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The Effects of Stocking Densities on Growth and Survival of *Clarias gariepinus* Burchell (1822) Fingerlings

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

189 Fingerlings were stocked at rate of 5, 10, 15, and 20 using a 30 liters capacity plastic tank in three replicates (E1 – E4 respectively) for period of six weeks which was carried out at Post Graduate Laboratory, Department of Zoology and Environmental Biology, Faculty of Science, Ekiti State University, Ado-Ekiti, Nigeria. The control experiment was stocked at 13 fingerlings per bowl, also in 3 replicates (E5). Feeding was done twice daily at 5% body weight. Water quality parameters monitored were pH, dissolved oxygen and temperature which fell within optimum limit for the growth of *Clarias gariepinus.* The initial mean weight and length of the fingerlings ranged from 0.82 - 0.9g and 4.81- 5.01cm respectively while the final mean weight and length of the fingerlings ranged from 14.61-17.93g and 11.96-13.16cm. Fingerlings stocked at 15 fingerlings per

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tank exhibited the lowest growth. Tank with 10 fingerlings per tank had the best specific growth rate. The stocking rate depends on the size of the container and it varies from 2 to 10 fingerlings per square meters (FAO, 2018). The survival rate for each group was recorded (Table 1). The growth and survival of African catfish (*Clarias gariepinus*) fingerlings reared at five stocking densities were evaluated. Fish of mean weight 0.1g were stocked in plastic tanks with three replicates for each treatment of 450 fish/m3. The fish were fed with 42% crude protein floating pellet at 5% body weight twice daily. The best growth performance and highest survival rate was obtained in E3 with mean weight gain of 17.06.±9.1g while E2 and E5 had 15.16±6.29g and 14.03±8.99g respectively. The specific growth rate was increasing daily; E1 to E5 has 6.86%, 6.94%, 5.06%, 6.67% and 6.77%, respectively. The survival rate was highest in E5 (80.77±6.44%) while E2 (80.00±6.32%), E4 (75.00±5.48%), E3 (71.11±8.07%) and E1 (63.33±8.16%) survival rate respectively. The mean weight gain, specific growth rate and survival rate were all dependent on stocking density. Therefore it can be recommended that for optimal growth of fingerlings and fast production of *Clarias gariepinus* should be stocked at maximum of 450 fish per cubic metre

Keywords: Stocking density; growth; survival; fingerlings and Clarias gariepinus.

1. INTRODUCTION

C. gariepinus have a number of distinct aquaculture characteristics and is popular cultured; They has a high fecundity rate, the ability to withstand environmental extremes and large stocking densities, as well as a great degree of plasticity in its feeding preferences [1,2,3,4]. In addition, *C. gariepinus* shows high disease resistance, and consumer acceptance [4]. However, lack of good quality seed has been a major limiting issue in *C. gariepinus* cultivation in Africa.

The most important part of *C. gariepinus* aquaculture is the rearing of fish in their early life stages (fingerlings), this is due to the fact that fish at these stages are extremely sensitive to numerous stimuli or production variables [5]. Fish producers face a huge difficulty when it comes to high mortality during the production of fish seed, correctly grasped the significance of this scenario, noting that commercially productive aquaculture is highly dependent on proper supply and management of fish seed to stock rearing enclosures [6]. Consequently, appropriate management strategies are thus viewed as strategic in halting this trend stocking density has been identified as one of the most important elements in regulating *Clarias gariepinus* aquatic behavior and the amount of biomass harvested [7]. This has been linked to issues such as reduced feed conversion efficiency, condition factor, and growth.

Fish growth, survival, and behavior are all known to be influenced by stocking density [8]. The culture pond/stocking tank's density is determined by the system used and the species cultured [9]. The main issues with stocking at high density are oxygen depletion and the accumulation of different metabolites; high stocking density has been shown to have a negative influence on growth rate in intensive systems in studies on some fish species [10].

Increased stocking density causes more stress which leads to increased energy demands and a decrease in growth rate and food usage [11]. Low stocking densities, on the other hand, may prevent fish from forming shoals/groups and feeling safe [11]. As a result, determining the optimal stocking density for a species is crucial not only for constructing an efficient culture system, but also for achieving optimal results [7].

