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Effect of Intensifying Stocking Densities and Proper Feed Management Techniques on Production of *Clarias Gariepinus* (Burchell, 1822) In Earthen Ponds in Nigeria.

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Abstract: *Clarias gariepinus was cultured in earthen ponds at three very high stocking densities- 27, 45, and 90 fingerlings/m^2 in replicates and fed with both commercial (CF) and formulated feed (FF). After eight weeks, fish fed CF had the highest mean daily weight gain of 0.591±0.004g/day; 0.491±0.004g/day; 0.576±0.001g/day respectively for 27, 45 and 90 fingerlings/m^2 with a corresponding MDWG of 0.576±0.001; 0.608±0.005 and 0.607±0.012g/day with FF. The weight and Condition Factor (g)(C.F.) for CF fed were 32.71g (0.93); 31.66g (0.68) and 32.0g (0.85) respectively for 27, 45 and 90 fingerlings/m^2, while FF correspondingly yielded 34.43g (0.80); 35.33g (0.47) and 35.33g (0.90). The survival rate was highest with CF at 27 fingerlings/m^2 and lowest with FF at 90 fingerlings/m^2. Consequently, a stocking density of 45 fingerlings/m^2 is recommended for earthen pond culture with either CF or FF. Feeding specificity, timeliness in feeding cum high quality feed enhanced fish growth and development.*

Keywords: *Earthen ponds, formulated, commercial feed, catfish, growth.*

I. INTRODUCTION

The effects of stocking densities on growth and survival have been studied on some African catfishes such as *Clarias gariepinus* (Haylor 1997; Solomon and Taruwa 2011) and *Heterobranchus longifilis* (Inyang and Odo 1996; Ewa-Oboho and Enyenihi 1999; Coulibaly *et al*. 2007; Okoye *et al*. 2007). The growth and survival of fish decrease with increase in stocking densities while the standing crop remains more or less the same (Ronald *et al* (2014). *C. gariepinus* is known to tolerate high stocking densities (Hogendoorn and Koops 1983; Huisman and Richter, 1987; Haylor, 1997)

Gabriel *et al* (2007) identified feed as one major input in aquaculture production and feed Technology as one of the least developed sectors of aquaculture particularly in Africa and other developing countries of the world. They equally stated that high cost of fish feed was observed as one of the problems hampering aquacultural development in Nigeria. Protein requirement and utilization vary with species (Ogino and Saita, 1970; Ofojekwu and Ejike, 1984). Fish respond better to high protein levels at higher water temperatures. The optimum level of dietary protein to be included in commercial catfish diets depends on the balance between energy and protein in the diet, the amino acid composition of the diet and feeding rate (Marimuthu, *et al.* 2011).

This project has dual aims of determining the optimum stocking density of *Clarias gariepinus* that will result in the highest yield in the earthen pond culture system and comparison of growth of juvenile to adult *C. gariepinus* fed with either commercial feed or formulated feed under earthen ponds conditions.

II. MATERIALS AND METHODS

The study was carried out in the University of Calabar Fish Farm and Hatchery complex, (4.56N; 8.22E). Calabar is located within the tropical rain forest belt of Nigeria. The City records heavy rainfall during the wet season (April – November). The favourable climate of tropical, humid dry and wet seasons gives rise to rich agricultural lands and fresh water bodies for aquaculture. *Clarias gariepinus* fingerlings were gotten from the University's Hatchery Complex. Five experimental ponds of dimension 9 m x 4 m x 1 m located at the Fish Farm Complex, Institute of Oceanography, University of Calabar, were partitioned using Indian bamboos and screened from bottom to top with mosquito nets into four smaller ponds each of dimensions 2.25 m x 1 m x 1 m. Eighteen of such ponds were used for this experiment. The ponds were drained, de-silted and limed using agricultural lime (CaO) at the rate of 200 kg/ha (Okoye, 1996). The ponds were then impounded with water from the farm's reservoir to a level of 0.75 m.

