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Effects of stocking density on growth performance and profitability of *Labeo bata* fry reared in earthen ponds

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Introduction

Bangladesh stands fourth in freshwater fish farming throughout the world (FAO, 2016). Aquaculture contributes more than fifty five percent of the national fish production, thus plays an essential role for the socio economic development of the Bangladesh through creating employment opportunities, alleviation of poverty and to supply protein for the growing population. Indian major carp contributes highest (19.36%) in the national fish production. However, substantial proportion of fish production comes from minor carp species annually (FRSS, 2017).

Labeo bata (Hamilton, 1822) is one of the indigenous minor carp species of Bangladesh, commonly well-known as bata. It is naturally found in rivers, canals, haors, baors, ponds and ditches. In Bangladesh, *Labeo bata* is commercially viable and target species for both small and large scale fishers due to its delicious taste, distinct flavor, high market demand and value as well as for its nutritional qualities (Ahmed *et al.*, 2012).

IUCN (2000) recorded *L. bata* as an endangered fish species due to the declination of stock to its natural habitats. However, recent studies reported *L. bata* as a least concern species in Bangladesh (Naser, 2014). This progression in present position from endangered to least concern is likely due to the initiatives taken by the government to increase the natural stock of *L. bata* via stock enhancement schedule as well as by the expansion of the aquaculture throughout the country. To maintain this fish population as well as its conservation and rehabilitation, development a suitable technology for breeding, rearing and nursing of fry and fingerlings is essential (Chakraborty *et al.*, 2007; Debnath *et al.*, 2016). Therefore, a suitable culture method for rearing of *L. bata* fry is very important to ensure reliable and regular supply of fingerlings. Stocking density, types and quality of fertilizer applied, and artificial feed supplied to earthen pond are determining factors of the fry and fingerlings growth, survival, production and its economic profitability (Drew *et *al*., 2007; Rahman *et al.*, 2013; Oprea *et al*., 2015).

To get maximum financial return, it would be necessary to stock the ponds at optimum stocking densities for desired growth and survival of fry. Therefore, this study was carried out to examine the effects of stocking density on growth, yield and profitability of *L. bata* fry reared in earthen ponds.

Materials and methods

This on-farm study was carried out in six private rearing ponds of 'Maa Fish Farm' Nawabgonj, Dinajpur, Bangladesh for a period of 60 days from August to October 2015. The surface area of each pond was 2 decimals with average water depth of 1 meter. The ponds were rectangular in shape, also had similar basin conformation, contour and bottom type. Fish fry were stocked at a rate of 750 fry decimal^{-1}, 1000 fry decimal^{-1}and 1250 fry decimal^{-1} designated as treatment-1 (T_1), treatment-2 (T_2) and treatment-3 (T_3), respectively, each with two replicates. The mean initial weight and sizes of fry was 1.02±0.06g and 3.42±0.07 cm, respectively.

Prior to stocking, preparation of rearing ponds were done according to the practice followed by Chakraborty *et al.* (2007) and Samad *et al.* (2014). Then, all ponds were stocked with *L. bata* fry which were collected from Fish Seed Multiplication Farm, Parbatipur, Dinajpur, Bangladesh. After stocking, all the ponds were fertilized with both organic and inorganic fertilizer recommended by (DOF, 2011) at weekly intervals to stimulate the primary productivity of the ponds.

Nursery feed (Aftab feed) was given to stocked fish at the rate of 10, 8, 6 and 5% for the fish attaining 1-3, >3-7, >7-10 and >10 g body weight, respectively. Fish were manually fed twice a day at 9 am and 4 pm with two equal splits of the ration. The feed was broadcast on the pond water surface. Proximate composition of the feed was analyzed according to AOAC (2012) method in the Nutrition Laboratory of the Department of Fisheries, University of Dhaka. Crude protein, crude lipid, crude fiber, ash and moisture of the experimental feed was 31.80%, 6.74%, 8.25%, 15.84%, and 11.12%, respectively.

Water quality parameters of the experimental ponds were monitored at 7 days interval between 9 am and 11 am. Portable digital thermometer (TFA Germany, D-97877 Wertheim) was used to record water temperature (˚C). Dissolved oxygen (DO), pH and transparency (cm) were measured using DO meter (HACH, HQ30d), pH meter (HACH, sensION^{TM} PH31) and Secchi disk, respectively. Alkalinity testing kit (HACH, AL-AP) was used to measure the total alkalinity of water samples.

Thirty (n=30) individuals from each pond were sampled by a fine-meshed nursery net at 15 days interval throughout the experimental period for the assessment of growth and for feed adjustment. At the end of trial, all fish were harvested and survival rate (%), finals weight and length, production (number ha^{-1} and kg ha^{-1}), specific growth rate (SGR=ln final weight−ln initial weight/days×100,%/day), feed conversion rate (FCR, weight of feed/gain in wet weight of fish) of each pond and treatment were calculated.

