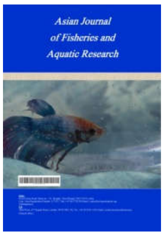

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Influence of Stocking Density on Growth Performance of *Labeo bata* in Cage at River Padma, Rajshahi, Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Authors NN and SA performed experiment and managed the analyses of the study. Author MIH designed the study. Authors MAS and FBF performed the statistical analysis, wrote the protocol and managed the literature searches. Author MLR wrote the first draft of the manuscript and coordinated manuscript for publication. All authors read and approved the final manuscript.

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ABSTRACT

As a result of climate change, aquaculturists are seeking adaptive culture techniques for sustainable aquaculture. In this case, cage culture is a suitable technique that can mitigate the challenge of climate change, but due to the lack of knowledge of proper stocking density, often productions are not satisfactory. Therefore, the experiment was conducted to evaluate the influence of stocking density on growth and production of an endangered minor carp bata (*Labeo bata)* in cages for a period of 120 days in Padma River, Rajshahi, Bangladesh. On an average initial weight of bata fingerling of 5 g was stoked in cages under three treatments each with containing three replications using three different stocking densities (106, 71 and 35 fingerling/m^3

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for T_1, T_2 and T_3, respectively). Supplementary feed (3% per body weight) was given to the cultured species twice in a day. The mean values of water temperature, transparency, pH and dissolved oxygen were in suitable range throughout the experimental period. Significantly ($p<0.05$) highest mean gross weight (85.82±0.70 g), specific growth rate (2.37± 0.02%), survival rate (83± 3.00%) and food conversion ratio (2.27± 0.03) was found in T_3 rather than T_2 and T_1. The net production in terms of biomass (18.23±2.43 kg/cage) was significantly ($p<0.05$) higher in T_2.The study suggests that, treatment T_2 (71 fingerling /m^3) as the optimum stocking density to produce maximum production by cage culture of *Labeo bata.*

Keywords: Cage culture; stocking density; endangered species; growth; production.

1. INTRODUCTION

Cage aquaculture is one of the most rising technology to accelerate fish production. To increase the productivity, management practices should be developed and improved techniques should be applied [1]. The scope for increasing fish production in inland waters through cage culture is highly expected in Bangladesh. Culture of fish in cages has gained much popularity throughout the world due to a number of advantages over the conventional methods of fish culture [2]. Low labor cost, proper use of water bodies, less chance of disease infection due to continuous water flow usually make cage culture advantageous than other culture methods. A widespread and profitable culture of fish in cages has already been developed successfully in Asia, Europe and America [3]. In South-East Asia, this practice started from late 1800s, since then many countries are practicing cage culture in freshwater and marine environments including ponds, rivers, haors, beels, open sea, estuaries, lakes, reservoirs, etc. [4]. Cage culture in open water bodies could provide a prospect for increasing fish production, uplifting livelihood of rural fish farmers and mitigating protein demand in the nation [5]. But, unfortunately cage culture on commercial basis should yet to be popularized in Bangladesh due to many reasons such as, lack of knowledge about proper management, selection of species, determination of appropriate stocking densities and socio-economic constraints [2]. Species selection is very important for cage culture as well as other intensive culture system, as all species are not suitable for all culture system. Among various cultural species, bata is considered endangered and demandable native species in Bangladesh, whereas in other countries, it comes under 'least concern' category due to intense aquaculture activities [6]. Bata is especially important because it fetches high market value even at a smaller size of 30-50 g. Bata is a commercially important minor carps having good consumer preference [7]. In Bangladesh, culture-based fisheries and small-scale aquaculture are often constrained by the lack of suitably sized seed stock. Although there is a large quantity of fry of cultured species in particular carp species produced in Bangladesh, fingerling production has lagged behind due to economic and land constraints [8]. Promoting cage culture could meet the demand of land for fish farming. Stocking density is an important factor in determining the productivity and profitability of commercial fish farming [9]. High stocking density decreases the production of fish and low stocking density is not commercially profitable [10]. Maintaining proper stocking densities is the key to success in aquaculture management. Stocking density has an effect on fish survival, growth, production, behavior, health and water quality [11,12]. The stress level increases with increasing the stocking density, along with competition for food and optimum space [10]. Hence, fish kept at higher density tend to have lower growth [11] and production [13]. However, under stocking also leads to under-utilization of available space, resulting in lower fish production [14]. Stocking density also influences the economics of cage culture, where higher/optimum stocking is more economical considering the cost and benefit of the system [15]. Therefore, it is necessary to determine the optimum stocking density for a species for successful cage culture.

