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Article

Impact of stocking density on growth and production performance of monosex tilapia (*Oreochromis niloticus*) in ponds

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Abstract: Stocking density is considered one of the important factors affecting fish growth. The study was aimed to compare the growth parameters of monosex tilapia at various stocking densities. The experiment was carried out during the period from 06 August to 22 December 2014. Three stocking densities were used as 125, 250 and 375 fish/dec and designated as treatment T_1, T_2 and T_3 respectively each having two replicates. All the fishes were of same age group having average initial body weight of 1.34g. A commercial feed was supplied at the rate of 40% of the body weight and then gradually it was readjusted to 20%, 10%, 5% and 3% respectively and continued up to the end of the experiment. The water quality parameters were monitored at 14 days interval and the ranges were: temperature 19.34 to 31.40°C, pH 6.83 to 8.03, dissolved oxygen 4.78 to 6.82 mg/l and transparency 29.02 to 49.45cm.The result of the present study showed that the mean weight gain was significantly ($P<0.01$) highest in T_1(120.58g) followed by T_2(89.74g) and T_3(74.58g).The average specific growth rates (SGR) was 2.590, 2.560 and 2.598 (%/day) in treatment T_1, T_2 and T_3 respectively. There was significant ($P<0.01$) differences among the survival rate. The survival rate 87% was significantly highest in T_1followed by 76% in T_2 and 69% in T_3.The fish productions were 13.25, 17.30 and 19.64 kg/decimal in T_1, T_2 and T_3 respectively. Although the highest production was obtained in T_3 but individually growth performance of monosex tilapia was highest in T_1. The highest net profit was found (BDT 3,373.30) inT_1compared toT_2 (BDT 3,017) and T_3 (BDT 2,918). The highest benefit cost ratio (BCR) was 1.79 in T_1followed by 1.44 in $T_2$and 1.28 in T_3. Based on the result of present experiment, fish farmers might be suggested to rear tilapia at lower stocking density to get higher growth, survival and benefit in a short period of time.

Keywords: stocking density; monosex tilapia; growth; production performance

1. Introduction

Aquaculture is 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 (Al Hassan *et al.*, 2012). Tens of millions of people are engaged in aquaculture production with majority involved in small-scale production (Subasinghe *et al*., 2012). Tilapia is seen as one of the most significant fish species which can reduce the gap of increasing worldwide demand for protein sources (Romano and Ng, 2013). Its production worldwide has been increased from 1,099,268 tons in 1999 to about 3,500,000 tons in 2010 (FAO, 2012). Tilapia is recognized as one rang of aquaculture system from single small scale waste fed fish ponds to intensive culture (Pullin, 1985). Overall performance of Nile tilapia and other fast growing tilapias have proved that they are no longer pests but have become to be known as `aquatic chicken' (Maclean, 1984). Tilapia (*Oreochromisniloticus*) is a hardy fish that can survive in shallow and turbid water conditions and a good converter of organic matter into high quality protein (Stickney *et al*., 1979). There are four strategies for mono-sex culture i.e. manual process by visual examination, hybridization (crossbreeding of two appropriate species); gene manipulation and masculinization via steroid hormone. The stocking density is the major concern for mono-culture. Sometimes excellent fish fry do not perform satisfactory growth unless correct stocking practices (Sanches and Hayashi, 1999). The optimum stocking density ensures sustainable aquaculture providing proper utilization of feed, maximum production, sound environment and health. In comparison to low stocking density, high stocking density exerts many negative impacts such as competition for food and shelter and rapid outbreak of disease if occurred. The objectives of the study to evaluate the effect of stocking density on growth of monosex tilapia in earthen ponds and to compare the production of monosex tilapia at various stocking densities.

2. Materials and Methods

The experiment was carried out in the Field Laboratory Complex of Bangladesh Agricultural University for a period of 134 days. The experiment was 3 treatments and 2 replications with different stocking densities (Table1). The pond size was 2 decimal each. Data was collected fortnightly to assess the impact of stocking density on growth and production of monosex tilapia.

Table 1. Research layout of mono-sex tilapia rearing.

