of dealing with problem of space shortage. The present study focuses on growth of the African catfish *Clarias gariepinus*

reared in net cages in ambient temperatures of the Kubanni (drinking water) reservoir of the Ahmadu Bello University, Zaria.

## 2.1 Biology of *Clarias gariepinus*

*Clarias gariepinus* is a member of the Clarridae family. They occur naturally in South East Asia and in Africa and are sometimes called African catfish or mudfish. *C. gariepinus* is well appreciated in many African countries (De Graaf *et al.,* 1996). The clariids exhibit many qualities which makes them suitable for culturing. They have a high fecundity, faster growth rate, disease resistance; can withstand handling stress as well as been highly palatable (Eroudu *et al.*, 1993; Nwandukwe, 1993). They are very adaptive to extreme environmental conditions and can withstand low oxygen level and pH level in the range of 6.5 - 8.0. (Huisman and Ritcher, 1987; Fabgenro and Sydenham, 1988). They are able to live in very turbid waters and can tolerate temperatures of $8^{o}$ - $35^{o}$C. The optimal temperature for growth is $28^{o}$ - $30^{o}$C (Teugels, 1986). *Clarias gariepinus* has a long-based rayed dorsal fin (Reed *et al.*, 1967) without an adipose tissue; two pairs of nasal and maxillary barbles on its dorsoventrally flattened head, elongated body with fairly long dorsal and anal fins and smallish eyes. This species can attain length of up to 1.7m including the tail and can weigh 59kg when fully grown. Their coloure ranges from dark grey to black dorsally and cream coloured ventrally (Skelton, 1993). It comprises of species such as *Clarias anguillaris, C. gariepinus, C. lazera and C. mossambicus* (Teugels, 1982a). The African catfish are omnivores (Reed *et al.*, 1967), feeding on a large variety of plant and animal materials like weed, planktons, small insects, small fish, crustaceans, snails, worms etcetera (Bakare, 1968) but they have high tendency towards been a carnivore as adults.

Catfishes are therefore said to be opportunistic feeder, feeding on virtually everything that comes their way.

## 2.2 Stocking Density and Culture

Stocking density is one of the main factors determining the growth (Engle and Valderrama, 2001; Rahman *et al*., 2005) and the final biomass harvested (Boujard *et al.,* 2002). Environmental variables, farming conditions and food availability are other factors that can affect fish growth. In terms of the fish production in cages, stocking density, which is related to the volume of water or surface area per fish is an important factor. Increase in stocking density results in increasing stress, which leads to higher energy requirements, causing a reduction in growth rate and food utilization (Aksungur *et al.,* 2007). Contrarily, in case of low stocking densities fish may not form shoals/group together and feel comfortable. Consequently, identifying the optimum stocking density for a species is a critical factor not only for designing an efficient culture system (Leatherland and Cho, 1985), but also for optimum husbandry practices. Controlling the fish size and production are the two important tasks to meet the market demands. Increase in stocking density to produce more fish which increases fish intensification may not be the best way of dealing with problem of space shortage (Aksungur *et al.,* 2007). In many cultured fish species, growth is inversely related to stocking density and this is mainly attributed to social interactions and food (Holm *et al.*, 1990; Haylor, 1991; Bjøernsson, 1994; Huang and Chiu, 1997; Irwin *et al*., 1999; Ma *et al*., 2006). Social interactions through competition for food or space can negatively affect fish growth while the price of fish is determined by the market demand of supply (size and production), which in turn depends on their growth. Papst *et al.* (1992) suggested that in intensive aquaculture the stocking density is an important indicator

that determines the economic viability of the production system. In intensive larvae and fry culture, several factors influence survival, welfare, growth, and production for example feeding (Kerdchuen, 1992; El-Sayed, 2002), water quality (Brazil and Wolters, 2002), and stocking density (Sahoo *et al.,* 2004; Rahman *et al.,* 2005; Schram *et al*., 2006). The effects of stocking density on growth and survival have been studied on some African catfishes such as *Clarias gariepinus* (Haylor, 1992) and *Heterobrancus longifilis* (Ewa-Oboho and Enyenihi, 1999; Coulibaly *et al*., 2007). The effects of stocking density on Tilapia production as reported by Otubusin and Opeloye (1985) in floating Bamboo-net cages in Kigera III reservoir New Bussa, Nigeria, shows that fish growth generally decreased with an increase in stocking density. The slow growth of the fish observed in the study may be attributed to low productivity of the Kigera III reservoir. Wannigamma *et al.* (1985) carried out an experiment using *Sarotherodon niloticus* in cages (at three stocking densities; 400, 600 and 800/$m^3$) fed varying crude protein levels for a period of four months; it was observed from his results that there was no significant difference in live weight gains and feed conversion ratios between stocking densities for a particular dietary crude protein level. Osofero *et al.* (2007) revealed that stocking density has an inverse relationship with level of protein intake which affects weight and growth of fish (*Oreochromis niloticus).* Growth is the manifestation of the net outcome of energy gains and losses within a framework of abiotic and biotic conditions. In fact, under crowded conditions at higher stocking densities, fish suffer stress as result of aggressive feeding interaction and eat less, resulting in growth retardation (Bjøernsson, 1994). Space is a factor which can be used to determine the fish growth rate in aquaculture (Otubusin, 2000). For family fish cage culture operations, an area of 500 $m^2$ to 1,000 $m^2$ water surface area is feasible. High density aquaculture has been

described by the United States Department of Agriculture as the most intensive form of agriculture practiced on a large scale today. Cage culture is one of the most intense forms of aquaculture (Masser, 2008).

## 2.3 Cage Culture

Cage culture is an aquaculture production system where fish are held in floating net pens. Cage culture of fish utilizes existing water resources but encloses the fish in a cage or basket on all sides and bottom by materials that hold the fish inside while permitting water exchange and waste removal into the surrounding water (Masser, 2008). Cages are constructed in a variety of shapes using materials such as bamboo or wooden slats and wire, nylon and other synthetic meshes. Support structures can hold cages on the water surface or suspended above the bottom of a body of water (Beveridge, 1984). Cages are widely used in commercial aquaculture overseas and individual cage units come in all shapes and sizes and can be tailored to suit individual farmer's needs. Cage units can be purchased through commercial outlets, but can also be made from readily available construction materials such as polypipe, bamboo, wood or/and steel. Cages can be used in both freshwater and marine environments. Modern cage culture began in the 1950s with the advent of synthetic materials for cage construction (Masser, 2008).

