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GROWTH PERFORMANCES OF GIFT TILAPIA (*Oreochromisniloticus)* IN CAGE CULTURE AT THE OLD BRAHMAPUTRA RIVER USING DIFFERENT DENSITIES

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Abstract

Fish cage culture allows intensive production in waterbodies without conventional preparation for aquaculture.Considering the importance and prospects of cage culture in Bangladesh, the present experiment was undertaken to study the effect of stocking density on growth performances and production potential of tilapia (*Oreochromisniloticus*) under cage culture conditions and to develop a suitable method of tilapia cage culture in inland open water body like Old Brahmaputra River. Three stocking densities (100, 150 and 200 fish m^{-3}) of 2.78 g mean initial individual body weight of fingerlings in three different treatments (T-100, T-150 and T-200) each with three replicates were used. The fishes were supplied with high protein (30%) commercial feed at 10% of body weight twice daily. Water quality parameters namely transparency, temperature, pH, dissolved oxygen, phosphate were found within the suitable limit for fish culture.The result of the present study showed that the fish in the treatment T-150 resulted the best individual weight gain (90.72g), average daily gains (0.67 g), percent weight gains (3263%), specific growth rates (1.13%day^{-1}) and the net production rates (13608gm^{-3}135 $days^{-1}$)followed by treatments T-100 and T-200, respectively.The net yield and growth performances showed a significant difference with increasing stocking density (P<0.01). The most effective stocking density was150 fish m^{-3} cage for Nile tilapia considering growth performances and production potential. Therefore, it can be concluded the growth performance of Nile tilapia is density dependent.

Keywords: Cage culture, stocking density,growth performance, production, *Oreochromisniloticus*

Introduction

Fisheries sector have been playing a very significant role and deserve future potential for the development of agriculture based economy of Bangladesh. Bangladesh holds the fourth position in fish production throughout the world (DoF, 2014). Fish accounts for about 60% of per capita protein intake and contributes about 4.39% of GDP, 22.76%of agricultural products and 2.46% of country's total export earnings. Approximately more than 11% of the total populations are directly or indirectly dependent on fisheries and related activities for their livelihood (FSYB, 2013).The dynamic fisheries resources of the country are divided into three groups, i.e. inland capture, inland culture and marine capture. Inland fisheries include mainly River and Estuary, *beels*, floodplain,lake, pond/ditch, *haor*, *baor*, shrimp/prawn farm, seasonal cultured water-body etc. Inland fisheries contribute 26.83lakh metric tons which is 82.26% of the total fish production (FSYB, 2013). The overall production from the inland waters can be increased since we have a large area of water bodies underutilized, need to be utilized properly and scientifically for fish culture.

Nile tilapia (*Oreochromisniloticus*), is called super tilapia, the product of the Genetically Improved Farmed Tilapia (GIFT) is the most widely farmed variety and performs 60% better in growth and survival than commercially available strains of tilapia. It performs well on cheap feed and fertilizer and can be raised in large tracts of water and cages (Eknath*et al.* 1993). Cage culture of fish is defined as the raising of fish from fingerlings to harvestable size in containers (cages) enclosed on all sides and bottom by wooden stalls, hard wire cloth, net or other materials that allow free circulation of water in/and out of the cages (Schimitton, 1969). Tilapias are able to survive in extremely adverse conditions and are frequently found in habitats where no other species could exist (Balarin and Haller, 1982).

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Modern fish culture technologies includes optimum stocking densities, proper feeding and fertilizer application, maintenance of physico-chemical parameters of water, disease prevention and other control measures (Balarin and Hailer, 1982). Fish culture on a small-scale basis has often failed due to inadequate knowledge in optimum stocking density. Stocking density is generally used to refer how many fishes are released per unit area of the ponds. It is considered to be one of the important factors that affect fish growth, feed utilization and finally fish production. In general, the stocking density and growth of fish are very much related (BFS, 2014). The optimum stocking density ensures good production, income, proper utilization of feed, sound environment and health. High stocking density causes severe problems such as higher competition for food and shelter, rapid outbreak of disease, and poor growth. The culture practice of tilapia varies to a great extent from country to country and even among the different farming systems.

