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EFFECT OF STOCKING DENSITY ON GROWTH AND PRODUCTION OF MONOSEX TILAPIA (*OREOCHROMIS NILOTICUS*) IN FLOATING CAGES AT DEKAR *HAOR* IN SUNAMGANJ

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Abstract

The study was conducted to evaluate the effect of different stocking densities on growth performances and production potential of monosex tilapia (*Oreochromis niloticus*) under cage culture conditions for a period of 120 days from 20 August to 16 December 2016 in Dekar *haor* of Sunamganj district. Three stocking densities under the experiment were maintained *viz.* 35, 40 and 45 fish m^{-3} and designated as treatment 1 (T_1), treatment 2 (T_2) and treatment 3 (T_3), respectively and each having three replicates. Stocked fry of tilapia were fed commercial floating diet at a decreasing rate of 10-5% of body weight at thrice daily until the previous day of harvest. Average initial weight of the fingerlings was 11.0 g. Water quality parameters like water temperature, transparency, dissolved oxygen, pH, total alkalinity and ammonia nitrogen were found within favourable aquaculture range. Survival rate of tilapia varied from 91.40 to 96.10% and the highest survival rate was found in T_2 (96.10%) followed by T_3 (95.40%) and T_1 (91.40%). Gross yield of tilapia obtained from all treatments ranged from 5.60 to 6.50 kg m^{-3} with the highest yield (6.50 kg m^{-3}) in T_2 and the lowest yield (5.60 kg m^{-3}) in T_1. Daily weight gain of tilapia was recorded as 1.36, 1.31 and 1.10 g in T_1, T_2 and T_3, respectively. The highest (Tk. 383.94 m^{-3}) net profit obtained in T_2 followed by T_3 (Tk. 337.10 m^{-3}) and T_1 (Tk. 285.91 m^{-3}). Cost benefit ratio (BCR) was also the highest in T_2 (1.97) and the lowest in T_1 (1.74). Result of the study indicates that tilapia stocking density of 40 no. m^{-3} is better among three treatments in respect of survival rate, growth, fish yield and economic return. Therefore, the farmers could be suggested to rear tilapia at lower stocking density (40 no. m^{-3}) in cages to get higher growth, survival and production in a short period of time.

***Keywords*:** Cage farming, stocking density, growth performance, survival rate, production.

Introduction

North-eastern region of Bangladesh is enriched with a huge inland water bodies in the form of small ponds, seasonal ditches, *beel*s, *haor*s, canals, small and large rivers. There are altogether 411 *haor*s in northeastern part of Bangladesh comprising an area of 51,797 km^2 situated in the district of Sunamganj, Sylhet, Moulvibazar, Hobiganj, Netrakona, Kishoreganj and Brahmanbaria of Bangladesh (Rahman and Akhter, 2015). This country is the fifth largest aquaculture producer in the world (FAO, 2014). Aquaculture in Bangladesh has grown rapidly over the last three decades at an average annual rate of 10.2% (Jahan *et al*., 2015). Fisheries sector contributed about 3.65% to the GDP and 1.92% of export earnings. It also provided 23.81% of total income of agricultural sector. The inland fisheries met up 83.85% to the total catch (inland open water 27.03% and inland closed water 56.82%) and remaining 16.15% come from the marine fisheries. Around one crore 82 lakhs people or 11 percent of total population of the country are directly and indirectly involved in fisheries activities for their livelihood (DoF, 2017).
Several species of tilapia are being cultured commercially but Nile tilapia (*Oreochromis niloticus*) is the predominant culture species worldwide. Monosex tilapia (*O. niloticus*) are the most abundantly cultured fish throughout the world because of their adaptableness to an extensive assortment of physical and environmental

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surroundings, resistance to handling stress and disease-causing agents compared to other cultured fish, better flesh quality, feed on a low tropic level and tremendous growth rate on a wide variety of natural and artificial diets. They are presently cultured in virtually all types of production systems in both fresh and salt water and in tropical, subtropical and temperate climates (Welker and Lim, 2011). Nowadays, great consideration has been paid to sex-reversed male tilapia (*O. niloticus*) culture due to their sexual size dimorphism, males grow significantly faster, larger and are more even in size than females (Ponzoni *et al*., 2005). This species also does not breed, which makes it easy for fish farmers to avoid uncontrolled breeding in their growing waterbodies. They are fast grower and become marketable size within 2-3 months in pond, pen and cage. They are the second most cultured freshwater fish in the world (after carps). However, they are increasingly recognized as the species of choice for intensive aquaculture and are likely to become the most important cultured fish in the world (Lim and Webster, 2006).

