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Effect of Stocking Density on the Growth Performance of Sex Reversed Male Nile Tilapia (*Oreochromis niloticus*) Under Pond Conditions in Tanzania

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Abstract: A study was conducted to compare the growth potential of monosex Nile tilapia at two different stocking densities. Fish of 2.6±0.1g average weight were stocked in ponds at the stocking density of 3fish/m^2 (low stocking density 'LD') and 13fish/m^2 (high stocking density 'HD') respectively. Locally feed (CP; 25 %) was administered at 5% of body weight three times a day for five months. Monthly sampling was conducted to assess growth by measuring weight and length of 30 fish from both systems to obtain the average weight and length for specific growth rate (SGR), feed conversion ratio (FCR), average daily gain (ADG), weight gain (WG) and Biomass (BM). There was significantly higher ($p<0.05$) fish growth performance in LD ponds; SGR (3.47%), ADG (0.57g), WG (83.5g) compared to HD; SGR (2.71%), ADG (0.27g) and WG (40.8g). BM in HD was significantly higher (565.3g) compared to LD (258.3). There was no significant difference ($p>0.05$) in FCR, although lower value was in HD (2.46) than LD (2.71). The differences in performance of Tilapia in the two stocking densities could have been attributed to stress, competition for food and living space. However, HD gave significantly higher biomass yield per area than LD and can be very useful to give good returns for local consumption and where resources like land, water and capital are inadequate. There is therefore need to determine the optimum management levels necessary to boost fish growth of under high-density systems.

Key words: Feed Conversion Ratio · Nile Tilapia · Specific Growth Rate · Biomass

INTRODUCTION

Aquaculture is still the fastest-growing food-producing sector and plays an important role in enhancing global food security, alleviating poverty and human dependence on depleted natural fish stocks [1]. Tens of millions of people are engaged in aquaculture production with majority involved in small-scale production [2]. Tilapia is seen as one of the most significant fish species which can reduce the gap of increasing worldwide demand for protein sources [3]. Its production worldwide has also increased from 1,099,268 tons in 1999 to about 3,500,000 tons in 2010 but production is still low to meet demand [4]. Tilapia is a group of freshwater omnivorous cichlids that are native to Africa and subsequently have been introduced, either deliberately or accidentally, throughout the world [5].

The Tilapine farming has also received considerable attention in Tanzania because of its promising aquaculture potential. Among all the species of Tilapia, *Oreochromis niloticus* is by far the most important with more than 95% of the farmers rearing it in earthen ponds under mixed-sex culture [6]. The importance of *O. niloticus* stems from biological reasons (fast growth, short food chain, high food conversion ratio, readily accepting artificial feeds, ease of breeding in captivity, disease resistance, high fecundity), social reasons (good table food quality, good market price) and physical reasons (tolerant to a wide range of environmental

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conditions) [7]. However, the tendency of small scale farmers in Tanzania growing mixed sex Nile tilapia to table/market size in ponds has been a very challenging task due to precocious maturity and uncontrolled reproduction of females which result in the overpopulation of production ponds hence management challenges.

Despite the great potential of Tilapia culture in the country, limited efforts have been devoted to determine appropriate stocking densities for Tilapia in Tanzania. Yet the determination of stocking density for cultured Tilapia is essential for the maximization of its production, profitability and sustainability. This is because stocking density is considered to be one of the important factors that affect fish growth, feed utilization and the gross fish yield [8]. In addition, many physicochemical parameters of water like temperature, dissolved oxygen, free carbon dioxide, transparency and pH are generally considered to have primary importance in fish culture [9] but also greatly affect the stocking densities. In many cultivated fish species, growth is inversely related to stocking density and this is mainly attributed to social interactions [10, 11], however available information regarding the effect of stocking density on Tilapia is inconsistent. For instance, Gall & Bakar [12] reported that the body size of Tilapia fry was not affected by stocking densities ranging from 10 to 200 fry L^{-1} when water flow is uniform. On the contrary, El-sayed [11] found that the specific growth rate and percentage weight gain were negatively correlated with stocking density. It is evident, therefore, that further studies are needed to verify the effects of stocking density on the growth performance of *O. niloticus* under pond conditions. This study was therefore conducted to determine the growth performance of male Nile tilapia grown under higher (HD) and lower densities (LD) to provide information to current and prospecting fish farmers with scientific evidence when deciding on the choice of farming methods to adopt.