The initial length and weight measurements of fingerlings stocked into each pond were recorded. Three stocking densities 27, 45 and 90 fingerlings/m^2 were assigned to three ponds and fed with commercial feed. Another set of ponds were fed with locally formulated diet of similar protein level with the commercial feed. Ponds for commercial feed were labeled C_{27}I, C_{27}II, C_{27}III, C_{45}I, C_{45}II, C_{45}III, C_{90}I, C_{90}II, C_{90}III while those for formulated feed were labeled F_{27}I, F_{27}II, F_{27}III, F_{45}I, F_{45}II, F_{45}III and F_{90}I, F_{90}II and F_{90}III. The subscripts 27, 45 and 90 represent the stocking densities while using commercial (CF) and formulated (FF) feeds. Feeding for each pond was location specific and at regular time of the day.

All food items after preparation were packaged in water impermeable bags (nylon bags) and kept in freezer until use following Gabriel *et al*, (2007) and Amisah *et al,* (2009). Fresh cow blood was collected from the slaughter house with a 10 liter plastic bucket. The blood was transferred into a cooking pot and congealed by cooking until the water content was drastically reduced. The congealed blood was sun dried, milled and bagged in an air tight bag. Crayfish trash collected from crayfish sellers was cleaned of waste and debris and milled into fine powder and bagged in an air tight bag. Cow bone was collected from the slaughter, burned and milled into fine powder and bagged. Groundnut cake, 'kuli–kuli' was bought from the Ika Ika Oqua Market in Calabar, Nigeria, and milled into fine powder then bagged. Soybeans were prepared into soybean meal by toasting for 30 minutes, dehulled and milled into fine powder and bagged. A 50 kg bag of wheat offal was purchased from the Flour Mill in Calabar. The desired quantity was milled into fine powder and bagged. Half a liter of fresh palm oil was bought from the market. Vitamin premix, a "Fish Growth Booster" was bought from a veterinary shop. Common salt was bought from the market. The bran from yellow maize after the starch has been collected was sun-dried and milled into fine powder and bagged. The starch gotten from the yellow maize was prepared with boiling water to make a binder.

The protein levels (55%, 45% and 42%) of feed to be formulated corresponded with those of the commercial feed. The percentage inclusion for each feed ingredient was calculated using the Pearson square method described by Falayi (2003). The entire mixture was held together by adding a small quantity of starch and molded into balls and sun dried. The formulated feeds were analyzed for proximate composition at the Biochemistry Laboratory of the University of Calabar, Nigeria following A.O.A.C (1999) analytical methods for moisture content, crude protein, crude fibre, ash content, crude fat, carbohydrate and caloric value.

The following water parameters: temperature (^{0}C), Hydrogen ion concentration (pH), dissolved oxygen (DO) and visibility were monitored thrice weekly. The visibility of the water was measured using a secchi disc that has an attached pre-calibrated rope. Other water parameters monitored monthly included Nitrate, Nitrite, Ammonia, Phosphate, Salinity, Conductivity and Chlorophyll a.

The productivity of the pond water was studied by filtering twenty liters of water from each pond using 50 µm plankton filters and the filtrate transferred into labeled sample bottles I, II, III, IV, and V. Two drops of Lugol's solution was used to fix the sample for both quantitative and qualitative analysis of phytoplankton and zooplankton while species identification followed Ward and Whipple, 1959; Newell and Newell, 1977; Needham and Needham, 1984; Jeje and Fernando, 1986.

For chlorophyll a determination, the amount of pigment in the original pond sample water was calculated using the equation below:

$$\text{Chlorophyll a} = 11.85\,E_{664} - 1.54E_{647} - 0.08E_{630}$$

Where E, stands for absorbance at different wavelengths. All data were calculated by means of the MINTAB software program (Mintab, 2008)

