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GROWTH RESPONSE AND PROFITABILITY OF THE AFRICAN CATFISH *(Clarias gariepinus* Burchell, 1882*)* CULTURED AT DIFFERENT STOCKING DENSITIES

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ABSTRACT

The growth response and profitability of *Clarias gariepinus* fingerlings held at five different stocking densities were studied with the aim of establishing the optimum stocking level that gives the fastest growth and the highest profit. The fingerlings(Mean weight 2.55 $\pm$ 0.23g) were cultured at five different densities (2, 5, 10, 15, and 20 fish/m^2 or 68, 170, 340, 510, and 680 fish per treatment respectively) in earthen ponds of 3.21m x 5.54m x 0.78m at the Department of Wildlife and Fisheries Management Research Farm, University of Ibadan for a period of 12 weeks. Harvest weights at the end of 12 weeks were, 6.43, 12.3, 19.8, 26.7 and 30.0 kg per treatment, respectively. Mean fish weight per treatment was highest at the lowest density of 2 fish/m^2 ($P<0.05$). Specific growth rate (SGR) and percent protein intake (% PI) decreased with increasing stocking density of fish. Survival percentage (SP) was independent of stocking density but total production however, increased with increasing stocking density. Mean Weight Gain was positive and correlated significantly with Feed intake ($r = 0.37$); SGR ($r = 0.22$); PI ($r = 0.37$); Weight change ($r = 0.64$); pH ($r = 0.19$) and Dissolved oxygen ($r = 0.11$). It however, correlated negatively with Feed conversion ratio ($r = -0.03$); Temperature ($r = -0.11$) and Alkalinity ($r = -0.19$)

Keywords: African catfish; Stocking density; Profitability; Growth response

INTRODUCTION

The African catfish or sharp tooth catfish, *Clarias gariepinus* is tolerant to a wide range of temperatures, as well as low oxygen and high salinity levels (Bovender *et al.*, 1987). However, the rate at which the fish is stocked is a factor that determines its growth and economic performance (Khuwuanjai *et al.*, 1996). The use of high stocking density according to Andrew *et al.* (1971) as a technique to maximize water usage and thus increase stock production in fish culture has been shown to exert severe adverse effects on growth.

Increasing stocking density results in stress (Leatherland and Cho, 1985). This stress leads to enhanced energy requirements causing reduced feed utilization and growth. The growth rate of fishes stocked at high densities has been found to be lower than those of fishes stocked at low densities (Leatherland and Cho, 1985).

Ponds with high stocking densities are also known to experience increased temperature, low dissolved oxygen level and high biological oxygen demand. These, in turn will reduce the growth performance of fish; promote the spread of diseases; lead to fish kill and ultimately reduce profitability. Negative effects related to stocking density have also been found in several experiments (Fagerlund *et al.*, 1981; Schreck *et al*., 1985; Holms *et al*., 1990). There is the need to understand how stocking density influences the growth and profitability in catfish farming in order to advice farmers appropriately. The aim of this study was therefore to investigate the interplay of stocking density with growth and economic performance of catfish reared at five different densities.

MATERIALS AND METHODS

Experimental Site and Design

The experiment was carried out in dugout ponds of 3.21m × 5.54m × 0.78m at the Department of Wildlife and Fisheries Management Research Farm, University of Ibadan. Experimental fish (*Clarias gariepinus*) fingerlings used for the study were purchased from Adnez Aquatic Farm along Arulogun, road, Ibadan. The mean weight of the fingerlings was 2.55 ± 0.23g. The ingredients for the experimental diet were pelleted at B & T firm along Arulogun road, Ibadan. The formulated diet had a crude protein level of 40% as recommended by Faturoti *et al.* (1986) for *C. gariepinus*. Feed ingredients were weighed into proportions using Pearson`s square method to calculate the percentage of inclusion of each ingredient in the final mix. The ingredients were thoroughly mixed before pelleting. The pelleted feed was sun-dried for three days and was then stored in an airtight enclosure to preserve its quality.