MATERIALS AND METHODS

Study Site and Experimental Animals: The study was conducted at the Tanzania Fisheries Research Institute (TAFIRI) in Mwanza where the Nile tilapia fry were produced as a result of hormonal sex reversal using 17α -Methyl Testosterone (MT). The fish was only stocked in ponds when they had attained an average weight of 2.6±0.1g at a density of 3 fish/m^2 and 13 fish/m^2 for LD and HD respectively both in triplicates. A total of six ponds were used with each pond filled with water to a level of 1.0 m depth at outlet and 0.8m at inlet. Water losses due to evaporation, seepage and quality deterioration were compensated on weekly basis.

Supplementary Feeding and Water Quality Parameters: Due to lack of commercial fish pellets in Tanzania, fish diets were prepared from locally available feed ingredients. Fish were fed on local feed (25% CP) made from fishmeal ('Dagaa'), cotton seed cake, maize bran, multivitamins and fish oil. The feed was administered to fish at 5% body weight fed three times a day (at 9.00, 13.00 and 16.00hrs) for 5 months. Feeding rate tables were adjusted every 2 weeks based on the average weight of fish. Feeding of fish was done by hand as this method enables regular inspection of the fish [13]. Three water quality parameters (pH, temperature and dissolved oxygen) were recorded weekly using a portable pH-Temperature meter (HI 991300 pH/EC/TDS/Temperature meter) and portable Oxygen meter (HI 9143 Microprocessor Oxygen meter HANNA instruments) at 08.00, 13.00 and 16.00hrs. These parameters were considered because of their major influence on fish growth.

Data Collection: Thirty fish were randomly sampled on a monthly basis and body measurements (weight and length) taken for each fish. After weighing, the fish were returned back to their respective ponds. Growth performances of fish were determined and feed utilizations were calculated as described by Alhassan *et al.* [1] and Sveier *et al.* [14] as follows.

$$\text{Food conversion ratio (FCR)} \ \frac{\text{Total feed given (g)}}{\text{Total weight gained (g)}} \quad (1)$$

$$\text{Specific growth rate/day (SGR)} = \frac{\ln(\text{Final weight}) - \ln(\text{Inital weight})}{\text{Culturing days}} \quad (2)$$

$$\text{Average daily gain (ADG)} = \frac{\text{Weight gain (g)}}{\text{Culturing days}} \quad (3)$$

$$\text{Weight gain (WG)} = \text{Final weight (g)} - \text{Inital weight (g)} \quad (4)$$

$$\text{Biomass (BM)} = \text{Number of fish} \times \text{Mean weight of fish} \quad (5)$$

$$\text{Survival rate (SR) (\%)} = \frac{\text{Number of fish harvested}}{\text{Number of fish stocked}} \times 100 \quad (6)$$

Data Analysis: Results are presented as means ± standard error. Fish growth rates, feed utilization efficiency and water quality variable results obtained from the experiment were subjected to one-way Analysis of Variance (ANOVA) using SPSS (version 17) program. Significance was established at $P<0.05$.

RESULTS

The different growth parameters (average daily gain, weight gain, specific growth rate) of *O. niloticus* fed with supplementary feeds under low and high stocking densities are shown in Table 1. SGR, ADG and WG were significantly ($p<0.05$) different, with fish stocked under high density of 13 fish/m^2 having higher values than fish reared under low density of 3 fish/m^2. SGR was 2.71±0.02 and 3.47±0.03%, ADG was 0.27±0.007 and 0.57±0.017g while WG was 40.8±1.1 and 83.5±2.5g for HD and LD reared fish respectively. However, BM was significantly higher in HD than that in LD. There were no significant differences ($p>0.05$) in FCR, although lower values (2.46) were obtained in HD cultured fish as compared to LD cultured (2.71). Food conversion ratio was therefore not significantly affected by stocking density ($P<0.05$). The survival rate was 96% for (HD), 98% for (LD) during the culturing period. Fish survival was therefore reasonably good for the two stocking densities.