Treatment	Replication	Pond size (Decimal)	Stocking density/decimal	Stocking size (g)
T_1	R_1	2	125	1.34
	R_2	2	125	
T_2	R_1	2	250	
	R_2	2	250	
T_3	R_1	2	375	
	R_2	2	375	

Mono-sex male tilapia (*Oreochromis niloticus*) spawn were collected from the "Kader Hatchery" in Tarakanda upazilla, Mymensingh. During stocking sufficient care was taken about the physico-chemical condition of the pond water. Throughout the experiment commercial floating feeds named "Mega Fish Feed'' was selected. This floating feed was used due to having high nutritive value. During the culture period feed was supplied three times per day at the rate of 40% of the body weight and it was readjusted to 20%, 10%, 5% and 3% respectively after 15 days interval and continued up to the end of the experiment. Sampling was performed by using a seine net. During each sampling 10 fish were collected from each pond. Sampling was done at an interval of 15 days. Water samples were collected between 08.00-09.00 a.m. at biweekly interval. The physico-chemical parameters like temperature (^oC), dissolved oxygen (mg L^{-1}), pH, and transparency (cm) were recorded by respective test kits. Growth performance was evaluated as mean cumulative weight (g), mean weight gain (g), percent weight gain (%), average daily gain (g),specific growth rate (SGR)(%/ day), survival rate (%) and production (kg/dec/134days) by using the formulae below:

a) Mean cumulative weight (g)= $\frac{\text{Total live weight}}{\text{Total numbers}}$

b) Mean weight gain (g) = Mean final fish weight (g) - Mean initial fish weight (g)

c) Percent weight gain(%)= $\frac{\text{Mean final weight (g) - Mean initial weight (g)}}{\text{Mean initial weight (g)}} \times 100$

d) Average daily gain (g) = $\frac{\text{Mean final weight (g) - Mean initial weight (g)}}{T_2 - T_1}$

Where, $T_2 - T_1$= Duration of experiment.

e) Specific growth rate (SGR) (%/day)= $\frac{\log W_2 - \log W_1}{T_2 - T_1} \times 100$

Where, W_1= Initial live body weight (g) of tilapia at time T_1(day)

W_2= Final live body weight (g) of tilapia at time T_2 (day)

T_2-T_1=Duration of the experiment (day)

f) Survival rate (%)= $\frac{\text{No. of fish harvest}}{\text{No. of fish stocked}} \times 100$

g) Production (kg/dec/134days)

Production (kg/dec/134days)= $\frac{\text{No. of fish harvested} \times \text{Average final weight of fish (g)}}{1000}$

One way analysis of variance (ANOVA) was used to determine the effects of stocking density on the growth and production of monosex Tilapia. This was followed by Duncan's New Multiple Range Test (DNMRT) at 1% level of significance to study any difference among treatment means (Zar, 1984).

$$\text{Benefit-cost ratio (BCR)} = \frac{\text{Total income}}{\text{Total cost}}$$

R = I – (Fc + Vc)
Where,

R = net return;
I = Totalincome from tilapia sale;
Fc = Fixed costs and
Vc = Variable costs.

