EFFECT OF STOCKING DENSITY ON GROWTH AND SURVIVAL OF HYBRID CATFISH FRY (*Heteroclarias*) IN OUTDOOR CONCRETE TANKS.

BY

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DEDICATION

To God whose courage and strength inspired me to disappoint failure and taking nothing short of success.

Also, to my lovely wife, Mrs. Diana Erima Wonah, my sweet daughters, Rosemary and Agatha and my son, Fortune Ogar Wonah.

DECLARATION

I, Mr. Wonah, Cletus Odey do hereby declare that this Thesis is original work done by me and has not been previously presented for any qualification at any other Institution.

All information that emanated from other works either published or unpublished have been duly acknowledged.

SIGN____________ DATE 29 - 09 - 16

CLETUS O. WONAH

CERTIFICATION

This thesis titled: EFFECT OF STOCKING DENSITY ON GROWTH AND SURVIVAL OF HYBRID CATFISH *(Heteroclarias)* IN OUTDOOR CONCRETE TANKS BY WONAH, CLETUS ODEY (M.TECH/SAAT/03/801), meets the regulation governing the award of the degree of M.Tech of Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

The growth and survival of Hybrid of *Heterobranchus longifillis* and *Clarias gariepinus* (*Heteroclarias*) fry with an average initial live weight of 0.3 g and total length of 9.00 mm was investigated at five different stocking levels (500, 1000, 1500, 2000 and 2500) in 2 x 2 x 1m² tank.

The final mean weight at the end of the study ranged from 176.23 g ± 43.99 S.E in treatment 1 to 257.90 g ± 72.98 in treatment 5, while the mean final length ranged from 145.00 mm ± 8.86 S.E to 157.27 mm ± 9.15. The specific growth rates at the end of rearing period were 8.95 g ± 0.28, 4.95 g ± 0.30, 4.73 g ± 0.27, 5.57 g ± 0.55 and 4.78 ± 0.42.

The mean daily weight were calculated as 2.70 g ± 0.49 (S.D.), 3.88 g ± 0.62, 3.39 g ± 0.63, 5.57 g ± 0.87 and 4.69 ± 0.83 respectively. There was no significant difference ($P > 0.05$) between the mean weight gain/day and the specific growth rate of fry held at different stocking densities. There was significant difference in the survival of fry held at the five different stocking levels. No significant difference ($P > 0.05$) in final weight between lower stocking densities, 500, 1,000 and 1,500 stocking levels but significant difference ($P < 0.05$) in 2,000 and 2,500/tank was recorded. A production of 2.9 kg (0.0016 kg/m^3) and survival rate of 3.3% was achieved in the highest stocking level (2,500/tank), while a production of 8.00 kg (0.16 kg/m^3) and a survival rate of 40% was achieved at a lowest stocking level (500/tank). Increasing stocking density from 500 to 2,500/tank increased mortality.

The growth and survival of hybrid (*Heteroclarias*) in this study was affected by densities and rates of cannibalism. Stocking at 500/tank may be more ideal, but fish farmers could use graded fish fingerlings for optimum production rather than fry stocking.

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CHAPTER ONE

INTRODUCTION

1.1 GENERAL INTRODUCTION

Catfish remains the major and most acceptable species for pond culture today in Nigeria. Its high demand, fast growth rate and the general acceptability are the major criteria for its culture. Many works have been done on this major species; Clariids (*Clarias* and *Heterobranchus*) including their hybridization.

In the study and the development of the hybrid of *Clarias gariepinus* and *Heterobranchus bidorsalis*, *H. longifillis*, the Nigerian Institute for Oceanography and Marine Research (NIOMR) in 1987, produced a hybrid of *Clarias gariepinus* (female) and *Heterobranchus longifillis* (male), while the National Institute for Freshwater Fisheries Research (NIFFR)'s work on similar project was first reported in 1994. The aim of developing these hybrids is to produce offspring of superior quality than the parent species (Ayinla and Nwadukwe, 2003). The aim of hybridization is to combine useful, positive or desirable traits of the species (Aluko, 1998).

One important factor to consider in pond production of fish is the desirable stocking density (fingerlings/m^2), which permit good growth and survival rates.

Many works and reviews have been done on stocking densities but no standard has been reached on the stocking density of any particular fish species in Nigeria. Though many stocking densities have been suggested and are in use, Anadu and Nwokoye (1993) and Okoye and Mohammed (1995) suggested a density of $3/m^2$ for Common Carp.

Experience has shown that, stocking densities maintained in some fish farms were speculative, thus there is need for research and standard approach to a finally acceptable stocking density. The optimum stocking densities for effective nursery management of fry to fingerling stage must be established since according to Viveen *et al.* (1986), the growth and survival of fry in confinement are influenced by stocking densities.

The characteristic behaviour, growth, aggression and migration of fish are related to effect of densities in rivers and lakes (Kalleberg, 1958; Fenderson *et al.*, 1968; Keenlyside and Yamamoto, 1962). Although studies on these characteristic behaviours in relation to densities were carried out in a low densities situations, and the result cannot be directly related to the crowded rearing tanks and ponds.

According to Webber and Riodan (1976), the characterization of the species for culture should be considered, indicating those biological needs that will make the species adoptable for culture. The authors also pointed out that the species for culture should as well be adaptable to intensive and semi-intensive management system as those that are being cultured for high yielding aquaculture. Refstie and Kittlesen (1976) pointed out that growth and behaviour of fish are also influenced by external factors of which density is an important one. According to Haylor (1991), the densities at which fry are stocked affect their growth rate and may alter their pattern of behaviours and is one of the most prevalent cause of mortality.

1.2 FEEDING

The knowledge of the feeding habit of a cultured fish is essential for proper management (Sneed *et al.*, 1970). Catfish fish species shows a lot of similarities in terms of feeding habit.

According to Bard *et al* (1976), *Clarias* shows great propensity for carnivorous feeding in a monoculture system. They have preference for a wide range of live feed, ranging from zooplankton, snails, frogs, insect larvae, to small fish and crustaceans. Jubb (1967) however, described catfish as omnivorous scavenger, because *Clarias* are said to feed on anything that comes its way and also a potential carnivore.

In hybrid production, experience shows that the rate of cannibalism is higher in offsprings (Hybrids) than the parent stock of *Heterobranchus* and

Clarias (Olufeagba, pers. comm.). This could have important implications in terms of optimal aquacultural production.

Food play an important role in the growth and survival of all living organisms both in aquatic and terrestrial environments. It is noticeable that some farmers considered feed supply for fry as a major factor for growth and survival, while some have attributed the higher mortality rates of fry to predators, inadequate feeding, poor water quality, over stocking and cannibalism by the fast growers (Dekimpe and Micha, 1974; Hogendoorn, 1979; Madu *et al.*, 1987).

The relative importance of behavioural patterns as causes of mortality is largely unknown, though it has important implications in terms of optimal aquacultural provision. In addition, fry growth and survival at high densities has not been subject of detailed investigation, but may be most productive.

The optimum stocking density is pre-requisite to reduce mortality and to enhance optimum production. Death rate is associated with high stocking densities in the pond system coupled with low quality feeds.

The effective management of the hatchery rearing of the fry and fingerlings of this hybrid species could be the only remedy for the fish farmers to obtain good quality seedlings.

The determining factors that reduce the problem of low productivity in fish farms are the acquisition of good quality seeds (fry/fingerlings), effective management of the hatchery reared fry/fingerlings of hybrids and high quality feeds supply.

Sibling cannibalisms have been a major problem with all catfishes and a decisive factor in low production of the seedlings, but the adoption of regular sampling by removal of jumpers and grading of the fingerlings is a measure to check the excesses of sibling cannibalism and also a size grading could reduce the problem.

1.3 STATEMENT OF THE RESEARCH PROBLEM

The effect of varying stocking density on the growth, survival/mortality and the production of the hybrid fish in 2 x 2 x $1m^3$ concrete tanks have been a concern (Dada *et al.,* 2000). There has been a paucity of information on optimum stocking density for growth of fry to fingerling stage of hybrid species during the outdoor management phase. Therefore, there is a need for detailed research work in order to achieve optimum stocking density for high production.

Studies on the effect of stocking densities on growth and survival/mortality of different fish species have yielded different results. Confinement of large population of fish for maximum production has been a major problem with fish stocking in aquaculture, and a limiting factor in obtaining a good yield in pond culture. This limitation can be overcome with the knowledge of appropriate stocking density of hybrid fry/fingerlings.

1.4 JUSTIFICATION

Fish culturist world over have been working on various stocking levels to arrive at appropriate stocking densities for commercial fry rearing (Refstie, 1977; Rana, 1981; Haylor, 1991; Anadu and Nwokoye 1993; Dada *et al.*, 2000; Dada and Wonah, 2003). A number of factors, biological and economical factors could be considered in fish stocking densities.

This study was therefore, the first attempt using NIFFR facilities to establish different stocking densities of Hybrid fry (*Heteroclarias*) in the outdoor nursery and rearing management. The inherent high growth rate of Hybrid species is an advantage over the pure line of *Clarias* and *Heterobranchus* (parents) and the demand for table size production for commercial marketing have not been met.

It is hoped that commercial fish farmers will benefit from the knowledge of appropriate stocking densities to enhance optimum fish production.

1.5 OBJECTIVE OF THE STUDY

The general objective of this study was to investigate the effect of different stocking densities on growth and survival rate of hybrid fry *Heteroclarias* up to the fingerling stage under outdoor nursery management system. The specific objectives are:

(a) To determine the growth rate of hybrid, *Heteroclarias* at different stocking densities

(b) To determine the survival rate of hybrid fry at varying stocking densities from fry to fingerling stage.

1.6 SCOPE AND LIMITATION OF THE STUDY

This research work addressed the effects of varying stocking densities on growth and survival/mortality of hybrid (*Heteroclarias*) fry reared in 2 x 2 x 1m^2 concrete tanks. This work was limited to a single species of Hybrid *Clarias* (*Heteroclarias*) and the duration of the experiment was twelve weeks.

CHAPTER TWO

LITERATURE REVIEW

2.1 CHARACTERISTICS OF CATFISHES

Clariids (*Clarias* and *Heterobranchus*) are endemic to tropical waters and are widely distributed in the inland waters of Nigeria. Catfishes are remarkable for their high growth rate and have high commercial value in the Nigerian market (Madu *et al*, 1988; Ayinla *et al.*, 1994). Catfish species have the capacity to with stand unfavourable environmental conditions in tropical warm waters. Catfish can survive for a long time buried in mud (Sadon, 1950).

They have the advantages for utilising atmospheric oxygen in the presence of adverse dissolved oxygen condition (Cockson, 1972).

Generally, catfishes have high consumers' acceptability and a first choice for aquaculture in Nigeria.

These species of fish are distributed throughout Africa (Clay, 1977; Brutton, 1988) and have potential for culture in ponds and standing waters.

2.2 FEEDING HABIT OF Clarias AND Heterobranchus

For effective management of cultured fish, the knowledge of their feeding habit is essential (Sneed *et al*, 1970).

The early work on the feeding habit and natural diet of catfish, (*Clarias*) concentrated largely on the anatomical features of the digestive system. Welman (1948); Reed *et al* (1967); Imevbore and Bakare (1970); Carreon *et al* (1973); Lewis (1974); Bard *et al* (1976); Ejike *et al* (1982); Olatunde (1983) described catfishes as omnivorous and have propensity for being cannivorous. Munro (1975) found that *Clarias gariepinus* population in Lake Millwain fed on large amounts of plant materials and two years later, Jubb (1967) redefined catfish species as omnivorous scavenger. They are found mostly at the river bed, swamps and muddy places where they feed on wide range of food from mud, plankton, snails, weeds, frogs, insects and their larvae, crustaceans and small fishes. There are various species of fish preyed upon by the catfishes and these include: *Labeo senegalensis, Ctenopoma kingslaye, Synodontis* and the Tilapia spp (Bakare, 1968); Lewis, 1974).