Among the various types of culture practices of tilapia, cage farming is recently found to be very promising worldwide. Cage culture is an important technology to boost up fish production. This practice was first started from late 1800s in South-East Asia, since then many countries are practicing cage culture in freshwater and marine environments including ponds, rivers, *haor*s, *beel*s, open sea, estuaries, lakes, reservoirs, etc (Balcazar *et al*., 2006, Eng and Tech, 2002). However, *haor*s with their unique hydro-ecological characteristics in north-eastern region of Bangladesh are accommodating 20 million people (MPHA, 2012). It is also a vital supplier of inland freshwater fisheries. Cage farming in open waterbodies like *haor* areas has a great prospect to mitigate increasing animal protein demand of the people (Hossain *et al*., 1987).

In cage aquaculture, fish stocking density has a great impact on growth, survival, health, quality of fish seeds/fingerlings, stocking sizes, water quality, production cost and economic return (Costa *et al*., 2013). For better survival rate, maximum fish production, highest profitability and sustainability in cage culture system, it is essential to determine its optimum stocking density. Very little works have been done on stocking densities of monosex tilapia in cages at *haor* conditions. Stocking densities and management measures practiced by cage operators in rivers and lakes of Bangladesh are not based on modern technical knowledge, thus resulting poor growth and survival rate of fry/fingerlings, and low income. Therefore, it is essential to investigate the effect of stocking densities on growth and production of tilapia in cage farming in *haor* environment. Considering the fact, the present experiment was undertaken in net cages in *haor* conditions to observe the effect of different stocking densities on survival rate, growth and production of monosex tilapia (*O. niloticus*).

Materials and Methods

Study area and duration

The study was carried out in the Dekar *haor* (naturally depressed seasonal-perennial open waterbody), one of the most important and largest *haor* of Bangladesh. The *haor* is bounded by four *upazilas* (Dakshin Sunamganj, Sunamganjsadar, Dowarabazar and Chhatak) of Sunamganj district. It is situated by the side of Sylhet-Sunamganj high way and closed to Sunamganj district town. The study was conducted for a period of 4 months from 20 August to16 December 2016.