Previously, the effect of stocking density on the growth of bata was determined in nursery ponds [16]. Although, stocking density of bata reared in the cages was also optimized at the floodplain wetland [17] and reservoir [18] in India, variable stocking density was determined may be due to different physico-chemical parameters of habitats like primary productivity, intensity of current and disease infestation etc. Since, there may have a relation between stocking density-dependent production and aquatic environment, the effect of stocking density on the growth performance of bata could be different in the rivers of Bangladesh. Therefore, the present experiment was designed to find out the optimum stocking density of endangered minor carp bata in cages by evaluating their growth performance, production and economics. The research would be a model for others in Bangladesh as well as rest of the world. The present study is the first report on cage culture of L. bata in river and these findings of the experiment would suggest proper instructions for optimizing stocking density of bata in rivers of Bangladesh.

2. METHODOLOGY

The study was conducted in Padma River at Jahajghat, Motihar Thana of Rajshahi City, Bangladesh in nine cages of equal size (2.45×1.52×1.52 = 5.66 m^3) for a period of four month (120 days) from July to October, 2017. Three different stocking densities were used in the experiment to observe its effects on growth, survival and production of *L. bata*.

The framework of rectangular shaped cages were made of bamboo stick and covered by high-density nylon net. The equal mesh size of the net was used about 1 mm. The fish fingerlings were collected from fish seed farm in local area, Meherchandi, Rajshahi. The mean initial weight of the fishes was 5g. Prior to release, fingerlings were acclimatized to the new environment in floating cage for several hours. Then 600,400 and 200 fingerling of *Labeo bata* were stocked in treatment I (cage - 1,2,3), treatment II (cage - 4,5,6) and treatment III (cage - 7,8,9), respectively. The stocking density of *L. bata* under three treatments is presented in Table 1.

For encouraging the growth of *Labeo bata,* supplementary feed (Wheat bran 60% + mustard oil cake 30% + rice bran 10%) were supplied to fish at the rate of 3% of fish body weight. Supplemental feed was administered twice a day, in the morning and afternoon.

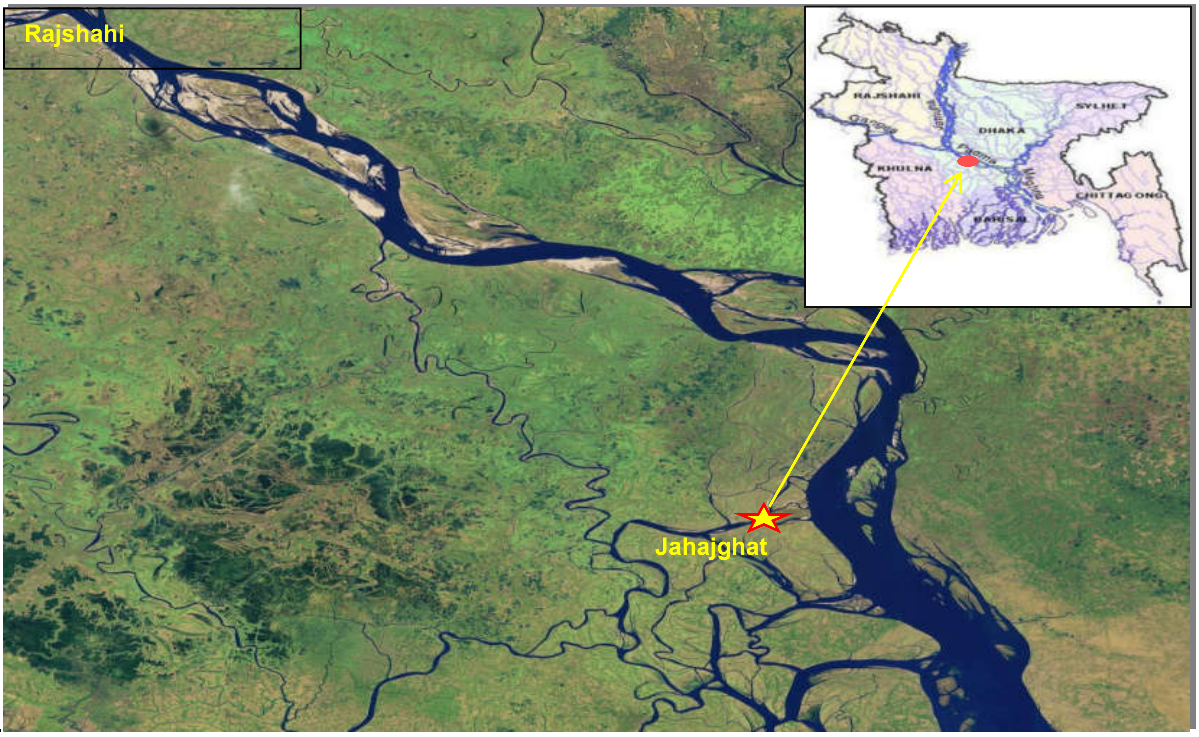

Fig. 1. Map showing the geographical location of sampling site

Table 1. Stocking density of *Labeo bata* in cages under three different treatments