Fish from LD system had a significantly ($p<0.05$) faster growth trend values from the first up to fifth month (Table 2). The weight of LD reared fish was two times that of HD cultured fish at five months and were 1.25 times longer (Figure 1).

Table 1: Growth parameters, food conversion ratio and survival rate of Nile Tilapia grown under LD and HD for five months

	Culture system	
Parameter	HD	LD
Food conversion ratio	2.46±0.07[a]	2.71±0.08[a]
Specific growth rate (%)	2.71±0.02[a]	3.47±0.03[b]
Weight gain (g)	40.8±1.1[a]	83.5±2.5[b]
Average Daily gain (g)	0.27±0.007[a]	0.57±0.017[b]
Biomass (g)	565.3±14.2[a]	258.3±7.6[b]
Survival rate (%)	96	98

Values in the same row sharing the same superscript are not significantly different ($p>0.05$. Data are represented as means ± standard error

Dissolved oxygen and pH values were significantly ($p<0.05$) higher in LD than HD, 6.7±0.3 and 5.7±0.3, 7.4±0.2 and 6.5±0.3 for LD and HD respectively (Table 3). However, no significant difference was observed in the temperatures (25.4±0.7 and 25.0±0.4) in LD and HD respectively; these parameters were however under the normal ranges in the two different stocking densities.

DISCUSSION

The growth of tilapia *(O. niloticus*) depends on the stocking density, food quality, energy content of the diet, its physiological status, reproductive state and environmental factors such as temperature, pH and dissolved oxygen [15]. In this study, there was a significant difference in growth ($P<0.05$) with two stocking densities. Higher SGR, ADG and WG in LD reared fish imply fast growth as compared to lower values observed from HD reared fish which indicated slow growth. This result is in agreement with the findings of Gibtan *et al.* [7] who studied the effects of stocking density (50/m^3, 100/m^3, 150/m^3 and 200/m^3) on the same species under cage culture and found that the highest weight (219.71g) of *O. niloticus* was attained at a density of 50fish/m^3 followed by average weight of 197.48g, 169.120g and 147.76g respectively. El-sayed [11] also studied the effect of stocking density (3, 5, 10, 15 and 20 fry L^{-1}) on the growth of Nile tilapia and found that best performance was achieved at fish stocked at 3 fry L^{-1}. The lower growth performance of tilapia exhibited at higher stocking density could have been caused by energy expenditure because of intense antagonistic behavioral interaction, competition for food and living space and increased stress. It has been reported that high stocking density of Nile tilapia fry might lead to 'social stress' which eventually leads to impaired fish growth [11]. To verify this, Barcellos *et al*. [16] reported increased resting plasma cortisol concentration of Nile tilapia fingerlings stocked at high densities, an indication of chronic stress attributable to social stress.

Fish survival was reasonably good at both low and high stocking densities. The findings may indicate that stocking density might have a limited effect on fish survival. The results are similar to those reported by Dambo & Rana [17] who reported that the survival of Nile tilapia fry was between 94.5% and 100% at stocking densities ranging from 2 to 20 fry L^{-1}. In addition, El-sayed [11] also found that the survival rate of Nile tilapia ranged from 90 to 100% stocked at different rates ranging from 3 fry L^{-1} to 15 fry L^{-1}. The higher survival

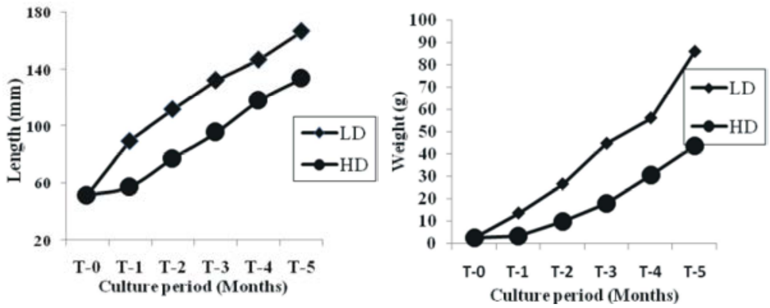

Fig. 1: Growth trends for HD and LD fish for weight (left) and length (right)