In a hatchery experiment, Olufeagba (unpublished) observed that, hybrid of a cross between *Clarias* and *Heterobranchus* have higher potential of faster growth rate, voracious and high cannibalism than the individual parent.

The catfishes can thus be seen as opportunistic feeders, feeding virtually on anything that comes their way and this is considered responsible for their success in natural and captive environment.

Time (night and day) and feeding frequency are known to affect performance of cultured fish. Growth rates increased with feeding frequency as demonstrated by Kerdchueen and Legendre (1991). They observed higher growth rates with continuous feeding.

Various feed combinations could increase the growth rate of culture fish (Swamy *et al.*, 1991). The authors obtained 560 pounds (254 kg) of *Channa stratus* cultured for 153 days in a tank using feeds of animal origin which includes freshwater mussels (crushed), snails and frog choppings, live minnows, larvae and trash fish. Wee (1982) obtained 7 – 156 t/ha/y on culture of snakehead (*Channa obscurus*).

The role of natural food in the growth of fishes could not be overemphasized. Live food fed to fingerlings of Carp (*Cyprinus carpio*) at 100% natural food stuff for 20 days at 24°C resulted in 94% survival and weight gain of 245 g. Based on this, Prowbin and Kekova (1983) recommended natural food as starter feeds to rear juvenile fishes.

Molla and Tang (1982) observed the effect of feeding periods of 3 times/day and 5 times/day on growth and survival of *Clarias* *macrocephalus* (Gunther) which showed significantly (P > 05) higher growth and survival than those fed at 1 time/day and 2 times/day.

Lovell (1977) recommended lower feeding rates, 3-4% body weight for channel catfish fingerlings to reach a market size taking into account, the season and the water temperature. The author pointed out that small fish fry requires a higher feeding percentage, while a swim-up-stage requires 6 – 10% food per body weight/day and at the size of 3.6 – 14 cm long, it needs 3 – 4% of their body weight of food/day.

Pond fed catfishes consumed more feeds and produced more biomass when fed twice daily than when fed once/day (Andrew and Page, 1975; Lovell, 1977). Many studies have shown that multiple feeding results in a more efficient utilization of feeds than a single feeding option, and also better growth rates are obtained with multiple feedings (Lovell, 1977).

In one of the earliest studies on the culture of channel catfish, Swingle (1958) gave the rate of feeding as decreasing from between 5 – 3% of the body weight/ day. These limits were set based on the growth rate and feeding conversion rations measured during rearing.

Halver and Tiews (1978) recommended large scale production based on provision of feeds in appropriate quantities and the use of natural organisms. However, the important ecologi8cal factors responsible for survival in warm-water fishes are temperature, dissolved oxygen levels, predations, feedstuff and sudden weather changes.

In hatchery experiment, Ketola et al (1991) reported that Coho Salmon with initial weight of 4 – 5g were fed low phosphorous diet moist pelletes for 315 – 321 days (45 – 46 weels), a weight increase of 85% was obtained at the end of the experiment. The author pointed out that food plays an important role in the growth and survival of fish.

2.3 GROWTH AND SURVIVAL

It is important to decide at the onset what level of production and management is most practicable. For intensive, extensive and cage production Wutz (1992) observed that 15.24 cm to 20.52 cm catfish fingerlings stocked at 8 ind. m^2 reached a size of 0.454kg to 2.37 kg in 210 days. In a high density pond production, Newton (1993) reported that catfish stocked at 3750 to 7500/ha ponds were fed once daily for 116 days. At harvest, a gross yield of 4.4 ton/ha and 2.2 t/ha was obtained from higher and lower density ponds respectively. An overall catfish weight increased approximately by 200 times and average fish size of 1.6 kg was obtained with a high survival rate of 93% and 96% respectively.

Awodiran *et al* (2000) observed that a cross between *H. longifillis* and *C. anguillaris* had a better growth performance than the pure line of *Heterobranchus longifillis* and *Clarias anguillaris*.

Nahrarysautzung and Waihstum (1976) reported on the growth efficiency of young white fish (*Oregnus fera jurine* 1852) fed on zooplankton and ration containing 13% calorific content, a mazimum specific growth rate of 5.4%/day was obtained with a growth efficiency of 44.4%.

Webster *et al* (1993) reported on the growth of juvenile channel catfish (*Ictalurus puntatus*) reared for 110 days at a density of 320 fish/m^3. A mean individual weight of 219g and a survival of 92.1% was obtained from this fish which was fed to satiation.

In the study of growth performance of *Heterobranchus longifillis*, Kerdchueen and Lengendri (1991) measured a higher rate of 2.36 to 2.64 g/day when 74 g *H. longifillis* was fed continuously for 56 days on a ration at a feeding rate of 3% body weight/day.

Also, study on the growth performance and survival of *Itahan sturgeon* fish cultured in freshwater for 8 months, gave a weight increase from 12.8 mg initial weight to 108 g, and a total length of 10 mm initial length to 317 mm final length and the survival was 78% (Giovanini *et al*, 1989).

In a mono culture experiment on milk fish (*Channos channos*), Lazarus and Nandakumaran (1986) obtained a maximum instantenous growth of 1.218 – 1.82 and a maximum of 88.8% survival in 180 days was observed under 1 fish/m2 with a production of 1751 kg/ha within the same period.

In a semi-intensive culture of *Heterotis niloticus* and *Clarias gariepinus*, Omorinkoba *et al* (1989) recorded a high growth rate using pond fertilization and supplementary feeds method. A total production of 4,401.47 kg (4.4 tons) in 365 days was obtained. Good quality feed and ecological factors are responsible for fish growth and survival.

2.4 HYBRIDIZATION

The need for hardy and fast growing fingerlings that will satisfy the culture requirements of fish farmers has resulted in the genetic manipulation of various fish species in search of fingerlings with improved qualitative traits. Hybridization is used to combine useful, positive or desirable trait from one species to another with the aim of producing offspring of superior quality than the parent species. The purpose is to produce fast growing superior genotype (Aluko and Aluko, 1998; Ayinla and Nwadukwe, 2003).

Madu *et al* (1991) conducted a preliminary work on the intergeneric hybridization of the high surviving *Clarias gariepinus* and the fast growing *Heterobranchus bidorsalis* to produce *Clariabranchus* sp (male *Clarias* x

Heterobranchus bidorsalis to produce *Clariabranchus* sp (male *Clarias* x female *Heterobranchus*) and *Heteroclarias* sp (male *Heterobranchu*s x female *Clarias*). The authors observed that during the first month of indoor management, heterosis was not prominent in the hybrid hatchlings. In the study, 85% survival was recorded with the indoor management before transferring for outdoor monitoring.

Aluko *et al* (2000) observed that hybrid obtained from two strains of *Heterobranchus* from Jos and Kainji gave 25% heterosis (hybrid vigor) within five months of concrete tank culture. He pointed out that increase growth rate will decrease the time it will take to grow a fish to market size. This will increase production efficiency, increase food production and also increase farmer's income.

Madu *et al.* (1992) reported that, a final weight of 46.33g and mean growth rate of 0.28g/day was achieved by hybrid *Heteroclarias* compared to 0.13g/day for *Clarias gariepinus*. The authors reported that the hybrids showed some genetic improvements in terms of growth and survival rates and this could be attributed to the heterosis or hybrid vigor. *Heteroclarias* embibed the fast growth characteristics of *Heterobranchus* species.

Hybridization of other species have been reported by many workers. Production of monosex Tilapia male (100%) has been described as the best solution to over production and prolific breeding behaviour of Tilapia in pond condition (Hickling, 1963).

Hybridization of all-male was observed to have advantageous growth rate over the females (Hickling, 1969; Kirk, 1972)..

All-male *Oreochromis niloticus* hybrids have been produced in Uganda by crossing native *O. niloticus* female with exotic A*ureus* male from Israel (Proginin, 1967). The work carried out by the author was to obtain solution to the prolific breeding by investigating the interspecific crosses that will yield monosex (all-male) broods of Tilpia for fast growing.

A considerable number of crosses between Tilapia species have resulted in over 50% male hybrids in Israel (Proginin *et al*, 1975). The crosses involving *Oreochromis niloticus* female and *E. aureus* male yielded all-male hybrid broods in Israel (Fishelson, 1962).

The intraspecific, interspecific and intergeneric hybrids of *Clarias* catfish have been reported by Aluko *et al* (1999). The authors recorded mean weight after 6 months of rearing in 2 x 2 x 1 m^3 concrete tanks from initial weight of 0.01 g to 106.22 g and 85.48 g for triploi and diploid hybrids respectively.

The growth performance of hybrid species of *Clarias* and *Heterobranchus* were reported by Madu *et al* (1993). In the study the authors recorded highest growth rate in hybrid *Clariabranchus* which had a weight of 930 g and a mean growth rate (2.60 g/day) and followed closely by hybrids *Heteroclaris* with a weight of 995.0g and a mean growth rate of 2.55 g/d. There was no significant difference ($P > 0.05$) in the mean growth values for the hybrids while the parental line showed lower growth rate.

The highest performance of hybrids could be attributed to the heterotic growth as a result of hybrid vigor. This is in line with Jensen *et al* (1983) and Bakos (1967)) who observed that hybrids, in most cases, were superior to the parental line in growth, food conversion, resistance to diseases, meat quality, reproductive ability and increased adaptation to environmental conditions.

Growth performance of Hybrid and the pure line of *Clarias* and *Heterobranchus* was conducted by the Genetic Unit of Aquaculture Division in NIFFR and the result obtained showed that Hybrid of *Heterobranchus* and Clarias (*Heteroclarias*) reared in concrete tanks for 10 months attained a weight of 1800g (1.8kg), while in the earthen ponds for 12 months, the weight reached 3 – 4 kg. *Heterobranchus* (pure line) reached a weight of 900g in 10 months in concrete tanks and 1.0 kg in 12 months in earthen ponds, while *Clarias* reared in concrete tank reached 250g in 10 months and in earthen pond, 900g (0.9kg) was obtained.

2.5 STOCKING DENSITY

The effect of stocking density on growth and survival of fishes have been reported by Stylzenk-joulwize (1979). These reports shows that aquatic organisms grow slowly, attained smaller final sizes (or stunted) and may die when reared alone in small volume of water or when cultured in a high stocking densities (Styezenk-joulwize, 1977).

Stocking density is supposed to take advantage of the fastest rate of growth, using the optimal stocking levels, and also considering time factors for rearing the animals.

Yashoove (1959) pointed out that, the daily fish production decreases when fish biomass approaches that limit of the carrying capacity of the rearing ponds.

A lot of works have been done on the effect of density on the growth and survival of fish species including *Clarias*, Carps, Tilapia, *Heterotis* and many other species of fish in lakes, rivers and in other confinements (Fenderson *et al*, 1971; Ondera, 1972; Otubusin *et al*, 1990; Wonah and Dada, 1996).

Dada and Wonah (2003) reported on growth differential in varying stocking densities on exotic *Clarias gariepinus* and pointed out that as stocking density increased, mortality increased.

Dada and Wonah (2003) reported on growth differential in varying stocking densities on exotic *Clarias gariepinus* and pointed out that as stocking density increased, mortality increased.

According to Reftslie and Kattleson (1976), Atlantic Salmon held at lower density (5 – 7 fish/m) grew better than those held at higher density, while Allen (1974) also reported that, mean fish weight, food conversion efficiency and survival ratios decreased with increased stocking densities.

Dambo and Rana (1992) pointed out that fry stocked at 15 and 20/L are affected in their growth when compared with those held at 2, 5 and 10 fry/L. The authors therefore, suggested that stocking rate should decrease in favour of 3 - 5 fry/L.