The growth rates for fish were determined using the following formula:

$$DW = \frac{\text{Final weight } (w_t) - \text{Initial weight } (w_o)}{\text{Time } (t)}$$

$$\text{Specific growth rate (SGR)} = \frac{\text{Ln } w_t - \text{In } w_o}{t} \times 100 \quad \text{(Viola } et\ al\text{, 1988)}$$

$$FCR = \frac{\text{Total weight of food presented (g)}}{\text{Total weight of fish produced (g)}} \quad \text{(Steffene, 1997)}$$

$$\text{The Protein Efficiency Ratio (PER)} = \frac{\text{Increase in Body weight (g)}}{\text{Protein consumption (g)}}$$

$$\text{Feed Efficiency (FE)} = \frac{\text{Total weight of fish produced (g)}}{\text{Total weight of food presented (g)}}$$

$$\text{And, Survival Rate (SR)} = \frac{\text{Number of fish harvested}}{\text{Number of fish stocked}} \times 100$$

III. RESULTS

The result of the water parameters monitored thrice per week is presented in table 1 below. Pond 4 (F_{90}I, F_{90}II, F_{90}III) recorded the least amount of dissolved oxygen (DO) of 4.34 ± 0.16 mg/l while pond 1 (C_{27}I, C_{27}II, C_{27}III) recorded the highest DO and pH values of 6.90/mg/l and 7.31 ± 0.140 and lowest temperature (25.44^{0}C) and visibility value of 0.385 m. The pH was lowest (6.72 ± 0.176) in pond 5 (F_{27}II, F_{27}III, F_{45}II, F_{45}III). Table 2 presents water parameters monitored monthly from the 6th week of culture. Nitrite was generally very low (0.000 – 0.001mg/l) in all the ponds. The conductivity, sulphate, ammonia, nitrate, phosphate and chlorophyll values were within acceptable ranges by WHO/EEC. The formulated feeds were analyzed along with the commercial feeds for proximate composition. The protein content of the commercial feed which was labeled by the manufacturers as 45% turned out to be 42.6 ± 0.7 upon analysis. The crude protein values of formulated feed calculated using Pearson method as 55%, 45% and 42% for samples A, B, and C after proximate analysis were 44.50 ± 0.61%; 42.6 ± 0.79% and 41.96 ± 0.03% respectively. Likewise, the commercial diets upon re-analysis did not tally with the labeled values. However, the analyzed values of moisture content, ash, crude fat, crude fibre, carbohydrate and caloric value for both the commercial and formulated diets were all within recommended ranges for the culture of *Clarias gariepinus*.

The pond productivity studies had two taxonomic groups (Chlorophyceae, Bacillariophyceae) of phytoplankton comprising five (5) species of Chlorophyceae and two (2) species of Bacillariophyceae identified. Cell densities for ponds 1, 2, 3, 4 and 5 were 5, 3, 2, 25 and 11 cells/ml respectively. The high cell density in pond 4 corresponded with the high chlorophyll value of the same pond (table 2). Zooplankton density ranged from 16 individuals/ml in pond 5 to 87 individuals/ml in pond 1. Five (5) genera belonging to copepoda, ostracoda, cladocera, rotifera and gastrotricha were identified and enumerated. The highest density of copepods was recorded in pond 1 while the lowest in pond 5.

Fish stocked at 27 fingerlings/m^2 and fed with commercial feed (Ponds C_{27}I, C_{27}II, C_{27}III) and formulated feed (ponds F_{27}I, F_{27}II, F_{27}III) (table 3) had mean initial length ($\bar{X}$ L) that ranged from 3.8±0.118 to 8.29±0.186 cm and mean initial weight ($\bar{X}$ wt) 1.0±0.001 to 1.2±0.801 g. Fishes from pond F_{27}I thus recorded the highest mean weight of 36.67±3.33 g by the 28th day of culture; the highest mean weight of 35.0±5.00 g was recorded in pond C_{27}I. By the 70th day of culture, the highest mean weight of 46.70±8.44 g was recorded in pond C_{27}III while the lowest mean weight of 37.50±6.26 g was recorded in pond F_{27}I.