Species	Treatment	No of replication	Stocking density (fry/m^3)
Labeo bata	T_1	3	106
	T_2	3	71
	T_3	3	35

2.1 Monitoring of Water Quality Parameters

The water quality parameter such as temperature (°C), Transparency (cm), pH and dissolved oxygen (mg/l) were recorded fortnightly throughout the culture period. Water temperature was recorded by a Celsius thermometer. Transparency was measured by using a Secchi disc of 40 cm in diameter, pH was recorded by using portable pH paper, HACH kit (HACH, Loveland, CO, USA) was used to determine dissolved oxygen of water.

2.2 Growth Parameters

Body weight (g) and length (cm) of fishes were measure after randomly collecting 20 fish sample from each cage at every 15 days interval. Growth performance of the fishes were estimated in terms of following parameters-

Weight gain (g) = Average final weight (g) – Average initial weight (g)

Length gain (cm) = Average final Length (cm) – Average initial Length (cm)

Specific growth rate (SGR, % bwd^{-1})

Specific growth rate (SGR, % bwd^{-1}) was calculated as-
[Ln (final weight) – Ln (initial weight)] / culture period (day) × 100

2.2.1 Survival rate

After completing the experiment of 120 days the number of total live fingerlings in cage was counted separately for calculation of survival rate using following formula-

Survival rate (%) = (Number of fish live / Number of fish used) × 100

Feed Conversion Ratio (FCR) = Amount of feed given (kg) / Fish weight gain (kg)

2.3 Economic Analysis

After completion of the experimental period, all fishes were caught by fishermen and sold at nearby fish market with prevailing price. Experiment operating cost like infrastructure preparation cost, feed, fingerlings were adjusted from sale of fish. Then a benefit cost ratio (BCR) and economic analysis were done to determine the profitability of bata culture in cages.

Benefit cost ratio (BCR)= Benefit ÷ Total cost

2.4 Statistical Analysis

All the data were subjected to ANOVA (Analysis of Variance) using SPSS software (Statistical Package for Social Science) version-20. The mean values were also compared to see the significant difference from the DMRT (Duncan Multiple Range Test p< 0.05 level of significance). Regression procedure of MS Excel 2010 was used to establish a relationship between specific growth rate and stocking density. Results are stated as mean ± standard error (SE).

3. RESULTS AND DISCUSSION

3.1 Water Quality Parameters

The mean values of physico-chemical parameters in different treatments have been presented in Table 2. The water quality parameters measured in the three treatments throughout the study period were found within the acceptable range for fish culture. The mean water temperatures in different treatments during the experimental period were not statistically significant (P>0.05). The minimum value was recorded in T_2 whereas the maximum value was recorded in T_3. As river is an open water body, that's why temperature may varies from 26°C to 31°C and this type of variation was also found by Rahman et al. [19] in river water where temperature varied from 26.06°C to 31.97°C. The present findings also agree with the findings of Haider et al. [20], Monir and Rahman [21] and Asadujjaman et al. [22].

The average value of transparency during the study period was insignificantly (P>0.05) highest in T_3 (28.35±2.91cm) followed by T_2 (28.03±2.88 cm) and lowest in T_1 (27.79±3.25 cm). Boyd [23] suggested transparency range from 15 cm to 40 cm is good for fish culture. Hosen et al. [24] observed that transparency varied from 24.54 ± 6.94 to 33.25 ± 5.98 cm in six poly-culture ponds at Bangladesh Agricultural University, Mymensingh, Bangladesh. Transparency level of the present study also showed similarity with the findings of Uddin [25].

The mean value of water pH during the study period was varied from 7.53 ± 0.10 to 7.6 ± 0.50. There was no significant (P<0.05) variation among the treatments. The minimum value was recorded in T_1 and the maximum value was recorded in T_3. The observation of Swingle [26] suggested that pH range 6.5 to 9.0 is suitable for fish culture. The value of pH in the present experiment was suitable for fish culture which was agreed with the findings of Real et al. [27] and Rumpa et al. [28].