The experiment was laid out in a completely randomized design (CRD). There were five treatments with three replicates per treatment. Fifteen earthen ponds were used in the experiment. Fish were stocked into the ponds at different stocking densities: 2, 5, 10, 15, and 20fish/m^2 or 68, 170, 340, 510 and 680 fish per treatment, respectively each representing treatments 1-5 (T1-T5). The lowest stocking density (2 fish/m^2) served as the control.

Feeds were administered manually twice daily between 8-9 a.m. and 4-5p.m. at 5% body weight of fish. At the early stage of the experiment, feeds were crushed after pelleting for easy picking and digestion by the fish. The feeding process lasted for 12 weeks. Fish were weighed every two weeks throughout the period of the experiment to record changes in weight and adjust feeding. Physicochemical parameters were also measured every two weeks for 12 weeks.

Data Collection and Analysis

The following growth and nutrient utilization parameters were measured: Weight Gain, Feed Intake, Specific Growth Rate (SGR), Percent Survival Rate (% SR), Protein Efficiency Ratio (PER), Feed Conversion Ratio (FCR) and Protein Intake (PI).

Mean Weight Gain (MWG) of individual fish in each pond was estimated by subtracting the initial mean weight from the final mean weight at harvest.

$MWG = W_2 - W_1$

Where W_2 = final mean weight of fish at week 12

W_1 = initial mean weight of fish at stocking

Specific Growth Rate (SGR) was calculated after Brown (1975) as follows:

$$SGR = \frac{\text{Inlog}_{w2} - \text{Inlog}_{w1}}{T} \times 100$$

Survival Rate expressed in percentage was calculated from the relationship;

$$\text{Percent SR} = \frac{\text{Initial number of fish-Mortality}}{\text{Initail number of fish stock}} \times 100$$

Feed Intake was calculated by the addition of daily mean feed intake of fish in each treatment throughout the experimental period.

Feed Conversion Ratio (FCR) was calculated with the equation:

$$FCR = \frac{\text{Feed consumed (g)}}{\text{Weight gained (g)}}$$

Protein Efficiency Ratio (PER) was calculated with the equation;

$$PER = \frac{\text{Mean weight gained (g)}}{\text{Protein consumed (g)}}$$

Protein Intake was determined from the proportion of protein content in total feed consumed by the fish:

PI = Total feed consumed x Percentage protein in feed.

Economic analysis of this study was carried out using the following return on investment parameters; operating costs; profit index and incidence of cost. Operating costs put into consideration the variable costs such as labour, feed, and fish seed e.t.c. expended during the experiment.

Return on investment was calculated by subtracting operating costs from the proceeds from the sales of the fish harvested.

Profit index was determined by the method described by Miller (1976) while the method of Vinke (1969) was used to determine the incidence of cost.

Analysis of variance (ANOVA) (Steel and Torrie, 1960) using statistical analysis program (SAS, 1988) was employed to test the effect of stocking density on the various growth and water quality parameters. Correlation analyses Zar (1984) were used for deriving prediction equations.

RESULTS

Growth and Nutrient Utilization

The results of the growth, nutrient utilization and economic parameters monitored in this study are presented in Table 1 while Figure 1 shows the growth response of *Clarias gariepinus* raised at different stocking densities.

The initial mean weight of the experimental fish ranged between 2.05 ± 0.16g in T5 and 2.55 ± 0.23 g in T1 while the final mean weight at harvest ranged from the highest value of 150g in T1 to 65.6g in T5. Significant differences (P<0.5) were observed in mean weight change between the treatments.