Rana (1981) considered 8 fry/L as optimal stocking density for *Sarotherodon mosambicus*. In a report presented by Wonah and Dada (1996) on stocking density, growth and survival of *Clarias gariepinus* fry reared in concrete tanks for 35 days, the mean harvest weight obtained was 6.72, 7.43, 9.02, 17.46 and 14.41 g respectively for fry reared in (500, 1000, 1500, 2000 and 2500) varying stocking densities.

The authors observed that there was significant difference ($P < 0.05$) between those stocked at lower densities and the highest stocking levels.

A production of 1.15 kg/tank and a survival rate of 34.2% was obtained at the lowest stocking rate (125/m^2).

The hypothesis put forward by some authors including Refstie (1977) was that high stocking density in the tank may have made it difficult for fish to move and reach the food, thereby, depressing the feeding rates. Also food availability could have been a limiting factor even though excess food was given.

In the same vein, Wedemyer and Mckny (1981) included decreased growth in hatchery production among the factors considered as a whole animal's response to environment stress. High stocking density increases crowding which influences competitions and stress (Schreck, 1981).

The fact that fish responded to changes in population density by modifying their growth rates has been noted earlier by Craig and Keppling (1983).

The ratio of out-growth (jumpers) in a high density stocking was reported by Wonah and Dada (2003). The authors pointed out that, the ratio of jumpers to normal (uniform) growth was significantly high, in higher stocking levels and the survival obtained was affected by the numbers of jumpers (out-growth) obtained, apparently in the different stocking densities.

Ita *et al* (1988) also observed that at higher stocking levels, bigger jumpers developed. These jumpers exhibit aggressive tendencies, cannibalizing on the smaller ones (normal growth). In a related study, Omorinkoba *et al* (1989) pointed out that density has influence on the growth and survival of fish.

Studies on the effects of stocking density on growth of artic Charr gave a result that does not show any direct negative correlation between stocking density and growth. This result is illustrated in Table 1.

Table 1. Estimated Fingerlings Size after 120 – 150 Days Growing Season at Different Stocking Densities

Fish/acre	Fish/m2	Average Length of Fingerling (inches)
10,000	$25/m^2$	7" – 10"
30,000	$75/m^2$	6" – 8"
53,000	$132.5/m^2$	5" – 7"
73,000	$182.5/m^2$	4" – 6"
95,000	$237.5/m^2$	3" – 3 "
120,000	$300/m^2$	3" – 5"
200,000	$500/m^2$	2" – 3"
300,000	$750/m^2$	1" – 2"
500,000	$1250/m^2$	1'

Source: Jensen et al (1977).

According to the table, the average length of fingerlings decreased with increase in stocking rates from $25/m^2$to the highest density $1250/m^2$.

Jorgensen *et al* (1992) reported that different results with regards to the growth performances of fish stocked at higher densities may possibly be due to differences in factors such as water quality, fish size and fish age.

CHAPTER THREE

MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE

This research study was carried out in the Hatchery Complex of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Nigeria, using both the indoor and the outdoor hatchery systems. Hatchery procedure as described by Madu (1989) and Ogbondeminu (1991) was followed for experimental fry production without any modification as presented in the following section. Three (3) breeding tanks measuring 2 x 2 x 1m^2 were used in the indoor while fifteen 2 x 2 x 1m^2 concrete ponds were used as rearing ponds. The experiment was conducted between September and December 2004.

3.2 INDOOR HATCHERY PROCEDURE

3.2.1 Brood Stock

Broodstocks of two males and two females of *Clarias* and *Heterobranchus* (ripe) were obtained from a private fish farm and acclimatized in the indoor holding tanks for 5 days prior to induction. Three (3) rectangular breeding tanks measuring 2 x 2 x 1m^3 each were used for the breeding.

The breeding tanks were washed thoroughly and filled to 30 cm with water. Spawning mats (Kakaban) were carefully placed in each tank.

After acclimatization of the parents, the fish were induced by Ovaprim (hormone) injection according to their body weight. The injection was done at about 8.00 pm to give a latency period of 12 hrs before stripping. After induction, the fish (males and females) were kept separately to disallow induced natural spawning in the holding tanks. 12 hrs after the injection, (latency period) at about 8.00 a.m., the brood stocks were carefully removed and kept in a bowl separately.

3.2.2 Stripping and Fertilization

Dry method was used in the stripping and fertilization exercise. The eggs from the female were carefully stripped into a dry container devoid of water. The males were killed and dissected to remove the testes. The testes were macerated in a lab-mortar to release the spermatozoa. Two ml (2ml) saline solution was added to the sperm fluid to allow free movement of the spermatozoa. This was carefully spread on the stripped eggs in a dry container and mixed carefully with feather. After mixing, some quantity of Saline solution and freshwater were added. The eggs were carefully spread on the spawning mats (Kakaban), and were incubated for 24 hours. The eggs hatched 24 hours after fertilization. The hatchlings were left for 3 days to absorb their yolk sac before feeding. The fry were fed with live food (zooplankton) on the 4th day after hatching 4 times/daily *ad-libitum* for a period of 14 days before transfer to the rearing outdoor tanks.

3.3 EXPERIMENTAL FISH

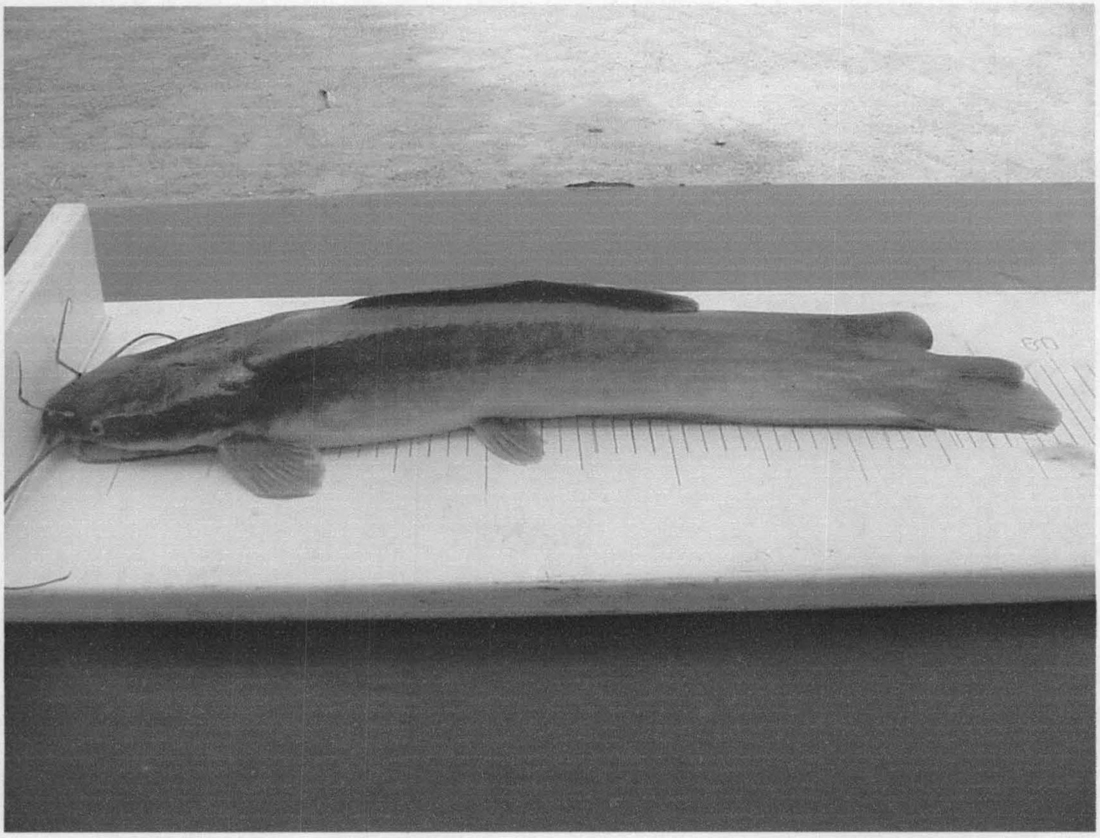
The hybrid fry of a cross between male *Heterobranchus longifillis* and female *Clarias gariepinus* (*Heteroclarias*) produced through induced spawning as described above were used to execute the experiment. Plates 1 and 2 show the different species of catfish (*Heterobranchus longifillis* and *Clarias gariepinus*) used for producing the hybrids.

3.4 EXPERIMENTAL DIET

The experimental diet consisted of live fish food (starter diet) zooplankton fed to fish fry in the indoor for 14 days, before changing to supplemental diet that contained 45% crude protein. This was fed to fish in the out door nursery ponds.

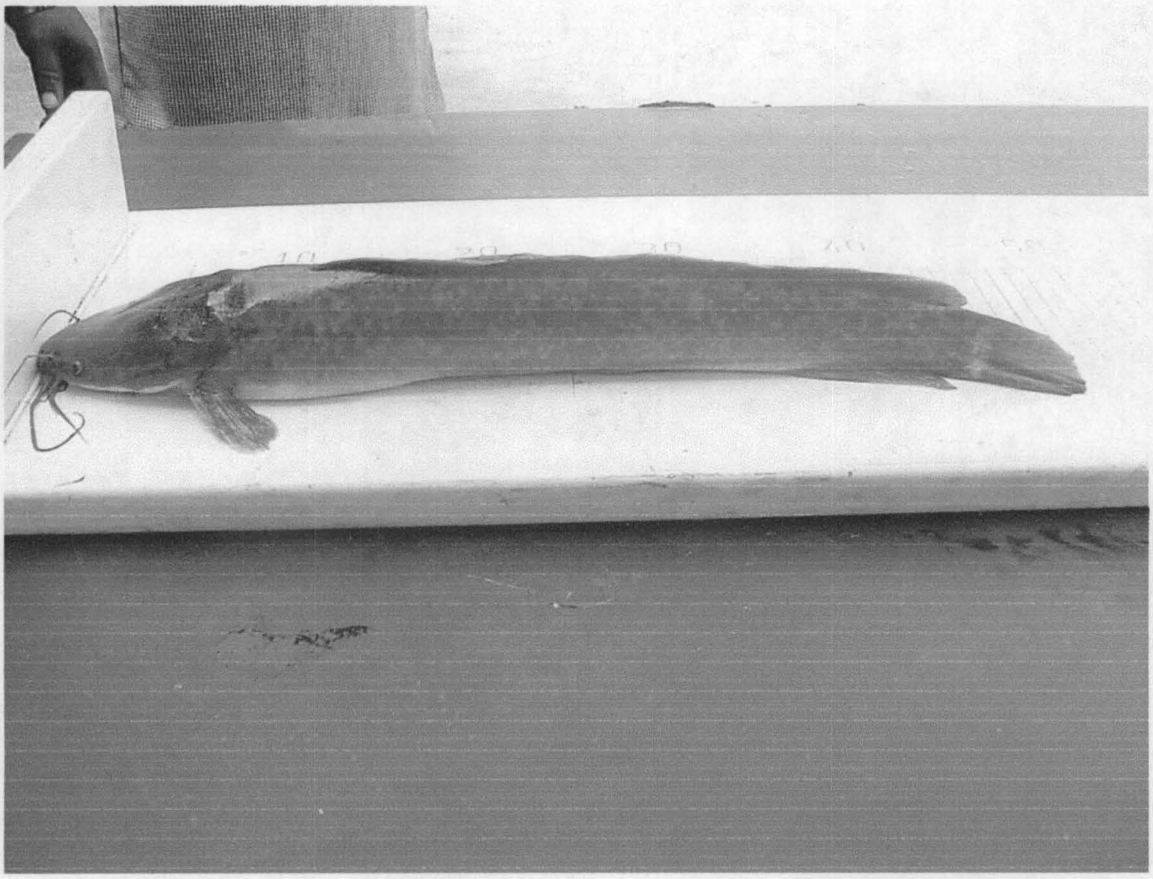
3.5 EXPERIMENTAL DESIGN

Fifteen (15) experimental concrete tanks, each measuring 2 x 2 x 1 m^3 were used for the project. The experimental design was randomized complete block design with five (5) treatments with three (3) replications with one factor, which is stocking density.