Dissolved oxygen (DO) content during the study period was found to be ranged from 5.48±0.02 to 5.72±0.11 mg/1 which were statistically significant (P>0.05). The minimum value was recorded in T_2 whereas the maximum value was recorded in T_3. DoF [8] reported that in a water body the suitable range of DO for fish culture would be 5-8 mg/1. Asadujjaman et al. [22] observed that dissolved oxygen ranged between (5.45 to 7.78 mg/1) during their experiment in BAU campus, Mymensingh. Rumpa et al. [28] measured dissolved oxygen between 2.45 to 5.5 mg/l during the experimental period while Munni et al. [29] obtained the values of the DO 1.1-6.9 mg/l, from the seven identified ponds situated at Santosh region of Tangail Sadar Upazila. However, the DO content was within the acceptable range throughout the experimental period.

3.2 Growth Performance and Production

Growth parameters in terms of final weight, weight gain, final length, length gain, specific growth rate, survival rate and feed conversion ratio of *L. bata* is shown in Table 3. The average weight of *L. bata* fingerlings under three different stocking densities throughout the experiment is shown in Fig. 2 which indicates that the increases of weight were always higher in T_3 followed by T_2 and T_1. The average final weight were obtained 49.10 ± 0.09, 63.21 ± 0.05 and 85.82 ± 0.70 g and the mean weight gain were 44.10 ± 0.10, 58.21 ± 0.10 and 80.82 ± 0.20 g in T_1, T_2 and T_3, respectively. The highest average final weight and weight gain, was observed in T_3 and lowest in T_1. There was significant difference (P<0.05) in average final weight and weight gain among the three treatments. The obtained results by Chakrabortya and Mirza [16] was much lower than the findings of present study might be due to variation of stocking density; feed utilized, initial size difference etc.

The mean Length of *Labeo bata* in the three treatments throughout the culture period is presented by Fig. 3. T_3 always represented higher increase rate of length than T_2 and T_1. The mean final length and length gain were showed higher in treatment T_3 compare to treatment T_1 and T_2. Our obtained findings are higher than the result acquired by Chakrabortya and Mirza [16] probably be due to the difference in size and density at which the fingerling were stocked. Final length and length gain was significantly (P<0.05) highest in T_3 and lowest in T_1.

The Specific growth rate (SGR % day) was significantly (P<0.05) higher in T_3 (2.37 ± 0.02) rather than T_2 (2.11 ± 0.01) and T_1 (1.90 ± 0.07) which coincide with the finding of Chakrabortya and Mirza [16] who obtained specific growth rate of *Labeo bata* 2.33 to 3.53%. Islam [30] observed the highest values of specific growth rate at the lowest stocking densities which had similarity with the present findings. Increase in stocking density led to decrease in specific growth rate establishing a linear relationship, y = − 0.0066x +2.5923, R2=0.9978 (Fig. 4)

Fingerlings of *Labeo bata* had significantly higher survival rate (83.0 ± 3.00%) in T_3, whereas the lowest was 67.0 ± 1.00% in T_1 and there were significant (P<0.05) differences among the treatments. Chakrabortya and Mirza [16] found survival rate of *Labeo bata*, 66.68 to 80.15% which was more or less similar to the present study. Yengkokpam et al. [17] observed the effect of stocking density on growth and yield of *Labeo bata* fingerlings reared in cages and obtained survival rate 85.50a ± 0.81 to 94.07 ±0.20% that was higher than the present experiment perhaps due to variation of number and size of fingerlings, physicochemical parameters, culture period etc.

Table 2. Mean value of physicochemical parameters in different treatments

Parameters	Treatment		
	T_1	T_2	T_3
Temperature (^oC)	28.50 ± 1.00^a	28.50 ± 0.50^a	28.50 ± 2.50^a
Transparency (cm)	27.79 ± 3.25^a	28.03 ± 2.88^a	28.35 ± 2.91^a
P^H	7.53 ± 0.10^a	7.59 ± 0.03^a	7.6 ± 0.50^a
DO (mg/l)	5.60 ± 0.07^b	5.48 ± 0.02^b	5.72 ± 0.11^a

Different superscript letters within one row indicated statistically significant differences at p<0.05