Considering the importance and prospects of cage culture in Bangladesh, the present experiment was undertaken to study growth performance of GIFT tilapia (*O. niloticus*) in cages at the Old Brahmaputra River under different stocking densities with the following specific objectives, to study the effect of stocking density on growth performances and production potential of tilapia under cage culture conditions; and to develop method of tilapia cage culture in inland open water body like Old Brahmaputra River.

Materials and Methods

Study period and area

The experiment was carried out for a period of 135 days commencing from 18th December to 1st May. The study was conducted in Old Brahmaputra River using 9 cages with three different densities at Taltola, Khagdohor, MymensinghSadar, Mymensingh.

Construction and setting of cages

Nine cage frames (box type) of 5.0 m × 2.50 m × 1.0 m (Length × breadth × height) of iron and bamboos were constructed. Nets made of synthetic twine (5.0 mm mesh size) were tightly fixed with the frame by nylon thread. There was a small window on the top of the cage through which the formulated feed could be provided to the fish and the fishes could be captured for sampling. Plastic drums of oil and acid were incorporated with the cage frame to facilitate floatation. All the cages were placed in three rows in the selected site of the Old Brahmaputra River.

Numbering of the cages

The cages were numbered arbitrarily (Cage 1-9) for three different densities to facilitate feeding, sampling and other observation.

Collection and stocking of fingerlings

The fingerlings of GIFTtilapia (*Oreochromisniloticus)* were collected from Bangladesh Fisheries Research Institute (BFRI), Mymensingh. The fingerlings were transported to the field using oxygen packs.The oxygen packs containing the fish were at first floated in the water for about 30 minutes for temperature acclimatization after which they were released into the cages.

Experimental procedure

The experiment was carried out in three densities (100, 150 and 200 fishes m^{-3}), having three replicates each, using nine floating cages (12.50 m^3)in the selected site of the Old Brahmaputra River. Floating cages were made of polyethylene netting hanging from bamboo poles. The treatments were designated as: T-100 (100 fish m^{-3}: cage 1, 2 and 5), T-150 (150 fish m^{-3}: cage 3, 7 and 9) and T-200 (200 fish m^{-3}: cage 4, 6 and 8).

Feeding

The average initial body weight of fingerlings was 2.78 g. A commercial feed(Mega feed) was supplied daily at the rate of 10% of body weight of stocked fishes and sampling was done regularly at an interval of 30 days to adjust the amount of feed to be administered. The fishes were fed twice daily; half of the ration was given in the morning at around 9:00 am and another half in the afternoon at around 4:00 pm.

Water quality parameters

The physico-chemical parameters such as dissolved oxygen (DO), temperature, pH, ammonia (NH_3), nitrate (NO_3), phosphates (PO_4) and transparency of the surface water in the cages were recorded around 10:00 am at different times during the study period. Temperature was measured using a thermometer, transparency by Secchi-disc and other water quality parameters were measured by using chemical testing kit (HANNA HI 3817)for DO, pH, and PO_4.

Fish sampling

The fishes were sampled at 30 days interval. For every sampling, 10 fishes were randomly sampled from each cage and their individual weights were recorded to the nearest grams using field balance(Model no.JS30-1). The fishes were visually examined to determine the possible outbreak of diseases. After 135 day of rearing i.e. at the time of termination of the experiment the final average weight of the individual fishes were recorded from the total fish biomass in each cage.

Data analysis

Data collected during the experiment were analyzed by using the following formula to evaluate fish growth.

Weight gain = Mean final fish weight – Mean initial fish weight

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

$$\text{Average daily weight gain ADG} = \frac{\text{Mean final fish weight} - \text{Mean initial fish weight}}{\text{Number of days in culture}}$$

$$\text{Specific growth rate (SGR)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \times 100$$

Where,
W_1 = The initial live body weight (g) at time T_1 (day)
W_2 = The final live body weight (g) at time T_2 (day)

Statistical analysis

A One-way analysis of variance (ANOVA) of mean individual weight gain, ADG, percent (%) weight gain, SGR and production rate to determine the significance of variation among the treatments using statistical software SPSS at 0.01level.