Knowing the proper stocking density to use is critical for boosting fish production to meet rising demand while also ensuring the profitability and economic sustainability of an aquaculture operation [12]. Hence, this study is mapped out because of the interactions between stocking density, production efficiency, and profitability, as it is necessary to determine the optimal stocking densities for *Clarias gariepinus* in production systems and within specific production phases in designed to facilitate efficient management and improve overall yields and profitability [13,14].

2. MATERIALS AND METHODS

2.1 Experimental Design

The experiment was carried out at the department of Zoology and Environmental biology, faculty of science Ekiti State University, Ado Ekiti, Ekiti State South -western, Nigeria. Prior to start of the experiment, 189 Fingerlings of catfish with average initial weight of 0.1g were purchase from faculty of Agriculture, Ekiti State university fisheries and aquaculture department, Ekiti State. The fish were reared in a 20 Litres of plastic tank 30 x 15 x 20cm (LXBXH) capacity and last for 42 days after acclimatization. The fish were there randomly stocked at the rate of five (5) per tank tagged E1 in three (3) replicates, ten (10), fifteen (15), twenty (20) and thirteen (13) control in line with the set objectives., Each tank was cover with nylon mesh. Fifteen (15) plastic tanks were used for this experiment, labeled E1 to E5 (E1 was the tank filled with 5 fingerlings, E2 with 10 fingerlings, E3 with 15 Fingerlings E4 with 20 fingerlings and E5 with 13 fingerlings (control of the experiment). There were four (4) Treatments according to the number of stocking rate except the control of the Experiment.

2.2 Fish Procurement and Acclimatization

The fish were purchased from Faculty of Agriculture fisheries and Agriculture Department, Ekiti State University Ado Ekiti State and was transferred in to the tank after acclimatization in the Zoology and Environmental Department Laboratory of Ekiti State University, Ado Ekiti, Ekiti State, Nigeria.

2.3 Experimental Diet

The feed for this experiment was commercial diet called Durantee 1.1 mm and the proximate analysis of the feed were 1.0 MP Fish Starter (1.1 MM) for mere crude protein; 57%, crude fat 15%, crude fibre, 0.4%,ash content; 10.5%, calcium ; 2.5%, sodium ; 0.8% and phosphorus ; 1.5%. The feed were measured 5% body weight, after measuring the weight of the fish and were hand fed by adding into each tank 10.00h (morning) and evening 16.00h(evening). The uneaten and feaces food were siphon out of the tank through siphon pipe.

2.4 Management of Fingerlings

The fish were fed at 5% body weight and twice a day (10:00 and 16:00 hour) with commercial diet (*Durantee 1.1 mm*) for 42 days. Approximately, 80% of the water in tank was replaced with fresh water twice a week to prevent pollution by uneaten feed and excreta. Uneaten feed and excreta was removed daily using siphon pipe with minimal disturbance to the fish. Dead fish in each tank was recorded daily. Dead or eaten fish was not replaced during the experiment.

2.5 Determination of Standard Length and Weight of the Fingerlings

Fish were weighed using electronic digital balance (PEC Medical USA TH-1000WITH CAPACITY 1000g x 0.1g) and total length taken in centimeters using centimeter ruler, after being scooped out with a tread. The weight of each fingerling was taken to the nearest 1.0 g, while the total length was measured to the nearest 0.1cm. The standard length and weight of the fingerlings was recorded every week. Growth rate was calculated percentage increase in length and increase in weight [6], as expressed in Equation 1and Equation 2 respectively.

Mean weight gain (g) Final mean weight Initial mean weight

$Lengh\ gain\ (cm\ )(\%)$ = [Final length - Initial length (cm)/ Initial length (cm)] x 100 (1)

$Weigh\ tga$ i $n(\%)$ = [(Final weight - Initial weight) (g) / Initial weight (g)] x 100 (2)

Where,

W_1 = Initial weight,
W_2 = Final weight,
d = stock density,
0.5 = constant.