Table 2: Weight and length of fish under HD and LD culture over five months

		Culture period (months)					
Parameter	System	0	1	2	3	4	5
Weight (g)	HD	2.6±0.1^{a}	3.3±0.1^{a}	9.8±0.4^{a}	17.9±0.7^{a}	30.6±1.2^{a}	43.5±1.1^{a}
	LD	2.6±0.1^{a}	13.5±0.6^{b}	26.5±1.4^{b}	44.8±1.5^{b}	56.2±1.9^{b}	86.1±2.5^{b}
Length (mm)	HD	51.2±1.0^{a}	57.1±0.5^{a}	77.1±1.0^{a}	95.5±1.3^{a}	117.9±1.6^{a}	133.4±1.2^{a}
	LD	51.2±0.1^{a}	89.8±1.3^{b}	111.8±1.6^{b}	132.4±1.4^{b}	146.9±1.5^{b}	166.7±1.4^{b}

Values in the same column sharing the same superscript under a parameter are not significantly different (p>0.05).Data are represented as means ± standard error

Table 3: Physicochemical parameters of water in HD and LD

	Culture system	
Parameter	HD	LD
Temperature (°C)	25.0±0.4^{a}	25.4±0.7^{a}
pH	6.5±0.3^{a}	7.4±0.2^{b}
DO (mg/l)	5.7±0.3^{a}	6.7±0.3^{b}

Values in the same row sharing the same superscript under a parameter are not significantly different (p>0.05). Data are represented as means ± standard error

rate at high stocking density could be attributed to diminished social dominance and also due to the fact that only male fingerlings were stocked so the challenges of early reproduction of females resulting into overpopulation of production ponds were eliminated.

On the hand, the FCR was not significantly affected (P>0.05) by the stocking density. The present results are similar to those reported by Silva *et al*. [18], who found that feed consumption of tetra hybrid red tilapia increased with increasing stocking density. The slightly lower FCR values obtained from HD reared fish as compared to the ones in LD could be the result of high density that the fish had to consume actively feed due to competition.

Increasing high densities may cause deterioration in water quality leading to stressful conditions [19]. In this present study, only three water quality parameters were considered. Ahmad *et al.* [20] reported that pH, temperature and dissolved oxygen are very important parameters and have great influence on fish growth. However, it was observed that in both LD and HD systems, these parameters were within the recommended ranges as suggested by Isyagi *et al.* [21]. The author reported that the water quality requirements for Tilapia seed production in pond based systems for pH to be in the range of 6-8; dissolved oxygen 5mg/L to saturation and temperature 25°C to 30°C which were found at LD and HD systems. This further explains that growth performance of *O. niloticus* was not limited by any of these parameters. These results are also in agreement with those reported by Moradyan *et al.* [19], who reported that the growth of rainbow trout alevins were not influenced by water parameters. In addition, Gibtan *et al.* [7] found that the growth performance of Nile tilapia at two sites under cage culture system was not affected by pH, temperature and Secchi disc transparency.

CONCLUSION

We concluded that LD reared fish had better individual growth performance than HD reared fish. This study also showed that high stocking density gave high biomass yield per area than fish stocked at low densities in ponds. However, stocking density in this study had no significant effect on the survival and FCR of the fish. In addition, the three water quality parameters recorded in this study did not affect the growth of *O. niloticus*. However, other water quality parameters may need to be investigated to ascertain their influence on fish growth.

There is also need to determine the management levels at HD that will promote faster growth of tilapia to table size. However, priority of individual fish size or total biomass obtained at harvest depends on the targeted market, for example; in some local markets, large number of small sized fish will be much preferred than one big fish for family consumption to assure everyone gets his/her own fish than a small piece from a big fish.

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