Male

PLATE 4.1: Photo of *Heterodranchus longifillis* (Valeenncines 1840)



Female

PLATE 4.2: Photo of *Clarias gariepinus* (Burchell 1822)

3.6 PREPARATION OF EXPERIMENTAL TANKS

This stocking trial was executed in fifteen (15) experimental concrete tanks each measuring 2 x 2 x 1 m^3. Before stocking the fish, the tanks were emptied, drained and washed thoroughly. The tanks were filled with mud soil to a thickness of 3 cm to simulate earth pond bottom condition to which catfishes are naturally accustomed.

The tanks were left for one week to dry before they were filled back with water from the reservoir. Each tank was filled to a depth of 0.5m (50 cm). Single super-phosphate (17.4%) pure phosphorus content was applied as the initial pond fertilizer at 5 $\mu g/m^2$ to develop plankton blooms.

3.7 STOCKING RATE

Hybrid catfish (*Heteroclarias*) fry produced at the age of 14 days with a mean initial weight of 0.3 g and a mean initial total length of 9.0 mm were stocked into the 4 m^2 (2 x 2 x 1 m^2) outdoor concrete ponds. The stocking rates were 500 (250/m^3); 1000 (500/m^3); 1,500 (750/m^3); 2000 (1000/m^3); 2500 (1250/m^3) respectively.

3.8 OUTDOOR ACCLIMATIZATION

After 14 days of indoor management, the fry were transferred to the outdoor concrete tanks and allowed to acclimatize for two (2) days and mortalities were recorded from each tank, counted and replaced by live fry to maintain the actual number stocked. No feeding was done for the first 48 hours of acclimatization in the outdoor ponds to allow them a gradual change from live feed to artificially formulated feeds.

3.9 FEEDING

The fry were fed 45% crude protein formulated diet (50kg) fed at the rate of 10% body weight per day, following Eyo (1989) recommendation. The formulated feed was based on trial and error method:

Clupeid meal	17.5%
Blood meal	2.5%
Soya bean meal	12.695
GNC	10.00%
Maize	3.44%
Bone meal	1.0%
Oil	1.0%
Starch	1.0%
Premix	0.5%
Methione	0.25%
Salt	0.10%
Vit. C	0.015%

The feed was fed in powdered form. This percentage of feed was split into 3 equal parts and fed to the fish three times per day, morning at 8.00 a.m., 1.00 p.m. afternoon and 6.00 p.m. in the evening. The feeding rate was adjusted according to weight changes. The feeding was done for 76 days (11 weeks) of study. The feed was dispensed manually into the rearing tanks. The records of length, weight and mortality/survival were monitored progressively bi-weekly.

3.10 SAMPLING FOR MEASUREMENT OF GROWTH, SURVIVAL AND MORTALITY RATES

A forth-nightly (bi-weekly) sampling of fish was done and the length/weight measurement was taken. Six (6) sampling was done in 84 rearing days at two weeks intervals. On the sampling day, no feeding was administered. 15 fish were randomly sampled from each treatment for length and weight measurements. Feeding ration was reviewed upward based on increase in the total weight of fish at sampling.

Sampling for weight and length measurements of fry was often done by lowering the water in the tank and scooping the fry using 0.05 mm size scoop net for a period of six weeks (6 wks). From the sixth week when the fish had reached fingerlings and post fingerling stage, sampling was normally done by gradual release of water through the outlet. The outlet was screened tight with hapa nets which eventually collect the fish. All the fish collected from each treatment were counted for the survival rate. After collection, the volume of the water was replaced immediately by releasing the inlet water through the pipe from the reservoir.

3.11 WATER QUALITY

The water quality parameters were determined weekly, were pH, Temperature, Conductivity, Dissolved Oxygen and Transparency using standard method (APHA, 1975; Boyd, 1981). Also, water fertility was determined from each treatment using plankton count in a sampled density using Ofojekwu (1990) method.

3.11.1 Phytoplankton Count

70μ mesh size conical plankton net of 25 cm diameter (standard) with a 60ml plastic bottle was used for sampling. The net was dipped into the tanks and dragged forward and backwards at a distance of 1m. The samples were then transferred into the 60ml plastic bottles and fixed with Lugol's reagent. The samples were stirred to give uniform suspension. 1 ml samples was quickly drawn using pipette before the organisms settle down. The 1 ml samples was then introduced into the counting chamber, a cover slide was placed without trapping air bubbles. The slide was then placed on the microscope and allowed to settle for 10 – 15 minutes. The organisms (phytoplankton) were then counted using identification index.

Phytoplankton estimation in a sample followed the formula adopted by Ofojekwu (1990).

Formular: $N = \frac{(a\ 1000)\ c}{L}$

Where: N = number of plankton per litre

a = the average number of planktons in 1ml of sample

c = concentrated sample

L = the volume of original water sample.

3.11.2 Temperature

Temperature data were collected by using Mercury in bulb thermometer. The temperature reading was taken directly by placing the thermometer into the water for 5 minutes and the temperature was read. This was done in the morning at about 10.00 a.m.

3.11.3 Conductivity

10ml of water samples was poured into a beaker and electrode of the conductivity was first placed in a buffer solution to give a conductivity of 0.0 (Boyd, 1981). The electrode was then submerged into the sample and the conductivity readings were taken directly in Siemens. It was measured in ohms/mm or Siemens.

3.11.4 Hydrogen ion Concentration (pH)

Water samples were collected from each treatment using 30 cl plastic bottles. The sampled water were analyzed in the laboratory using digital pH meter. The measurement was taken by:

(a) Drawing 10ml of sampled water into a beaker

(b) Dipping electrode of pH meter in a buffer solution to standardize the meter at 7.0

(c) The electrode was then dip into the beaker containing sample.

(d) The pH was then read directly.

3.11.5 Dissolved Oxygen (DO) Using Winkler's Method

Water samples were collected in 250 ml bottles from each treatment. The sample bottles were lowered down, turned up-side-down and the water was collected immediately and corked to disallow atmospheric oxygen not to come in contact with the sample (Boyd, 1981). The samples were therefore subjected to Dissolved Oxygen analysis.

The sample was transferred into a 250 ml stoppered bottle and allowed for 20 seconds without air bubbles entrapped.

The bottles were stoppered without trapping any air bubbles.

The stoppered bottles were carefully removed and 2 ml of Magnesium sulphate was added to it. Then 2 ml of Alkaline iodine solution using separate pippetes for each solution.

The stopper was then replaced and there was displacement of water with a formation of a while precipitate.

The samples were shaken several times for proper mixing. The flocculent precipitate was allowed to settle.

After sample had settled, the stopper was removed and 2 ml concentrated Sulphuric acid was then added with a tip of the pipette and vigorously shaken until precipitate dissolved leaving a yellow colors of free iodine.

2 ml of treated samples was transferred into a conical flask. 0.025 N solution Sodium thiosulphate was then used for titration by rotating the flask until sample turns faint (pale yellow in color).

1 ml or 5 drops of starch solution was added and the sample turned dark-blue.

Titration was continued until blue color first appeared

The amount of Sodium thiosulphase used was then calculated using Ofojekwu (1990) method.

Calculation:

$$\text{DO concentration in Mgl-1} = \frac{V(D) \times N(D) \times 8 \times 1000}{\text{Volume of Sample}}$$

Where: v(D) = volume of $Na_2S_20_3$ used in titration

N(D) = normal of $Na_2S_20_3$ (0.025 N)

3.11.6 Transparency

This was achieved by lowering the Secchi disk into the water gradually and a depth reading was taken at the point the disk disappeared from sight. The disk was gently raised from the water and another reading was taken at the point the disk reappeared. The average of the two readings was taken and the correct Secchi disk reading for the concrete ponds (Ovie and Adeniji, 1993).

3.12 DATA ANALYSIS

The data obtained were subjected to one-way Analysis of Variance (ANOVA) and differences among means were detected with least significance difference multiple range test at the 5% probability level, using SPSS Computer package (Sokai and Rohif, 1981).

Parameters measured at the sampling period were calculated as:

3.12.1 Growth

wt – wo

where:

wt = final mean weight

wo = initial weight

3.12.2 Daily Weight Gain

Average daily weight gain (g) was calculated as:

(wt – wo)t

where:

wt = final mean weight

wo = initial weight

t = time at sampling (days)

3.12.3 Specific Growth Rate

Specific growth rate was also calculated using the formula

$100 \times (\log^{e}$ final wt – log initial wo)/t:

where

loge = natural log

wt = final weight in (g)

wo = initial weight (g)

t = duration of stocking in days

Length = final mean length – initial mean length.

3.12.4 Condition Factor

Condition factor (k) was measured using length/weight relationship applying formula:

$$K = \frac{100w}{L^3}$$

Where

W = final weight of fish (in g)

L = Total length of fish (in mm)

3.12.5 Survival

Survival/mortality was calculated based on the total sampled – initial stocking densities.

No thinning or removal of jumpers (out-growth) was done because this was the major factor to determine the survival of the fish in the culture medium.

CHAPTER FOUR

RESULTS

4.1 WATER QUALITY

Table 2 shows the summary of water quality readings from all the treatments of the study in the outdoor concrete tanks.

4.1.1 Temperature

The mean temperature range recorded during this study were 24.5°C minimum and 25.8°C maximum with a mean of 25 ± 3.27 S.E. There was a slight temperature variation between the treatments. The lowest mean temperature value recorded throughout the readings was 24.5°C observed in treatments 1 and 2, while treatments 3, 4 and 5 had 25.8°C. Low temperature was generally observed during the study period that corresponds to cool dry period (September to December).

The difference in temperature between the treatments was not significant ($P > 0.05$). The temperature trend as shown in Table 4.1 indicate that there was a slight fluctuation in temperatures between the rearing months (September to December).

Table 4.1. Results of Water Quality Parameters obtained on BI-weekly for 12 Sampling Weeks

Parameter	Bi-Weekly					
	WK2	WK4	WK6	WK8	WK10	WK12
Temperature	24.2	25.02	24.9	25.6	25.2	25.80
Dissolved Oxygen mg/l	6.20	5.2	4.2	4.62	3.24	3.2
Conductivity	140	142	150	154	168	200
pH	7.0	7.2	7.1	7.0	7.2	7.0
Sechi Disk (SD)m	0.28	0.28	0.50	0.50	0.50	0.50

Table 4.2. Summary of the Water Quality Parameters from all the Treatments over 84 Days in Outdoor Concrete Tanks

	Minimum	Maximum	Mean ± S.E.
Temperature (°C)	24.2	25.8	25 ± 3.27
Dissolved Oxygen (D.O.) (mg/L)	3.2	6.20	4.7 ± 0.05
Conductivity	140	200	170 ± 4.59
pH	7.0	7.0	7.0 ± 0.13
Secchi Disk (S.D) (m)	0.28	0.50	0.39 ± 0.01

4.1.2 Dissolved Oxygen (DO)

The range for dissolved oxygen (D.O.) mg/L showed a minimum value of 3.2 mg/L and maxim um of 6.20 mg/L with mean value of 4.7 ± 0.05 mg/L. There was a variation in dissolved oxygen between the treatments. The lowest mean values was obtained in treatments 2, 3, 4 and 5 having the higher stocking densities (1,000/m², 1,500/m², 2,000/m² and 2,500/m²) respectively, and the highest mean value was recorded in treatment 1 (500/m²). There was no significant difference in DO between the treatments ($P > 0.05$) (Table 4.2). There was a general decline in DO from about 6.20 mg/L – about 3.2 mg/L between treatments (T_2, T_3, T_4 and T_5). The DO for treatment 1 (T1) never exceeded 6.20 mg/L for the period of study.