In Norway, cages were used to culture Atlantic salmon (*Salmo salar*) in the early 1960s; in Scotland the whale fish Authority commenced salmon cage rearing trials around 1965. Coche (1982) reported that cage culture practiced in inland waters had spread through the world to more than 35 counties in Europe, Asia, America and Africa, and that by 1978, more than 70 species of freshwater fish had been experimentally cultured in cages. Milne (1974) reported that experimental cage fish farming started in 1954, and the commercial culture of

yellowtail, *Seroila quinqueradiata* followed three years later. Culture of tilapia in cages (*Oreochromis niloticus)* is of a recent origin and owes its beginning to work carried out at Auburn University U.S.A in the late 1980's (Schimittou *et al.*, 1984). The Philippines are rated to be the second highest producer of tilapia fish in cages and pens, at 100,000 tons with production increasing annually (Roderic, 2000). Cages can be used in both freshwater and marine environments. The advantages and disadvantages of cages compared with other culture systems include:

- They are practiced in existing water-bodies, whether marine, brackish or freshwater;
- Technical simplicity in the use of locally sourced materials with which farms can be established or expanded;
- Lower capital cost compared with land-based farms;
- The system permits higher stocking density (surface area per fish) of fish compared to the pond culture system;
- Easier stock management and monitoring compared with pond culture;
- The productivity of the system is much higher than the pond culture system considering the inputs and surface area (Chua and Teng, 1980).

Catfish farming had been traditionally practiced in many counties especially in Asia (Ling, 1971). In Nigeria, cage fish culture was first practiced at experimental stage in Kainji Lake Research Institute (Now National Institute for Freshwater Fisheries Research NIFFR) by an F.A.O. aquaculture expert in 1975 (Konikoff, 1975). Research work on cage culture was resuscitated in the 1980s at the institute (NIFFR) generating more practical information as reported in NIFFR (1989), ( Otubusin, 1985, 1987, 1988; Otubusin *et al.,* 1991; Otubusin, 1992, 1993, 1997, 2000, 2001, 2002). These works contributed to more knowledge on cage

culture technology under the Nigerian environment. Lindergh (1979) reported that interest of cage fish culture in the United States had been stimulated by experiences of Doom-sea Farms Inc. of Bremerton, Washington.

## 2.4 Supplemental Feeding

Supplemental feed is a feed that does not completely satisfy the nutritional requirements of fish, but which supplements naturally available food. Supplemental feeding of fish increases fish production and allows for higher stocking densities. Unconsumed artificial diet in the culture system acts as fertilizer which helps to stimulate rapid growth of plankton population. Artificial feeding allows the farmer to observe behavior of the cultured fish during feeding regarding the level of feeding and health status. Supplemental feeding should have the benefits of promoting greater production in terms of yield per hectare and efficient growth of fish in an aquacultural system depends on feeding best feed at quantity not exceeding the dietary requirements (Banyigyi *et al.*, 2001). ADCP (1983) reported that feed represents 40 – 60% of the total operating cost in intensive aquaculture but in order for the venture to be profitable, cost of feed should not exceed 20% of the farm gate value of the fish (Pullin Pers. Comm).

Sado (1989) reported that supplemental feeding allows the measuring of what quantity of feed in kilogram produces 1Kg of fish i.e. feed conversion rate, although it also depends on a number of other factors such as density of stocking, individual weight, age of fish, state of health, water temperature and method of feeding. According to Campbell *et al.* (1995) reporting on the large scale commercial cage farming of *S. niloticus* concluded that fish production was directly proportional to the amount of food given and Beveridge (1984)

had suggested that yield from extensive cage culture are between 1% and 3% of primary production.

Intensively cultured fish usually require high protein feeds and since feeds are normally the largest variable cost item in commercial production; the profitability of intensive aquaculture is closely related to the world supply and cost of feed protein (Hoffman *et al*., 1997). Generally, increasing protein levels in fish diets can lead to improved fish production though it may be expensive. To evaluate the effect of stocking density on production performance with more precision, the performance index (PI) was calculated according to Zacharia and Kakati (2002); Mohanty (2004). This index was calculated by combining two responses such as growth and survival.

## 2.5 Nutritional Requirements

### 2.5.1 *Protein Requirement*

Dietary protein requirements of African catfish have been reported by several authors; Jamabo and Ockiya (2008) reported 40% crude protein for *H. bidorsalis*, Olufeagba (1999) recommended 45% for triploid *H. longifilis*, while Fagbenro *et al*. (1992) reported 42.5% dietary protein requirement for *H. longifilis*.

In *Clarias gariepinus*, the protein requirement of fingerlings, juveniles and adult fish varies; for instance, the juveniles and fingerlings require more protein compared to the adult. Havler (1978) reported that the gross protein requirements are highest in initial feeding and that it decreases as fish increase in size. Machiels and Henken (1986), Ayinla (1988) and Degani *et al.* (1989), concluded that *Clarias gariepinus* brood stock requires about 40% crude protein while the fingerlings and juvenile requires about 31-34% crude protein, Madu (1992) recommended 40% crude protein for *C. anguillaris* and Fagbenro *et*

*al.* (1992) recommended 40-42.5% for *Heterobrancus bidorsalis.* The quality of protein in any feed stuff is principally influenced by its amino acid composition (Ayinla, 1991) and this in turn induces its digestibility in the diet. Digestibility of some amino acids varies amongst ingredients. Fish utilizes both plant and animal proteins although the later is more nutritionally better. The more closely the dietary protein meets the qualitative requirement of indispensable amino acid by the fish, the greater its utilization. For cultured fish fry to grow at a maximum rate, it must have a diet in which half its digestible feed ingredients consist of balanced protein (indispensable amino acid). Ayinla (1991), stated that deficiencies in any of these ten essential amino acids will cause reduced appetite, reduced growth rate, disease or even death in fish. The ten indispensible amino acids needed for growth are arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, valine, threonine and tryptophan (NRC, 1993). Fagbenro *et al*. (2000) reported the estimated essential amino acid requirements in (g/kg protein) for *Clarias gariepinus* as argenine (445), histidine (21.5), isoleucine (30.6), leucine (52.2), lysine (57.0), methionine (18.3), phenylalanine (27.3), threonine (31.6) and valine (29.0).

### 2.5.2 *Carbohydrate Requirement*

The carbohydrate-based feedstuffs are usually the cheapest source of energy for cultured fish due to their relative abundance. 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. Fiber has no nutritional value in feeds (Sado, 1989) apart from aiding the passage of food into the gut of fish. A dietary excess or deficiency of useful energy can reduce growth rate because energy needs for maintenance and voluntary activity must be satisfied before energy is available for growth. Energy is a

nutritional requirement for the culture of animals. Failure to include adequate quantity in diet may result in reduced growth while excessive quantities of energy results in undesirable fat deposition or reduced feed consumption (NRC, 1993).

### 2.5.3 *Fats requirements*

Lipids include free fatty acids, triglycerides, phospholipids, oils, waxes and sterols. All these lipids provide dietary energy which is about twice as much as the energy produced by carbohydrates and protein (Sado, 1989). Catacutan (1991) revealed that homoeothermic animals have dietary requirements for essential fatty acids. Dietary lipids are an important source of energy and the only source of essential fatty acids (EFA) in fish; only differs in species and from age and size (Shepherd and Bromage, 1992).