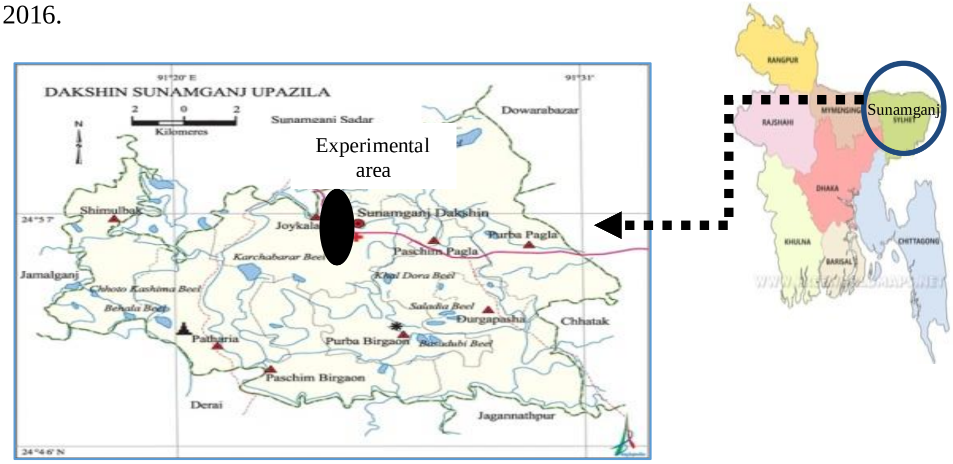

Fig. 1. Map of Dakshin Sunamganj showing the experimental area

Cage preparation and setting

Nine newly constructed floating nylon net cages (3 m × 3 m × 1.5 m) were set in the periphery of the *haor*. Frames of cages were made by GI pipes and aluminium drums (250 L) were used to float the cages in water. Wet cages were made of knotless polyethylene net (mesh 1.0 cm). Cages were hanged with cage frame. Bamboo made platform was set up over the cages and all cages were fixed with poles of the platform. Cages were installed at both sides of the platform for easily feed supply and intensive supervision. Open part of each cage was covered with another piece of nylon net (mesh 7 to 7.5 cm) to avoid escaping of fish and predation by bird.

Stocking density

The study was a one factorial in which three stocking densities like T_1 (35 no. m^{-3}), T_2 (40 no. m^{-3}) and T_3 (45 no. m^{-3}) were used. Each treatment of the experiment had three replicates. The place selected for setting the cages was cleaned manually and limed with CaO at a rate of 250 kg ha^{-1}. After 5 days of liming, all cages were stocked with required quantity of fry of all male tilapia (*O. niloticus*).

Monosex tilapia fry were purchased from a private hatchery and was transported in oxygenated polythene bags from hatchery to experimental site. Before stocking, fry were carefully acclimatized to the cage water for one hour period. Initial average weight and length of 30 fishes were measured and kept into record before stocking in cages.

Feeding

Commercial Mega floating feed was used for feeding purposes. Feeding was started at 10% of body weight of fish initially and gradually decreased up to 5% until the end of the study. Total feed for a day was divided into three equal and was applied in the morning between 8.00-9.00 am, in noon12.00-1.00 pm and in evening 5.00-6.00 pm. Feeding rates were adjusted every 15 day intervals depending on the body weight of stocked tilapia. Net of the cages were cleaned and checked every 15 day intervals. Behavior of tilapia was regularly observed especially after providing feed in the morning and in the evening to determine their conditions such as movement, infection, colorations and diseases.

Stocked fry of tilapia were fed with commercial feed Mega at a decreasing rate of 10-5% of body weight thrice daily until the previous day of harvesting. Proximate compositions as moisture, crude protein, crude lipid, ash, crude fiber, carbohydrate of supplemented feed were 11, 30, 7, 15, 8 and 29 %, respectively.

Sampling of fish

Fortnightly sampling was done to determine the growth of tilapia fry and to adjust the feed rations. Growth was measured in respect of weight (g) with digital balance (CAMRY digital electrical balance Model EK 3052, Bangladesh) and length by measuring scale. Sampling was continued until harvesting.

Water quality measurement

Water quality parameters of water as surface temperature, transparency, dissolved oxygen (DO) concentration, pH, total alkalinity and ammonia were determined at fortnightly intervals between 9 and 10 am at the time of fingerlings sampling. Surface water temperature was measured *in situ* using a standard centigrade thermometer. Transparency was recorded using Secchi disc. Dissolved oxygen was determined using a portable DO meter (YSI digital DO meter, Model 58, HANNA Company, America). pH of cage water was recorded using pH meter (HANNA Company, America). Total alkalinity was measured by titrimetric method (APHA, 2000). Nitrate and ammonia were measured using ammonia test kit (Biosol, A.A. Biotech PVT LTD., Fishtech BD LTD).

Observed parameters

Tilapia were harvested after 120 days of culture. They were caught using hand scoop and lifting all cages from water on the same day. After harvesting, all tilapia of cages were counted and weighed individually to determine survival rate, growth and yield. Specific growth rates (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) and survival rate (%) were calculated following the equation as cited by Pechsiri and Yakupitiyage (2005). The equations are as follows:

Weight gain: Mean final weight-Mean initial weight
Survival rate (%): (Total number of harvested fish/ Total stocked fish) ×100
SGR (% day^{-1}): {Ln (final body weight)-Ln (initial body weight) x 100}/cultured period (day).

Protein efficiency ratio (PER): Weight gain (g)/protein consumed (g)
Feed conversion ratio (FCR): Feed consumed (g dry weight)/Live weight gain (g wet weight) of fish.
Yield of fish: No. of fish caught × (average final weight of fish-average initial weight of fish).

