

Full Length Research Paper

Effect of stocking density on tilapia (*Oreochromis niloticus* Linnaeus 1757) growth and survival in bamboo – net cages trial

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The study was carried out to evaluate the effect of varying stocking densities on the growth, survival, and yield of tilapia (*Oreochromis niloticus* Linnaeus 1757) at the freshwater reservoir (average depth, 1.7 m) of the University of Agriculture Abeokuta, Nigeria, for a period of 3 months. Tilapia juvenile with a mean weight of 29 ± 4.81 g were randomly (Complete Randomized Design) stocked at 50, 100, 150 and 200 specimen per cage (1 m^3) were fed with commercial feed (34.55% Crude Protein). 20% of stocked fish was sampled for growth fortnightly. Profit index of the fish harvested under each treatment was evaluated. Relevant physico-chemical parameters like pH, conductivity, temperature, water depth and dissolved oxygen were also monitored forth nightly. The experimental fish and fish carcass (before the experiment and at harvest) from each treatment were analysed in replicates for their proximate composition. There were no significant differences ($P > 0.05$) in daily weight gain, specific growth rate, final weight, relative growth rate, feed conversion ratio (FCR), survival, protein efficiency ratio for all the treatments. However there were significant differences ($P < 0.05$) in fish production (harvest), profit index, crude protein, crude fat, and ash composition of the fish carcass (at harvest). As stocking density increased, the crude protein content of the fish carcass decreased indicating an inverse relationship. The stocking density of 150 juvenile/cage with a final weight of 82.74 g per fish, feed conversion ratio of 2.15, survival of 99.35% and fish production of 24.79 kg/cage was considered best on the basis of the profit index of 2.01 compared with the range of 1.45 to 1.82 for the other three treatments.

Key words: Stocking density, profit index, survival, growth.

INTRODUCTION

Tilapia is the second most important farmed fish in the world, after carps. Tilapia culture is being practiced in most of the tropical, subtropical and temperate regions. Great attention has been paid to tilapia culture in recent years. The food and Agriculture Organization of the United Nations (FAO 1999) reported that the production of farmed tilapia has risen at an annual rate of 12% since

1984. As a result, this production has jumped from 308 234 metric tones (mt) in 1988 to 1099 268 mt in 1999 with a 356% increase (FAO 2001). During the same period, the value of these fish has increased from 383 to 1427 million US\$ (FAO 2001).

As human population increase and natural fisheries resources diminish, fish culture is becoming very important (Meryl, 1996). Many small-scale farmers have failed to culture fish because of inadequate knowledge such as stocking fry at too small size and at too high density (Edward and Demaine, 1988).

This paper presents an analysis of effects of varying

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Table 1. Summary of the growth performance at different densities of tilapia (*Oreochromis niloticus*) cultured in bamboo – net cages for 91 days.

Treatment	Initial (g)	Final (g)	Weight (g)	RGR (%)	SGR (%/day)	FCR	Survival (%)	DWG (g/day)	Production (Kg/cage)	Water depth (m)	PER
I 50/cage	32.5	111.66	79.16	242	1.35	1.92	99.00	0.88	8.83 ^a	0.61	0.94
II 100/cage	25.75	93.65	67.9	267	1.43	1.56	99.50	0.76	13.9 ^b	0.59	1.26
III 150/cage	29.15	82.74	53.59	183	1.14	2.15	99.35	0.59	24.79 ^c	0.50	0.86
IV 200/cage	30.75	84.02	53.27	179	1.11	2.21	98.50	0.59	28.56 ^c	0.59	0.89

^{abcd}Values with different superscript in the same column were significantly different at $P < 0.05$.

SGR, Specific Growth Rate; **FCR**, Feed Conversion Ratio; **RGR**, Relative Growth Rate; **DWG**, Daily Weight Gain; and **PER**, Protein Efficiency Ratio.

stocking densities on growth and survival of tilapia in eight 1 m³ experimental bamboo cages at the University of Agriculture, Abeokuta, Nigeria freshwater reservoir.