Determining requirements for fatty acid is difficult for fish because the metabolic requirement is very small and fatty acids stored in the body or even carried over from egg yolk can influence performance of the experimental fish according to Lovell (1987).

### 2.5.4 *Vitamins and Minerals*

Vitamins are organic compounds required by fish in very small amounts for growth, metabolism of tissue nutrient and disease resistant. Vitamins are either fat or water soluble; water soluble are easily leached from pelleted feeds when they come in contact with water and they include thiamine, riboflavin, pyridoxine, pantothenic acid, nicotinic acid, biotin, inisitol, choline, folic acid, B-12 and ascorbic acid (Ayinla, 1991). In highly stocked cages, it is important to feed fish with complete diets since it is doubtful if the nutrient supply of natural food organisms in the water body will be adequate to meet the vitamin requirements of the fish.

Mineral requirement of fish is similar to those of terrestrial animals. Fish require minerals in trace amounts for tissue formation and other metabolic activities. Most important minerals are calcium (Ca) and phosphorous (P) which must be supplied in sufficient quantities (Lall, 1991) although fish absorbs some of these minerals in water and reduce their requirement. Nevertheless, it is safer to supply adequate amount of calcium in the feeds to forestall possible deficiency symptom in fish. Comparably, P is lower than Ca in natural water so it does not occur in reasonable amounts. The most reliable source of phosphorous for fish is through its diet (Sado, 1989). Aduku (1993) reported that blood meal, bone meal and limestone inclusions into feeds can effectively take care of the deficiency.

## 2.6 Water Quality parameters

Fish and other aquatic organisms such as shrimps and crayfish are known to be very rich in protein and the need to cultivate these in clean water in the locality is highly needed. The need for clean water to raise this protein rich and most needed aquatic commodity cannot be overemphasized. The productivity of a given body of water is determined by its physical chemical and biological properties. The environmental properties of water need to be conducive for fish to grow well; therefore an ideal water condition is a necessity for the growth and survival of fish. The population density of organisms of any water system such as inland fresh water and lakes always vary according to the physico-chemical factors such as hydrogen-ion concentration (pH), dissolved oxygen (DO), conductivity, nutrients and temperature (Abolude, 2007).

### 2.6.1 Temperature ($T^0C$)

Water temperature is one of the major environmental factors that affects and control food utilization at all levels and stages of fish growth. The suggested temperature ranges

from $20^0$C to $30^0$C while the lethal levels are from $2^0$C to $42^0$C. Fish are poikilothermic and water plays an important role in their feeding as it affects their metabolic activities, feeding potential, growth, survival, reproduction in all species of fishes (Dupree and Hunner, 1994) and efficiency of food conversion (Martinez-Placious *et al*., 1993).

Temperature has a pronounced effect on the rate of chemical and biological processes in water; for instance, fish require twice as much oxygen at $30^0$C than at $20^0$C (Adeniji and Ovie, 1990). It is recommended that fish in the tropics be kept in water whose temperature range is between $25^0$C and $30^0$C (Auta, 1993). Sudden increase in temperature will stress or even kill fish and this has formed the basis for the acclimitation of fish (Adeniji and Ovie, 1990). Temperature has been found to affect the dominance and distribution of phytoplankton in water as it influences the growth rates and mortality of zooplanktons and other organisms (Orchutt and Porter, 1983). Temperature is known to influence other factors such as Dissolved Oxygen and may affect organisms to varying degrees, depending on their sensitivity; thus fish survival in lakes depend on temperature and dissolved oxygen (Countant, 1987).

### 2.6.2 Dissolved Oxygen (DO)

Dissolved oxygen in water is very essential to life in the aquatic environment as it affects the physiology and distribution of the aquatic organisms. Nearly all aquatic organisms, with the exception of some bacteria must have oxygen to survive and most of these organisms must extract their oxygen from liquid water. The two main sources of oxygen into the aquatic environment are the atmosphere and photosynthetic activities of aquatic plants. The ideal range of dissolved oxygen in the water must be at least 5mg/l, is required to sustain fish and other aquatic life in water bodies (Adakole, 2000). Insufficient

dissolved oxygen (DO) in a water system tend to cause anaerobic decomposition of organic materials in water thereby leading to the production of obnoxious gases such as carbon dioxide, hydrogen sulphides and methane which bubbles to the surface. The physiology of aquatic organisms is such that they can tolerate only narrow ranges of temperatures, outside which they cannot function normally (Willoughby, 1976).

Kutty (1968) and Kutty and Sunders (1973) reported that Atlantic salmon stopped swimming when dissolved oxygen concentration remained below 5ppm but goldfish, tilapia and carps swim at oxygen level of 1- 2ppm. Inadequate dissolved oxygen has many effects on fish like reduced feeding; impaired growth and leading to fish becoming stressed thereby becoming more susceptible to diseases. Cold water fish require large amounts of dissolved oxygen with a temperature range of $5^0$C - $15^0$C while, warm water fish with a temperature range of $20^0$C - $40^0$C are able to survive with low oxygen content.

### 2.6.3 Hydrogen-ion concentration (pH)

The hydrogen-ion concentration (pH) of any water is the measurement of the acidity or alkalinity of that water body. It is usually measured on a scale of 0 - 14 with 7 being neutral. The effects of pH on the chemical, biological and physical properties of a water system, makes its study very crucial to the lives of the organisms in the medium. Freshwaters with a pH ranging from 6.5 - 9.0 have been known to be productive and recommended as suitable for fish culture (Adeniji, 1986; Auta, 1993). Increase in acidity and alkalinity of any water body may increase or decrease the toxicity of poison in that water; solar radiation and temperature accelerates photosynthesis, which in turn increases carbon dioxide absorption altering the bicarbonate equilibrium and producing $OH^-$ thus raising the pH (Branco and Senna, 1996).

Hynes (1974) observed that pH values of below 5 or above 9 are harmful to most animals. Within the normal range, according to Wuhramann and Woker (1982) and Krenkel (1974), pH has more influence on some poison. Chronic pH levels may reduce fish reproduction and are associated with fish die-offs (Stone and Thomforde, 2006). Adeniji and Ovie (1990) reported that acid and alkaline deaths points are approximately at pH 4 and 11 respectively.

## 2.7 Total dissolved solids (TDS) and Total suspended solids (TSS)

Total dissolved solids (TDS), refers to the inorganic substances that are dissolved in water while Dissolved solids are finely divided materials in suspension (organic or inorganic) particles that tend to screen out light from the bottom of a water body (Abolude, 2007). These substances include carbonate, bicarbonate, chloride, sulphate, nitrate, calcium, sodium etcetera. When some of these substances are in suspension, they cause turbidity in the water, reducing photosynthesis, decreasing the amount of dissolved oxygen and affect the feeding habits of the organisms that depend on sight to catch its prey. A certain level of these ions in water is necessary for aquatic life (Stone and Thomforde, 2006). TDS and TSS are parameters used in measuring the fitness factor and as a general measure of edaphic relationship that contributes to productivity within a water body (Ryder, 1965; Welcomme, 1979).