Table1: Growth response, nutrient utilization and economic analysis of *C. gariepinus* reared at different stocking densities in earthen ponds

Parameter	Stocking density				
	T_1	T_2	T_3	T_4	T_5
Production period (week)	12	12	12	12	12
Stocking density/m^2	2	5	10	15	20
Initial number of Fish	68	170	370	510	680
Final number of the Fish	43	123	235	322	457
Initial weight of fish (g)	2.55	2.18	2.25	2.13	2.05
Harvest (kg)/treatment	6.43	12.3	19.8	26.7	30
MWG (g)	147.5	100	84.3	83.0	65.6
F1 (g)	129.1	85.9	75.5	65.4	50.4
SGR	18.1	16.6	16.0	15.9	15.0
FCR	0.87	0.88	0.92	0.81	0.79
PER	2.91	2.92	2.80	3.22	3.76
PI	51.6	34.4	30.2	25.1	16.9
Fingerling cost (N3.50k/fish)	238	595	1190	1785	2380
Feed used (kg)	8.78	14.1	29.0	32.0	28.8
Cost of feed (₦)	383	615.9	1264.5	1396.7	1254.5
Maintenance cost (₦)	1280.0	1280.0	1280.0	1280.0	1280.0
Total input cost (₦)	1901.0	2490.9	3734.5	4461.7	4914.5
Value of fish (₦)	1607.5	3075.0	4950.0	6675.0	7500.0
Net profit (₦)	-293.5	584.1	1215.5	2213.3	2585.5
Profit index (₦)	4.20	5.0	3.91	4.78	5.98
Incidence of cost	59.6	50.1	63.9	52.3	41.8

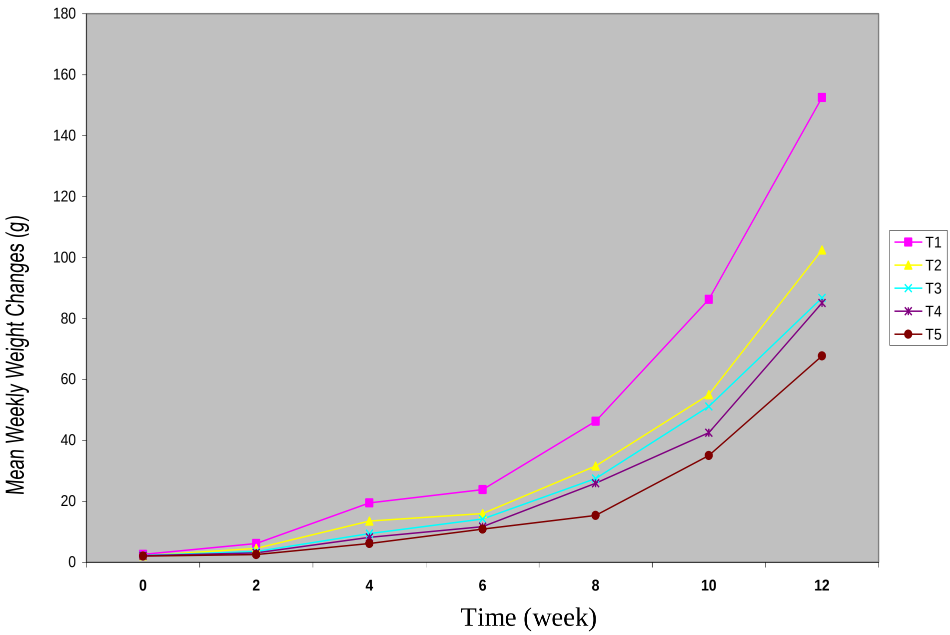

Fig 1: Growth response of *C. gariepinus* at different stocking densities in earthen ponds.

There were differences in mean weight between treatment 1 (2 fish/m^2) and the other four higher densities. There were also significant differences between fish in treatment 2 (5fish/m^2) and treatment 3 (10 fish/m^2), but treatments 3 and 4 showed no significant difference ($P>0.05$). Feed conversion ratio (FCR) was high for fish stocked at 10fish/m^2, 5fish/m^2 and 2 fish/m^2 respectively whereas it was low for fish held at 20fish/m^2 and 15fish/m^2. Specific growth rate (SGR) and %PI decreased with increasing density of fish. Treatment 1 had the highest protein retention rate while the least protein retention was in treatment 5. Protein Efficiency Ratio (PER) was in the order T3<T1<T2<T4<T5. Percent survival rate (SR) was highest at T2, T5 and T3 whereas it was lowest at T1 and T4 (Figure 2). Total production, however increased with increasing density. T5 with the highest stocking density had the highest net profit and profit index whereas T1 with the lowest stocking density recorded a loss. Significant differences ($P<0.05$) existed between the initial and the final fish weights at the various stocking density (Table 1). The gross composition and proximate analysis of the experimental diets are presented in Table 2. The proximate analysis of the experimental fish showed significant differences ($P<0.05$) among the parameters of both the initial and final fish (Table 3).