The data were analyzed through one-way analysis of variance (ANOVA) followed by Tukey test for post hoc comparisons. All data were expressed as mean±SD. Estimation of the net benefits from different treatments was simply done by cost-benefit analysis.

Results and Discussion

Result showed that mean value of temperature, DO, pH and total alkalinity did not show the significance differences (p>0.05) among the treatments, whereas transparency significantly (p<0.05) increased with increase of fish density (Table 1). The production of the aquatic organisms is immensely depends on the suitable water quality (Ahsan *et al.*, 2012). Throughout the experiment water quality parameters, were within the appropriate range for fry or fingerlings production (Daudpota *et al.*, 2014; Monir and Rahman, 2015; Debnath *et al.*, 2016; Fatema *et al.*, 2017). Rahman *et al.* (2013), noted that mean transparency varied significantly with different stocking density, possibly due to the reduction of the plankton population by higher density of fish.

Table 1: Water quality parameters of the rearing ponds during the experimental period.

Parameter	Treatment		
	T_1	**T_2**	**T_3**
Temperature (°C)	$28.66±1.42^a$	$28.50±1.40^a$	$28.48±1.37^a$
Dissolved oxygen (ppm)	$5.50±0.27^a$	$5.20±0.36^a$	$5.10±0.44^a$
pH	$7.28±0.32^a$	$7.20±0.43^a$	$7.16±0.46^a$
Total alkalinity (mg L^{-1})	$130.55±14.38^a$	$134.68±20.22^a$	$133.17±20.17^a$
Transparency (cm)	$29.73±2.52^a$	$35.5±2.58^b$	$43.34±3.38^c$

Data are represented as mean ± SD. Values in the same row having the same superscript are not significantly different (p>0.05).

Growth, in terms of *L. bata* fry weight increases at 15 days intervals are shown in Fig. 1. The increase in weight was the highest in T_1 and lowest in T_3. T_1 showed significantly higher growth performance (p<0.05) in term of final length and weight, net length and weight gain and SGR of the *L. bate* followed by T_2 and T_3 (Table 2), although the same food comprising 31.80% crude protein was supplied in all the treatments at an equal ration. De Silva and Davy (1992) reported that a dietary protein of 31% is required for the optimal growth of the carp species. However, T_3 showed the higher FCR followed by T_2 and lowest in T_1. Similar results were reported by Liu *et al.* (2017). Furthermore, there was a significant variation (p<0.05) in survival rate between T_1 and T_3 as well as between T_2 and T_3, but no such significance variation was observed between T_1 and T_2 (Table 2).

Chakraborty and Mirza (2007) found the significant variation in survival rate of *Labeo bata* hatchlings with different stocking densities among all treatment. But our experiment did not represent the significant variation (p>0.05) in survival rate of fish between T_1 and T_2 but both T_1 and T_2 significantly varied (p<0.05) with T_3. Bolivar *et al*. (2004) reported that higher survival rate was obtained when culture pond stocked with bigger size fry or fingerlings.

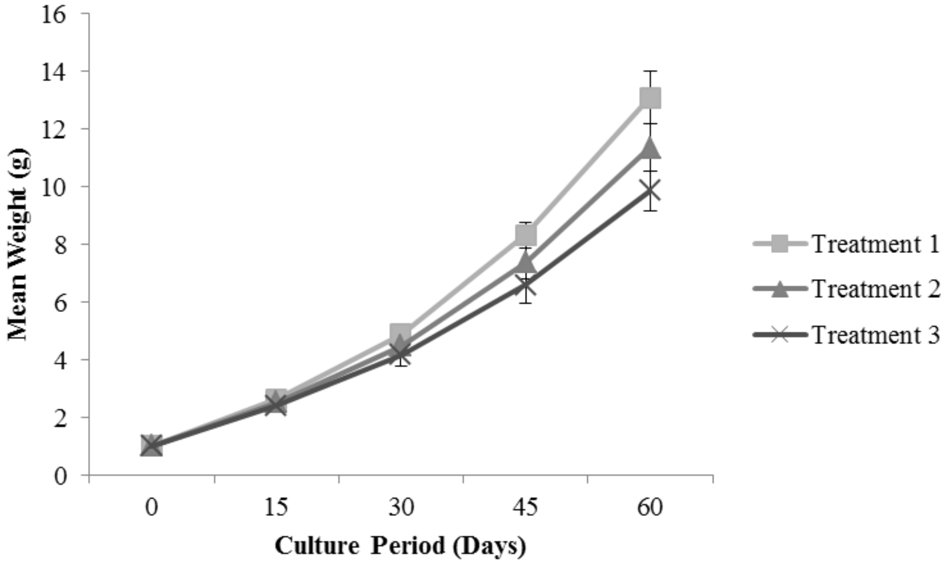

Figure 1: Fortnightly mean weight increase in *Labeo bata* at different stocking densities over a period of 60 days.