Changes in TDS and TSS concentration can be harmful to the animal due to the density of the flow of water in and out of the organism's cells. In fish, concentrations too high or low, may affect the growth of fish and death may result. Reduction in water clarity can contribute to a decrease in photosynthetic activity combined with toxic compounds and heavy metals; may lead to an increase in water temperature (Murphy, 2005).

## 2.8 Electrical Conductivity (EC)

Electrical conductivity is the ability of a water body to receive and conduct electrical current in correlation to its salt content. It is an indicator of the type and number of ions present or dissolved in water or in solution, which are almost proportional to the amount of dissolved matter. Freshwater fish thrive over a wide range of electrical conductivity. The desirable range is 100 – 2,000µSi/cm and the acceptable range, is 30 – 5,000µSi/cm (Stone and Thomforde, 2006). Lind (1979) reported that estimation of total ion in matter in a solution or water bodies is related to its fertility while, Ryder *et al*. (1974), reported that electrical conductivity and mean depth of a reservoir could be used to calculate the potential fish yield of a lake. High conductivity is an indication of the presence of large amount of dissolved salts while, at low level major ions may be determine by the nature of the fauna (Moss, 1993).

## 2.9 Water depth (Mean Depth)

The water depth or mean depth of any water body has a great influence in mixing and re-suspension form of the top sediments. In an aquatic system, the physical, chemical and biological elements changes with time and depth (Goldman and Horne, 1983). Carpet and Bechmann (1993) observed that lakes with large surface areas and fetch are particularly susceptible to changes in lights and sediment re-suspension. The transport of dissolved materials across the sediment water interface, as well as within the sediments, is an important factor affecting the chemical characteristics of lakes and reservoirs (Enell and Longfres, 1988).

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 The Experiment Site

The study site is the Kubanni lake also called Ahmadu Bello University dam located approximately within latitude N 11$^{o}$ 11□ and longitude E 07$^{o}$ 38□ at an elevation of 2,200m above sea level and approximately 122m in width and a mean depth of 6m in Samaru-zaria, Kaduna state (Figure1). It is located within the premises of Ahmadu Bello University main campus. The lakes tributaries are the Samaru and Kampagi streams.

### 3.2 Experimental fish

Three hundred juveniles of *Clarias gariepinus* (Tuegels) were procured from Mairuwa farms in Funtua and transported to the Department of Biological Sciences Ahmadu Bello University, Zaria, in two 50 litres open plastic containers. They were acclimatized for three days in two concrete tanks and fed with coppens (an artificial pelleted floating feed containing 42% crude protein) twice daily, 8.00 - 9.00am in the morning and 5.00 - 6.00pm in the evenings.

**Figure 1. Map showing Kubanni Lake.**

## 3.3 Experimental Cages

### 3.3.1 Cage Construction and Setting

The experiment was conducted at Kubanni water reservoir in 6 floating bamboo net cages ($1m^3$). Each cage was made up of a wooden frame lined with net (210/9, 12.7mm mesh size) and bamboo lattices walls with lockable lids. A cage usually has a roof and walls for protection against sun and rain. The bottom of the cages has an additional hapa (1.5mm mesh size) aside from being double net walled. Kuralon rope (No. 15) was used to attach to the upper side of each cage are two well sealed empty plastic kegs (20 litres) which served as floats. The cages were clearly labeled with numbers from one to six for identification.

Two units of floating bamboo poles (11m in length), were joined to another two units of 3 m lengths at right angles to give a 10 m x 2 m (L x B) apartment using 6□ nails. These were the framework (Raft) for the cages. The raft were launched manually by carrying into the water and towed by both to the required site. The six cages were launched manually and dragged by boat to the floating bamboo raft, where they will be arranged at 0.5m spacing within the raft using Kuralon ropes to fasten them in place at the four top corners. The raft was anchored to site with a six 9 - inch concrete blocks at the four corners and middle (5m) with the aid of polypropylene anchor ropes to secure the cages and protect them from being swept away by wind or floods. A free board (above water space) of 0.2m was maintained in each of the cages throughout the duration of the experiment. The longest side of the cage is oriented perpendicular to the direction of the wind.

### 3.3.2 Experimental Layout

The bamboo net cages were arranged in one row nested within a bamboo frame towards the shore line (plate 1). The cages were anchored by means of Kuralon (No. 15) ropes.



Plate 1. Cage layout at the experimental site.

### 3.4 Experimental Design

The fish were conveyed to Kubanni reservoir and further acclimatized in the reservoir by placing them in plastic container in the water near the shore for two hours before stocking. Each cage was stocked with Juveniles of 5.93 ± 0.23g average weight per fish replicated in a complete randomized design (CRD), randomly stocked at densities of 25, 50 and 75 per cage corresponding to treatment I, II and III respectively (Bi-factorial designed).

### 3.5 Fish Feed and Feeding

The fish were fed with coppens, a floating pelleted diet (Table 1) at 5% total biomass per treatment for the first sixty days, then 1% for the remaining ninety days. The feed for each treatment and its replicate were weighed in separate nylon bags for on ward feeding. Fish were fed five days a week manually by administering the feed inside the cages on the water surface.

### 3.6 Fish Sampling

A 5m fiber glass canoe and a paddle were used for transportation to and from the experimental site. A life jacket was worn before entering the canoe. Sampling of fish was carried out once a month, early morning between 7.00am and 9.00am using a scoop net; 20% of the stocked fish in each cage were sampled out and weighed using a Philip top loading balance (model SP). Immediately after weighing, the fish were returned to their respective cages. As the water level increased the position of the cages were adjusted to maintain a fairly regular 200cm water level in the cages.

**Table 1. Coppens: an Artificial Complete Floating diet**

| Feed Composition | |
|---|---|
| Crude Protein…….42% | Vit A……..15000iu/kg |
| Crude Fat……13% | Vit $D_3$…….2000iu/Kg |
| Crude Fiber……1.9% | Vit E……200mg/Kg |
| Ash…….9.5% | Vit C (stable)……150mg/Kg |
| Phosphorus…….1.1% | Copper…….5mg/Kg (cupric sulphate pentahydrate) |
| NFE……33.6% | |

Vit = Vitamins
NFE = Nitrogen free extract

### 3.7 Fish Harvesting

The fish were harvested after 150-day culture period by moving the cages to the shore, one after the other. All the fish inside the cages were scoped out for mass weighing per cage and the total number of fish in each cage counted.

