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GROWTH PERFORMANCE AND SURVIVAL OF *Clarias gariepinus* UNDER VARYING STOCKING DENSITY

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ABSTRACT

The experiment evaluated the growth performance and survival of *Clarias gariepinus* under varying stocking density. Three-day-old hatchlings (15,750 in number) were selected from the bred population after absorption of their yolk sac and were randomly stocked at three different densities of 40 fish/litre (T1), 20 fish/litre (T2) and 10 fish/litre (T3). The fish were sampled every 10 days for 60 days. The result showed that fish in T3 has the highest mean final weight which was not significantly different ($p>0.05$) from the value recorded in T2 but was significantly different ($p<0.05$) from the value recorded in T1. There was no significant difference ($p>0.05$) in the specific growth rate among the treatments, the highest was recorded in T3 while the least was recorded in T1. The highest performance index was recorded in T3 and was significantly different ($p<0.05$) compared to other treatments with higher stocking densities, the least was recorded in treatment with the highest stocking density (T1). The percentage survival (58.80±2.55) at the end of the experiment in T3 was significantly higher compared to T1 (16.72±1.72) and T2 (28.97±0.58). It could be concluded that lower stocking density will increase the survival as well as enhance the growth performance of *C. gariepinus* fingerlings.

Keywords: Aquaculture, Fish fry, Hatchery, Stocking density

INTRODUCTION

The production of fast-growing fry is vital to the development of a viable aquaculture venture for enhanced protein security (Young-Sulem and Brummett, 2006). Aquaculture production in Nigeria has increased vastly due to high demand for fish protein. Nigeria is the largest aquaculture producer, largest fish consumer in Africa and among the world largest consumer with over 1.5 million metric tons consumed annually (Ekunwe and Emokaro, 2009). However, with the domestic catch estimated at 450,000 metric tons/year, the country has to bridge the gap with importation which accounted for over 900,000 metric tons (Ozigbo *et al.*, 2013).

Rearing of the early life stages of fish (fry and post fry) is the most critical aspect of aquaculture (Madu *et al.*, 1990; Ibrahim *et al.*, 2008). Fish at these stages are very delicate and highly sensitive to the various factors of production. The fast growth rate, hardiness, air-breathing characteristics, attractive market price and ease of breeding in captivity of *Clarias gariepinus* has led to its use in aquaculture (Olurin *et al.*, 2012; Ndimele and Owodeinde, 2012). Many researches have been conducted on its nutrition (Yong-Sulem *et al.* 2006a; Adewolu *et al.*, 2008), production of fingerlings (Yong-Sulem *et al.* 2006b; Toko *et al.*, 2007) among others.

There have been emphasises on stocking density as significant aspect of aquaculture practice, which is linked with problems such as reduction in feed conversion efficiency, condition factor and growth (Ellis *et al.*, 2002). Stocking density can be defined as the weight of fish per unit volume or per unit volume in unit time of water flowing through or contained in the holding environment (Ashley, 2007). The effect of stocking densities on the early life stages of C. *gariepinus* is scarcely available (Olurin *et al.*, 2012). At high densities, there is a competition for space which increases social interaction and in turn, causes social stress, thereby affecting reproductive efficiency (Uedeme-Naa and Nwafili, 2017). Although the hatchlings are produced in large quantity in the hatcheries, mortality of these larvae within the first month of life poses a big problem to hatchery operators (Madu and Ufodike, 2001). The effect of fry stocking density on survival, growth and performance index of *C. gariepinus* is, therefore, necessary to be investigated.

MATERIALS AND METHOD

Experimental site

The experiment was carried out at the Hatchery Unit of Motherhood Freshwater Fish Farms, Obantoko, Abeokuta, Ogun State, Nigeria.