Results and Discussion

Results

Throughout the experimental period (from 18thDecember to 1st May), a number of water quality parameters were determined. Weight gains of fishes at different stocking densities in different sampling dates were recorded and growth performances in different stock densities were calculated by using standard formula.

Water quality parameters

The water quality parameters such as transparency, temperature, pH, dissolved oxygen, ammonia, nitrate and phosphate in different cages were monitored. The water quality parameters observed in different months are presented in Table 1.

Table 1. Water quality parameters of *O. niloticus*incages over a 135 days experimental period

Parameters	18 Dec.	2 Feb.	5 Mar.	1 Apr.	1 May
Transparency (cm)	170	180	175	150	150
Temperature (ºC)	20	20	26	30	30
pH	7.8	8.2	7.8	7.5	7.4
Dissolved oxygen (mg l^{-1})	13.5	15	13	11	9.5
Phosphate (mg l^{-1})	2	1	2	1	2

Water depth (m)

Water depth of the river of experimental area varied from 2.0 m to 3.65 m. The highest water depth (3.65 m) was recorded during the month of December and the lowest value (2.0 m) was recorded during the month of April.

Transparency (cm)

The minimum value of transparency was recorded 150 cm during the monthof April and the highest value 180 cm was recorded during the month of February.

Temperature (°C)

The value of water temperature measured in the morning in different cages during the study period varied between 20 and 30°C. The maximum value of temperature(30°C) was recorded during the month of April and the minimum value(20°C) was recorded during the month of December.

pH

The water pH in different treatments during the study period varied between 7.4 and 8.2. The highest pH value (8.2) was observed in the month of February and the lowest pH value(7.4) was observed in the month of May.

Dissolved oxygen (ppm)

The highest oxygen concentrations 15 ppmwasfound during February while the lowest oxygen concentration (9.5 ppm) was measured in May.

Phosphate

The phosphate concentration was found to be 1 to 2 mg l^{-1}.

Growth performances

Growth performances of *O. niloticus* in terms of mean final individual body weight, mean individual weight gain (g), percent (%) weight gain, average daily gain (ADG), specific growth rate (SGR)% growth day^{-1}were analyzed using standard formula (Table 2).

Table 2. Growth performances of *O. niloticus*at three different treatments during 135 days experimental period

	Treatments				
Parameters	**T-100**	**T-150**	**T-200**	**LSD**	**Level of sig.**
Mean initial individual body weight (g)	2.78±0	2.78±0	2.78±0	-	-
Biomass at stocking (gm^{-3})	278±0	417±0	556±0	-	-
Mean final individual body weight (g)	80.5±9.50^a	93.5±8.41^a	50±3.00^b	8.68	**
Mean individual weight gain (g)	77.72±9.50^a	90.72±8.41^a	47.22±3.00^b	8.68	**
Average daily gain ($gday^{-1}$)	0.58±0.07^a	0.67±0.06^a	0.35±0.02^b	0.06	**
Percent (%) weight gain (g)	2796±341.73^a	3263±302.56^a	1699±107.91^b	312.34	**
Specific growth rate (SGR) % growth day^{-1}	1.08±0.04^a	1.13±0.03^a	0.91±0.02^b	0.04	**

*** = Significant at 1 % level of significance, LSD = Least significance difference, a & b = significance difference in each row*

Growth in terms of individual weight gain

In T-100, the average initial individual body weight 2.78 g reached to a final weight of 71 g (Cage 1), 80.5 g (Cage 2) and 90 g(Cage 5). The average weight gain of individual fish in this treatment was 80.5 g.

In T-150 (cage 3, 7 and 9) the mean initial individual body weight 2.78 g reached to a final weight of 103 g (Cage 3), 90.5 g (Cage 7) and 87 g (Cage 9). The average weight gain of individual fish in this treatment was 93.5 g.

In T-200 (cage 4, 6 and 8) the mean initial individual body weight 2.78 g reached to a final weight of 53 g (Cage 4), 50 g (Cage 6) and 47 g (Cage 8). The average weight gain of individual fish in this treatment was 50 g.

The growth of *O. niloticus* in terms of individual weight gainin different treatments is presented in Fig. 1.

