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., 2016).
Ahmed 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 (*T₁*), treatment-2 (*T₂*) and treatment-3 (*T₃*), 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™ 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 d

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28.66±1.42&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dissolved oxygen (ppm)</td>
<td>5.50±0.27&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>pH</td>
<td>7.28±0.32&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total alkalinity (mg L&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>130.55±14.38&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Transparency (cm)</td>
<td>29.73±2.52&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

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<sub>1</sub> and lowest in T<sub>3</sub>. T<sub>1</sub>
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<sub>2</sub> and T<sub>3</sub> (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<sub>3</sub> showed the higher FCR
followed by T<sub>2</sub> and lowest in T<sub>1</sub>. Similar
results were reported by Liu et
al. (2017). Furthermore, there was a
significant variation (p<0.05) in
survival rate between T<sub>1</sub> and T<sub>3</sub> as well
as between T<sub>2</sub> and T<sub>3</sub>, but no such
significance variation was observed
between T<sub>1</sub> and T<sub>2</sub> (Table 2).
Chakraborty and Mirza (2007) found the significant variation in survival rate of *Labeo bata* hatchlings with different stocking densities among all treatments. But our experiment did not represent the significant variation (*p* >0.05) in survival rate of fish between T₁ and T₂ but both T₁ and T₂ significantly varied (*p*<0.05) with T₃. 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.](image)

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

<table>
<thead>
<tr>
<th>Variables</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial length (cm)</td>
<td>3.42 ± 0.07ᵃ</td>
<td>3.42 ± 0.07ᵃ</td>
<td>3.42 ± 0.07ᵃ</td>
</tr>
<tr>
<td>Final length (cm)</td>
<td>10.40 ± 0.10ᵃ</td>
<td>10.20 ± 0.11ᵇ</td>
<td>9.90 ± 0.10ᶜ</td>
</tr>
<tr>
<td>Length increase (cm)</td>
<td>6.98 ± 0.06ᵃ</td>
<td>6.78 ± 0.13ᵇ</td>
<td>6.48 ± 0.11ᶜ</td>
</tr>
<tr>
<td>Initial weight (g)</td>
<td>1.02 ± 0.06ᵃ</td>
<td>1.02 ± 0.06ᵃ</td>
<td>1.02 ± 0.06ᵃ</td>
</tr>
<tr>
<td>Final weight (g)</td>
<td>13.10 ± 0.90ᵃ</td>
<td>11.37 ± 0.82ᵇ</td>
<td>9.87 ± 0.70ᶜ</td>
</tr>
<tr>
<td>Net weight gain (g)</td>
<td>12.08 ± 0.91ᵃ</td>
<td>10.35 ± 0.89ᵇ</td>
<td>8.85 ± 0.70ᶜ</td>
</tr>
<tr>
<td>SGR (% day⁻¹)</td>
<td>4.25 ± 0.14ᵃ</td>
<td>4.02 ± 0.13ᵇ</td>
<td>3.77 ± 0.14ᶜ</td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>87.80 ± 1.23ᵃ</td>
<td>86.85 ± 1.48ᵃ</td>
<td>76.16 ± 1.81ᵇ</td>
</tr>
<tr>
<td>FCR</td>
<td>1.51 ± 0.02ᵃ</td>
<td>1.62 ± 0.01ᵇ</td>
<td>1.83 ± 0.03ᶜ</td>
</tr>
<tr>
<td>Production (number ha⁻¹)</td>
<td>162,755 ± 227³ᵃ</td>
<td>214,658 ± 367₁ᵇ</td>
<td>235,296 ± 559³ᶜ</td>
</tr>
<tr>
<td>Production (kg ha⁻¹)</td>
<td>2132.09 ± 29.78</td>
<td>2440.67 ± 41.74</td>
<td>2322.38 ± 55.20</td>
</tr>
</tbody>
</table>

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 T3 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 T3 (Larsen et al., 2012; Chattopadhyay et al., 2013).

Production of fingerlings in terms of number per hectare in T3 was significantly higher than T2 and T1. Despite of this, T2 showed the consistently higher production of fingerlings in kg followed by T3 and lowest in T1, because of higher stocking density and insignificance variation in survival rate compare to T1 and higher weight gain in comparison to fish reared under T3. 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 T2 and lowest in T3. However, the total cost of production with different densities was found to be lower in T1 than T2 and highest in T3. Despite of the total cost of production, highest net benefit was obtained from T2 than those of T1 and T3 (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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount of Taka(tk.) ha⁻¹ month⁻¹</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>A. Variable cost (VC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Price of fry (approx. 0.26 tk. fry⁻¹)</td>
<td>47,270</td>
<td>63,026</td>
</tr>
<tr>
<td>2. Feed (tk. 40.00 kg⁻¹)</td>
<td>139,873</td>
<td>171,787</td>
</tr>
<tr>
<td>3. Lime (15 tk. kg⁻¹)</td>
<td>3750</td>
<td>3750</td>
</tr>
<tr>
<td>4. Cowdung (1.0 tk. kg⁻¹)</td>
<td>5270</td>
<td>5270</td>
</tr>
<tr>
<td>(Pre-stocking and Post-stocking)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Fertilizer (Urea 16 tk. kg⁻¹, TSP 22 tk. kg⁻¹)</td>
<td>5260</td>
<td>5260</td>
</tr>
<tr>
<td>6. Dipterex (750 tk. kg⁻¹)</td>
<td>7500</td>
<td>7500</td>
</tr>
<tr>
<td>7. Labour (6,000 tk. month⁻¹ person⁻¹)</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>8. Pond operational cost including Harvesting</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>Total variable cost (TVC)</td>
<td>227,923</td>
<td>275,593</td>
</tr>
<tr>
<td>B. Fixed cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Pond rental value</td>
<td>34,603</td>
<td>34,603</td>
</tr>
<tr>
<td>Total fixed cost (TFC)</td>
<td>34,603</td>
<td>34,603</td>
</tr>
<tr>
<td>Total cost (TC=TVC+TFC)</td>
<td>262,526</td>
<td>310,196</td>
</tr>
<tr>
<td>Total return (TR)</td>
<td>426,418</td>
<td>488,134</td>
</tr>
<tr>
<td>Net benefits (TR-TC)</td>
<td>163,892</td>
<td>177,938</td>
</tr>
</tbody>
</table>

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.

Acknowledgements
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