4.1.3 Conductivity

The mean value for conductivity was 170 ± 4.59 S.E. The minimum value mg/L was 140 mg/L and maximum 200 mg/L. There was a variation in conductivity (Table 4.1) between the treatments because of negative correlation between conductivity, D.O, Temperature and pH. The lowest mean values for conductivity was observed in treatments T_1 and T_2 corresponding to the lower stocking densities. The highest values were obtained in treatments T_3, T_4 and T_5 respectively with higher stocking densities.

The difference in conductivity between the treatments was significant ($P > 0.05$) (Table 4.2). Conductivity shows a negative correlation with temperature, pH and DO ($P > 0.05$).

4.1.4 pH

The pH range was 7.0 and 7.2 with a mean value of 7.0 ± 0.13 S.E. There was no variation in pH between the treatments. The mean values obtained in all the treatments were 7.0 ± 0.13 (Table 2). pH correlated negatively with conductivity and was insignificant ($P < 0.05$). The trend for pH as shown in Table 4.1 indicates that there was no decline in the pH during the study period.

4.1.5 Secchi Disk (S.D.) Readings

The mean value for Secchi Disk readings for water transparency measured in all the treatments was 0.39m acceptable in fish ponds. The minimum values 0.28 was obtained in lower stocking densities T1 (500 fish/m^2), and T2 (1000 fish/m^2), while the maximum value 0.50m was observed in T_3, T4 and T5 (1500/m^2, 2000/m^2, 2500/m^2) respectively as shown in Table

4.1. Water turbidity was more visible in these treatments which were due largely to the population and larger jumpers' presence.

4.2 GROWTH RATES

The final mean weight gain ranged from 176.23 g ± 43.98 in treatment 1 to 345.60 g ± 72.98 in treatment 5. During the 84 days study, growth of fish increased from the initial uniform weight of 0.3g to final mean weight of 176.23 ± 43.98 in T_1, 228.85 ± 52.53 in T_2, 232.06 ± 53.27 in T_3, 345.60 ± 63.52 in T_4 and 257.80 ± 72.98 in T_5 as presented in Table 3.

Figure 4.1 shows changes in weight over 84 days of Hybrid (*Heteroclarias*) fry kept at five different stocking levels between 500 and 2,500 fry/tank

In the treatments, the fish increased rapidly in weight, with significant ($p < 0.05$) increased weight for successive 14-day period measured between day 14 and day 84.

Table 4.3. Growth Performance of Hybrid (*Heteroclarias*) Fry at Different Stocking Densities Reared for 84 Days in Outdoor Concrete Tanks

Parameter	Stocking Density/Tank					
	T_1	T_2	T_3	T_4	T_5	
	500	1,000	1,500	2,000	2,500	± S.E.M.
Initial Mean weight (g)	0.3 ± 0.002^{a}	0.3 ± 0.002^{a}	0.3 ± 0.002^{a}	0.3 ± 0.002^{a}	0.3 ± 0.002^{a}	0.00
Final Mean weight (g)	176.23 ± 43.98^{a}	228.86 ± 52.53^{a}	232.04 ± 53.27^{a}	345.60 ± 64.92^{b}	257.80 ± 72.98^{b}	14.63
Mean Weight gain (g)	176.03 ± 42.87^{a}	228.65 ± 51.41^{a}	231.83 ± 52.16^{a}	345.40 ± 63.81^{b}	257.60 ± 71.87^{b}	14.63
Average Daily weight gain (g)	2.7 ± 0.49^{a}	3.88 ± 0.62^{a}	3.39 ± 0.62^{a}	5.57 ± 0.87^{b}	4.69 ± 0.83^{b}	0.26
Specific Growth Rate/day	4.58 ± 0.28^{a}	4.95 ± 0.30^{a}	4.73 ± 0.27^{a}	5.57 ± 0.55^{b}	4.78 ± 0.42^{b}	0.09
Mean Initial Length (mm)	9.00 ± 0.03^{a}	9.00 ± 0.03^{a}	9.00 ± 0.03^{a}	9.00 ± 0.03^{a}	9.00 ± 0.03^{a}	0.00
Mean Final Length (mm)	145.00 ± 8.86^{a}	146.07 ± 9.40^{a}	145.00 ± 21.47^{a}	217.00 ± 45.47^{b}	157.27 ± 9.15^{b}	7.34
Mean Length gain (mm)	136.00 ± 7.74^{a}	137.07 ± 7.62^{a}	136.00 ± 7.74^{a}	208.00 ± 43.34^{b}	148.27 ± 8.09^{b}	7.35
% Survival	40	13	5.3	4.0	3.3	NS
% Mortality	60	87	94.7	96	96.7	S
Production (kg/m^{2})	8.0	4.2	6.5	3.1	2.9	

Means in rows having same letter are not significantly different (P > 0.05).

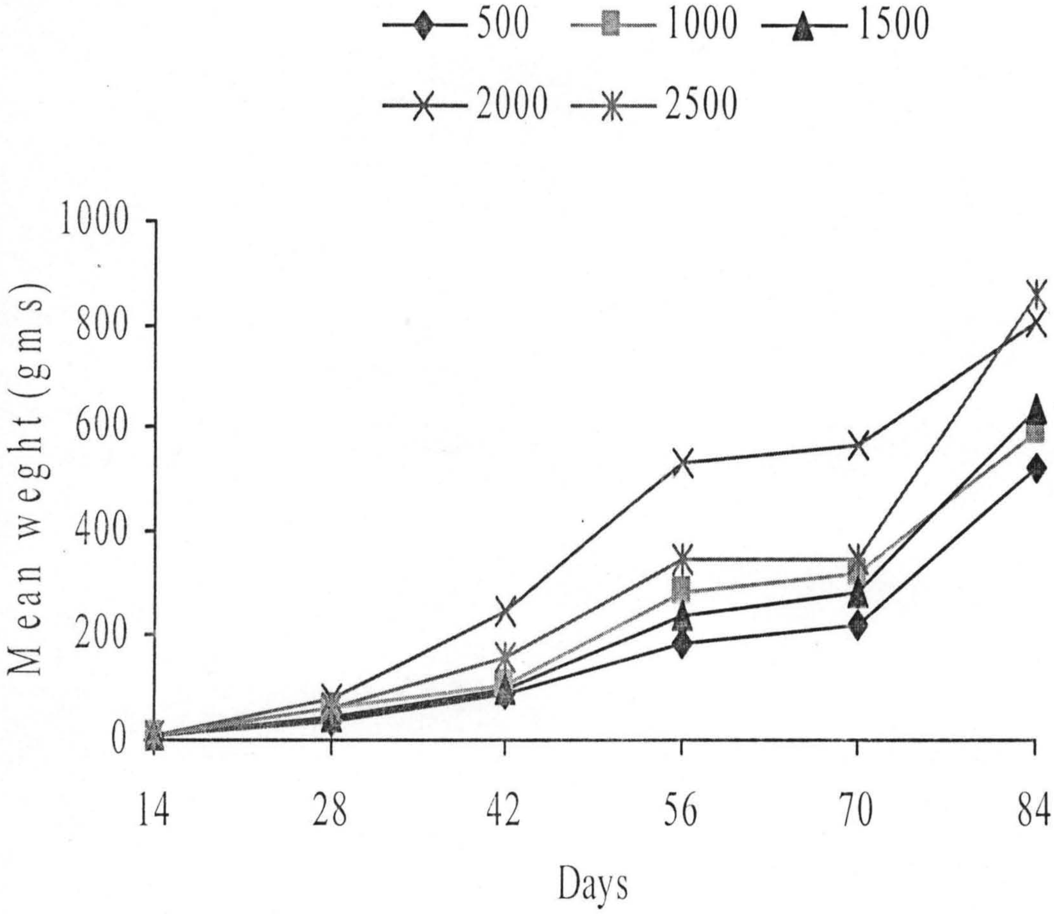


Figure 4.1: Mean weight increase of Hybrid (*Heteroclarias*) fry over 84 days at five different stocking levels

The highest weight gain (345.60 g) recorded in treatment 4 (2,000) could be attributed to the fewer but bigger number of fast growers (jumpers) in the treatment resulting in lower survival rate of 4.0% attributable to cannibalism.

There was no significant difference ($P > 0.05$) in the growth rate between treatments 1, 2 and 3, while 4 and 5 show significance difference when one way ANOVA tested at 5% was employed (Table 4; Appendix I).

At 500 fry/tank, fish gain more significant ($P < 0.05$) weight at every 14 days period of sampling than at higher stocking densities. This agrees with the findings of Haylor (1991) who reported growth decrease in relation to increasing stocking density under controlled hatchery production of *Clarias gariepinus*.

Figure 4.2 shows the mean weight gain/day. The weight gain was 2.70 ± 0.49, 3.88 ± 0.6, 3.39 ±0.62, 5.57 ± 0.89 and 4.69 ± 0.83 respectively for the five treatments. No significant difference ($P > 0.05$) in weight gain when tested at 5% levels (Appendix II).

The highest value (weight gain) was obtained between day 70 and 84 in treatment 5, while 0.4% lowest was obtained between day 56 and 70 in treatment 1.

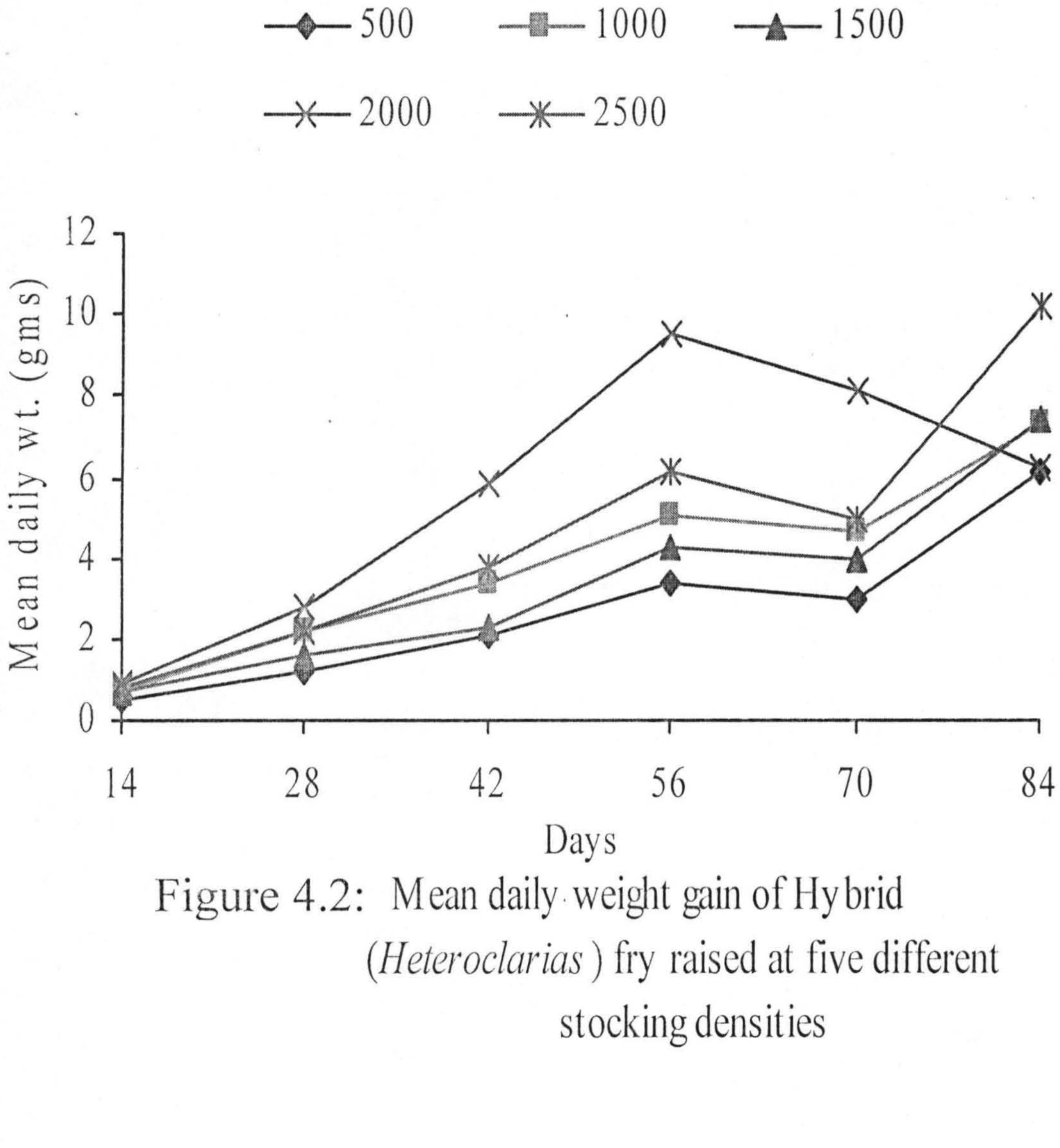


Figure 4.2: Mean daily weight gain of Hybrid (*Heteroclarias*) fry raised at five different stocking densities