2.6 Determination of Water Quality Parameters

The selected water quality parameters measured during the study included temperature, PH and Dissolved Oxygen. Temperature of water determined using a PH meter (Jinotech PH 5-25 precision pH/MV meter. Determination of dissolved oxygen was carried out using water aquaculture kit titration methods [11].

2.7 Determination of Specific Growth Rate

Specific Growth Rate (SGR) was calculated using the formula as described by Omitoyin [15] in Equation 4.

SGR (%) = [In (Final weight) (g) – In (Initial weight)] (g) / Time interval (days) x 100 (3)

2.8 Determination of Survival Rate

Survival rate was calculated at the end of the sampling period as shown in Equation 3 according to Omitoyin [15]

$Survival\ rate(\%)$ = (Final number of fish harvested / Initial number of fish stocked) x 100 (4)

2.9 Determination of Mortality Rate

The mortality rate was calculated using total number of the dead fish dived by number of the fish stocked multiply by one hundred; it is expressed as;

Mortality (%) = (Total number of dead fish)/(Total numberof fish stocked)×100 (5)

2.10 Determination of Performance Index

Performance index was evaluated to determine the effect of stocking density on growth and survival of performance with more precision. This was calculated by combining two responses; growth and survival as shown in Equation 5

Performance Index = [(survival rate x Final mean body weight (mg) – Initial mean body weight) / Duration of rearing Days] (6)

2.11 Determination of Food Conversion Ratio

Food conversion ratio was expressed as shown in equation 7 [15].

Food conversion ratio = (weight of dry feed fed(g))/(Mean weight gain (g))

2.12 Statistical Analysis

All experimental data were expressed as means (plus/minus standard deviation / error) such as final mean weight, survival and SGR, weight gain were subjected to one way analysis of variance (ANOVA) to determine the significant difference in stocking densities. Significant mean values were separated by Duncan's multiple range tests using Harmonic Mean Sample Size analysis (version 21) [7].

3. RESULTS

3.1 Temperature of Water Medium

The water temperature in all tanks ranged between 20.40 – 20.46ºC. The mean temperature of water in the Tanks E2 was highest with (20.46ºC) and a lowest (20.40ºC) in E1 as shown in Table 1. Water temperature is lower than the 26⁰C reported by Johnny et.al (2017) for similar study. This is as well lower than the position that *Clarias gariepinus* fingerlings will not survive in the temperature as high as 40⁰C. There is a direct relationship between the water temperature and availability of the dissolved oxygen. The lower water temperature of about 20⁰C reported in this study compared to about 30°C reported Erondu, [11] contributed to the level of dissolved oxygen in this study higher than 2.2mg/l reported by Erondu [11].

3.2 pH of Water Medium

Increase in acidity and alkalinity of any water body may increase or decrease the toxicity of contaminant in water [16]. Chronic pH levels may reduce fish production which associated with fish die-offs. pH mean values in all rearing tanks ranged from 6.35-6.51 with the highest pH mean value recorded for tank E4 (tank with twenty fingerlings)from 0.91±5.49. The acidic effects of pH on Fish is lowest growth. For all treatments, pH values remained within acceptable limits of 6.5 – 9.0 [13].

Table 1. Water quality results of test media

Parameters	Samples				
	E1	E2	E3	E4	Control
	E1 (5 fingerlings per tank)	**E2** (10 fingerlings per tank)	**E3** (15 fingerlings per tank)	**E4** (20 fingerlings per tank)	**E5** (13 fingerlings per tank)
Temperature (Cº)	20.44±0.19	20.46±0.27	20.40±0.14	20.42±0.10	20.43±0.14
PH	5.49±0.03	5.82±0.45	6.35±0.91	6.51±0.91	5.80±0.49
Dissolved oxygen (mg/L)	2.61±3.04	3.10±2.72	4.17±4.92	5.66±4.55	4.70±2.69

Results +are expressed as Mean ± SD of three replications

Table 2. Growth performance and survival rate of *Clarias gariepinus* reared in plastic tanks at different stocking densities for six weeks