The mean length ($\bar{X}$ L) and mean weight ($\bar{X}$ wt) of fish stocked at 45 fingerlings/m^2 and fed commercial feed (ponds C_{45}I, C_{45}II, C_{45}III) and formulated feed (ponds F_{45}I, F_{45}II, F_{45}III) ranged from 1.0 ± 0.018 g to higher 1.5 ± 0.015 g. The highest mean weight of 33.00 ± 5.39 g by the 28th day of culture came from pond F_{45}II while pond C_{45}I had the lowest of 25.00 ± 3.16 g. At the 56th day of culture the highest mean weight of 37.00 ± 7.00 g was recorded in pond F_{45}III and the lowest of 26.00 ± 6.78 g in pond C_{45}III.

The mean initial weight of fingerlings stocked in ponds C_{90}I, C_{90}II, C_{90}III were 4.2 ± 0.801 g, 4.5 ± 0.761 g and 4.7 ± 0.810 g respectively. The mean weight of fish at 28th day of culture for ponds C_{90}I, C_{90}II and C_{90}III were 31.50 ± 5.78 g, 30.50 ± 5.08 g and 30.00 ± 6.62 g respectively. The mean weight of fish at 28th day of culture for ponds F_{90}I, F_{90}II and F_{90}III were 36.50 ± 4.54 g, 35.50 ± 3.83 g and 32.00 ± 4.73 g, respectively. Day 56 had the highest mean weight (42.00 ± 5.17 g) in pond F_{90}I while the lowest (27.50 ± 3.52 g) was recorded in pond C_{90}II.

The daily weight gain (DW) on the 56th day of culture was highest (0.728g/day) in pond F_{90}I and lowest (0.410g/day) in pond C_{90}II while the specific growth rates (SGR) was highest in pond C_{27}III (6.86%) and lowest in pond C_{90}III (3.23%). Amongst the stock fed with commercial feed the mean daily weight gain was highest (0.591±0.004) in ponds stocked at 27 fingerlings/m^2 and lowest (0.491 ± 0.004) in ponds stocked at 90 fingerlings/m^2. The mean specific growth rate (SGR) was highest (6.31%) in 27 fingerlings/m^2 stocking density fed with commercial feed and lowest (3.50%) at 90 fingerlings/m^2 fed with commercial feed. The highest survival rate of 34.5% was recorded at 27 fingerlings/m^2 fed with commercial feed while 90 fingerlings/m^2 fed formulated feed recorded the least survival rate of 0.3%. Stocking density of 27 fingerlings/m^2 also yielded the highest daily weight gain and specific growth rate (Table 3).

Analysis of variance test showed that there is no significant difference (P>0.05; p>0.01) in the final weight of fish stocked at 27 fingerlings/m^2; 45 fingerlings/m^2 and 90 fingerlings/m^2 and fed with either commercial or formulated feed.

IV. DISCUSSION

The water quality parameters were within the levels recommended by Boyd (1981) and APHA (1999) for the culture of *Clarias gariepinus* as defined for warm water fish species. The Clariid fishes known to be capable of growing on a wide range of natural and low cost artificial foods, can withstand low oxygen and pH levels (Huisman & Richter, 1987; Fagbenro & Sydenham, 1988). Sule *et al.* (1996) in a preliminary trial on the use of free flow borehole pond for fish culture in the Northeast zone of Nigeria with *Oreochromis niloticus* and *C. gariepinus* reported that *O. niloticus* fingerlings grew from an initial mean weight of 35g to 200.0g with daily weight gain of 0.58/day while *C. gariepinus* grew from an initial mean weight of 20.0g to 550.0g and daily weight gain of 1.8/day after culture for 280 days. Juxtaposing Sule *et al*. (1996) equivalent daily percentage increases in weight from the initial weights (5.1%, 9% for *O. niloticus* and *C. gariepinus* respectively) to the present study, the present research yielded far better percentage increases in weight gain of 53.7%, 44.72% and

52.36% for *C. gariepinus* at stocking densities of 27, 45 and 90 indiv./m^2 due most probably to better management approach, particularly, adequate and timely feeding.

Feeding at a particular time and at specific location as well as with quality feed enhanced growth of *Clarias gariepinus*. Specificity of feeding location was catalytic and most probably did stimulate/promote sensory organs and healthy competition given sufficient feed to avoid survival of the fittest syndrome setting in amongst the few weaker ones. Timeliness in feeding led to healthy and uniform growth and allowed no starvation moment that otherwise would have caused decrease in growth. Marimuthu *et al.* (2011) opined that feed management such as optimization of feeding rate is crucial in both marine and freshwater fish cultures.