On day 28, significant difference ($P < 0.05$) in the daily weight gain was observed in treatments 4 and 5 compared to treatments 1, 2 and 3 in which there were no significant difference ($P > 0.05$) when tested at 5% levels.

Figure 3 shows the specific growth rate (SGR) over time (84 days) culture period. In the treatments, no significant difference ($P > 0.05$) in SGR was observed (Appendix III). The highest specific growth rate (SGR) was 5.57g ± 0.65 S.E. measured between day 56 and 70 while the lowest SGR recorded was 4.58g ± 0.28 . measured between day 28 and 42.

On day 28, significant difference ($P < 0.05$) weight gain was apparent between treatments 4 and 5 but was not reflected in treatments 1, 2 and 3.

4.2.1 Length/Weight Relationship

The final mean length and weight relationship are shown in a regression graph as shown in Figure 4.4. In the regression analysis, the result shows that there were significant difference in the final mean length and weight $P < 0.05$ ($P = 0.03$). This showed a positive relationship between length and weight.

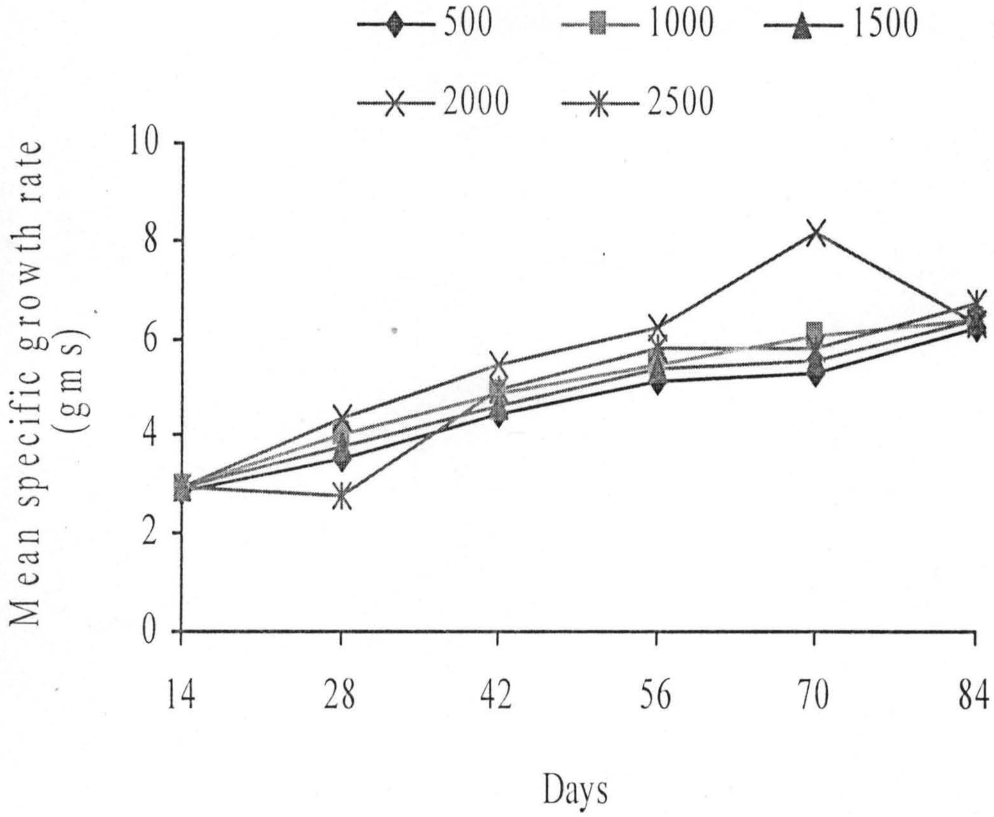


Figure 4.3: Mean specific growth rate over time of Hybrid (*Heteroclarias*) fry raised at five different stocking densities

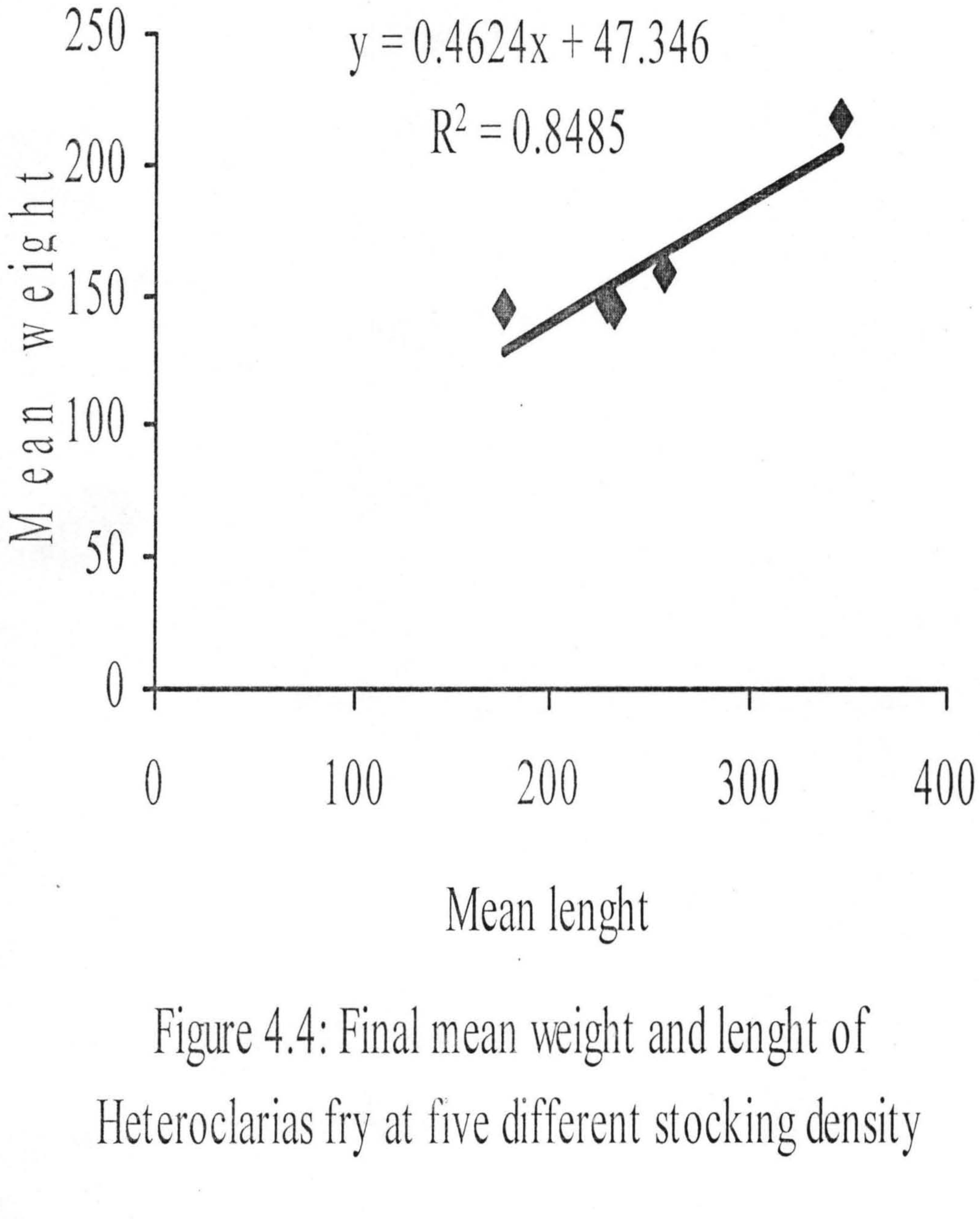


Figure 4.4: Final mean weight and lenght of Heteroclarias fry at five different stocking density

The mean length gain was highest in 2000 fish/tank, 217.00g ± 45.47 corresponding to bigger number of fast growers (jumpers), while the lowest mean length was obtained in 500 fish/tank, 145.00mm ± 8.86 with apparently uniform growth.

4.2.2 Condition Factor

A density effect upon condition factor shows that treatments 1, 2 and 3 were not significantly different ($P > 0.05$) while treatments 4 and 5 show significant difference ($P < 0.05$) as a result of high mortality rate with larger fast growers. The value obtained for treatments 1, 2 and 3 were 1.90 while treatments 4 and 5 had a mean of 1.76.

Figure 4.4 shows the total mean length of hybrid (*Heteroclarias*) fry raised at five different stocking densities.

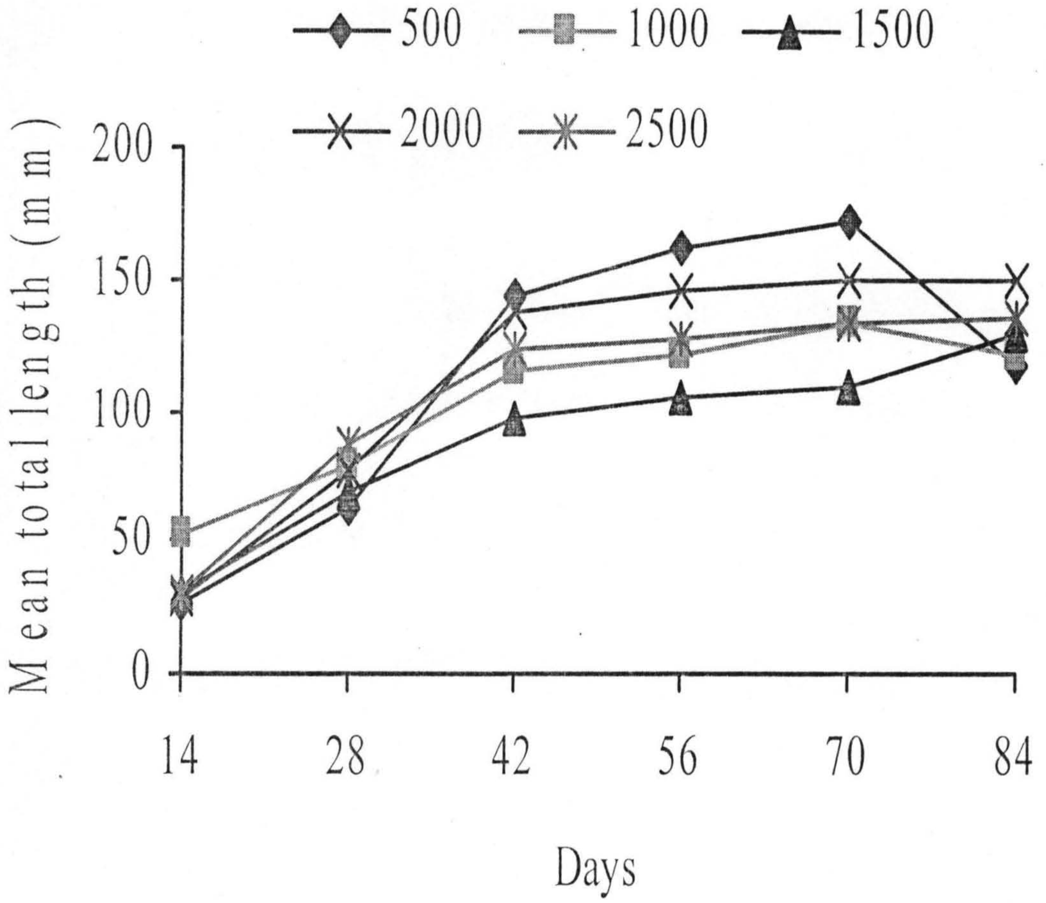


Figure 4.5: Total mean length of hybrid (*Heteroclaria* s) fry raised at five different stocking densities

No significant difference (P > 0.05) was observed in the length relationship in all the treatments.