### 3.8 Growth Response

To determine the growth response of the fish, the following parameters were calculated:

#### 3.8.1 Mean Weight Gain (g) (MWG)

$MWG = Wt_2 - Wt_1$ ……..……....……..……1

Where $Wt_1$ = initial mean weight of fish at time $T_1$

$Wt_2$ = final mean weight of fish at time $T_2$

#### 3.8.2 Feed Conversion Ratio (g) (FCR) (Hepher, 1988)

$$FCR = \frac{\text{weight of feed given (g)}}{\text{Fish weight gain}}$$ ……...……..……..……2

#### 3.8.3 Relative Conversion Ratio (RCR) (Wannigamma *et al.*, 1985)

$$RGR\ (\%) = \frac{(W_f - W_i) \times 100}{W_i}$$ ……...…….....3

$W_f$ = final average weight at the end of the experiment

$W_i$ = initial average weight at the beginning of the experiment

#### 3.8.4 Protein Efficiency Ratio (PER) (Wilson, 1989)

$$PER = \frac{\text{fish Weight Gain (g)}}{\text{Protein intake (g)}}$$ …….....….....4

Where;

$$\text{Protein intake} = \frac{\%\ \text{protein in feed} \times \text{total diet consumed}}{100} \quad \text{.....5}$$

### 3.8.5 Specific Growth Rate (SGR) (Hepher, 1988)

$$SGR = \frac{100\ (\text{Log}_e\ Wf - \text{Log}_e\ W_i)}{\text{Time (days)}} \quad \text{.....6}$$

$W_f$ = final average weight at the end of the experiment

$W_i$ = initial average weight at the beginning of the experiment

$\text{Log}_e$ = Natural Logarithm reading

Time = Number of days for the experiment

### 3.8.6 Survival rate (%)

$$\text{Survival Rate (\%)} = \frac{\text{Number of fish that survived} \times 10}{\text{Total number of fish stocked}} \quad \text{.....7}$$

### 3.8.7 Production ($Kg/m^3$) (Osofero *et al.*, 2007)

$$\text{Production } (Kg/m^3) = \frac{\text{Total weight of fish cropped @ } \square 500.00/Kg}{\text{Cost of feed + Cost of juveniles \& cage}} \quad \text{.....8}$$

### 3.8.8 Production Index (Mohanty, 2004)

$$PI = \frac{\text{survival rate} \times \text{final weight (g)} - \text{initial weight (g)}}{\text{Duration of rearing period (days)}} \quad \text{.....9}$$

### 3.9 Water Quality Analysis (Water Parameters)

Physicochemical analysis of water was measured once a week during the duration of the study. The followings were tested for using HANNA instruments: HI-98129, HI-987130, water temperature, hydrogen ion concentration (pH), electrical conductivity and total dissolved solids while dissolved oxygen (DO) was analysed using dissolved oxygen test kit

HI-3810 following the manufacturer's instructions. Water depth was measured using a calibrated bamboo pole.

### 3.9 Data Analysis

Data were analysed by One-Way Analysis of variance (ANOVA) (Snedecor and Cochran, 1982) and difference between means was examined using Duncan's Multiple Range Test (Duncan, 1955). Correlation co-efficient was used to determine the relationship between weight gain and food conversion ratio, stocking density and growth, weight gain and protein efficiency ratio and production and food conversion ratio.

# CHAPTER FOUR

## 4.0 RESULTS

## 4.1 Water Quality Parameters

### 4.1.1 Temperature

The water temperature in all treatments ranged between $24.5^0$ - $32.6^0$C. The temperature of water in the cages was highest in May ($32.6^0$C) and a lowest ($24.5^0$C) in September (Table 2).

### 4.1.2 Hydrogen Ion Concentration (pH)

The hydrogen ion concentration ranged from 6.8 - 8.5. The pH (8.5) was highest in May and lowest (6.8) in October (Table 2).

### 4.1.3 Dissolved Oxygen (DO)

Dissolved oxygen (DO) during the culture period ranged from 4.6mg/l to 12mg/l. Dissolved oxygen (DO) increased from May to October, and the highest (12mg/l) was in September (Table 2).

### 4.1.4 Electrical Conductivity

The highest electrical conductivity (190µs/cm) was recorded in May and lowest (45µs/cm) in August (Table 2).

### 4.1.5 Total Dissolved Solids (TDS)

The mean monthly total dissolved solids ranged between 24 - 95ppm. The highest (95ppm) was in May and lowest (24ppm) in August.

**Table 2. Mean of some Physicochemical Parameters of Water in all the Treatments for the culture Period**

| | PARAMETERS | | | | |
|---|---|---|---|---|---|
| MONTHS | COND (µs/cm ) | pH | DO (mg/l) | TEMP ($^0$C) | TDS (ppm) |
| MAY | 190 | 8.5 | 4.8 | 32.6 | 95 |
| JUNE | 103 | 8.1 | 4.6 | 30.6 | 71 |
| JULY | 93 | 7.2 | 5.0 | 26.4 | 48 |
| AUGUST | 45 | 7.7 | 8.6 | 27.0 | 24 |
| SEPTEMBER | 50 | 7.2 | 12.0 | 24.5 | 27 |
| OCTOBER | 50 | 6.8 | 10.0 | 28.0 | 30 |
| S.E.M | ±22.65 | ±0.26 | ±1.29 | ±1.21 | ±11.65 |

S.E.M = standard Error of Mean
pH = Hydrogen Ion concentration
TDS = Total Dissolved Solids
DO = Dissolved Oxygen
TEMP= Temperaure
COND=Conductivity

## 4.2 Growth Performance of *Clarias gariepinus*

The summary of the growth performance of *Clarias gariepinus* are shown in table 3, table 4 and figure2.

### 4.2.1 Mean Weight Gain (MWG)

The mean initial weight in all the treatments was 5.93±0.23g; range was between 5.4 - 7.0g while the mean final weight ranged from 679g - 858g. the daily weight gain show an inverse relationship; as stocking density increased, the Treatment I (25 juveniles /cage) had the highest final mean weight of 828g then 774g in treatment II (50 juveniles /cage) and the least 693g was recorded in treatment III (75 juveniles /cage)(Table 4). Daily weight gain was low in all treatment in the first 30 days, but gradually increased and the highest was recorded from day 60 - 90 in all the treatments (Fig. 2). There was no significant difference ($P<0.05$) in the daily weight gain in all treatments. There was a high correlation ($r = 0.01$) between the Daily Weight Gain and the Protein Efficiency Ratio, Feed Conversion Ratio and Mean Weight (Table 5).

### 4.2.2 Relative Growth Rate (RGR)

Relative Growth Rate in all the treatments was high. Treatment I (14.71), followed by treatment II (12.95) and the least was in treatment III (11.11). There was significant difference ($P \square 0.05$) in relative growth rate in all the treatments. The Specific Growth Rate decreased with increase in stocking density while. The highest value was 3.33% in treatment I, followed by 3.25% in treatment II and the least 3.14% was in treatment III (Table 3).