The calculated values of crude protein for the formulated feed were slightly higher than proximate values exemplifying the limitations in using Pearson's Square method which is most effective when only two feeds are involved in determining protein or energy composition during livestock feed formulation. The values were however within recommended ranges for the culture of *Clarias gariepinus*. Similar results of crude protein content for *C. gariepinus* was observed by Faturoti *et al* (1986).

The plankton abundance and diversity in experimental earthen ponds revealed that phytoplankton were highest in pond 1 and lowest in pond 5. Plankton are required as the first food for many cultured fish including *Clarias gariepinus*. They are valuable natural sources of protein, amino acids, lipids, fatty acids, minerals and enzymes required for effective growth of fish larvae (Ajah 1997, 1998, 2010; Ajah and Enyenihi 2007). The very low densities of phytoplankton in ponds 1, 2 and 3 could be attributed to grazing by zooplankton (Ajah and Ajah 2005).

The effect of three very high stocking densities 27, 45, and 90 fingerlings/m^2 in contrast to 2-3 fingerlings/m^2 under earthen pond conditions on the mean final weight, SGR and DWG were compared. The mean final weight, SGR and DWG were highest in ponds stocked at 27 fingerlings/m^2. There was however no significant difference in the final weight of fish in the three stocking densities at 5% and 1% levels of significance. Thus, there was optimum growth and development of the clariid at the three stocking densities. When stocking densities are astronomically increased in ponds as shown, the duration of culture should not exceed 8-10 weeks. Thereafter, the population should be thinned down into other ponds to optimize yield.

Survival rate was highest in ponds stocked at 27 fingerlings/m^2 and fed with commercial feed. The lowest survival rate was recorded in ponds stocked at 90 fingerlings/m^2 and fed with formulated feed. The cause of the high mortality was however suspected to be due to the presence of a fish eating reptile, Iguano, which was reported to have entered ponds F_{27}II, F_{27}III and F_{45}I, F_{45}III, F_{90}I, F_{90}II and F_{90}III. The significant difference in the survival rate of fish stocked at 45 fingerlings/m^2 and 90 fingerlings/m^2 is attributed to the activities of the fish eating reptile. Hogendoorn & Koops (1983) summarized mortality causes during the culture of *Clarias gariepinus* to include: predation by various organisms, shortage of adequate feed and poor water quality. According to Viveen *et al* (1985), predators can either enter the pond through the inlet pipes (eggs and larva as well as some adult frogs and toads) or through the air (insects and birds). Yong-sulem, *et al.* (2007) working on predator defense and feeding adapted stocking of *C. gariepinus* showed that adult amphibians, aquatic insects and flying predators were responsible for 28%, 6% and 23% respectively of mortalities. In the present experiment, Iguano, a reptile that feeds on fish in the ponds was implicated.

On the other hand, the highest mortalities (19.2% survival and 0.3 survival rates respectively) recorded in ponds stocked at 90 fingerlings/m^2 fed with either commercial or formulated feed could be as a result of increasing stocking density. Okoye *et al.* (2007) in a study on the effect of stocking density on the growth rates of *C. gariepinus* in a floating hapa system showed that mortality was highest in net hapas (1m x 1m x 1m) stocked 100 fish/m^3 when compared with the same size hapas stocked with 25/m^3 and 50/m^3, respectively. The high mortality was attributed to handling stress due to long distance from study station and the method of capture. The result showed slight differences in mean final weight and food conversion of the fish at the end of the study with no significant statistical difference thus ruling out the probable effect of food as a limiting factor. High mortality could be an indication of shortage of adequate food (Hogendoorn & Koops 1983), possibly exacerbated by increased competition and cannibalism (Hetcht *et al.* 1989), a common problem that led to mortality rates in the region of 98%, particularly at stocking densities of about 100 fry/m^2 (De Graaf and Janssen, 1996). Maximal protection of earthen ponds from aquatic reptiles and other organisms that could constitute a threat to the survival of pond raised fish cannot be over emphasized as maximization of production may not be achieved in earthen ponds without adequate screening of the ponds against predatory organisms.