Selection of Broodstocks

Six (6) gravid broodstocks (3 males and 3 females) of *Clarias gariepinus* with body weight range of 1200-2000 g were procured from a reputable fish farm in Abeokuta, Ogun State. They were maintained under temperature range of 25-29 °C and fed with 40% crude protein commercial diet. The selected samples were properly maintained separately in a holding tank of 1.5 x 0.7 x 1 m^3 before being used for breeding.

Artificial breeding

Matured female broodstock were injected with a single dose of artificial hormone called Ovaprim according to the method of Goudie *et al.* (1992). The hormone is a low viscous liquid containing 20 µg Salmon gonadotropin-releasing hormone (GnRH) and 10 mg of dopenridone, which is a dopamine antagonist. The recommended dosage of the hormone by the manufacturer is 0.5$mlkg^{-1}$ of female's body weight. The fish were stripped for eggs after twelve hours at water temperature of between 25-30 °C according to the method described by De Graaf *et al.*, (1995).

Milt was obtained by sacrificing the male and testes removed. The testes were cleaned with filter paper to remove blood stain. The milt in the testes was obtained by piercing the testes with razor blade and squeezed it directly on the eggs. The milt and eggs were gently mixed with a plastic spoon for 5 minutes as described by De Graaf *et al.*, (1995)

Incubation of eggs

Fertilized eggs were spread on a rectangular framed mosquito's netting material of 1.5 mm mesh size in glass aquarium incubation tanks of 1 x 0.4 x 0.35 m^3. Aeration was maintained by water flow through system and supported with aerator. Hatching occurred at a time range of 24 – 26 h at temperature ranging between 26 and 30 °C and care of hatchlings commenced immediately. Hatchlings were separated from deformed larvae by removing the meshed net with un-hatched eggs out of the incubation tank. While the hatchlings clustered at dark corners of the incubation tank. 1.5 mm rubber hose was used to clean out the rearing tank as part of the general sanitation.

Experimental design and set-up.

Three stocking densities considered as treatments were used for this study, with each treatment replicated thrice in a completely randomized design (CRD), which makes a total of nine (9) experimental units. Nine (9) experimental tanks 0.6 x 0.25 x 0.5 m^3 in dimension were used for the experiment. Each experimental unit was stocked with different stocking densities ranging from 10 to 40 fish/litre. Each tank was filled with water up to ¾ capacity (56 litres). Exactly 15,750 three days old hatchlings were selected from the bred population after absorption of their yolk sac and were randomly distributed into the tanks. The fish were stocked at three different densities as shown below.

Treatment 1 = 40 fish/litre
Treatment 2 = 20 fish/litre
Treatment 3 = 10 fish/litre

The fish were reared under a flow through system, at a constant flow rate of 6 litre/minute for 60 days rearing period. The hatchlings were fed with decapsulated artemia for 14 days. After which they were fed with 0.5 mm and 1 mm commercial feed. The fish were fed to satiation throughout the period of experiment. The weights of the hatchlings were determined using sensitive electronic balance (Torbal AGZN120). During the experiment, leftover feed and wastes were siphoned out twice daily, in the morning (7.00 h) and in the evening (16.00 h). Dead fish in each of the tanks were recorded.

Survival and Mortality rates

Percentage mortality and survival rates were determined with the formula described by Bargenal, (1978):

$$\text{Percentage Survival} = \frac{\text{Cumulative Survival}}{\text{Total number stocked}} \times 100$$

Growth parameters

The growth parameters determined were weight gain, specific growth rate and daily growth rate (DGR) according to the method described by Kim *et al.,* (1996).

$$Wieght\ gain\ (w) = Final\ weight\ (Wt) - Initial\ weight\ of\ fish\ (Wi)$$

$$Specific\ growth\ rate\ (SGR, \%\ per\ day) \frac{(Loge\ Wt - Loge\ Wi)x\ 100}{D}$$

$$DGR = \frac{Wt - Wi}{D * Wi}$$

Where Loge, Wi and Wt are the natural logarithm, initial and final mean weight respectively and 'd' represents the number of feeding days.