Parameters	Sample				
	E1 (5 fingerlings per tank)	**E2 (10 fingerlings per tank)**	**E3 (15 fingerlings per tank)**	**E4 (20 fingerlings per tank)**	**E5 (13fingerlings per tank)**
Initial mean length (cm)	5.01±0.57	4.98 ±0.49	4.96±0.52	4.81±0.58	4.86±0.64
Final mean length s(cm)	11.96±2.72[a]	12.99±1.63[b]	13.16±2.29[b]	12.04±2.23[a]	12.17±2.38[a]
Initial mean weight (g)	0.83 ±0.18	0.87 ± 0.17	0.85 ± 0.21	0.82 ± 0.21	0.90 ± 0.17
Final mean weight (g)	14.76 ± 7.75[a]	16.00 ± 6.30[b]	17.93 ± 9.03[c]	14.61 ± 8.22[a]	14.83± 8.95[a]
Mean length gain (cm)	6.85 ± 2.91	7.96 ± 1.72	8.12 ± 2.4	7.13 ± 2.21	7.42 ± 2.4
Mean weight gain (g)	13.9 ± 7.75	15.16 ± 6.29	17.06 ± 9.1	13.75 ± 8.29	14.03 ± 8.99
Specific growth rate (%)	6.86[c]	6.94[c]	5.06[a]	6.67[b]	6.77[b]
Survival rate (%)	63.33 ± 8.16[a]	80.00 ± 6.32[c]	71.11± 8.07[b]	75.00 ± 5.48[b]	80.77 ± 6.44[c]

Mean at different superscripts in a row differ significantly at P<0.05

3.3 Dissolved Oxygen of Water Medium

Water quality in the ponds deteriorated with increased stocking density, as can be expected. The parameters which were influenced negatively were dissolved oxygen and water transparency. Adequate levels of DO are essential for maintaining optimal fish growth. Problems of low DO are particularly prevalent in fish ponds with high stocking densities. Extreme water quality conditions in fish ponds such as low DO may cause death to fish and other benthic organisms. Dissolved oxygen (DO) during the rearing period ranged from 0.9 - 5.56mg/l. Dissolved oxygen (DO) at the different stoking rate increases in the order E1< Control < E2 < E3 < E4 as shown in Table 1. The mean value obtained for all the dissolved oxygen investigated were within the acceptable limits for fish growth and health [17]. The relatively high DO in the present study was due to the practice of regular exchange of water. During the trial, the dissolved oxygen in the two lower stocking density treatments remained comfortably above the minimum 2.2 mg L-1 required for optimal culturing of *C. gariepinus* [11]; however for the highest stocking density the values were well above 2 mg L- throughout. In this particular study, (5.6mg/L) was reported as the highest Dissolved oxygen which is relatively higher than 2.2mg/l reported by Erondu [11].

The reduction of dissolved oxygen at higher stocking density is also expected, due to increased oxygen consumption by higher numbers of fish and higher oxygen demand from higher numbers of microbes [10]. Dissolved oxygen (DO) at the different stoking rate increases in the order E1< Control < E2 < E3 < E4 as shown in Table 1.

4. DISCUSSION

According to FAO, [18], stocking density is an important factor affecting growth, food supply and environmental conditions. The optimum stocking density rate for *Clarias gariepinus* fingerlings varies from 2 to 10 fingerlings per meters square depending on the size of the tanks and marketable size of the fish [18], With stocking density rate of 1 g fry at 40- 80m/^{3}, recommended tanks with 1.15m^3 water volume for rearing and that stocking of tank is 100kg/m$^{3.}$ Also the initial weight of the *Clarias gariepinus* fingerlings was 0.8-1.0g which amount to 10g/m^2, the 30 litre tank used for this research is 10m/s^2 .The optimum stocking density of *Clarias gariepinus* according to FAO, [18] depends on the rate marketable desired and varies from 2 to 10 fingerlings meter.