3. Results and Discussion

The temperature ranged from 19.34 to 31.40°C during the study period. The maximum water temperature was 31.40°C in T_1 on 17 September 2014 and the minimum water temperature was found 19.34ºC in T_2 on 10 December 2014. The mean (±SE) values of water temperature were 26.89 ± 1.17, 26.79 ± 1.25 and 26.78 ± 1.14°C in T_1, T_2 and T_3. which was within the range for suitable culture of fish reported by Kohinoor (2000), Islam (2007), Hossain (2007) and Begum (2009) who measured water temperature in ponds of BAU, Campus Mymensingh and found to vary from 18.50 to 32.90°C, 22 to 32.20°C, 26.0 to 32.80°C and 26.30 to 33.00°C respectively. Haque (2014) found temperature 20.32 to 33.47°C which is more or less similar to our present study. The dissolved oxygen fluctuation was more or less similar in all of the three treatments. The dissolved oxygen ranged from 4.78 to 6.82 mg/l. The maximum dissolved oxygen was 6.82 mg/l in treatment T_1 on 03 September 2014 and the minimum dissolved oxygen was found 4.78 mg/l in treatment T_3 on 10 December 2014. The mean (±SE) values of dissolved oxygen content were 5.889 ± 0.194, 5.826 ± 0.168 and 5.443 ± 0.139 mg/l in T_1, T_2 and T_3 respectively. According to Rahman (1992) dissolved oxygen content of a productive pond should be 5.0 ppm or more. DoF (1996) reported that the range of suitable dissolved oxygen for fish culture would be 5.50 to 6.50mg/l. The concentration of dissolved oxygen in the present study was similar to findings of Dewan (1991) 2.2 to 8.8 mg/l; Alam *et al.* (1997) 4.0 to 7.0 mg/l; Daud pota *et al.* (2014) 5.8 to 6.4 mg/l; Haque (2014) 4.98-5.71 mg/l; and Sayeem (2014) 4.0 to 6.0 mg/l. The pH ranged from 6.83 to 8.03. The highest value of pH was 8.03 in T_2 on 29 October 2014 and the lowest value was 6.83 in T_3 at the same date. The mean (±SE) values of pH were 7.399 ± 0.066, 7.608 ± 0.066 and 7.472 ± 0.119 in T_1, T_2 and $T_{3,}$ respectively. Islam (2007) reported that the range of pH of water body suitable for fish culture would be 6.8 to 8.27. Begum (2009) and Kohinoor (2000) reported pH 7.7-8.25 and 6.5-8.0 respectively. According to Alam (2009) the range of pH would be 7.72-8.3.Transparency varied from 49.45 to 29.02 cm during the study period. Remarkable variation of water transparency were found in the ponds throughout the study period with the minimum values of 29.02 cm in T_1 on 10 December 2014 and the maximum values of 49.45 cm in T_3 on 06 August 2014. The mean values of water transparency were recorded as 35.83 ± 1.80, 37.68 ± 1.79 and 37.52 ± 1.74 cm in T_1, T_2 and T_3 respectively. Dewan (1991), Nirod(1997), Rahman (2000), Kohinoor (2000), Sarker (2000) who measured water transparency (cm) in ponds of BAU Campus, Mymensingh and found to vary from 54 to 90 cm, 25 to 67 cm, 26.5 to 36.6 cm, 15 to 58 cm, 27 to 35 cm and 12 to 19 cm, respectively which is more or less similar to our present study.

Table 2. Statistical analysis (ANOVA) for fish growth performances (Average ± SE) values of tilapia under different treatments during the study period.

Parameters	**T_1**	**T_2**	**T_3**	**LSD**	**Level of sig.**
Mean initial weight (g)	1.34	1.34	1.34	0.00	ND
Mean final weight (g)	44.44 ± 0.02^a	35.94 ± 0.34^b	34.25 ± 0.82^b	1.094	**
Mean weight gain (g)	49.26 ± 0.03^a	39.54 ± 0.39^b	37.62 ± 0.94^b	1.250	**
Percent weight gain (%)	3676.22 ± 2.45^a	2951.11 ± 29.58^b	2807.56 ± 70.14^b	93.304	**
SGR (%/day)	2.590 ± 0.012	2.560 ± 0.019	2.598 ± 0.014	0.108	NS
Average daily gain (g)	0.621 ± 0.003^a	0.539 ± 0.003^b	0.530 ± 0.010^b	0.015	**
Survival rate (%)	87.00 ± 2.00^a	76.00 ± 1.00^b	69.00 ± 1.00^b	3.00	**
Total production (kg/134 days)	53.03 ± 2.030^c	69.22 ± 0.800^b	78.58 ± 1.100^a	2.993	**

**= significant at 1% level of probability (P≤0.01)
NS= Not significant
Values having a different superscripts are significantly different (**P<0.01) (as per DNMRT).

Table 3. **Growth, survival rate and production of monosex tilapia (*O. niloticus*) under three treatments during the study period form10 August 2014 to 22 December 2014.**

Treatments	Stocking of fish (Initial no.)	Initial weight (g)	Final weight (g)	Total harvest (Final no.)	Total mortality (no.)	Survival rate (%)	Total production (kg/134 days)	Production (kg/dec/134 days)	Production (kg/acre/134 days)
T_1	500		121.92	435	65	87	53.03	13.25	1325
T_2	1000	1.34	91.08	760	240	76	69.22	17.30	1730
T_3	1500		75.92	1035	465	69	78.58	19.64	1964

Table 4. Benefit-cost analysis of monosex tilapia (*O. niloticus*) under three different treatments during the study period.