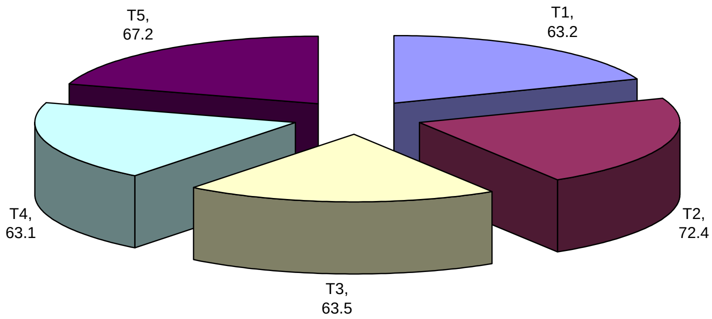

Fig 2: Percent survival of fish by treatment

Table 2: Gross and proximate compositions of experimental diets.

Ingredients	Inclusion level (%)	Parameter	Composition (%)
Fish meal	16.2	Crude protein	37.5
Groundnut cake	48.6	Crude fibre	2.83
Bone meal	1.00	Crude fat	3.61
Maize	10.8	Ash	7.49
Wheat middling	21.5	Moisture content	10.1
Salt	0.5	N.F.E.	38.4
Micromix (Vitamins)	1.50		

Table 3: Proximate composition of experimental fish at different stocking densities in earthen ponds.

Parameters	Before experiment	After experiment				
		T1	T2	T3	T4	T5
Crude protein	56.84^{b}	68.59^{a}	69.22^{a}	66.10^{a}	68.05^{a}	65.79^{a}
Crude fibre	1.86^{c}	3.15^{a}	$3{,}81^{a}$	2.96^{ab}	3.06^{a}	2.63^{b}
Ash	6.23^{d}	8.97^{b}	9.41^{a}	7.68^{c}	8.96^{b}	7.55^{c}
Moisture content	9.22^{d}	11.34^{bc}	12.03^{a}	10.91^{cd}	11.10^{bc}	10.74^{cd}
Fat	3.12^{c}	5.11^{a}	5.29^{a}	4.25^{b}	4.83^{ab}	4.12^{b}
N.F.E.	22.73^{a}	1.55^{d}	0.14^{e}	8.10^{b}	3.93^{c}	9.14^{b}

Means in a row followed by same letter (s) are not significantly different (P> 0.05).

The correlation coefficients for growth, nutrient utilization and water quality are presented in Table 4. MWG was positive and significantly correlated (P<0.05) with F1, SGR, P1, weight change, pH and DO. It was however negatively and significantly correlated (P<0.05) with FCR, temperature and alkalinity.

Table 4: Relationship between the growth, nutrient utilization and water quality analysis of *C. gariepinus* reared at different stocking density in earthen ponds

Variable	MWG	FI	SGR	FCR	PI	Wt. Change	Temp	pH	DO	Alkalinity
MWG										
FI	.37									
SGR	.22	-.54								
FCR	-.03	.44	-.54							
PI	.37	1.00	-.54	.44						
Weight Change	.64	.95	-.36	.32	.95					
Temp.	-.11	.06	-.23	.24	.06	.01				
pH	.19	.13	.20	-.16	.13	.18	-.36			
DO	.11	.26	.13	.00	.26	.27	-.37	.65		
Alkalinity	-.19	-.10	.20	-.12	-.10	-.13	-.21	.20	.63	1.00