Performance index

To evaluate the effect of stocking density on production performance with more precision, the performance index (PI) was calculated (Zacharia and Kakati 2002; Mohanty, 2004). This index was calculated by combining two responses such as growth and survival.

$$\text{PI} = \text{Survival rate x} \frac{\text{Final mean body weight (mg)} - \text{initial body weight (mg)}}{\text{Duration of rearing(days)}}$$

Water parameters

Water quality parameters including temperature, dissolved oxygen (DO), pH and conductivity were monitored daily at 6.30 am. Temperature was measured with mercury in-glass thermometer, pH, dissolved oxygen (DO) and turbidity were determined using HANNA 4 in 1 (MODEL 198129). Ammonia, nitrate, chlorides, nitrite and ammonium were tested with Merck test kits 3 days per week.

Statistical Analysis

The data were analysed for significant differences ($P<0.05$) by Analysis of Variance (ANOVA) using computer Statistical Package for Social Sciences (IBM SPSS version 20). The differences among the means were separated using Duncan Multiple Range Test (DMRT).

RESULT

The growth response of *Clarias gariepinus* stocked at varying densities (Table 1) showed that fish stocked at 10 fish/litre (T3) had the highest mean final weight followed by fish stocked with 20 fish/litre (T2) while the least final weight value was recorded in fish stocked at 40 fish/litre (T1). The value of final weight of fish in T3 was not significantly different ($p>0.05$) from fish in T2 but was significantly different ($p<0.05$) from the fish in T1. The mean weight gain follows the same trend as the mean final weight in this study.

Table 1: The growth response of *Clarias gariepinus* stocked at varying densities in same sized tank

Parameters	T1	T2	T3
Initial Weight (g)	0.02±0.00	0.02±0.00	0.02±0.00
Final Weight (g)	2.48±0.19 [b]	2.97±0.03 [a]	3.13±0.01 [a]
Mean weight gain (g)	2.45±0.20 [b]	2.95±0.03 [a]	3.10±0.01 [a]
Specific growth rate (%/day)	7.79±0.20	8.15±0.05	8.17±0.05
Survival (%)	16.72±1.72 [c]	28.97±0.58 [b]	58.80±2.55 [a]
DGR (%)	1.80±0.22	2.21±0.07	2.22±0.07
Performance Index	0.69±0.12 [c]	1.43±0.02 [b]	3.04±0.13 [a]

[abc] Means with same superscript along the same row are not significantly different ($p>0.05$)

The highest value of specific growth rate (SGR) was recorded in fish stocked at 10 fish/litre (T3) while the least value of SGR was recorded in T1. However, there was no significant difference ($p>0.05$) in the specific growth rate among the treatments. The daily growth rate of fish in all the treatment follows the same trend as the specific growth rate.

In this study, it was recorded that treatment 3 recorded the highest percentage survival followed by fish in T2 while the fish in T1 had the least value of percentage survival. However, the percentage survival in T3 was statistically different ($p<0.05$) from T1 and T2. There was significant difference ($p<0.05$) between T1 and T2 in terms of their percentage survival.

The result showed that the performance index (PI) was highly significant at higher stocking densities. The highest performance index was recorded in T3 (10 fish/litre) and it was significantly different ($p<0.05$) compared to other treatments with higher stocking densities. The least value of performance index was recorded in treatment with the highest stocking density (T1)
The growth pattern of *Clarias gariepinus* stocked at varying densities (Figure 1) revealed that the fish growth in all the treatments was almost the same at the first 20 days and began to show differences in their growth pattern before day 30. It was observed that T3 which has the least stocking density has a better growth curve followed by T2 with 20 fish/litre stocking density while the least was observed in T1 with 40 fish/litre.