### 4.3.0 Feed Utilization

Tables 3 shows the feed utilization of *Clarias gariepinus* at different stocking densities.

### 4.3.1 Food Conversion Ratio (FCR)

The analysis of the food conversion ratio, which expresses the efficiency of fish in converting food to flesh, was best in treatment III (3.43) while the least (4.99) was recorded in treatment II. There was no significant difference (P □0.05) in the FCR in all the treatments. Production was highest in treatment III (64.97Kg) followed by treatment II (48.34Kg) and the least (25.86kg) was recorded in treatment I (Table 3).

### 4.3.2 Protein Efficiency Ratio (PER)

Protein Efficiency Ratio was high (4.80) in treatment II and I, (4.79) while treatment III had the lowest (4.48). There was no significant difference (P □0.05) between the treatments (Table 3).

### 4.4 Survival Rate

The mean survival rate ranged between 99.33% and 100%. Cages 1, 2 and 6 had the highest survival rate followed by cages 5 and 4 while the lowest was in cage 3.

Fish escaped during sampling was first observed in cage 5 in the fourth month, while mortality was observed in all the treatments at the fifth month in cages 4 and cage 3.

**Table 3. Summary of the Mean Growth Performance at Different Stocking Densities of *Clarias gariepinus* cultured in Bamboo – Net Cages**

| TRT | (SD) | I WT (Kg) | F WT (Kg) | WTG (Kg) | RGR (%) | SGR$ (% /day) | FCR | SURV (%) | DWG (Kg/day) | PRO (Kg/cage) | Water depth (m) | PER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | (25) | 0.14 | 20.69 | 20.55 | 14.71 | 3.33 | 4.73 | 99.84 | 0.14 | 25.86 | 0.5 | 4.79 |
| II | (50) | 0.3 | 38.67 | 38.37 | 12.95 | 3.25 | 4.99 | 99.67 | 0.26 | 48.34 | 0.5 | 4.80 |
| III | (75) | 0.47 | 51.97 | 51.5 | 11.11 | 3.14 | 3.43 | 99.5 | 0.35 | 64.97 | 0.5 | 4.48 |
| S.E.M | | 0.1 | 9.06 | 8.97 | 1.04 | 0.06 | 0.48 | 0.1 | 0.06 | 11.33 | 0 | 0.11 |

TRT = Treatment
IWT = Initial Weight
WTG = Weight Gain
S.E.M = Standard Error of Mean

SD = Stocking Density
FWT = Final Weight
SGR = Specific Growth Rate
RGR = Relative Growth Rate

PER = Protein Efficiency Ratio
DWG = Daily Weight Gain
FCR = Feed Conversion Ratio
PRO = Production

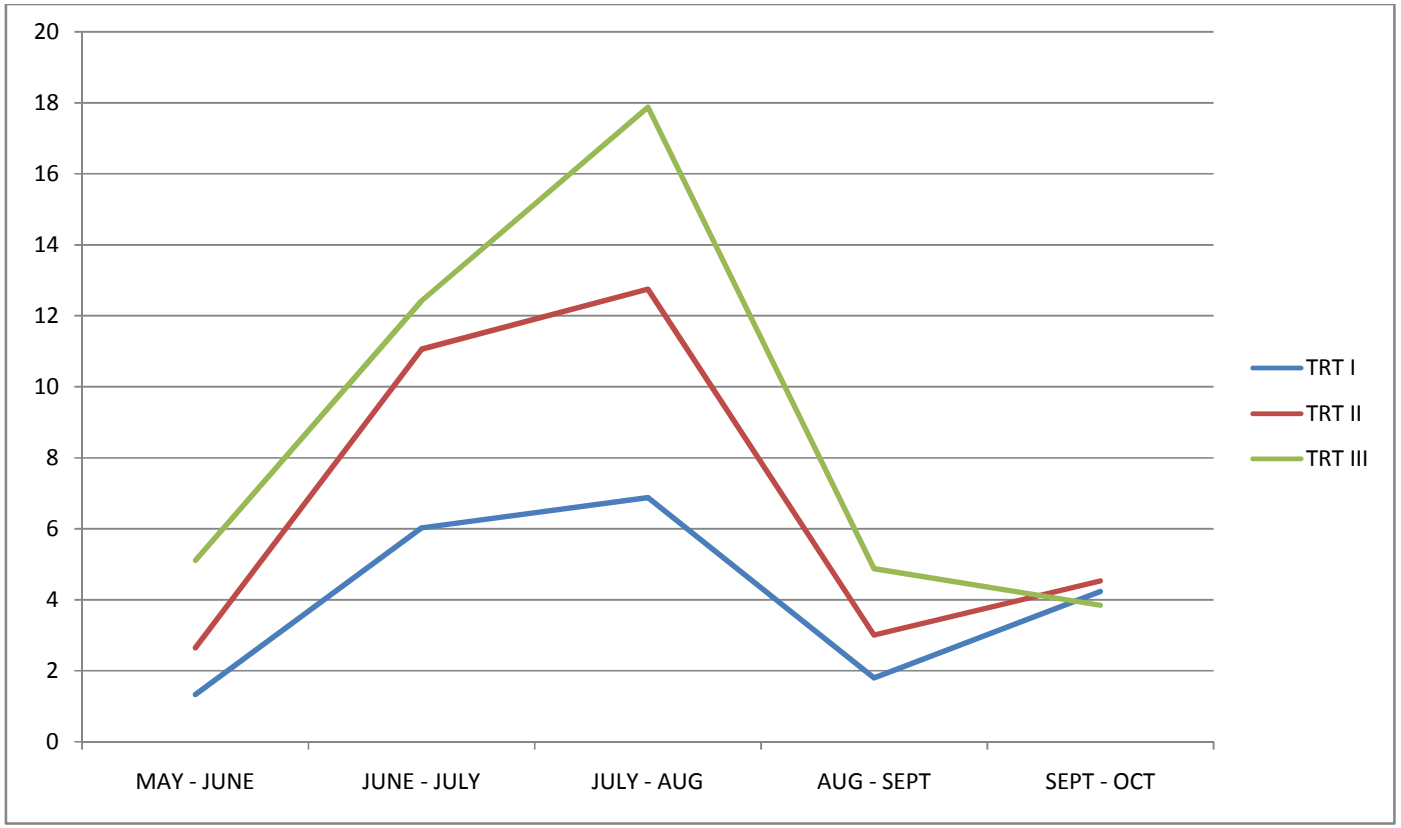



**Figure 2. Mean Growth rate (monthly weight gain) of The African Catfish (*Clarias gariepinus)* at Different stocking Densities in Bamboo net-cages for the culture period**