MATERIALS AND METHODS

Eight bamboo cages (1 m x 1 m x 1 m) internally lined with net hapas were placed inside the University of Agriculture, Abeokuta, 3 – hectare reservoir, with two-third of the cages immersed in water. The cages were tied to blocks (four per each) which served as base with the aid of kuralon rope (no 15). The cages were randomly stocked with tilapia juveniles with a mean weight of 29.54 ± 4.81 g at 50, 100, 150 and 200 per cage (replicated twice) corresponding to treatments I, II, III and IV, respectively. All the fish throughout the three months culture period were fed twice daily, six days per week at a rate of 5% of their biomass for the first month and 3% of their biomass for the rest of the culture period.

After three months of culture, the cages were moored to the shore of the reservoir where the fish were harvested, counted, measured and weighed. Fish sampling were carried out once a night, this was usually conducted in the morning between 7:30 and 9:00 am using a scoop net. During sampling, 20% of the stocked fish in each cage was scooped out and weighed using Philips electronic kitchen scale. As the water level reduced, the cages were relocated to maintain approximately the same level of water in the cages. The fish were harvested at the 90th day by moving the cages to the shore one after the other. All the fish inside the cages were scooped out for mass weighing per cage and the total number of fish in each cage counted. To determine the growth response of the fish, the following parameters were calculated; Mean Weight Gain (MWG), Feed Conversion Ratio (FCR), Relative Growth Rate (RGR), Specific Growth Rate (SGR), Protein Efficiency Ratio (PER), and Mortality and Survival Rate.

$$MWG = Wt_2 - Wt_1$$

Where Wt_1 = Initial mean weight of fish at time T1 and Wt_2 = Final mean weight of fish at time T2.

$$FCR = \text{Weight of feed given (g)} / \text{Fish weight gain (g)}$$

$$RGR (\%) = [(W_f - W_i) / W_i] \times 100$$

Where W_f = Final average weight at the end of the experiment and W_i = Initial, average weight at the beginning of the experiment.

$$PER = \text{Fish Weight Gain (g)} / \text{Protein Intake (g)}$$

$$SGR = [(\log_e W_f - \log_e W_i) / \text{Time (days)}] \times 100$$

Where W_f = Final average weight at the end of the experiment, W_i = Final average weight at the beginning of the experiment, \log_e = Natural logarithm reading and Time = Number of days for the experiment (91 days).

Survival Rate (%) = (Number of fish that survived / Total Number of Fish stocked) X 100. Proximate analyses of feed and fish carcass were carried out according to the procedure in AOAC (1984). Data collected were analysed using analysis of variance technique (Steel and Torrie, 1980). Significant difference in means were separated using Duncan Multiple Range Test (Duncan, 1955), the entire statistical test was done on SPSS 10 version for Windows.

RESULTS AND DISCUSSION

The percentage survival rates of fish in all the treatments at harvest are presented in Table 1. The mean survival rate ranged between 98.5 and 99.5%, with treatment II having the highest survival rate of 99.5% and treatment IV with the lowest survival rate of 98.5%. Mortality was first observed in treatment IV during the second week of culture. The result of this study indicated an inverse relationship between survival rate and stocking density. Table 1 shows the summary of the initial and final average weights (g) of fish, daily weight gain (DWG, g/day), relative growth rate (RGR) and specific growth rate (SGR, %/day). Treatment I with 50 juveniles/cage had the highest final mean weight of 111.66 g, while treatment III had the lowest weight of 82.74 g. Values of daily weight gain were not significantly different for all the treatments, but there were perfect correlation between Daily Weight Gain of tilapia and protein intake ($P < 0.01$). The ability of the fish to convert feed given to flesh decrease as stocking density increased, except for treatment II which had a higher Feed Conversion Ratio than Treatment I. This could be explained as due to the higher water volume in cages under treatment II (0.62 m³) compared to the water volume in cages under treatment I (0.59 m³).

Fish production increased as the stocking density increased, the production was generally high in this experiment. High production obtained could be attributed

Table 2. Means and ranges of some physico-chemical parameters of water inside the cages of different densities of tilapia for 91 days culture period.

Parameters	Treatments			
	I	II	III	IV
Conductivity ($\mu\text{s}/\text{cm}$)	199.8 (161.3 – 230)	200.9 (159.95 – 234.5)	200.9 (160.25 – 231.5)	200.8 (161 – 230)
pH	7.33 (6.88 – 7.75)	7.27 (6.99 – 7.43)	7.35 (6.97 – 7.76)	7.23 (6.90 – 7.69)
Temperature IV ($^{\circ}\text{C}$)	30.00 (29 – 31.3)	30.2 (29.5 – 32)	30.2 (29.5 – 31.3)	30.8 (29.5 – 32.9)

Table 3. A Summary of Cost benefit evaluation results of different densities of tilapia culture.