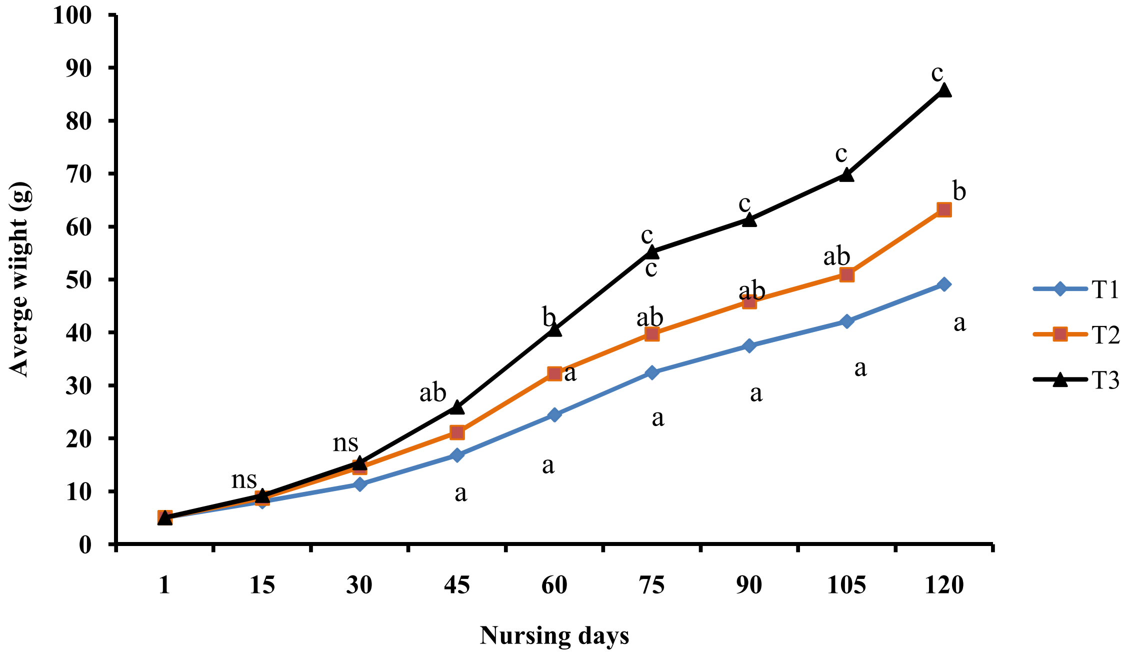

Fig. 2. Fortnightly mean weight (g) gain of *Labeo bata* under three treatments over a period of 120 days. T1: 106 fish/m^3, T2: 71 fish/m^3, T3: 35 fish/m^3. Different superscript in the same nursing days signify statistical difference (P<0.05). ns- Not significant

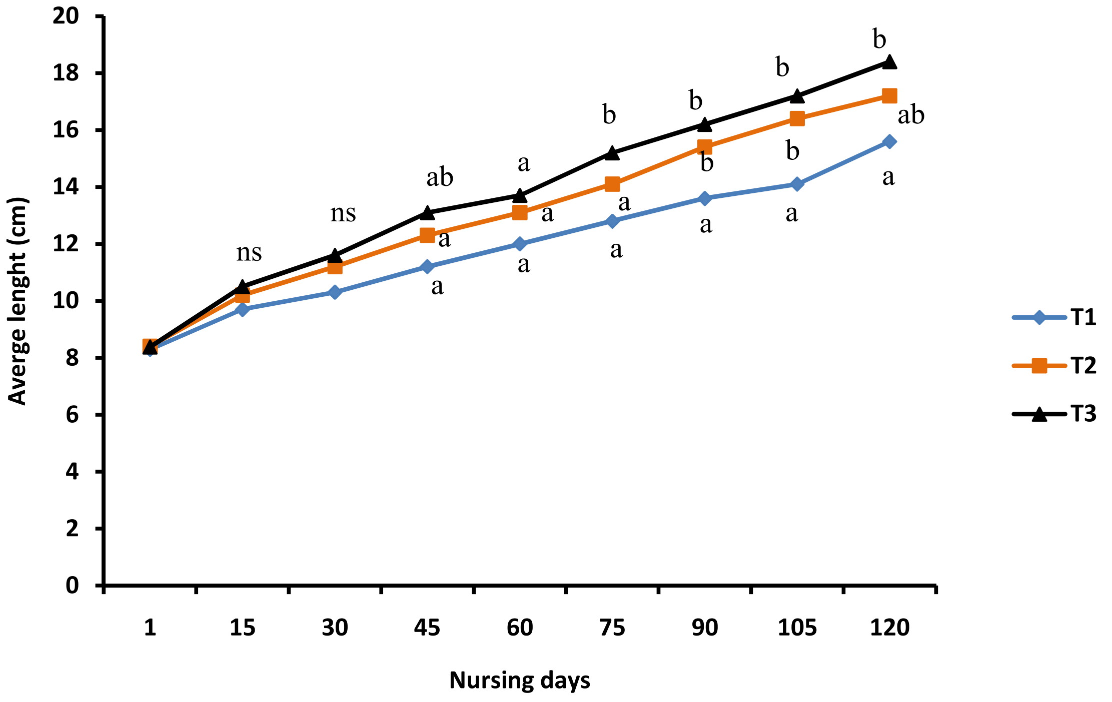

Fig. 3. Fortnightly mean length (cm) gain of *Labeo bata* under three treatments over a period of 120 days. T1: 106 fish/m^3, T2: 71 fish/m^3, T3: 35 fish/m^3. Different superscript in the same nursing days signify statistical difference (P<0.05). ns- Not significant

