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Growth and Economic Performance of *Clarias gariepinus* Fry Reared at Various Stocking Densities

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Abstract

The biological and economic performance of *Clarias gariepinus* fry was investigated at various stocking densities. Five aquaria tanks were stocked at 100 (STK1), 150 (STK2), 200 (STK3), 250 (STK4) and 300 (STK5) fry/L. Triplicate groups of experimental fish were fed for 28 days with commercial diets. Water quality parameters were monitored throughout the experimental period, with pH, dissolved oxygen and temperature within the recommended range for the culture of *C. gariepinus*. Mean weight gain was significantly higher (P<0.05) in STK1 and STK 2 groups. Specific growth rate also followed the same trend, with the highest (8.47) recorded in STK 1, while the least (6.55) was recorded in STK 5. Performance indicator reduced with increasing stocking density. Profitability index were high in STK1 (3.21) and STK2 (3.30) while Incidence of costs were significantly lower in these two groups. This study reveals that stocking density significantly affects the performance and survival of fry of the African catfish, therefore stocking density of 100-150 fry/L is recommended for *C. gariepinus* fry.

Keywords: Stocking density; *Clarias gariepinus*; Survival; Growth

Introduction

The ultimate goal of aquaculture is the production of high quality fish in the highest quantity, within the shortest possible time at the least cost. This is achievable with careful selection of species, appropriate feeding, and good water quality and to a great extent, the density to which the fish are stocked [1]. The determination of the optimum carrying capacity of an aquatic environment is therefore very important.

The number of organism that can be stocked in a culture medium per unit area or volume is referred to as stocking density and described optimum stocking density as the density at which yield is maximized without negatively affecting growth rate.

Studies concerning the relationship between stocking density and growth in fish have shown that optimal stocking density for obtaining the highest possible fish yields depend upon the amount and the quality of food available [2].

In Nigeria, *Clarias gariepinus* is widely cultured because they tolerate many extremes in water quality and generally adapt to culture environment, although intensive culture, where fish are kept crowded under high stocking density, fish natural abilities to repel diseases are weakened and thus more susceptible to disease attacks [3]. Schreck and Essa [4-5] noted that high stocking density as a technique to maximize water usage and thus increase stock production has an adverse effect on growth on *Oncorhynchus kisutch* and the hybrid of *Oreochromis niloticus X O. aureus*. Studies on the stocking densities of C. gariepinus fingerlings and other bigger sizes abound, however, information on the optimal stocking density of fry to actualize the farmers' objective of economic growth and profit maximization is inadequate.

This study investigates the growth, survival and economic performance of *C. gariepinus* fry at different stocking density, to establish the optimum stocking density for this species.

Materials and Methods

Experimental fish and rearing units

The experiment was conducted using fifteen aquaria (105 Litre capacity) filled with 80 L of aerated-water. Fry of *C. gariepinus* (initial mean weight 0.021 g) were obtained from the University of Ibadan Fish hatchery.

At the start of the experiment, a total of 50 fry were taken in duplicate from the common stock in order to determine initial weights. Wet weight was recorded using an electronic weighing balance (accuracy of ± 0.01 mg). Fish were counted and stocked at 100, 150, 200, 250 and 300 fry/L to give STK1 (8000 larvae), STK2 (12000 larvae), STK3 (16000 larvae), STK4 (20000 larvae), and STK5 (24000 larvae) respectively, and each treatment replicated thrice. Daily water exchange in the tanks was 1.5 L/min. Fish were fed encapsulated brine shrimp *(Artemia salina)* four times daily to satiation for the first 3-days, after which they were fed at 10% of total biomass three times daily (At 7:00, 12:00 and 17:00 hrs.) with commercial diet (45% Crude protein). Excess or uneaten feed and faecal wastes were siphoned using 2 mm hose with a screen once daily. Dead fish in each tank were removed and recorded. Tanks were uniformly aerated. Water temperature and dissolved oxygen were measured using a Combined Digital Probe (YSI Model 57, VWR Company, New Jersey), weekly pH were measured using pH meter (Metler Toledo-320 model, U.K), while ammonia and nitrite were measured using API test kits.