Growth in terms of average daily gain (ADG)

Average daily gain of *O. niloticus*in different treatments; T-100, T-150 and T-200 were 0.58±0.07 $gday^{-1}$, 0.67±0.06 $gday^{-1}$ and 0.35±0.02 $gday^{-1}$, respectively. The highest average daily weight gain 0.67±0.06 $gday^{-1}$ was recorded in T-150 and the lowest weight gain 0.35±0.02 $gday^{-1}$in T-200 (Table 2).

Growth in terms of percent (%) weight gain

Percent weight gain of *O. niloticus*in different treatments; T-100, T-150 and T-200 were 2796±341.73 %, 3263±302.56 % and 1699±107.91 %, respectively. The highest percent weight gain 3263±302.56 % was recorded in T-150 and the lowest weight gain 1699±107.91 % in T-200 (Table 2).

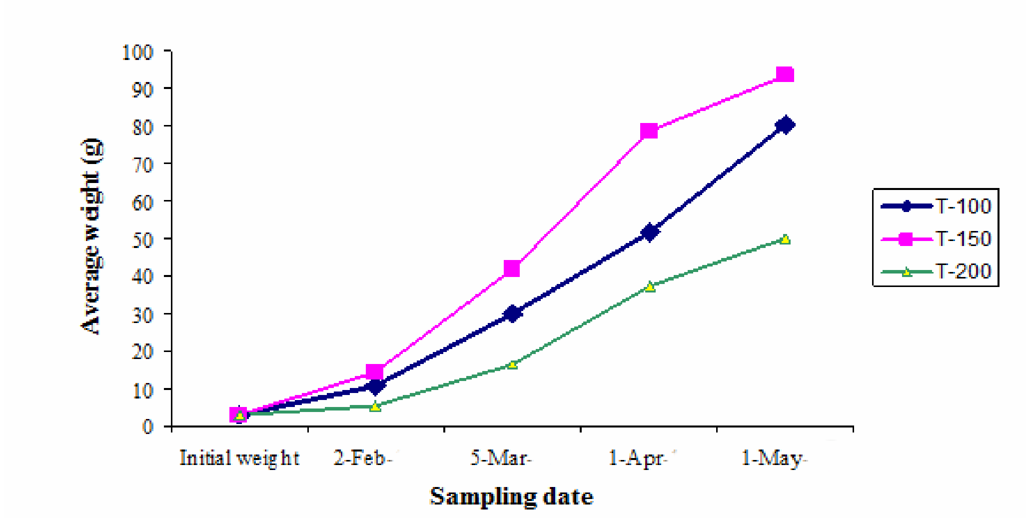

Fig. 1. Growth of *O. niloticus* in terms of individual weight gain in three treatments during the study period

Growth in terms of specific growth rate (SGR) % growth day^{-1}

The specific growth rate of the experimental fish in different treatments; T-100, T-150 and T-200 were 1.08±0.04 % day^{-1}, 1.13±0.03 % day^{-1} and 0.91±0.02 % day^{-1}, respectively. The highest SGR 1.13±0.03 % was recorded in T-150 and the lowest SGR 0.91±0.02 % was recorded in T-200 (Table 2).

Growth in terms of net production rate (gm^{-3}135 days^{-1})

The net production rate of fish in different treatments; T-100, T-150 and T-200 were 7772±950 gm^{-3}135 days^{-1}, 13608±1261.7 gm^{-3}135 days^{-1}, 9444±600 gm^{-3}135 days^{-1}, respectively. The highest production rate 13608±1261.7gm^{-3}was found in T-150 and the lowest 7772±950gm^{-3} was found in T-100 (Table 3).

Table 3. Gross and net productions of *O. niloticus*of three treatments during the period of 135 days