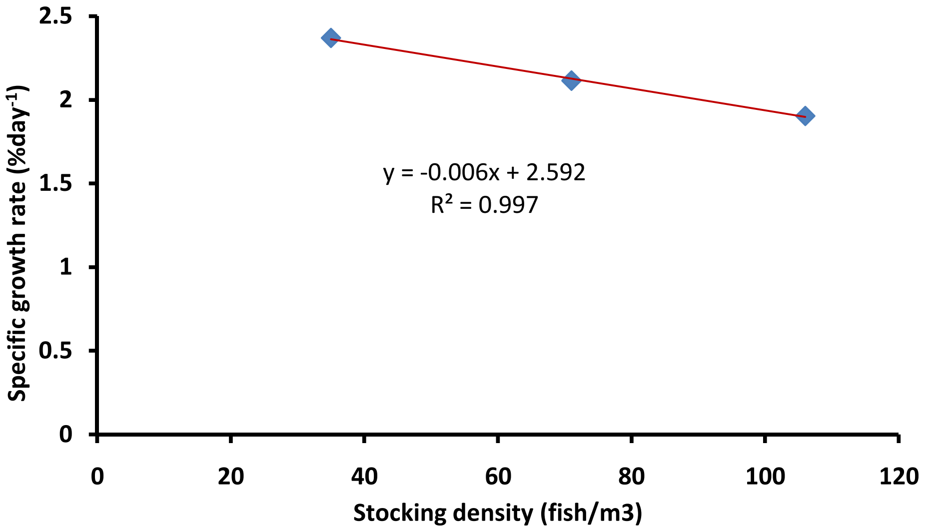

Fig. 4. Relationship between specific growth rate and stocking density of *Labeo bata*

Table 3. Growth parameters and production of *Labeo bata* in different treatments over the culture period (120 days)

Growth parameters	Treatments		
	T_1	T_2	T_3
Initial average body weight	5.00 ± 0.20^a	5.00 ± 0.10^a	5.00 ± 0.30^a
Final average body weight	49.10 ± 0.09^c	63.21 ± 0.05^b	85.82 ± 0.70^a
Average weight gain	44.10 ± 0.10^c	58.21 ± 0.10^b	80.82 ± 0.20^a
Initial average length (cm)	8.29 ± 1.00^b	8.40 ± 0.05^a	8.38 ± 0.07^a
Final average length(cm)	15.60 ± 0.08^c	17.20 ± 0.10^a	18.40 ± 0.05^b
Average length gain (cm)	7.31 ± 0.08^c	8.80 ± 0.20^b	10.02 ± 0.25^a
SGR (% day)	1.90 ± 0.04^c	2.11 ± 0.03^b	2.37 ± 0.02^a
Feed apply (Kg)	32.19 ± 0.05^a	31.27 ± 1.00^a	21.03 ± 0.10^b
Food conversion ratio (FCR)	2.18 ± 0.18^a	2.05 ± 0.05^b	2.27 ± 0.03^c
Survival rate (%)	67 ± 1.00^c	80 ± 3.00^b	83 ± 3.00^a
Gross production (kg)	19.74 ± 1.69^a	20.23 ± 2.83^a	14.25 ± 2.25^b
Initial production (kg)	3.00 ± 0.50^a	2.00 ± 0.40^a	1.00 ± 0.50^a
Net production (kg)	16.74 ± 1.07^a	18.23 ± 2.43^a	13.25 ± 2.02^b

Different superscript letters within one row indicated statistically significant differences at p<0.05

The Food Conversion Ratio (FCR) of T_2 (2.05± 0.05) was found to be significantly (P<0.05) lower than T_1 (2.18 ± 0.18) and T_3 (2.27 ± 0.03). The FCR values of the different treatments were acceptable and indicated better food utilization, which is agreed by Yengkokpam et al. [17] who found FCR of *Labeo bata* 1.35a ± 0.08 to 3.58 ±0.21.