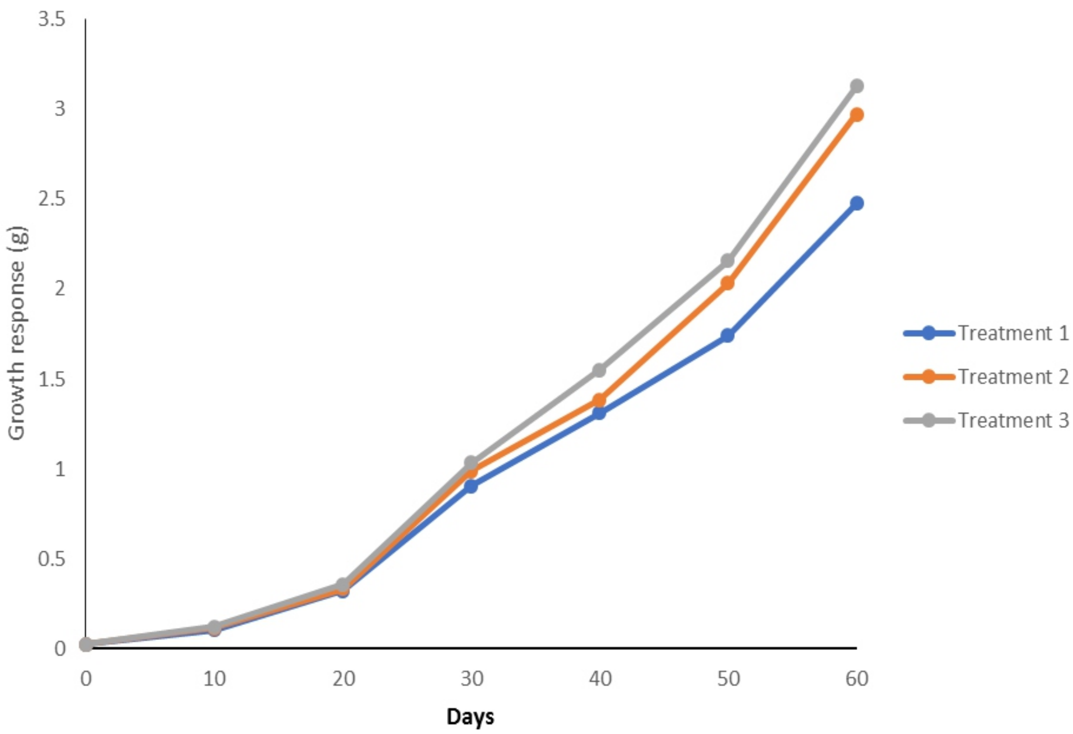

Figure 1: Growth pattern of *Clarias gariepinus* stocked at varying densities in same sized tank

The mean cumulative mortality and survival rates for *Clarias gariepinus* fry stocked at different densities (Tables 2 to 4) revealed that the percentage mortality increases with increased stocking density while the percentage survival is inversely related to percentage mortality. The 40 fish/litre treatment showed that percentage mortality increases geometrically from day 10 to 30.

In treatment stocked with 20 fish/litre, the percentage mortality at the end of the experiment was 14.5% and the variation was not as large as those stocked at 40 fish/litre. The percentage survival in T2 was 85.5% which is significantly higher than percentage mortality.

The percentage cumulative survival in T3 (79.33) at the end of the experiment was higher than the value (20.67%) of percentage cumulative mortality.

Table 2: Mean cumulative Mortality and Survival Rates for *Clarias gariepinus* Fry stocked at 40 fish/litre for 60 days

Period (Day)	Mortality	% Cumulative Mortality	Survival	% Cumulative Survival
0	0	0.00	2000.00	100.00
10	194.00	9.70	1806.00	90.30
20	438.33	21.92	1561.67	78.08
30	783.00	39.15	1217.00	60.85
40	859.00	42.95	1141.00	57.05
50	1030.33	51.52	969.67	48.48
60	1119.33	55.97	880.67	44.03

Table 3: Mean cumulative Mortality and Survival Rates for *Clarias gariepinus* Fry stocked at 20 fish/litre for 60 days