Fifty fish were weighed per tank biweekly, using electronic top-loading balance (OHAUS corporation model: V21PW15) and the average weight calculated, this was used to adjust for feed requirement. After 28 days of rearing, all surviving fry were collected, counted, weighed, and individual body weight recorded. Specific Growth Rate (SGR), Mean Daily Weight Gain (MDWG), Apparent Food Conversion Ratio (AFCR), Survival Rate (S.R) and Performance Index (P.I) were calculated as follows:

$$SGR = 100 \times \frac{\text{Ln(Final body weight) - Ln(Initial body weight)}}{\text{Duration of rearing period (days)}}$$

$$MDWG\left(\frac{mg}{day}\right) = \frac{\text{Final mean body weight(g) - Initial mean body weight (g)}}{\text{Duration of rearing period (days)}}$$

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$$\text{AFCR} = \frac{\text{Dry weight of total feed given (g)}}{\text{Harvested biomass (g)}}$$

$$\text{SR}(\%) = 100 \times \frac{\text{Final number of larvae}}{\text{Initial number of larvae}}$$

$$\text{PI} = \text{Survival rate} \times \frac{\text{Final mean body weight(g) - Initial mean body weight (g)}}{\text{Duration of rearing period (days)}}$$

Economic analysis

The cost of production of experimental fish was calculated as described by [6] as follows;

Investment Cost Analysis (ICA)=Cost of feeding (N)+Cost of fry Stocked (N)

Net Production Value (NPV)=Mean Weight gain of fish (g)×Total survival (n)×Cost per kg (N)

$$\text{Gross Profit(GP)} = \text{NPV(N) - ICA (N)}$$

$$\text{Profit Index(PI)} = \frac{\text{NPV (N)}}{\text{Cost of feeding (N)}}$$

$$\text{Incidence of Cost} = \frac{\text{Cost of feeding}}{\text{Weight of fish produced}}$$

$$\text{Benefit Cost Ratio(BCR)} = \frac{\text{NPV (N)}}{\text{ICA (N)}}$$

Statistical analysis

The data obtained were subjected to a one way analysis of variance and the difference between means were separated using Duncan Multiple Range Test at P>0.05, using SPSS version 17.

Results and Discussion

The growth performances of experimental fish are shown in Table 1. The results showed that mean weight gain were significantly higher (p<0.05) in STK1 and STK2 groups. Highest weight gain (0.21 g) was recorded in STK1, while the least value (0.11 g) was recorded in STK5. This same trend was observed in the SGR. Availability of space and reduced competition and stress may have contributed to the result obtained in this present study. Higher stocking density was observed to increase stress, leading to higher energy requirements, causing a reduction in growth rate and food utilization [7]. This result is in agreement with [8] who reported better growth in Heteropnestes fossilis at lower stocking density. Significant decrease in weight gain was also reported in the works of [9,10] for *C. gariepinus* and the hybrid as a result of high stocking density. Superior SGR in fish stocked at lower stocking density was observed in [11].

Significant variation (p<0.05) is observed in the feed intake of experimental fish. Higher stocking density resulted in reduced feed intake per fish. Reduction in growth could directly be attributed to this, as growth in fish has been shown to depend on food intake and a host of intrinsic factors [12]. The result of this present study is corroborated by [2]. The AFCR values of 1.04 and 1.01 recorded in STK1 and STK2 respectively, were superior to values recorded in other groups. This shows that feed conversion may be more efficient when competition is less. Feed utilization efficiency has also been reported to decrease with increased stocking density [13,14]. The highest performance indicator (0.72) was recorded in STK1 and this continuously reduced with increase in stocking density.

Survival rate ranged from 81.0% in STK5 to 96.0% in STK1, indicating that stocking density significantly affected survival of *C. gariepinus* fry. This negative influence of high stocking density on survival rate has earlier been reported in the work of [1] on *Clarias batrachus*. However, harvested biomass was higher at higher stocking density, as shown in Table 2.

For profitability of aquaculture investment, it is important for stocking density to be economically viable [15]. Investment cost analysis (ICA) was significantly increased (P<0.05) with increase in stocking densities. The highest Net Present Value (NPV), Profit Index (PI) were recorded in STK2, while the Incidence of cost (IC) was significantly lower (P<0.05) in STK1 and STK2. From the result of this study, an economic stocking density is evident in STK2 group.