Growth parameters (final weight, weight gain, final length, length gain, specific growth rate), survival rate and feed conversion ratio of *Labeo bata* showed significantly (P<0.05) higher in T_3 in case of stocking density of fishes were 35/m^3 compared to T_2 (71 fish/m3) and T_1 (106 fish/m3). Although the same fish feed with equal ratio was applied in all the treatments. The lower growth performance was observed in T_1 and T_2 compared to T_3, perhaps due to increased competition for habitat and food for higher number of fish stocking [31,32, 33,34]. Powell [35] mentioned the harmful effects of higher stocking density on the culture of fish were reduction of growth rate, increase of food conversion ratio and lowering of survival rate. High density of fingerlings in the rearing system might have produced a stressful situation which could be the probable cause for poor growth in T_1 and T_2 [36,32].

Table 4. Economic analysis of *Labeo bata* culture in cage over a period of 120 days

Particulars	Treatments		
	T_1	T_2	T_3
Cage preparation cost (Tk)	266 ± 4^a	266±4^a	266± 10^a
Feed apply (Kg)	32.19± 0.05^a	31.27± 1.00^a	21.03± 0.10^b
Cost by feed (Tk/Kg)	32± 1^a	32±5^a	32±2^a
Total feed cost (Tk)	1030.08±3^a	1000.64±10^b	672.96±7^c
Fingerlings cost (Tk)	750±50^a	500±60^b	250±10^c
Labor cost (Tk)	600±10^a	600±5^a	600±6^a
Total Production cost (Tk)	2646.08±23^a	2366.64±8^b	1788.96±4^c
Total income (Tk)	4935± 7^b	5057.5± 28^a	3562.5± 1^c
Profit (Tk)	2268.92± 23^c	2690.86± 1^a	1773.54± 3^b
Benefit-cost ratio	0.87± .02^b	1. 14± .04^a	0.99± .04^a

Different superscript letters within one row indicated statistically significant differences at p<0.05
1 US$ = Tk. 81.39 [31/10/17]

The net Production of *Labeo bata* in the experiment was 16.74± 1.07, 18.23± 2.43 and 13.25± 2.02 kg in T_1, T_2 and T_3, respectively. Production was height in T_2 where *Labeo bata* was stocked at 71 fish/m^3 and lowest in T_3 where *Labeo bata* was stocked at 35 fish/m^3. However, production of *Labeo bata* increased significantly (P<0.05) in T_2 than T_1 and T_3 (Table 3). Fish production tends to increase with increasing the stocking density until the cage carrying capacity is reached [13,37]. Shiremen et al. [38] and Ahmed et al. [39] reported that the growth and production of fish are to a certain extent, dependent on the population density.

In the present experiment stocking density greatly influenced on the growth, production and cost benefit ratio. Low growth of *Labeo bata* was observed at higher stocking density might be due to fishes did not found suitable environment for their growth and competed with one another for food and habitat but production was higher at the same stocking density perhaps due to more biomass for more fish.

3.3 Economic analysis

A simple benefit-cost analysis was performed to evaluate the amount of profit. The result of the analysis is shown in Table 4. Production costs of culturing *Labeo bata*, includes cost for feed, fingerlings, cage preparation and labor cost. Though a large amount of money was needed for cage preparation, the life time of cage is at least 10 years and so the total cost of cage preparation was distributed according to its life time. In economics, it is called depreciation cost. As cage is made by hard material so it has scrap value (its material can be used for other purpose after ending the experiment). Finally cage preparation cost was calculated by deducting the depreciation cost and scrap value from the total cost of cage preparation. The total production cost was significantly (P<0.05) higher in T_1 that was 2646.08 BDT. (Bangladeshi currency, Taka) than those of T_2 (BDT. 2366.64) and T_3 (BDT. 1788.96). The total cost increased with increasing stocking density due to higher cost of fingerlings and feed at higher stocking density. The total income from *Labeo bata* culture was significantly (P<0.05) higher in T_2 (BDT. 5057.52) than those of T_1 (BDT. 4935.00) and T_3 (BDT. 3562.5). Significantly (P<0.05) highest net benefit was obtained in treatment T_2 (BDT. 2690.86) compare to T_1 (BDT. 2268.92) and T_3 (BDT. 1788.96). As the higher production of *Labeo bata* was recorded in T_2, significantly (P<0.05) higher net benefit (BDT. 2690.86) and benefit-cost ratio (1.14) was also found in T_2. The most economic stocking density is the one which can yield higher biomass per unit area, highest net revenue and the highest BCR (Yengkokpam et al. [17]. Increase in profit with increasing the stocking density was reported in case of Asian river catfish [37]. In T_3 fishes were grown in larger size due to its low stocking density compare to the other treatments but finally T_2 showed good economic results due to its higher production. Thus, a stocking density of T_2 (71 fish/m^3) can be considered as optimum stocking density for cage culture of *Labeo bata.*