Period (Day)	Mortality	% Cumulative Mortality	Survival	% Cumulative Survival
0	0	0.00	1000.00	100.00
10	63.00	6.30	937.00	93.70
20	114.67	11.47	885.33	88.53
30	119.33	11.93	880.67	88.07
40	122.67	12.27	877.33	87.73
50	129.33	12.93	870.67	87.07
60	145.00	14.50	855.00	85.50

Table 4: Mean cumulative Mortality and Survival Rates for *Clarias gariepinus* Fry stocked at 10 fish/litre for 60 days

Period (Day)	Mortality	% Cumulative Mortality	Survival	% Cumulative Survival
0	0	0.00	500	100.00
10	43.33	8.67	456.67	91.33
20	52.00	10.40	448.00	89.60
30	65.33	13.07	434.67	86.93
40	79.00	15.80	421.00	84.20
50	82.67	16.53	417.33	83.47
60	103.33	20.67	396.67	79.33

The mean water quality parameter for pH, temperature, dissolved oxygen, ammonia, nitrite and nitrate of the various concentrations did not vary significantly ($P < 0.05$) among the treatments. The mean value recorded for the various treatment levels were within the same range as shown in table 5. The mean value of temperature recorded in all the treatments was 28±2.5 °C while the mean values for pH, dissolved oxygen and turbidity were 7.2±0.8, 6.4±0.62 and 5.04±0.1 respectively.

Table 5: The mean water quality parameter

Parameters	T1	T2	T3
Temperature (°C)	29±2.5	28±2.2	27±2.6
pH value	7.3±0.6	7.2±0.8	7.0±0.9
Dissolved Oxygen (mg/L)	5.9±0.62	6.0±0.56	6.5±0.52
Ammonia (NH_3) (mg/L)	0.5±0.04	0.5±0.02	0.5±0.01
Nitrate (NO_3^-) (mg/L)	0.05±0.00	0.05±0.00	0.05±0.00
Turbidity (NTU)	5.40±0.2	5.00±0.3	5.00±0.1
Total solids (mg/ L)	262±13.5	259±10.5	255±9.5
Chlorides (ppm)	33±10.8	32±10.6	30±11.8
Nitrite (NO_2^-) (mg/L)	0.01±0.00	0.01±0.00	0.01±0.00
Ammonium (NH_4^+) (mg/L)	0.02±0.00	0.02±0.00	0.02±0.00

DISCUSSION

Stocking density influenced environmental conditions in culture tanks, which, in turn determines growth and survival of the fish. High accumulation of metabolic wastes arising from higher density of post fry led to significant concentrations of nitrogen compounds and simultaneously lowered oxygen in T1 and T2. Low levels of dissolved oxygen and pH are considered limiting factors in intensive fish culture. For example, low levels of dissolved oxygen have been attributed to decreasing growth in channel catfish (*Ictalurus punctatus*) larvae reared in tanks (Brazil and Wolters, 2002). In general, poor growth performance of cultured species takes place at pH < 6.5 (Mount, 1973). Nevertheless, the values of water quality parameters observed in this study fall within the range (3-9 mg/L for dissolved oxygen), (24 – 32 °C for temperature) and (6.5-9 for pH) reported by Boyd (1979) as the best for tropical fishes.

At high densities, there is a competition for space which increases social interaction and in turn, causes social stress, thereby affecting reproductive efficiency (Uedeme-Naa and Nwafili, 2017).

The effect of stocking density on growth (SGR and MDWG) and performance index (PI) was highly significant at higher stocking densities (T1 and T2). This implies that yield would be higher at T3 stocking densities than at T1 and T2. Under crowded conditions, fish suffer stress as a result of aggressive feeding interaction and eat less, resulting in growth retardation (Bjoernsson, 1994). The results indicated that fry of *C. gariepinus* stocking densities above 20 fish/litre will compromise growth. In a study on the effect of stocking density on growth and survival of *C. batrachus* larvae reared in tanks, Sahoo *et al.* (2004) reported similar effects of high stocking densities on growth and SGR.