V. SUMMARY AND CONCLUSIONS

In the bid to identify with grassroots fish farmers, production was intensified in earthen ponds. Three very high stocking densities 27, 45 and 90 fingerlings/m^2 in three replicates was administered with both commercial and formulated feeds in 18 experimental ponds (2.25 m x 1 m x 1 m each). 70 days (10 weeks) post-culture showed that there was no significant difference in the final weight of fish for all the categories ($P>0.05$; $P>0.01$). 45 fish per square meter is hereby recommended for earthen pond culture with either commercial or formulated feed as there was no significant difference between the final weight and SGR of fish stocked at 45 fingerlings/m^2 and the existing practice of 2-3 fingerlings/m^2. However, it is recommended that such dense population should be thinned down from the 8th - 10th week of culture for optimal growth.

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Table 1: Mean of routine Water Parameters of Earthen Ponds Monitored.

Ponds(P)	DO(mg/l)	pH	Temp. (^{0}C)	Visibility (m)
P1(C_{27}I,C_{27}II, C_{27}III)	6.901±0.312	7.305±0.140	25.44±0.199	0.385±0.017
P2(C_{90}I,C_{90}II, C_{90}III, F_{27}I)	6.596±0.120	6.955±0.093	26.967±0.199	0.544±0.018
P3(C_{45}I,C_{45}II, C_{45}III,F_{45}I)	6.148±0.276	6.981±0.141	26.389±0.339	0.574±0.014
P4(F_{90}I,F_{90}II, F_{90}III)	4.344±0.155	7.226±0.386	27.50± 1.02	0.596±0.023
P5(F_{27}II, F_{27}II,F_{45}II,F_{45}III)	5.97±1.70	6.715±0.176	28.16±1.04	0.586±0.08

NB: P1 –P5 = Ponds 1 to 5; C=commercial; F = formulated feed

Table 2: Result of Water Parameters of Earthen Ponds Monitored on the 6th Week.

Parameter	C_{27}I, $_{27}$II, C_{27}III	C_{90}I, C_{90}II, C_{90}III, F_{27}I	C_{45}I, C_{45}II, C_{45}III, F_{45}I	F_{90}I, F_{90}II, F_{90}III	F_{27}II, $_{37}$II, F_{45}II,F_{45}III
	P1	P2	P3	P4	P5
Conductivity (μ s/cm)	106	89	94	115	103
Sulphate (mg/l)	5.332	4.497	4.729	5.785	5.182
Ammonia (mg/l)	0.364	0.761	0.324	0.349	0.657
Nitrite (mg/l)	0.000	0.001	0.001	0.000	0.001
Nitrate (mg/l)	0.857	0.507	0.427	0.554	0.774
Phosphate (mg/l)	0.012	0.016	0.009	0.013	0.008
Chlorophyll (μ g/l)	50	50	70	70	60

NB: P1 –P5 = Ponds 1 to 5; C=commercial; F = formulated feed

Table 3. Comparison of growth Performances of *Clarias gariepinus* in Earthen Ponds using commercial and formulated feeds.

	Commercial Feed			P-value	Formulated Feed			P-value
	27fish/m^2	45fish/m^2	90fish/m^2		27fish/m^2	45fish/m^2	90fish/m^2	
Initial weight g)	1.06	1.43	4.46		2.13	1.22	1.3	
Final weight (g)	32.77	31.66	32.0	p>0.05	34.43	35.33	35.33	p>0.05
Initial C.F	1.52	2.5	0.68	P>0.05	1.63	1.63	1.61	P>0.05
Final C. F	0.98	0.68	0.85	P>0.01	0.80	0.47	0.90	P>0.01
DW (g/day)	0.591	0.539	0.491		0.576	0.608	0.607	
SGR (%)	6.31	5.51	3.50		5.30	6.03	5.88	
Survival Rate	34.5	32.5	19.2		16.0	5.9	0.3	