Economic analysis of the different treatments was calculated on the basis of purchasing prices of tilapia fry, feed, fertilizer, lime, transport cost and the revenue from the sale of tilapia. At the end of the study, all fish were sold at local market. Tilapia were sold at a rate of Tk. 120.0 kg^{-1}. The analysis was performed based on market prices in Bangladesh for fish and all other items expressed in Bangladeshi taka (Tk.).
The net profit and cost benefit ratio (BCR) were calculated using the following formula:
Net profit: Total return – total cost
BCR: Total return/total cost

Statistical analysis

Survival rate, growth and yield variables were analyzed using one way analysis of variance (ANOVA) to compare the treatments means. If the main effect was found significant, the ANOVA was followed by Duncan's Multiple Range Test (DMRT). All ANOVA were tested at 5% level of significance using SPSS (Statistical Package for Social Science) version 20.0.

Results and Discussion

The highest mean final weight was recorded in T_1 (175.07±17.52 g) and the lowest in T_3 (143.00±14.92 g). Significantly ($p<0.05$) higher final weight of tilapia was found in T_1 than those of T_2 (169.3±15.19 g) and T_3 (143.00±14.92 g) (Table 1) due to low stocking density compared to others. Dev (2015) reported the final weight of tilapia as 167.15–189.67 g for 99 days rearing in nylon net cages applying floating feed without probiotics at pond of Sylhet Agricultural University (SAU), Sylhet, Bangladesh, which supports the present findings. Male tilapia attained an average weight of 176.20 g after rearing of 240 days in pond system reported by Dagne (2013) and Alam *et al*. (2014) estimated mean final body weight as 50.0 to 93.5 g using commercial Mega feed twice daily at a density of 100–200 no. m^{-3} in cage at old Brahmaputra river, Mymensingh, which are much lower than the present findings. Average final weight and initial weight (10.7-11.8 g) of tilapia recorded in present study was lower than that of Ahmed *et al.* (2014), who reported an average final weight of 207.90–271.48 g with 33.66 g of initial weight at density of 50 m^{-3} for 120 days rearing of monosex tilapia in the suspended cages applying feed supplemented with probiotics at Dakatia river, Chandpur, Bangladesh.

In the present study, daily weight gain of tilapia was 1.10 to 1.36 g by rearing for 120 days at different densities and supplemented with floating feed (Table 1). Alam *et al.* (2014) measured daily weight gain 0.35 to 0.67 g by

Table 1. Growth, survival rate and yield (mean±sd) of tilapia (*O. niloticus)* in three different treatments during the study period

Parameters	Treatments		
	T_1 (35 no.m^{-3})	T_2 (40 no.m^{-3})	T_3 (45 no.m^{-3})
Average initial weight (g)	11.8±2.15	11.0±2.95	10.7±2.48
Average final weight (g)	175.07±17.52^{a}	169.33±15.19^{b}	143.00±14.92^{c}
Daily weight gain (g)	1.36	1.31	1.10
FCR	1.60	1.50	1.65
PER	2.55	2.78	2.87
SGR (%/day)	2.25	2.27	2.16
Survival rate (%)	91.40±3.72^{c}	96.10±4.57^{a}	95.40±4.90^{b}
Yield (kg m^{-3})	5.60±0.88^{c}	6.50±1.08^{a}	6.15±1.15^{b}

Mean values in the same row with same superscript letters are not significantly different ($p>0.05$).

culturing of 135 days at 100 to 200 fish m^{-3} density and applying floated Mega feed in cages at Brahmaputra river. On the contrary, Hussain *et al*. (2000) reported daily weight gain of 0.71 g for GIFT reared for a period of 180 days and fed with rice bran. So daily weight gain of tilapia in the present study is higher compared to above mentioned researchers. But the findings of the study is slightly lower than the finding of Ahmed *et al*. (2014) and Ahmed *et al*. (2013), who obtained daily weight gain of 1.45-1.98 g using commercial floated feed with probiotics in cages at Dakatia river and 1.56 g using prepared feed and 1.78 g using commercial feed only for monosex tilapia reared for 70 days in the earthen ponds.