On the other hand, Haylor (1992) reported that stocking density did not affect survival of C. *gariepinus* fry reared in floating cages. However, Jamabo and Keremah, (2009) reported that survival rate, mean body weight, mean total length and specific growth rate were stocking density-dependent for C. *gariepinus* fingerlings, which substantiates the findings of the present study. In fish stocked with 20 fish/litre, the percentage mortality at the end of the experiment was 14.5% and the variation was not as large as those stocked at 40 fish/litre. The percentage survival in this (T2) was 85.5% which was greatly higher than percentage mortality in the same treatment. However, De Graaf *et al.* (1995) reported a survival rate of 41.5% for *C. gariepinus* reared under a medium stocking density for a short duration in protected tanks. These observed differences might have been caused by water quality management, rearing condition and the culturing system.

At the 20th day of the experiment, the percentage cumulative survival in fish stocked at T1, T2 and T3 were 78.08%, 88.53% and 89.60%. For low survival rate of treatment 1 and 2 it might be due to cannibalistic behaviour of this fish. After a 15-day feeding period of intensive rearing of *Clarias gariepinus* larvae at a stocking density of 20/L by Appelbaum and Damme, (2007) fish reached a mean weight of 141.0 mg. Survival after 15 days was higher than 78% in all densities. He reported that cannibalism was the main cause of mortality and was responsible for losses of up to 28% after 45 days. This work agreed with the present study. Cannibalism was influenced by the stocking density, food availability and size (Al-Hafedh and Ali, 2004).

The fish stocks at 10 fish/litre (T3) had the highest mean final weight followed by fish stocked with 20 fish/litre (T2) while the least final weight value was recorded in fish stocked at 40 fish/litre (T1). This was in line with the work of Agbebi *et al.*, (2009) who recorded highest weight gain values in Clariobranchus fingerlings stocked with lower densities (20 to 40 fish/m^3) compared with those stocked at higher densities (60 to 80 fish/m^3). He recorded same trend with the final weight of the fish which corroborate the result obtained in this study. This shows that increased stocking density will significantly reduce the growth of fish. Jha and Barat (2005) observed similar trend where fish growth was confirmed to be dependent on stocking densities. He concluded that higher stocking density may cause the crowding of fish and reduce their growth significantly. Bjoernsson, (1994) attributed the effects of high stocking density to aggressive feeding interaction among the fish which may lead to stressful condition in the fish and eventually resulting in growth retardation.

The highest value of specific growth rate was recorded in fish stocked at 10 fish/litre (T3) while the least value of SGR was recorded in T1. However, there was no significant difference ($p>0.05$) in the specific growth rate among the treatments. Madu, (1989) ascertained that fish stocked at higher densities showed a significant decrease in the specific growth rate compared to those at the lower stocking densities. Suziki *et al.*, (2001) observed that increase in stocking density will lead to higher energy dissipation causing a reduction in growth rate and food utilization.

It was observed that T3 (10 fish/litre) which has the least stocking density has a better growth curve followed by T2 with 20 fish/litre stocking density while the least was observed in T1 with 40 fish/litre. This was in agreement with the observation of Kuronuma and Fukusho (1984) who reported that sea bass reared in tanks with lower initial density of larvae had higher survival rate. It was stated that the optimum stocking density for larval catfish was 100/m^2 (De Graaf *et al.*, 1995).

CONCLUSION

Stocking density is one of the substantial factors in the production systems for aquatic organisms. In this study, the highest performance index, final weight, weight gain and daily growth rate were recorded in treatment with lowest stocking density. It could be concluded that lower stocking density will enhance the survival, growth rate and performance of *Clarias gariepinus* fry.

REFERENCES

Adewolu M.A., Adeniji C.A., Adejobi A.B. (2008). Feed utilization, growth and survival of *Clarias gariepinus* (Burchell 1822) fingerlings cultured under different photoperiods. *Aquaculture,* 283(1-4): 64-67.