**TRT I= Treatment 1**
**TRT II= Treatment 2**
**TRT III= Treatment 3**

**Table 4. Mean Growth (Weight Gain) (kg/day) for *Clarias gariepinus* during the culture period**

TREATMENTS

| | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| I | $0.14^{b}$ | $1.48^{c}$ | $7.50^{b}$ | $14.38^{c}$ | $16.18^{c}$ | $20.69^{c}$ |
| II | $0.30^{b}$ | $2.94^{b}$ | $14.00^{ab}$ | $26.75^{b}$ | $29.75^{b}$ | $38.39^{b}$ |
| III | $0.47^{a}$ | $5.58^{a}$ | $18.00^{a}$ | $35.88^{a}$ | $40.75^{a}$ | $51.97^{a}$ |
| S E M | 0.10 | 1.20 | 3.06 | 6.23 | 7.11 | 9.56 |

*Values with different superscript in the same column are significantly different at P□0.05*

S.E.M = Standard Error of Mean

**Table 5. Correlation Matrix of Growth Parameters of *Clarias gariepinus* during the culture period**

| | *IWT* | *FWT* | *WTG* | *RGR* | *SGR* | *FCR* | *SURV* | *DWG* | *PRO* | *PER* |
|---|---|---|---|---|---|---|---|---|---|---|
| IWT | 1 | | | | | | | | | |
| FWT | 0.99463** | 1 | | | | | | | | |
| WTG | 0.99452** | 0.99999** | 1 | | | | | | | |
| RGR | -0.99999** | -0.9951** | -0.99499** | 1 | | | | | | |
| SGR | -0.99731** | -0.98436** | -0.98417** | 0.99695** | 1 | | | | | |
| FCR | -0.78859** | -0.72073** | -0.71997** | 0.78571** | 0.83157** | 1 | | | | |
| SURV | -0.99985** | -0.99629** | -0.99619** | 0.99992** | 0.99587** | 0.77771** | 1 | | | |
| DWG | 0.99503** | 0.99999** | 0.99999** | -0.99548** | -0.98504** | -0.72341** | -0.99662** | 1 | | |
| PRO | 0.99463** | 1.00000** | 0.99999** | -0.99511** | -0.98437** | -0.72074** | -0.99629** | 0.99999** | 1 | |
| PER | -0.86099** | -0.80373** | -0.80308** | 0.85860** | 0.89598** | 0.99173** | 0.85196** | -0.80603** | -0.80375** | 1 |

RGR= Relative Growth Rate
FCR= Food Conversion Ratio
PER= Protein Efficiency Ratio
IWT = Initial Weight
SURV=Survival

SRG= Specific Growth Rate
WTG= Weight Gain
PRO= Production
FWT = Final Weight
DWG=DailyWeightGaim

** Significant at P□0.01

**Table 6. Summary of Cost Benefit Analysis.**

| | TREATMENTS | | |
|---|---|---|---|
| | I | II | III |
| Production period (days) | 150 | 150 | 150 |
| Stocking Density (per cage) | 25 | 50 | 75 |
| Net production (Kg/cage/150days) | 25.86 | 48.34 | 64.97 |
| Value of Fish @ □500.00/Kg | 12,930.00 | 24,170.00 | 32,485.00 |
| Feed Input (Kg) | 10.22 | 19.07 | 27.47 |
| Cost of feed/ Kg (□) | 313 | 313 | 313 |
| Cost of Feed used (□) | 3,198.86 | 5,968.91 | 8,598.11 |
| Cost of Fingerlings (□) | 500 | 1,000 | 1,250 |
| Cost of cage (□) | 416.70 | 416.70 | 416.70 |
| Total cost of Production (□) | 4,115.56 | 7,385.61 | 10,514.81 |
| Gross Profit (□) | 8,814.44 | 16,784.39 | 21,970.19 |
| Profit Index | $3.14^{b}$ | $3.27^{a}$ | $3.09^{c}$ |

*Values with different superscripts in the same row are significantly different at P□0.05*

## 4.5 Economic Analysis

The profit index was significantly different ($P<0.05$) in all the treatments. The cost of producing six (6) bamboo net cages including cost of materials: red wood, nets, nails, ropes, floaters and bamboo, transportation and labour was eighteen thousand naira (□18,000.00) while the cost of procuring 300 juveniles of *Clarias gariepinus* at Twenty Naira per fish was six thousand naira (□6,000.00). The cost of using a cage for the duration of the experiment five (5) months was calculated based on life-span of the construction material used (bamboo) which gave □416.70 as the cost for all the treatments. The value of fish was based on current market price of □500.00/Kg for *Clarias gariepinus* as at the period of the experiment. The amount of feed used during the experimental period was determined by using the feeding adjustments recorded during each sampling period. Feed consumption increased as the stocking density increased. The cost of feed was based on the market price for coppens □4,700.00 as at the period of the experiment and cost per Kg per feed □313.00 was used to calculate the total cost of feed used in each treatment. The total cost of production was determined by the summation of the cost of using a cage, juveniles and cost of feed used, while the gross profit was determined by subtracting the values of the cost of production from the value of fish cropped per treatment (Table 6). The cost of production increased as the stocking density increased, a profit index of 3.27 in treatment II was highest while the least 3.09 in treatment III.

# CHAPTER FIVE

## 5.0 DISCUSSION

The survival of *Clarias gariepinus* ranged between 99.50 - 99.84% which was comparable to similar work done by Otubusin (2000) and Osofero *et al*. (2007) with a range of 98.5 – 99.5%. The high survival rate recorded in all the treatments could be attributed partially to the physico-chemical parameters of the water body and also due to the good health condition of the fish. This result also indicates an inverse relationship between survival rate and stocking density; it was noticed that as the stocking density increases, the survival decreases. This could probably be due to stress experienced as a result of aggressive feeding behaviour where energy meant for growth is used up in frenzy feeding activities. The low mortality (2.3% = 7 fish) recorded in this study is an indication of proper handling of experimental procedures, though death and escape of fish (during sampling) in cages cannot be ruled out (Secretan, 1979).

The water temperature range in this study falls within the ideal temperature required for catfish culture in fresh water. The temperature range of 24.5 – 32.6 also agrees with the work of Adeogun *et al.* (2004) on the culture of *Heterobrancus* and *Heteroclarias* in pond water.

The water pH range of 6.8 - 8.5 reported during the experiment falls within tolerable range for fish cultivation and also compares with the pH ranges observed by Thomas and Michael (1999), khattab *et al.* (2000) and Otubusin and Olaitan (2001).

The dissolved oxygen of 8.3mg/l recorded in this study indicates that it was not limiting in the cages and similar value was reported by Otubusin and Olaitan (2001) in a similar work on *Clarias gariepinus* in bamboo net-cages.

The growth and mortality of C*larias gariepinus* cultured at various stocking densities were not initially affected by density but, the overall harvest productions in terms of final weight and size were directly related to the stocking density. As the stocking density increased, the weight gain decreased; this depicts an inverse relationship as was observed in similar works by Otubusin and Olaitan (2001). Growth is a manifestation of the net outcome of energy gains and losses within an environment. Weight gain is one of the important indices for measuring growth which was obvious among the different treatments.