Treatment					
Parameters	**STK1**	**STK2**	**STK3**	**STK4**	**STK5**
Initial WGT	0.023 ± 0.00^{a}	0.021 ± 0.00^{a}	0.021 ± 0.00^{a}	0.021 ± 0.00^{a}	0.021 ± 0.00^{a}
Final WGT	0.233 ± 0.01^{c}	0.224 ± 0.00^{c}	0.173 ± 0.01^{b}	0.144 ± 0.00^{a}	0.136 ± 0.00^{a}
Mean WGT gain	0.209 ± 0.01^{c}	0.202 ± 0.00^{c}	0.1513 ± 0.01^{b}	0.123 ± 0.00^{a}	0.114 ± 0.00^{a}
Feed Intake	0.242 ± 0.00^{e}	0.227 ± 0.00^{d}	0.208 ± 0.00^{c}	0.204 ± 0.01^{b}	0.192 ± 0.01^{a}
SGR	8.47 ± 0.08^{c}	8.32 ± 0.09^{c}	7.53 ± 0.24^{b}	6.82 ± 0.04^{a}	6.55 ± 0.19^{a}
AFCR	1.04 ± 0.06^{a}	1.01 ± 0.03^{a}	1.20 ± 0.09^{c}	1.41 ± 0.05^{d}	1.40 ± 0.04^{d}
Performance Indicator (PI)	0.717 ± 0.06^{d}	0678 ± 0.02^{d}	0.474 ± 0.01^{c}	0.373 ± 0.01^{a}	0.330 ± 0.01^{a}
SR	96.00^{e}	93.76^{d}	87.50^{c}	85.00^{b}	81.00^{a}
Biomass Harvested	1792.53 ± 104.82^{a}	2426.66 ± 162.29^{b}	2524.23 ± 61.23^{bc}	2453.46 ± 83.64^{bc}	2643.20 ± 81.78^{c}

Means of values with same superscript along rows are not significantly different (P>0.05)

Table 1: Growth performance of Larvae at varying stocking density.

	Treatments				
Parameters	**STK1**	**STK2**	**STK3**	**STK4**	**STK5**
Investment cost Analysis (ICA)	3251.81 ± 0.00^{a}	4721.40 ± 0.05^{b}	5960.00 ± 0.00^{c}	7346.00 ± 0.00^{d}	8527.20 ± 0.05^{e}
Net Present Value (NPV)	4012.53 ± 0.03^{a}	5681.75 ± 0.00^{e}	5295.50 ± 0.05^{c}	5227.50 ± 0.05^{b}	5540.36 ± 0.03^{d}
Profit Index (PI)	3.21 ± 0.00^{d}	3.30 ± 0.00^{e}	2.70 ± 0.00^{c}	2.23 ± 0.01^{b}	2.19 ± 0.01^{a}
Incidence of Cost (IC)	0.70 ± 0.01^{a}	0.71 ± 0.01^{a}	0.77 ± 0.00^{b}	0.95 ± 0.00^{c}	0.96 ± 0.00^{c}
Benefit Cost Ratio (BCR)	1.23 ± 0.01^{e}	1.21 ± 0.00^{d}	0.88 ± 0.01^{c}	0.71 ± 0.00^{b}	0.65 ± 0.00^{a}

Means of values with same superscript along rows are not significantly different (P>0.05)

Table 2: Economic analysis of varying stocking density of *C. gariepinus* fry.

Treatments					
Parameters	**STK1**	**STK2**	**STK3**	**STK4**	**STK5**
Temperature °C	28.46 ± 0.45[a]	29.30 ± 0.26[b]	29.10 ± 0.10[b]	29.43 ± 0.05[b]	29.56 ± 0.05[b]
Dissolved oxygen (mg/l)	5.40 ± 0.01[d]	5.20 ± 0.01[c]	5.24 ± 0.01[c]	5.10 ± 0.02[b]	4.95 ± 0.05[a]
pH	7.18 ± 0.02[b]	7.11 ± 0.02[b]	7.03 ± 0.05[ab]	7.00 ± 0.02[ab]	6.91 ± 0.18[a]
Nitrate mg/l (NO_3)	0.08 ± 0.01[a]	0.09 ± 0.01[a]	0.10 ± 0.01[c]	0.12 ± 0.01[d]	0.13 ± 0.01[d]
Nitrite mg/l (NO_2)	0.02 ± 0.00[a]	0.08 ± 0.10[a]	0.03 ± 0.00[a]	0.04 ± 0.00[a]	0.04 ± 0.00[a]

Means of values with same superscript along rows are not significantly different (P>0.05)

Table 3: Mean Water quality parameters of experimental units.

Hydrogen ion concentration (pH) ranged from 6.91 and 7.18; water temperature ranged from 28.46 to 29.56; and dissolved oxygen from 4.95 to 5.40. All these parameters as shown in Table 3 fall within the recommended range [16]. Nitrate levels in experimental units were significantly higher (p<0.05) in STK4 and STK5, while nitrite levels marginally increased with increase in stocking density. This may be as a result of the increase in waste generation associated with increasing biomass. The result obtained here is in agreement with [17].

In conclusion, the results of the present study have shown that higher stocking density affected the feed utilization, growth performance and survival of *C. gariepinus* fry. Therefore, a stocking density of 150 fry/L is recommended.

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