Items	T_1	T_2	T_3
Variable cost (BDT)			
Pond preparation	100	100	100
Cost of fry	500	1000	1500
Artificial Feed cost	1810	3155	3990
Labor	150	150	150
Fixed cost (BDT)			
Lease Cost (BDT/dec)	400	400	400
Total cost	2960	4805	6140
Financial returns (BDT)			
Total fish production(kg)	53.03	69.22	78.58
Price of fish/kg	100	100	100
Gross Profit	5303	6922	7858
Net Profit	3373.3	3017	2918
Benefit–cost ratio (BCR)	1.79	1.44	1.28

3.1. Growth and production performances of the fish

There was significant difference ($p \leq .01$) among the different treatments. The highest mean weight gain (120.58±1.32g) was found in treatment T_1, whereas the lowest mean weight gain (74.58±2.65g) was found in treatment T_3. The present experiment showed the highest mean weight gain of fish in treatment T_1 which was stocked at lower densities although same feed and feeding rate were applied in all the treatments. These phenomenon indicated that lower stocking density reduces competition among the fishes which influenced them to take feed properly and it might be absent in the treatments with higher stocking densities. Ahmed *et al*. (2013) obtained a weight gain of 123.48 g and 111.82 g from two different treatments of monosex tilapia for a period of 70 days which were more or less similar to the present study. Ahmed *et al.* (2015) found the mean lowest weight gain (94.45g) which is higher to our present findings. There was significant difference in of percent weight gain ($p<0.01$) among the different treatments. The highest mean (±SE) value (8998.507±98.507) was found in T_1 where as the lowest mean (±SE) value (5565.671±197.761) of percent weight gain was found in T_3. Ahmed *et al.* (2015) found highest percent weight gain 7310.71 ± 340.30 for monosex tilapia treatment T_1 which is much higher than the value obtained in the present study and 6746.43± 454.93 for monosex tilapia treatment T_2 which is much lower than the value obtained in the present study (Table 3). The results indicated that the growth rates varied in different stocking density which coincides with the findings of Begum (2009), Rubel (2008), Rashid (2008), and Islam (2007). The average values of specific growth rate of monosex tilapia were observed as 2.590%, 2.560% and 2.598% in treatments T_1, T_2 and T_3, respectively. There was no significant difference ($P<0.01$) among the different treatments. Islam (2007), Begum (2009), Rahim (2010) and Ahmed *et al.* (2015) who recorded specific growth rate ranged 2.363 to 2.655%, 3.65 to 3.79%, 3.09 to 3.34% and 2.04 to 2.08. Islam (2007) obtained the highest values of SGR at the lowest stocking densities which coincide with the present findings. The highest survivability was recorded in T_1 (87%) and the lowest survivability was in T_3 (69%). There was significant difference ($P<0.01$) among the different treatments. Variation in stocking density of fish may change growth and survival rates (Table 3). According to Kohinoor *et al.* (2007) survival rate of monosex tilapia were varied from 79% to 92%. The highest production was observed to be 19.64 Kg/dec/134 days in treatment T_3 and the lowest production was observed to be 13.25 Kg/dec/134 days in treatment T_1. Although the mean weight gain in treatment T_1 was highest but total production was highest in treatment T_3 which might be due to higher stocking densities (Table 2). Begum (2009) observed the highest production was 14.63 kg/dec/120 days which is much higher to our present findings. The present result also supports the findings of Haque (2014) and Hasan (2007) who achieved the higher production from higher stocking densities compared to that achieved with the lower ones.

3.2. Benefit-cost analysis

From the experiment it was found that the highest net profit was BDT 3,373.30 in T_1 followed by BDT 3,017 in T_2 and BDT 2,918 in T_3. That time the market price was BDT 100/kg fish. Culture of monosex tilapia (*O. niloticus*) at stocking density (125 fish/dec) showed higher benefit in short period of time. The benefit cost ratio was 1.79, 1.44 and 1.28 in T_1, T_2 and T_3, respectively (Table 4). Alim (2013) stated that the benefit-cost ratio was 1.35, 1.52 and 1.30 in T_1, T_2 and T_3, respectively which is lower than our present findings. So it can be concluded that the benefit-cost ratio (BCR) in T_1 was more beneficial than $T_2$and T_3.

4. Conclusions

Under the experimental condition, different treatments showed different growth rates. From the present experiment, it was found that the total production was increased with the increase of stocking density. But the individual fish growth rate was decreased with the increase of stocking density. Present findings indicated that comparatively highest individual weight gain was found in T_1 which received lower stocking density (125 fish/dec) and highest production was found in T_3 which received higher stocking density (375 fish/dec). Water quality parameters were found within suitable range. From the experiment it might be suggested that the stocking density (125 fish/decimal) performed the better results and further study is needed to explore the economics of tilapia farming with different stocking densities.

Conflict of interest

None to declare.

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