Food conversion ratio (FCR) of male tilapia in the present investigation was ranged between 1.50 and 1.65. During the study period the FCR in three treatments were 1.60, 1.50 and 1.65 in T_1, T_2 and T_3, respectively (Table 1). FCR of the present study is lower than that of 1.71 to 1.77 for GIFT and 1.81 to 2.05 for monosex tilapia in cage culture, respectively as reported by Hossain *et al*. (2004) and Moniruzzaman *et al.* (2015). The obtained FCR is slightly higher than the findings of Dev (2015) and Ahmed *et al*. (2014), who recorded FCR of tilapia in cage culture as 1.18 to 1.25 and 1.11 to 1.41, respectively. Ahmed *et al.* (2013) found FCR of monosex tilapia as 1.40 to 1.51, which is more or less coincided with the present findings. Significantly higher protein efficiency ratio (PER) of monosex tilapia was found in T_3 (2.87) compared to T_1 (2.55) and T_2 (2.78), respectively (Table 1). The observed PER values are in agreement with the findings of Begum *et al*. (2017) and Khatun and Saha (2017), who recorded PER 2.26–3.10 and 2.29–2.90, respectively in cage culture and in earthen ponds.

Mean specific growth rate (SGR) of tilapia in different treatments was ranged from 2.16 to 2.27%. But higher SGR (2.27%) was found in T_2 than those of T_1 (2.25%) and T_3 (2.16%), respectively (Table 1). Dev (2015) recorded SGR of 4.60–4.72% using commercial floated diet twice a day for tilapia in small cages at SAU pond. In earthen pond, Diana *et al*. (1996) demonstrated SGR of *O. niloticus* as 3.10% using feed and fertilizer in Thailand, and Ahmed *et al*. (2013) reported SGR of monosex tilapia as 3.09% using prepared feed (55.24% protein) and 2.97% using commercially available feed in Bangladesh. The findings of above mentioned workers are higher than the present findings.

Survival rate of male tilapia in this study ranged between 91.40 to 96.10%. Higher survival of tilapia was found in T_2 (96.10%) followed by T_3 (95.40%) and T_1 (91.40%) (Table 1). Overall survival of tilapia was slightly lower than the reported values in cage culture: 95.76 to 97.54% (Ahmed *et al*., 2014), 95.39 to 95.87% (Dev, 2015) and 83.1 to 96.8% (Moniruzzaman *et al.*, 2015) but higher than the reported value in earthen pond of 75.55 to 90.37% (Ahmed *et al*., 2013).

Yield of tilapia obtained from all treatments ranged from 5.60 to 6.50 kg m^{-3} with the highest yield (6.5 kg m^{-3}) in T_2 and the lowest yield (5.6 kg m^{-3}) in T_1 (Table 1). Ahmed *et al.* (2014) obtained 9.93 to 11.63 kg m^{-3} of tilapia in cages at 50 m^{-3} density, which is higher than the yield of the present study. The fish yield of the present study is mostly closed to the yield (7.7 to 9.4 kg m^{-3} and 6.35 to 8.82 kg m^{-3}) recorded by Alam *et al*. (2014) and Begum *et al.* (2017). It is intensively observed that fish yield depends on several factors as size of the cage, initial weight of fry, quality of fish fry, stocking density, quality of feed, feeding frequency and management practices.