Parameter	I	II	III	IV
Production period (days)	91	91	91	91
Stocking density (per cage)	50	100	150	200
Net production (Kg/cage/91days)	8.832	13.944	24.789	28.558
Value of fish @ N200.00/kg	1766.4	2788.8	4957.8	5711.6
Feed Input (Kg)	10.55	14.05	23.55	31
Cost of feed/Kg (N)	50	50	50	50
Cost of feed used (N)	527.50	702.50	1177.50	1550.00
Cost of fingerling (N)	300.00	600.00	900.00	1200.00
Cost of cage	387.50	387.50	387.50	387.50
Total cost of production	1215.00	1690.00	2465.00	3137.00
Gross profit (N)	551.40	1098.80	2492.80	2574.10
Profit index	1.45 ^a	1.65 ^b	2.01 ^c	1.82 ^d

to high crude protein content of the feed, the favourable physico-chemical conditions of the reservoir and the design of the cage whereby it was internally lined allowing for the maximum utilization of the feed. Water quality parameters measured in the cages were pH 7.23 – 7.35, temperature 30 – 30.8 $^{\circ}\text{C}$ and conductivity 199.8 – 200.9 $\mu\text{s}/\text{cm}$ (Table 2).

The culture of *O. niloticus* juvenile in cages at high densities seems to be feasible. Treatment II had the highest survival rate of 99.5% which was comparable with survival for tilapia (99%) cultured in cages and reported by Alev and Dikel (2003) in Seyham Dam Lake. The result of this study indicated an inverse relationship between survival rate and stocking density. The daily weight gain obtained for treatment III (0.59 g/day) was higher than the highest 0.34 ± 0.015 g/day obtained by David et al. (2005) and 0.27 ± 0.00 g/day reported by Quattara et al. (2003) with the same stocking density. High production obtained in this experiment could be attributed to high crude protein content of the feed, the favourable physico-chemical conditions of the reservoir and the design of the cage whereby it was internally lined allowed for the maximum utilization of the feed.

The profit index for all the cages were significantly different ($P < 0.05$; Table 3). The higher profit index in treatment III over that of treatment IV probably pointed to the fact that 150 juveniles per cage (1 m^3) may be better in economic terms than 200 juveniles per cage. This is also reflected in the lack of significant difference ($P > 0.05$) in the Feed Conversion Ratio and Specific Growth Rate for all the treatments. It is therefore apparent that biological and economic benefit will be achieved in intensive cage culture of tilapia juvenile when stocked at 150 juveniles/ m^3 .

REFERENCES

- Alev DA (2003). Tilapia – A successful second crop to trout, fish farmer International file, 17(1): 28-30.
- Association of Official Analytical Chemists AOAC (1984). Official Methods of Analysis. 14th edn. AOAC, Arlington, VA, p. 1141.
- David ML, Bernard F, Jonathan MM, Michael S, Herwig W, Gerold W (2005). Effects of open-pond density and caged biomass of Nile Tilapia (*Oreochromis niloticus* L.) on growth, feed utilization, economic returns and water quality in fertilized ponds. Aquac. Res. 36: 1535-1543.
- Duncan DB (1955). Multiple Range and Multiple F – Test Biometric, 11: 1-12.

- Edwards P, Demaine H (1988). Rural Aquaculture: Overview and Framework for country reviews. RAP Pub. 1997/36. Rap/fao. Bangkok.
- Meryl W (1996). The transition in the contribution of Living Aquatic resources to food security, food and environmental Discussion paper 12, International food policy, research Institute, Washington D.C. 1pp.
- SPSS for Windows, release 10.0.1 (27 Oct. 1999) copyright SPSS incorporated.
- Steel RDG, Torries JH (1980). Principles and procedure of statistics. Biometric approach, 2nd Ed. McGraw Hill Book Co. Inc, New York.
- Ouattara NI, Teugels GG, Douba VN, Philippart JC (2003). Aquaculture potential of the black 190 chinned tilapia, *Sarotherodon melanotheron* (Cichlidae). Comparative study of the effect of stocking density on growth performance of landlocked and natural populations under cage culture conditions in Lake Ayame (Co`te d'Ivoire) Aquaculture Res. 34: 1223-1229.