Various studies on *Clarias gariepinus* fingerlings report difference according to type of culture media, fish reared at highest density has been shown to have lowest final mean weight showed that the highest stocking (E4 tank with 20 fingerlings) showed the lowest final mean weight 14.61±8.22 (g) while the tank with 10 fingerlings (E2 and E5) (Control) tank with 13 fingerlings. The final mean weight were inversely proportional to stocking density, which was particularly evident when average weight of fish held at the lowest and highest densities were compared .However , only the average weight of fish reared at lowest density was significantly different from weight of fish reared at the highest densities. Result from this study showed the final mean length gain of *Clarias gariepinus* fingerlings was higher in E3 (tank with 15 fingerlings) with 13.16± 2.29 (g) while the lowest mean length gain was found E1 (tanks with fingerlings) with 5fingerlings) with 112.96 ±2.72g. Also the mean weight gain was recorded in E3 with 17.93±9.03g while the lowest mean weight gain was in E1 with 13.9±7.75 (g). The result was not in agreement with the result obtained by Machiels and Dam [19]; who reported that growth rates were inversely related to the stocking density from the study of African cat- fish fry; he reported that growth rate was inversely related to stocking density. The difference in the results obtained in this study might be related to the difference in biology and environmental requirements of the species. Aksungur et al. [20] Reported that, fry attained highest length and achieved maximum weight when stocked at $100m^{-2}$ might be due to fewer fry per unit space. This also was inversely related to stocking density. [20] Also found that high stocking density had negative effect on the mean body weight, final mean total length SGR and weight in *Clarias batrachus* fry.

Growth performance and survival rate of *Clarias gariepinus* fingerlings reared at different stocking rates in this present study showed that stocking densities at which fingerlings were reared significantly ($p<0.05$) affected the final mean length, final means weight and the specific growth rate The growth were high with E2 (tank with ten fingerlings) with 6.94%. This result disagreed with the report of Aksungur et al. [20] in the African cat fish raised in aquaria in raceways. The mean net weight gain was highest in E3 (tank with fifteen fingerlings) (7.96±1.72 g) and least in E4 (tank with twenty fingerlings). Best growth rate was observed at stocking density of 10 fish (E2) with E3 15 fish as the poorest. The mean survival rate ranged between 63.33 and 88.77% and increased in the order: E1<E3<E4<E2<E5. The Low dissolved oxygen could be responsible to low survival rate in E1. When the fish was reared at stocking density. A related phenomenon was reported by Sayed [21] that increase in stocking density results in increasing stress, which leads to higher energy requirement, causing a reduction in growth rate and food utilization. Also the specific growth rate has been reported to be inversely proportional to the stocking density. The survival rate decrease as the stocking density increases and this could be attributed stress factor as a result of competition for space, food and interaction which probably lead to the death of the weaker fish. Similar observation was earlier reported by Basuki et al. [12]. This research show that *Clarias gariepinus* can survive and can be reared for profitable and commercial purposes in tanks.

Water temperature which ranged from 20.46^{0C} that fish conformed to the optimum values reported by [14] that fish grow fast in optimum temperature of 26^{0}C but would not survive in the temperature as high as 40^{0}C. pH mean values in all rearing tanks ranged from 6.35-6.51 with the highest pH mean value recorded for tank E4 (tank with twenty fingerlings)from 0.91±5.49 . The acidic effects of pH on Fish were lowest growth. Dissolved oxygen (DO) Values in all tanks ranged from 2.61-5.66mg/L and increased with decreasing stocking densities. The mean value obtained for all the parameters investigated were within the acceptable limits for fish growth and health [17].

5. CONCLUSION

The result from this study indicated that fingerlings rearing expressed by stocking density significantly impacted the growth performance and survival of *Clarias gariepinus* in plastic tanks The best stocking density was found in E2 (tank with 10 fingerlings) and in the control tank (tank with 13 fingerlings). The highest weight gain, growth rate and survival rate were recorded in to culture tank with 15 fingerlings. The growth and survival of cultured fish have been established to be dependent on the stocking density. The African catfish fingerlings tend to perform better at 10 fish/m^2 stocking density depend on the size of the tank. Therefore it will probably be unprofitable to stock fingerlings of *Clarias gariepinus* at very high stocking densities. The harmful effects that higher stocking density had on the culture under fish have been shown to include reduction of growth and survival rates and increase of food conversion ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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