Table 2: Growth performance and nutrient utilization of *Labeo bata* fry or fingerlings after 60 days of rearing under different stocking densities.

Variables	T_1	T_2	T_3
Initial length (cm)	3.42 ± 0.07^a	3.42 ± 0.07^a	3.42 ± 0.07^a
Final length (cm)	10.40 ± 0.10^a	10.20 ± 0.11^b	9.90 ± 0.10^c
Length increase (cm)	6.98 ± 0.06^a	6.78 ± 0.13^b	6.48 ± 0.11^c
Initial weight (g)	1.02 ± 0.06^a	1.02 ± 0.06^a	1.02 ± 0.06^a
Final weight (g)	13.10 ± 0.90^a	11.37 ± 0.82^b	9.87 ± 0.70^c
Net weight gain (g)	12.08 ± 0.91^a	10.35 ± 0.89^b	8.85 ± 0.70^c
SGR (% day^{-1})	4.25 ± 0.14^a	4.02 ± 0.13^b	3.77 ± 0.14^c
Survival rate (%)	87.80 ± 1.23^a	86.85 ± 1.48^a	76.16 ± 1.81^b
FCR	1.51 ± 0.02^a	1.62 ± 0.01^b	1.83 ± 0.03^c
Production (number ha^{-1})	$162{,}755 \pm 2273^a$	$214{,}658 \pm 3671^b$	$235{,}296 \pm 5593^c$
Production (kg ha^{-1})	2132.09 ± 29.78	2440.67 ± 41.74	2322.38 ± 55.20

Data are presented as mean ± SD. Different superscripts in each row indicate significant differences among stocking (p<0.05).

The low growth rate of fry and fingerling in treatment T_3 appeared to be related with higher densities and increased competition for food and space (Jha and Barat, 2005). High density of fingerlings in combination with increased concentration of food in the rearing system might have produced a stressful situation and toxic substance which could be the probable cause for poor growth in treatment T_3 (Larsen *et al*., 2012; Chattopadhyay *et al*., 2013).

Production of fingerlings in terms of number per hectare in T_3 was significantly higher than T_2 and T_1. Despite of this, T_2 showed the consistently higher production of fingerlings in kg followed by T_3 and lowest in T_1, because of higher stocking density and insignificance variation in survival rate compare to T_1 and higher weight gain in comparison to fish reared under T_3. The total revenue earned from selling of fish at fixed price set by the "Maa Fish Farm" (200 taka kg^{-1}) was constantly higher in T_2 and lowest in T_3. However, the total cost of production with different densities was found to be lower in T_1 than T_2 and highest in T_3. Despite of the total cost of production, highest net benefit was obtained from T_2 than those of T_1 and T_3 (Table 3).

Table 3: Cost and benefits from the rearing of *Labeo bata* fry in 1 hectare earthen ponds for a culture period of 60 days.

		Item	Amount of Taka(tk.)[a] $ha^{-1}month^{-2}$			
			T_1	T_2	T_3	Remarks
A.		Variable cost (VC)				
	1.	Price of fry (approx. 0.26 tk. fry^{-1})	47,270	63,026	78,783	Fish fry was sold at the rate of tk. 250 kg^{-1}
	2.	Feed (tk. 40.00 kg^{-1})	139,873	171,787	214,807	
	3.	Lime (15 tk. kg^{-1})	3750	3750	3750	
	4.	Cowdung (1.0 tk. kg^{-1}) (Pre-stocking and Post-stocking)	5270	5270	5270	
	5.	Fertilizer (Urea 16 tk. kg^{-1}, TSP 22 tk. kg^{-1})	5260	5260	5260	
	6.	Dipterex (750 tk. kg^{-1})	7500	7500	7500	
	7.	Labour (6,000 tk. $month^{-1}.person^{-1}$)	12,000	12,000	12,000	
	8.	Pond operational cost including Harvesting	5000	5000	5000	
	9.	Miscellaneous	2000	2000	2000	
		Total variable cost (TVC)	227,923	275,593	334,370	
B.		Fixed cost				
	1.	Pond rental value	34,603	34,603	34,603	tk. 70 $decimal^{-1}.month^{-1}$
		Total fixed cost (TFC)	34,603	34,603	34,603	
		Total cost (TC=TVC+TFC)	262,526	310,196	368,973	
		Total return (TR)	426,418	488,134	464,476	On an average sale price of fish fixed by the Maa Fish Farm was tk. 200 kg^{-1}
		Net benefits (TR-TC)	163,892	177,938	95,503	

[a] 80 taka=1 US$

Therefore, this study suggested that the culture of *L. bata* is feasible at the density of 1000 fry $decimal^{-1}$, which could be recommended to adopt. Moreover, further studies are also required to find out suitable culture techniques that could enhance the production experimenting with different feeding frequencies as well as by manipulating culture systems.

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