Water quality parameters (water temperature, transparency, dissolved oxygen, pH, alkalinity and ammonia) of the study are presented in Table 2. In the present study, water temperature was between 29.7°C to 30.0°C. Dev (2015) and Begum *et al*. (2017) in ponds of SAU Campus found to 28.5°C and 28.7°C, respectively. FAO (1981) and DoF (2009) reported the optimum water temperature for aquatic production as 23–31°C and 25–30°C, respectively. These findings support the findings of the present study. Values of water transparency were ranged from 36.33 to 36.72 cm. Begum *et al.* (2017) reported water transparency ranges from 34.35±1.52 to 36.33±1.48 cm in ponds of SAU Campus. Boyd (1982) stated that suitable range of transparency for fish culture is 15–40 cm. These findings match with the findings of the present study. Dissolved oxygen concentration of the study was 4.35 to 4.42 mg l^{-1}, which is supported by Begum *et al. (*2017). Alim (2013) recorded the dissolved oxygen content as 4.80 to 5.9 mg l^{-1}. Hasan (2007) and Maghna (2012) reported dissolved oxygen (mg l^{-1}) in ponds of BAU Campus, Mymensingh as 4.15 to 8.60 mg l^{-1} and 4.8 to 5.4 mg l^{-1}, respectively. These are in agreement with the findings of the present study. In present study, pH was 7 to 7.5. Alim (2013) and Haque (2014) reported that pH varied from 6.56 to 8.71 and 7.03 to 7.57, respectively. Begum *et al.* (2017) found water pH from 7.0 to 7.5 in SAU pond. The present findings are consistent with the above findings. Alkalinity values ranged from 119.10 to 122.20 mg l^{-1} in all the cages. Mairs (1966) reported that waterbodies having alkalinity 40 ppm or more are considered more productive than waterbodies of lower alkalinity. Moyle (1946) opined that total alkalinity ranged from 0.0–20.0 ppm are low and from 40.0–90.0 ppm are medium to high production. Observed alkalinity values were within the productive ranges. Concentrations of ammonia nitrogen in all treatments were varied from 0.01 to 0.02 mg l^{-1}. Begum *et al.* (2017) and Dev (2015) recorded 0.010 to 0.013 mg l^{-1} and 0.011 mg l^{-1} ammonia concentration, respectively in SAU pond, which are coincided with the present findings. Meade (1985) stated that the maximum safe concentration of ammonia level was unknown but he concluded that the permissible level was higher than the value of 0.012 mg l^{-1} commonly accepted by fish culturists.

Table 2. Water quality parameters (mean±sd) recorded from the cages under three treatments during the study period

Parameters	Treatments		
	T_1	**T_2**	**T_3**
Temperature (^oC)	29.7±1.8	29.8±1.9	30.0±1.8
Transparency (cm)	36.43±2.48	36.72±1.28	36.33±1.72
DO (mgl^{-1})	4.42±0.81	4.40±0.79	4.35±0.80
pH	7.3 (7.0—7.5)	7.5 (7.0—7.4)	7.2 (7.0—7.4)
Total alkalinity (mg l^{-1})	119.10±6.62	121.31±6.70	122.20±5.60
NH_3-N (mg l^{-1})	0.01±0.002	0.02±0.001	0.02±0.002

Net profit was of tilapia farming as secured in the present study was the highest (Tk. 383.94±32.68 m^{-3}) in T_2 followed by T_3 (Tk. 337.10±22.44 m^{-3}) and T_1 (Tk. 285.91± 47.1 m^{-3}) (Table 3). Cost benefit ratio (BCR) was also the highest in T_2 (1.97) than that of T_3 (1.84) and T_1 (1.74), respectively (Table 3). However, it is indicated that the highest net benefit and BCR were obtained from the treatment of 40 no. m^{-3} (T_2) than others. Based on the results of the study, it may be concluded that tilapia stocking density of 40 no. m^{-3} (T_2) is better among the three treatments in respect of survival rate, growth, fish yield and economic return. Therefore, this stocking density can be suggested to follow in tilapia cage farming in the open waterbodies for increasing fish production with a high economic return.

Table 3. Economic analysis of tilapia (*O. niloticus*) farming in floating cages under three treatments during the study period

Items	Treatments		
	T_1 (35 no. m^{-3})	**T_2 (40 no.m^{-3})**	**T_3 (45 no.m^{-3})**
Total gross return (Tk. m^{-3})	672.50±90.4	780.46±85.8	738.52±89.94
Total cost (Tk. m^{-3})	386.60±43.3	396.52±53.12	401.41±67.5
Net profit (Tk. m^{-3})	285±47.1^c	383.94±32.68^a	337.10±22.44^b
Cost benefit ratio (BCR)	1.74:1	1.97:1	1.84:1

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