4.3 PERCENTAGE (%) SURVIVAL

Table 6 shows the survival rates of fry of *Heteroclarias* reared in the outdoor concrete tanks. The lowest stocking level 500/tank had the highest survival (63.14%). Stocking density of 1000/tank had 43.71%, 1500/tank had survival of 39%, 2000/tank had 36.14% and 2500 had 34.87%. From the result obtained, it means that mortality was higher than survival rate.

The mean number of fast-growers was found to be highest in 2000/tank while the lowest number of fast-growers was recorded in the lowest stocking density 500/tank. Higher stocking density gave rise to bigger but fewer fast-growers (jumpers).

In this experimental trial, statistical analysis using ANOVA; testing at 5% levels shows no significant difference (P > 0.05) in the growth performance of the hybrid fish (Appendix I) but generally shows low survivability as shown in Table 4.2. Significant difference (P < 0.05) was observed between growth and survival.

4.4 PRODUCTION EFFICIENCY

The production efficiencies of the five treatments (stocking levels) were calculated from the survival data obtained and summarized in Table 4.2.

The production efficiency was generally low compared to the stocking levels. The highest production of 8.00 kg by wet weight was obtained in treatment 1 while treatments 4 and 5 had least production efficiency 3.1 kg and 2.9 respectively.

This low production is not unconnected with the high rate of cannibalism among the species and incidence of fast growers that manifested in all the treatments as indicated in Table 4.3.

Table 4.3 **Summary of Total Production of Hybrid (*Heteroclarias*) at Five Different Stocking Densities for 84 Days**

Treatment	Stocking levels	Fish/m^2	Fish/m^3	Mean Initial Wt (g)	Mean Final Wt (g)	Average Wt gain/day	Specific Growth Rate\day	Mean Initial Total Length (mm)	Mean Final Length (mm)	Number of Fish Harvested	Normal Growth at Harvest (g)	No. of Fast Growth at Harvest	% Survival	Production (kg/treatment)
1	500	125	250	0.03	176.23±43.98	2.70±0.49	4.59±0.28	9.00	145.00±8.86	200	189	11	40	8.00 kg
2	1000	250	500	0.03	228.85±52.53	3.88±0.62	4.95±0.32	9.00	146.07±09.40	127	110	17	13	4.2 kg
3	1500	375	750	0.03	232.04±53.27	3.37±0.62	4.73±3.27	9.00	145.00±21.47	90	80	10	5.3	6.5 kg
4	2000	500	1000	0.03	345.60±64.92	5.57±0.87	5.57±0.55	9.00	217.00±45.47	71	46	25	4.0	3.1 kg
5	2500	625	1250	0.03	257.80±72.98	4.69±0.83	4.78±0.42	9.00	157.27±9.15	82	66	16	3.3	2.9 kg

Values are means of treatments
Average daily weight gain = (Wt – Wo)t
Specific growth rate = 100 x (log final Wt – log initial Wo)/t
Wt and Wo represent mean final and initial body weight of fish in grams, and
t = the duration of the stocking trials in days.

CHAPTER FIVE

DISCUSSION

5.1 GROWTH

Growth of Hybrid Catfish (*Heteroclarias*) from this study is comparable to that reported for other species of fish under intensive grow-out systems. The results from this study showed that stocking densities affect growth and survival of Hybrid species of Catfish under outdoor nursery management. Some results have been obtained in other Catfish: Exotic *Clarias gariepinus, Heterobranchus bidorsalis* and other fish species like *Channa obscurus, Heterotis niloticus* and many others. Dada *et al.* (2000) observed that *Heterobranchus bidorsalis* maintained at 250 fish/m^3 grew significantly faster than when held at 750 fish/m^3.

The results of this finding does not show any definite pattern in the mean final and specific growth rate as reported by Dada and Wonah (2003) in the study of Exotic *Clarias gariepinus* held at the same stocking levels. This variance could be attributed to higher and bigger fast growers (jumpers) recorded in the present study than in the previous works.

Hybrid catfish are noted for their fast growth and exercise aggressive cannibalism than the parent species (Olufeagba, unpublished). In this study, the higher mean final weight was obtained in higher stocking level (2,000 fish/tank) with the high number of fast growers.

Fish stocked at lower density (500 fish/tank) grow more uniformly than those at higher stocking densities as shown in this trial. At 500 fish/tank, the final mean weight obtained was 176.23g ± 43.98 and percentage survival of 40% compared to those held at higher stocking levels which showed survival of between 13 – 3%.

There was no significant difference ($P < 0.05$) in the specific growth rate in this study. Dada and Wonah (2003) reported a highest specific growth rate in 500 fry/tank and lowest in the highest stocking level (2,500 fry/tank), which conformed with the finding of Dada *et al* (2000), who stated that specific growth rate decrease with increased density.

The increase in fast growers (jumpers) as stocking density increases was evidenced in this study and further supports the effect of overcrowding in fish culture. Ita *et al.* (1988) observed that at higher density, fewer but bigger jumpers developed. Growth and production of fish depend to a large extent on population density (Sidiqui *et al*, 1989).

In a survival study of *Channa obscura*, Swamy *et al* (1991) reported on growth of *Channa striatus* reared in concrete tanks and fed with food of animal origin including freshwater mussels (crushed) snails and frog chopping, live minnows, larvae and trash fish for 153 days. The result obtained showed that 254 kg was harvested at the end of 153 days. Food of animal origin contain higher protein compared to formulated feed as demonstrated in this Hybrid of Catfish trial where only 45% crude protein (formulated) was fed to the fish. Also, Qin *et al* (1996) pointed out that fish larvae fed combined diet of formulated feed and live food had significantly greater ($P > 0.05$) weight gain than species fed on formulated diet only.

In this investigation, Hybrid (*Heteroclarias*) catfish fed formulated feed (45% crude protein) did not only show good response in terms of acceptability but show significant difference in growth and survival.

The result obtained in this present study cannot be compared to what Qin *et al* (1996) obtained using formulated feed of 50% crude protein and 16.0% fat combined with live food.

In a semi-intensive culture system, Webster, Tidwel and Goodgames (1993) reported a growth increase in the juveniles of Channel catfish reared at a density of 320 fish/m^3 and fed to satiation twice daily for 110 days, the initial mean weight of the fish was 2.5 g, and a final mean weight of 1.6 kg wet weight at harvest was obtained.

The total weight of fish obtained in this trial experiment cannot be correlated to what was reported by these authors because regular sampling to remove the shooters (jumpers) and size grading was not employed in this experiment. This could be a deciding factor when culturing fish for optimum growth and survivability.

Wonah and Udo (1999) pointed out that even when fish species (carnivores) are fed *albitum,* substantial cannibalism can still occur if there is large deviation in fish sizes at stocking. Cannibalism can only be minimized through size sorting to remove large individuals on a regular basis.

It is well known that, food preferences of fish changes as individual grow older (Welcome, 1979). This is also probably true with Hybrid species; in which the smaller length groups feeds more on insects and detritus while the larger length group depend more on the smaller ones.

In this study, the concrete ponds were fertilized, using inorganic fertilizer to produce natural live food for the fish species. Since the natural food alone cannot sustain higher biomass of such species, therefore, supplementation with formulated feeds (45% crude protein) was used. According to Rubright *et al* (1981) and Garson *et al* (1986), supplementation with formulated feeds can increase fish yield.

Qin (1996) recommended that supplementation of formulated feeds to a high level carnivore such as Catfishes and *Channa obscurus* should follow an approach; larval (fry) fed with zooplankton or *Artemia nauplii* which are supplemented with formulated feeds. After 30 days of culture, gradually eliminate the live food over 7 – 10 days period. Alternatively, feed larval fish exclusively with live zooplankton or *Artemia nauplii* for 30 days to be followed with 7 – 10 days mixed feeding with both live zooplankton and formulated feeds before switching completely to formulated feeds.

This recommendation was applied in this present study. The fish larval were fed exclusively on live zooplankton for 14 days recommended for catfish by Madu (1988) and 7 – 10 days mixed feeding with zooplankton and formulated feeds before cultured in the fertilized concrete ponds and fed whole with formulated feeds (45% C.P.) for 84 days.

;.2 STOCKING LEVELS

As already state, growth and production of fish are to a certain extent dependent on the population density (Sidiqui *et al*, 1989). In this growth trial, the harmful effects that higher stocking densities had on rearing of the fry were reduction in growth and lowering of survival. A similar trend was reported by Dada *et al* (2000) for fry of *H. bidorsalis* and Dada and Wonah (2003) for fry of exotic *Clarias gariepinus* under outdoor hatchery management system.

The stocking density in this investigation is consistent with Dada *et al* (2000) for H. bidorsalis; Dada and Wonah (2003) for Exotic *Clarias gariepinus* reared in outdoor concrete ponds.

Stocking around 5 fish/m^2 has been reported to be limiting densities between extensive and semi-intensive culture systems (Herono, 1983; Lawrence, 1985). The density used in the present study does not correspond to those used by Herono (1983) and Lawrence (1985). The stocking levels used in this trial was higher; using 500 fry/tank, 1000 fry/tank, 1500 fry/tank, 2000 fry/tank and 2500 fry/tank.

According to Refstie and Kettleson (1979), fish held at lower densities grew better than those held at higher densities. Allen (1974) also reported that, mean harvestable fish weight, food conversion efficiency and survival rate decrease with increase stocking densities. The result obtained in this investigation agrees with the author's.

Dambo and Rana (1992) pointed out that, fry stocked at 15 to 20/L are affected in their growth performance when compared with those reared at 2, 5 and 10 fry/L. These authors therefore, recommended that stocking rate should decrease in favour of 2, 5 and 10/L. Rana (1981) in his report recommended 8 fry/L as optimal stocking levels for *Sarotherodon mosambicus*.

Similar reports by Dada and Wonah (2003) on varying stocking levels showed different growth range and survival. The low survival in this study could be attributed to the presence of predation as jumpers (out-growth) developed more in the higher stocking densities which agrees with other previous works. However, growth and survival were more appreciated compared to what Dada and Wonah obtained in their study *op. cit* using the same stocking levels of Exotic *Clarias gariepinus*.

The overall production, growth and survival rates as shown in Table 6 in this study is probably related to high numbers and bigger jumpers (out-growth), which is also a characteristic features of monoculture system.