DISCUSSION

This study showed that the final mean weight were inversely proportional to the stocking density which was particularly evident when the average weights of fish reared at the lowest and highest densities were compared. According to Jarimopas *et al.* as cited by Khuwuanjai *et al.* (1996), stocking density influenced the growth of *C. marcrocephalus x C. gariepinus* hybrids cultured in concrete ponds at three different densities. Fish reared at the highest density had the lowest final mean weight. Viveen *et al.* (1985) reported that growing catfish in tanks required 24-28 weeks to reach a size of 300-500 g. In ponds, in which the fish were fed for the same period, catfish grew to a weight of 200 g. However, Hogendoorn and Kopps (1983) found that the fish under field condition reached 300 g in only 22 weeks. During the same period but in fertilized ponds and without supplemental feed, catfish reached a maximum weight of 135 g (Bok and Jongbloed cited by Khuwuanjai *et al.*, 1996). Results from this study showed that catfish fingerlings reared in unfertilized earthen ponds but with supplemental feeding reached weights ranging from 65.6-150 g in only 12 weeks when stocked at an average weight of 2.55 g.

Specific growth rate and protein intake were inversely related to stocking density. Specific growth rate and protein intake were high at the lowest density. The results of this study agreed with those reported for experiment conducted on African catfish fry by Haylor (1991). Faturoti and Adebayo (1995) studied the effect of stocking density on survival and growth of *Heterobranchus bidorsalis* fry and they observed that specific growth rate was highest at the lowest stocking density. This conforms to the findings of Safronios *et al.*, (1987) who stated that specific growth rate increased with increase in density. Steffens, (1989) also found that growth rates in rainbow trout were inversely related to stocking density. Increased competition and swimming speed at feeding periods had also been observed at high densities (Kebus *et al.*, 1992) while depressed growth can potentially be related to a reduction in access to food through competition or reduced visibility (Holm *et al.*, 1990). North *et al.* (2006) concluded that it is possible to rear rainbow trout at high densities (up to 80 kg m^{-3}) as long as good water quality is maintained. In a comprehensive review article focusing on the impact of stocking density on rainbow trout, Ellis *et al.* (2002) found that the majority of density studies reported adverse effects as a result of increased density.

Survival rates were independent of stocking density. Khuwanjai *et al.* (1996) reported that the survival of African catfish fingerlings reared in cages was not clearly influenced by stocking density. These results however disagree with that of Haylor (1991), who found that the mortality rates in African catfish fry were directly related to stocking density. The trend of increased production and final harvest as a result of increasing stocking density agreed with the results of Cruz and Ridha (1989) for Tilapia (*Oreochromis spillurus*) reared in cages and those of Teng and Chua (1979). Production estimates which are based on biomass estimates adjusted for mortality and corrected for growth rate according to Chapman (1968) are the basis for estimating the economic yield from both fish culture operations. There was a positive linear relationship between production and fish density in the ponds. The profit margin increased with increasing density. It was only treatment 1 that recorded negative profit (loss). The loss recorded in treatment 1 was due to high mortality, low final biomass with attendant high operating cost. However, the results obtained agreed with that of Omitoyin (1995) in an experiment conducted on African catfish fed poultry waste (offal). The results are also in conformity with what Khuwuanjai *et al.*(1996) obtained in their study on the effect of stocking density on yield, growth and mortality of the African catfish (*C. gariepinus*) cultured in cages. When economic indices such as profit index, incidence of cost and net profit are taken into consideration, rearing *C. gariepinus* at lower stocking density seems more profitable than at higher density provided satisfactory survival rate is maintained.

CONCLUSION

The results from this experiment showed that low densities favored good growth and high final biomass. The results also showed that on a small scale production profit may not be maximized at high stocking density as a result of increased cost of production associated with high stocking density. Although this may not be the case in intensive aquaculture, since the higher the stocking density the lower will be the production cost per fish assuming that satisfactory survival and growth are maintained. Lower stocking densities of between 2-5 fish per square meter are encouraged for a small-scale aquaculture production. However, in intensive fish farming higher stocking densities of between 5-20 fish/square meters, which will enhance good growth and at the same time reduce miscellaneous costs should be encouraged.

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