		Gross production			Net production		
Treatment	**Replication**	**g m^{-2} 135day^{-1}**	**Kgha^{-1} yr^{-1}**	**Tonha^{-1} yr^{-1}**	**g m^{-2} 135day^{-1}**	**Kgha^{-1} yr^{-1}**	**Tonha^{-1} yr^{-1}**
T-100	1 (Cage 1)	7100	191963	192	6822	184447	184
	2 (Cage 2)	8050	217648	218	7772	210132	210
	4 (Cage 4)	9000	243333	243	8722	235817	236
	Mean	8050	217648	218	7772	210132	210
T-150	3 (Cage 3)	15400	416370	416	15033	406448	406
	7 (Cage 7)	13575	367028	367	13158	355753	356
	9 (Cage 9)	13050	352833	352	12633	341559	342
	Mean	14008	378743	378	13608	367920	368
T-200	4 (Cage 4)	10600	286593	287	10044	271560	272
	6 (Cage 6)	10000	270370	270	9444	255338	255
	8 (Cage 8)	9400	254148	254	8844	239116	239
	Mean	10000	270370	270	9444	255338	255

Discussion

Water quality parameters

The water quality parameters analyzed from the cages (temperature, dissolved oxygen, pH, and phosphate) during the experimental period were found suitable for fish farming and did not hamper the normal fish growth (Meade, 1989).Kapinga*et al.* (2014) and Moradyan*et al.* (2012) also found similar results in tilapia culture.

Growth performances

The study showed a substantial growth performances and production potential of GIFT tilapia under cage culture conditions at different densities which are discussed below:

Weight gain

A correlation between weight gain and stocking density of fish fry has been postulated by a number of authors. Yi and Lin (2001) observed that increased fish biomass of Nile tilapia in cages had a significant negative effect on the mean final body weight. Diana *et al.* (2004) reported that sex reversed Nile tilapia stocked in ponds at a low density showed better growth than at a higher density. The lower growth performance of tilapia at higher stocking density might be due to voluntary appetite suppression, more expenditure of energy because of intense antagonistic behavioral interaction, competition for food and living space (Diana *et al.*2004) and increased stress (Ouattara*et al.*2003). Dambo and Rana (1992) reported that increasing stocking density of Nile tilapia fry might have led to diminishing social dominance, resulting in lower individual growth rates. Similarly, we found the highest weight gain at lower stocking densities. In T-150 weight gain was higher than T-100 and T-200 because of higher availability of feed given to the fish at lower stocking densities.

Average daily gain (ADG)

The results of the present study clearly showed that the highest ADG (gday^{-1}) of *O. niloticus*was found in T-150 and lowest with lowest in T-200. That means ADG was directly affected with the stocking density. Additionally, KheirandSaad (2003) proved that the highest weight gain found in tilapia pond with least stocking densities.

Percent (%) weight gain and specific growth rate

According to the data obtained in the study, the highest percent (%) weight gain and SGR was found in T-150. In our study, stocking density affected percent (%) weight gain and SGR (%day^{-1}). Similar observations was reported by Watanabe *et al*. (1990) in the marine cage culture of monosex male Florida red tilapia in a 84 days culture period at 100, 200 and 300 fish m^{-3} densities.

Production rate (g m^{-3}135 days^{-1})

The highest production rate was observed in T-150for the stocking density of 150 fishm^{-3}. The lower production rate was recorded at a lower stocking density (100 fishm^{-3}) and higher stocking density (200 fishm^{-3}). Osofero*et al.* (2007) found the highest production (28560g m^{-3}) of *O. niloticus*at the stocking density of200 fishm^{-3}. A similar result was found by Balcázar*et al.* (2006) with hybrid red tilapia stocked at densities of 200, 300 and 400fishm^{-3} in replicated cages and obtained the highest production at the density of 400 fishm^{-3}. Asase (2013) conducted a study in Ghana with the stocking densities of 50, 100 and 150 fish m^{-3}and thehighest gross production was obtainedin150fishm^{-3}in cage culture system.Ofori*et al.* (2009) reported the highest stocking density (7000 fish 48 m^{-3}) which resulted less gross and net yields compared to others in cage culture condition.

From the experiment it can be concluded that stocking density affect the growth performances and production potential of tilapia under cage culture conditions. The mean final individual body weight (g), mean individual weight gain (g), average daily gain (g), percent (%) weight gain, specific growth rate and production rate (g m^{-3}day^{-1}) were increased with the increasing stocking densities for a certain level. However, after a standard density it began to decrease. Further research work with more stocking densities are needed to be more sure and specific in this regard. However, this experiment suggested that optimum stocking density (150 fish m^{-3}) performs the better results with the highest growth performances and production potential for tilapia culture in cage culture system.

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