The result is also in line with Olufeagba (unpublished) who claimed that Hybrid grow faster and show more aggressive cannibalism than other Catfish species.

The number of fast growers increased with increase in stocking densities as demonstrated in this study. This conforms with Ita (1988), Dada *et al* (2000), Dada and Wonah (2003) reports which stated that the number of jumpers increased with increase in stocking densities.

In this present study, the relationship between the growth, survival production efficiency and stocking densities have not been established. The stocking densities here is consistent with those employed by Dada *et al* (2000) and Dada and Wonah (2003). The result obtained in this study also indicated that growth, survival and production efficiency of Hybrid species in the different treatments were significantly different ($P < 0.005$). This agrees with Dada and Wonah (2003) reports on the growth and survival performance of *Clarias gariepinus*.

The growth rate of the species attained in the present investigation is at variance with what Dada *et al* (2000) obtained on *Heterobranchus bidorsalis* fry cultured in concrete ponds. The growth rate determined in this study is greater than what was reported for other catfish species in Dada *et al* (2000), Dada and Wonah (2003).

For animal to survive and grow, there must be enough and qualitative food available for such an organism. Eyo (1988) recommended a protein level of 45% for fry of *Heterobranchus bidorsalis* which is well within range used to obtain higher growth. This recommendation was adopted in the present investigation and the response of the species to the artificially formulated feed was appreciated.

In the culture system, at the early stages of growth, one would expect that if fish gets enough food during this period, they would have uniform growth rates at all densities. As fish grow larger however, some become aggressive and dominate, depressing the growth of others. This fact was supported by work carried out by Refstie (1977) on *Salmon* species, with larger ones (30.2g) preyed on smaller ones with lengths of 6.0 cm.

5.3 SURVIVAL

In the results obtained in this trial investigation, the survival rate was affected by the densities. There was significant difference in all the treatments ($P < 0.05$). The survival rate was greater in treatment 1 (500 fry/tank) with percentage survival of 40% and had more uniform size grade than treatments 2, 3, 4 and 5 (1000/tank 1500/tank, 2000/tank and 2500/tank) respectively. The least percentage survival was in treatments 4 and 5 (2000/tank and 2500/tank) with 4% and 3.3% respectively.

The high survival in treatment 1 (500/tank) was favoured by the low stocking density and was recommended as the normal stocking level for Catfish fry (Dada *et al*, 2000). Generally, the lower level of survivability could be attributed to high cannibalism as a result of high and bigger out-growth (jumpers). Natural mortality of the species was poorly measured because most of fish were lost due to sibling cannibalism and the predation of smaller ones by the bigger fast growers.

The overall percentage survival obtained during the 84 days study period was affected by the number of fast growers obtained apparently in all the stocking levels. The number of fast growers was high and bigger in the higher stocking levels (1500/tank, 2000/tank and 2500/tank).

The result obtained in this experiment agrees with that of Ita *et al* (1988) which pointed out that, at higher density, fewer and bigger jumpers develop. At 2500 fish/tank, 16 jumpers were obtained with mean weight of 140 g. The differential growth exhibited by Catfishes have other negative effects. The effect of competition among species was highlighted by Doyle and Talbot (1986). These authors reported that allocation of resource (food and space) control relative growth rates. A disproportionate amount of food goes to superior competitors which subsequently grow faster. According to Koebele (1985), if there is no disproportionate food acquisition, there will not be size difference effect. Once a size difference exists in a population established, the smaller fish are inhibited from feeding satisfactorily because of the presence of the large individuals.

The sharp increase in growth rate as recorded in treatment 3, 4 and 5 were the results of fewer but bigger jumpers which also affects the survival in these treatments. The analysis of the survival however, was the losses caused by predations.

5.4 WATER QUALITY

The water quality parameters was well within the acceptable limit reported by many authors. Table 2 showed the summary of the water quality parameters taken during the experimental period. The parameters taken include Temperature, Dissolved Oxygen, Conductivity, pH and Secchi disk reading.

In this study, the mean temperature obtainable was 25°C ± 3.27 S.E. The range fell within the period of dried-cool season (Hamattan season). The range obtained is within an acceptable limit for fish growth.

The Dissolved Oxygen (mg/L) in all the tanks were normal at a mean of 4.7 mg/L ± 0.05. Reports by workers indicated that temperature and dissolved oxygen (DO) affect the activities, behaviours, feeding and growth of fish (Dupree and Huner, 1984). A Temperature range of 24.2°C – 24.8°C is considered low at this period of the year but it was observed that the fish responded to feeding activity, showing that catfish species can thrive well even in cool environment. Dissolved oxygen range of 3.20 – 6.20 was acceptable in warm water fish culture (Boyd and Lichkoppler, 1977; Dupree and Huner, 1984). 0.18 g/m^2 of calcium carbonate (Agric lime) was applied at 7 days interval to maintain the pH level of 7.0 ± 0.13 during the study period.

A water fertility index was measured as a result of the application of inorganic fertilizer for primary productivity of the rearing tanks. This was measured in terms of phytoplankton count/ml in all the treatments.

Table 5.1. Water Quality Index

ALGAL COUNT/ML					
FAMILY- CHLOROPHYCAE (GREEN ALGAE)		BACIULLARIOPHYCAE (DIATOM)		CYNOPHYCAE (BLUE-GREEN ALGAE)	
Species	**Count/mL**	**Species**	**Count/mL**	**Species**	**Count/mL**
Scenedesmus	16	Synedra	16	Anacytist	10
Chlorella	27	Melosira	18		
		Pedeastrum	21		
		Staurastrum	15		
Total	**43**		**70**		**10**

The amount of algae count present in the family of Chlorophycae (green algae) and Bacellamophycae (Diatom) indicate a good fertility while Cynophbycae (blue-green algae) an index of water pollution was at minimal level as shown in Table 8.

The implications of these results of the water quality are related to the performance of the fish. The water quality parameters were at the optimal levels necessary for growth and survival of the experimental fish. The poor performance for this trial investigation in the concrete ponds cannot be traced to water quality but probably to overcrowding, bigger number of fast growers (jumpers) and predation apparently in all the treatments.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

It could be deduced from this study that, the result obtained showed that the growth and survival rate of fry of Hybrid (*Heteroclarias* sp) in the outdoor concrete tanks were related to the stocking densities and rate of cannibalism.

This investigation shows that the overall production was considerably affected by the densities. It could be recommended here that stocking at 500/tank measuring 2 x 2 x 1 ($4m^3$) is ideal. In the same vein, stocking of fry may not be advantageous to fish farmers because of the inherent growth differences among the species that results in high levels of cannibalisms by the fast growers as evidenced in this study.

Therefore, it could also be recommended that fish farmers should stock graded sizes of fingerlings at a rate of 5 – 10 fingerlings/m^2 to enhance uniformity in survival and growth for optimum production.

In order to obtain optimal production of fish in 2 x 2 x 1/m^3 ($4m^3$) concrete tanks, certain management procedures should be adopted. These include a water exchange interval of two times in 7 days to improve Dissolved Oxygen of the rearing water.

In addition, weekly sampling to remove the fast growers (jumpers) is recommended to eliminate predators and enhance increase production. In some cases, regular sampling will help to reduce the incidence of insect predation, removal of frogs and other unwanted animals in the rearing tanks.

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APPENDIXES

APPENDIX I: ONE-WAY ANALYSIS OF VARIANCE FOR TOTAL WEIGHT

One- Way Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Sig. Prob.
Between Groups	4	277082.0421	69270.5105	1.1270	.3493
Within Groups	85	5224504.239	61464.7557		
Total	89	5501586.281			

Count	Mean	Std Dev	Std Error	95 Pct Interval	Turkey Mean
18	176.2322	186.6207	43.9869	83.4280	269.0365
18	228.8556	222.8836	52.5342	118.0181	339.6930
18	232.0444	226.0233	53.2742	119.6457	344.4432
18	345.6000	275.4383	64.9214	208.6278	482.5722
18	257.8000	309.6234	72.9789	103.8279	411.7721
Total 90	**248.1064**	**248.6274**	**26.2076**	**196.0324**	**300.1804**

Mean		
176.2322	Treat 500	
228.8556	Treat 1000	
232.0444	Treat 1500	
257.8000	Treat 2000	
345.6000	Treat 2500	*

(*) Indicate significant differences

APPENDIX II: ONE-WAY ANALYSIS OF VARIANCE FOR AVERAGE DAILY WEIGHT

Daily growth rate of Hybrid (*Heteroclarias*) at the end of 84 days experimental period

One –Way Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Sig.
Between Groups	4	89.9551	22.4888	2.5442	.0453
Within Groups	85	751.3230	8.8391		
Total	89	841.2780			

	Count	Mean	Std Dev	Std Error	95 Pct Interval	Turkey mean
	18	2.7044	2.0993	.4948	1.6605	3.7484
	18	3.8800	2.6319	.6203	2.5712	5.1888
	18	3.3861	2.6525	.6252	2.0671	4.7051
	18	5.5706	3.6749	.8662	3.7431	7.3980
	18	4.6867	3.5102	.8274	2.9411	6.4322
Total	**90**	**4.0456**	**3.0745**	**.3241**	**3.4016**	**4.6895**

Mean	Type	
2.7044	T500	
3.3861	T1000	
3.8800	T1500	
4.6867	T2000	*
5.5706	T2500	* *

(*) Indicate significant differences

APPENDIX III: ONE-WAY ANALYSIS OF VARIANCE FOR SPECIFIC GROWTH RATE

One –Way Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Sig. Prob.
Between Groups	4	10.6145	2.6536	1.0213	.4011
Within Groups	85	220.8613	2.5984		
Total	**89**	**231.4758**			

Multiple range analysis for specific growth rate

	Count	Mean	Std Dev	Std Error	95 Pct Interval	Turkey Mean
	18	4.5856	1.2082	.2848	3.9847	5.1864
	18	4.9550	1.2851	.3029	4.3159	5.5941
	18	4.7356	1.1683	.2754	4.1546	5.3165
	18	5.5711	2.3189	.5466	4.4179	6.7243
	18	4.7828	1.7715	.4176	3.9018	5.6637
Total	90	**4.9260**	**1.6127**	**.1700**	**4.5882**	**5.2638**

Mean		
4.5856.1.1.1	Treat 500	
4.7356	Treat 1000	
4.7828	Treat 1500	*
4.9550	Treat 2000	*
5.5711	Treat 2500	**

(*) Indicate significant differences

APPENDIX IV: ONE-WAY ANALYSIS OF VARIANCE FOR TOTAL LENGTH

One-Way Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Sig. Prob.
Between Group	4	56.1152	14.028	.5610	.6917
Within	70	1750.4947	25.0071		
Total	74	1806.6099			

Multiple range analysis for total weight

	Count	Mean	Std Dev	Std Error	95 Pct Interval	Turkey Mean
	15	14.5000	3.4320	.8861	12.5994	16.4006
	15	14.6067	3.6411	.9401	12.5903	16.6231
	15	14.5000	8.3159	2.1472	9.8948	19.1052
	15	16.6600	4.2765	1.1042	14.2918	19.0282
	15	15.7267	3.5435	.9149	13.7643	17.6890
Total	75	15.1987	4.9410	.5705	14.0618	16.3355

Mean	Type
14.5000	Treat500
14.5000	Treat1000
14.6067	Treat1500
15.7267	Treat2000
16.6600	Treat2500 ***

(*) Indicate significant differences

APPENDIX V: LENGTH/WEIGHT RELATIONSHIP ANALYSIS

Regression

Statistics

Analysis

Regression Statistics	
Multiple R	0.921117
R Square	0.848456
Adjusted R Square	0.797942
Standard Error	27.88562
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	13060.92	13060.92	16.79628	0.02627865
Residual	3	2332.823	777.6076		
Total	4	15393.74			