Agbebi O., Ajagbe O., Makinde L. and Afolabi O. (2009). Production, Growth and Effect of varying stocking densities of Clariobranchus fry. *Journal of Fisheries International*, 4 (4): 73-78, 2009

Al-Hafedh Y. S. and Ali S. A. (2004). Effects of feeding on survival, cannibalism, growth and feed conversion of African catfish, *Clarias gariepinus* (Burchell) in concrete tanks. *Journal of Applied Ichthyology, 20 : 225–227*

Appelbaum, S. and P.V. Damme, (2007). The feasibility of using exclusively artificial dry feed for the rearing of Israeli *Clarias gariepinus* (Burchell, 1822) larvae and fry. *Journal of Applied Ichthyology*, 4(3): 105-110.

Ashley P.J. (2007) Fish welfare: Current issues in aquaculture. *Applied Animal Behavior Science*, 104: 199-235.

Bagenal T.B. (1978). Aspects of fish fecundity. In: S.D. Gerking (Ed) Ecology of Freshwater Fish Production. Blackwell Scientific Publications, Oxford: 75-101.

Bjoernsson B. (1994) Effect of stocking density on growth and survival of halibut (*Hippoglossus hippoglossus*) reared in large circular tanks for three years. *Aquaculture,* 123: 259-271.

Boyd C.E. (1979). Water quality in warm water fishponds. Auburn. Craftmaster printers, Opelika. P. 359.

Brazil B.L. and Wolters W.R. (2002). Hatching success and fingerling growth of channel catfish cultured in ozonated hatchery water. *North American journal of Aquaculture,* 64 (2): 144 – 149.

De Graaf, G.J., Galemoni, F. and Banzoussi, B. (1995). The artificial reproduction and fingerling production of the African catfish *Clarias gariepinus* (Burchell 1822) in protected and unprotected ponds. *Aquaculture Research*, 26: 233-242.

Ekunwe, P.A and Emokaro, C.O. (2009). Technical Efficiency of Catfish Farmers in Kaduna, *Nigeria Journal of Applied Sciences Research*, 5(7): 802-805.

Ellis T., North B., Scott A.P., Bromage N.R., Porter M. and Gadd D. (2002) The relationship between stocking density and welfare in farmed rainbow trout. *Journal of Fish Biology,* 61: 493-531.

Goudie C.A., B.A. Simco, K.B. Davis, N.C. Parker (1992). Reproductive performance of pigmented and albino female channel catfish induced to spawn with HCG or Ovaprim. *Journal of World Aquaculture Society*, 23: 138 – 145.

Haylor G.S. (1992) controlled hatchery production of *Clarias gariepinus* (Burchell, 1822): growth and survival of fry at higher stocking density. FAO, 22: 405-422.

Ibrahim M.S.A., Mona H.A., Mohammed A. (2008) Zooplankton as live food for fry and fingerlings of Nile Tilapia (*Oreochromis niloticus*) and Catfish *Clarias gariepinus* in Concrete ponds. Central Laboratory for Aquaculture Research (CLAR), Abbassa, Sharkia, Egypt. *8th International Symposium on Tilapia in Aquaculture*, pp 757-769.

Jamabo N.A., Keremah R.I. (2009) Effect of stocking density on the growth and survival of the fingerlings of *Clarias gariepinus*. *Journal of fisheries international,* 4: 55-57.

Jha P., Barat S. (2005b). Management induced changes in food selection, growth and survival of koi carp, *Cyprinus carpio* var. *koi* L., in tropical ponds. *The Israeli Journal of Aquaculture – Bamidgeh,* 57: 115–124.

Kim, J., Massee, K.C. and Hardy, R.W., (1996). Adult Artemia as food for first feeding Coho salmon (*Onchorhynchus kisutch*). *Aquaculture*, 144: 217-326.

Kuronuma, K., and Fukusho, K. (1984). Rearing of marine fish larvae in Japan. Ottawa, out., IDRC. p. 109.