The feed conversion ratio in this study showed that treatment III had the best conversion ratio of 3.43 while treatment II had the lowest of 4.99; the ability of C*larias gariepinus* to utilize feed nutrients at maximum biochemical efficiency allows for higher feed conversion ratio. This study shows that at higher stocking density fish expend more energy due to aggressive feeding than converting it to flesh. The overall weight gain at stocking density of 75fish/$m^3$ cage was low and may be attributed to high energy being expended during feeding (aggressive feeding), whereas at lower stocking density (25fish/$m^3$), higher conversion to flesh and weight was obvious. The values of Food Conversion Ratio in this study shows that stocking density has an effect on the ability of fish to convert its feed into flesh and may also be attributed to the feeding technique, quality of feed and temperature variations. The feeding rate of 3% and 1% used in this study were attributed to the high productivity of Kubanni reservoir (Adakole *et al.,* 2003).

The Specific Growth Rate decreased with an increase in stocking density. The growth rate of 3.2g/day observed in this study was lower than 4.2g/day reported for C*larias gariepinus* in net-cages by Otubusin and Olaitan (2001) and 7.3g/day as reported by Otubusin *et al.* (2004), but higher when compared with other culturing system like

concrete tank monoculture for hybrid catfish; 2.6g/day as reported by Salami *et al.* (1993) and 0.012g/day by Egwui (1986) in home stead concrete tanks. This result is similar to the findings by Otubusin (1997) who reported 3.28g/day for C*larias gariepinus* in a polyculture study in net-cages. Growth rate according to Bowen (1982) is determined through the combined effects of quantity and food quality. The quality and quantity of a given food or feed is directly proportional to its ability to support growth.

Fish production increased as the stocking density increased. The high production obtained in all treatments in this study could be linked to the favourable physico-chemical condition of water and maximum utilization of feeds and design of the cages. It could also be attributed to the high crude protein content of the feed.

In this study, the effect of stocking density on growth (SGR and DWG) and performance index (PI) was highly significant at higher stocking density, while there was no significant variation among SGR, DWG and PI. Production and final weight were positively correlated and highly significant at $P<0.01$. The mean production of $38Kg/m^3$ cage in this study indicates an optimum production performance at stocking density (Treatment II), where yield is significantly higher. In fact, under crowded conditions at higher stocking densities, fish suffer stress as a result of aggressive feeding interaction and eat less, resulting in growth retardation (Bjøernsson, 1994). This indicates that in *Clarias gariepinus* fingerlings, stocking densities above 50 fish/$m^3$ may delay growth. In a study on the influence of population stocking density in *Clarias batrachus* larvae reared in tanks, Sahoo *et al.* (2004) reported a similar effect of high stocking densities on growth and SGR. This result suggests that, at lower stocking densities all larvae received adequate amounts of food, compared to those of higher densities. Higher stocking densities resulted in lower SGR.

FCR decreased in high stocking densities. Food conversion ratio, production and weight gain were negatively correlated with stocking density in *Clarias gariepinus* fingerlings. This result indicates that high stocking density reduced feed efficiency. Similar results have been reported in both *Cyprinus carpio* larvae (Jha and Barat, 2005) and *Tor putitora* larvae (Rahman *et al.,* 2005). However, Haylor (1992) reported that the stocking density did not affect survival of *Clarias gariepinus* larvae reared in floating cages.

The Profit Index for all treatments was significantly different at P□0.05 and this is reflected in the FCR and SGR of all the treatments. It is therefore apparent that biological and economic benefit will be achieved in intensive cage culture of C*larias gariepinus* juvenile when stocked at 50/$m^3$. The higher profit index in treatment II over the other treatment shows that the 50 fish per 1$m^3$ cage may be economically viable in terms of final weight and size than 75/$m^3$ cage for *Clarias gariepinus* when feed with a diet containing 42% crude protein.

Some encountered problems during the course of this study include algal growth around the bamboo raft and cages. Fouling by algae is one of the major problems in cage culture (Masser, 2008). There were also instances of weeds growing on the lid of the cages. The cages and weeds may have given the appearance of an 'island' from afar which attracted the birds. The faecal droppings of the birds may have acted as organic manure that assisted growth or even a secondary source of the weed. The presence of the birds and fish probably attracted the snake that was found on the cage. Birds and reptiles have been reported as pest and predators in cage culture ( Secretan, 1979). Strong winds were encountered in August to September during the course of the study which generated strong currents that disturbed the bottom of the cages, resulting in stress and may have contributed to the sudden sharp fall in the growth rate observed in that month (fish were

obviously stressed and therefore suffered a retarded growth) although growth improved subsequently and such disruption by strong winds have been reported by Beveridge (1984).

# CHAPTER SIX

## 6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Summary

The amount of researches concerning Clarias species has increased significantly in the last years, including many areas of interest for aquaculture because of the high importance of Clarias the world over. The stocking density still attracts attention because it aims at higher profit without significant losses in growth ratio and environmental quality. Furthermore, the growth of Clarias depends upon the stocking density, dietary protein quality, energy content of the diet, the physiological status of the fish, age, reproductive state, and the environmental factors such as temperature, salinity, etcetera. It is important to take fish density into account when ranking families or progeny groups for growth performance where density is an important factor affecting growth and maturation. Also, fish density could affect the efficiency of food utilization where the number of fish stocked in a pond increases, the amount of feed available to each fish decreases. The African catfish, C*larias gariepinus* high performance and survival in this study may be attributed to; the stocking density, cage design, feed used, feeding techniques, high protein content of diet, favourable physico-chemical parameter, high productivity of the water body and adherence to culture practices.

### 6.2 Conclusions

In conclusion, stocking density of 25 - 75 juveniles per $1m^3$ cages having a mean weight 5.9±0.23g was successfully. Stocking density of $50/m^3$ cage had the highest economic return in this study in terms of final size and weight obtained. Therefore commercial catfish cage culture in reservoirs and other water bodies which are abundant

in the northern parts of Nigeria as a means of increasing the domestic production and allowing land meant for arable farming to boost the economy is encouraged.

### 6.3 Recommendations

It is recommended that since wild-capture fisheries have declined and aquaculture has expanded, opportunities to increase fish cage production with the optimal utilisation of our water bodies mostly in the Northern region of Nigeria cannot be overemphasized. Cage culture is best recommended for artisan farmers during the off season period in Nigeria. Other recommendations are;

- There should be dissemination of information on the cage culture system via media, seminars, extension workers etcetera;
- Cage culture of other fish species for example, mono-sex tilapia;
- Polyculture of fish species in cages;
- The use of larger cage sizes and assessment of its economic returns;
- Regular maintenance of cage, security to avoid pilfering (theft).

Finally, there should also be legal considerations on the use of cages in private waters and the regulatory authorities should develop policies towards cage culture.

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