Madu C.T., Udodike E.B.C., Ita E.O. (1990) Food and feeding habits of hatchlings of mudfish *Clarias anguillaris* (L). *African Journal of Aquatic Science*, 5: 27-31.

Madu C.T., Ufodike E.B.C. (2001). Growth and Survival of Mudfish, (*Clarias anguillaris*). Hatchlings fed various natural and artificial feeds as test starter diets for indoor nursery management. *Journal of Aquatic Sciences,* 16 (2): 127-131.

Madu, C.T. (1989). Hatchery management of the mudfish, *Clarias anguillaris* (L.). PhD. Thesis. University of Jos, Nigeria, pp:215

Mohanty R.K. (2004) Density-dependent growth performance of Indian major carps in rainwater reservoirs. *Journal of Applied Ichthyology*, 20: 123-127.

Mount D.I. (1973) Chronic exposure of low pH on fathead minnow's survival, growth and reproduction. *Water Research*, 7: 987-993.

Ndimele, P.E., F. G. Owodeinde, (2012). Comparative Reproductive and Growth Performance of *Clarias gariepinus* (Burchell, 1822) and Its Hybrid Induced with Synthetic Hormone and Pituitary Gland of *Clarias gariepinus*. *Turkish Journal of Fisheries and Aquatic Sciences*, 12: 619-626.

Olurin, K.B., P.O. Iwuchukwu and O. Oladapo (2012). Larval rearing of African catfish, *Clarias gariepinus* fed decapsulated Artemia, wild copepods or commercial starter diet. *African Journal of Food Science and Technology*, 3(8): 182-185.

Ozigbo Emmanuel, Anyadike Chinenye, Forolunsho Gbadebo, Okechuckwu Richardson, Kolawole Peter (2013). Development of an Automatic Fish Feeder" International Institute of Tropical Agriculture Postharvest Unit, Ibadan. *African Journal of Root and Tuber Crop*, 10(1): 27-32.

Sahoo S.K., Giri S.S., Sahu A.K. (2004) Effect of stocking density on growth and survival of *Clarias batrachus* (linn) larvae and fry during hatchery rearing. *Journal of Applied Ichthyology*, 20: 302-305.

Suziki, N., M. Kondo, E. Gunes, M. Ozongun and A. Ohno, (2001). Age and growth of turbot Pstta maxima in the Black Sea, Turkey. *Turkish Journal of Fisheries and Aquatic Science*, 1: 43-53.

Toko I., Fiogbe E.D., Koukpode B., Kestemont P. (2007). Rearing of African catfish (*Clarias gariepinus*) and vunducatfish (*Heterobranchus longifilis*) in traditional fish ponds (whedos): Effect of stocking density on growth, production and body composition. *Aquaculture*, 262(1): 65-72.

Uedeme-Naa B., Nwafili S. A. (2017). Influence of African catfish (*Clarias gariepinus*) brood stock size on fingerlings growth rate. *Applied Science Reports*, 19 (3), 2017: 85-88

Yong-Sulem S., Tchantchou L., Nguefack F., Brummett R.E. (2006a). Advanced nursing of *Clarias gariepinus* (Burchell (1822) fingerlings in earthen ponds, through recycling of tilapia recruits. *Aquaculture*, 256(1-4): 212-215.

Yong-Sulem S., Tomedi E.T., Mounchili S., Jekeng S., Brummett R.E. (2006b). Survival of *Clarias gariepinus* fry in earthen pond. Effects of composts and leaks. *Aquaculture*, 260(1-4): 139-144.

Young-Sulem S., Brummett R.E. (2006) Intensity and profitability of *Clarias gariepinus* nursing systems in periurban Yaounde, Cameroon. *Aquaculture Research*, *37:* 601-605.

Zacharia S., Kakati V.S. (2002) Growth and survival of *Penaeus merguiensis* post larvae at different salinities. *Israeli Journal of Aquaculture Bamidgeh*, 54:157-162.