4. CONCLUSION

In the present study, cage farming of *Labeo bata* at different stocking density has revealed that stocking density is negatively correlated along with growth, although most suitable stocking density is selected according to cost-benefit ratio. From this experiment it could be concluded that stocking density of T_2 (71 fish/m^3) is advisable and most suitable rather than the lowest and highest stocking density for successful cage culture farming of *Labeo bata.*

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. Regional fisheries livelihoods programme for south and Southeast Asia (RFLP). Improving the Quality of Fishery Products and Market Chains. 2013;1-13.
2. Kohinoor AHM, Rahman MM. Preliminary study on the production of common carp cultured in freshwater river cages. Int. J. Agril. Res. Innov. & Tech. 2013;4(1):24-27. ISSN: 2224-0616.
3. Beveridge MCM. Cage aquaculture. Fishing News Books Ltd. Farnhan, Surrey, England; 1987.
4. Balcazar J, Aguirre A, Gomez G, Paredes W. Culture of hybrid Red tilapia (*Oreochromis mossambicus* × *Oreochromis niloticus*) in marine cages: Effects of stocking density on survival and growth. University of Zaragoza, Zaragoza, Spain; 2006.
5. Das P, Islam MS, Biswas M, Das PR, Arif ASM. Effects of probiotics on growth and production of monosex tilapia (*Oreochromis niloticus*) in nylon net cages at dekar haor, sunamganj, bangladesh. J. Asiat. Soc. Bangladesh, Sci. 2018; 44(1):69-78.
6. Devi RKR, Ali A. *Labeo bata*. The IUCN Red List of Threatened Species; 2011. DOI:https://doi.org/10.2305/IUCN.UK.2011 1.RLTSe.T166595A6243968T166595A624 3968.en
7. Behera BK, Das P, Singh NS, Sahu AK. Observations on the induced breeding of *Labeo bata* (Hamilton) with ovaprim and ovatide as inducing agents with a note to its development. J. Aqua. 2007;15:11-16.
8. Mohsin A, Islam M, Hossain M, Galib S. Constraints and prospects of carp production in Rajshahi and Natore districts, Bangladesh. University Journal of Zoology, Rajshahi University. 2013;31:69-72.
9. Ellis MM, Westfall BA, Ellis MD. Determination of water quality. Fish and Wild Life Service, U.S. Dept. Interior, Res. Rept. 1952;9:122.
10. M'balaka M, Kassam D, Rusuwa B. The effect of stocking density on the growth and survival of improved and unimproved strains of *Oreochromis shiranus.* The Egyptian Journal of Aquatic Research. 2012;38:205-211.
11. El-Sayed A. Effects of stocking density and feeding levels on growth and feed efficiency of nile tilpia (*Oreochromis Niloticus* L.) fry. Aquacult. Res. 2002; 33:621-626.
12. Kohli MPS, Ayyappan S, Langer RK, Dubey K, Prakash C, Reddy AK, Deshmukhe G. Cage culture of carps, *Labeo rohita* and *Cyprinus carpio* at Powai Lake, Mumbai, Maharashtra. appl. Fish. Aquaculture. 2002;2:1-4.
13. Hengsawat K, Ward FJ, Jaruratjamorn P. The effect of stocking density on yield, growth and mortality of African catfish (*Clarias gariepinus* Burchell 1822) cultured in cages. Aquaculture 1997;152:67–76.
14. Rahman MN, Islam MN, Halder GC, Tanaka M. Cage culture of sutchi catfish, *Pangasius sutchi* (Fowler 1937): Effects of stocking density on growth, survival, yield and farm profitability. Aquacult. Res. 2006;37:33-39.
15. Biswas P, Kohli MPS, Chadha NK, Bhattacharjya BK, Debnath D, Yengkokpam S, et al. Optimizing stocking density of *Labeo rohita* fry in cage aquaculture system as a tool for floodplain wetland fisheries management. Proc. Acad. Sci. India, Sect. B. 2015;85:181-190.
16. Chakrabortya BK, Mirza MJA. Effect of stocking density on survival and growth of endangered bata, *Labeo bata* (Hamilton–Buchanan) in nursery ponds. Aquaculture. 2007;265:156–16.
17. Yengkokpam S, Das BK, Debnath D, Das P, Yadav AK, Sharma N, et al. Effect of stocking density on growth and yield of *Labeo bata* fingerlings reared in cages. Aquaculture Reports. 2020;18:100506.
18. Karnatak G, Das BK, Mishal P, Tayung T, Kumari S, Sarkar UK, et al. Impact of

stocking density on growth, feed utilization and survival of cage reared minor carp, Labeo bata (Hamilton, 1822) in Maithon reservoir, India. Aquaculture. 2021;532:736078
19. Rahman MS, MY Chowdhury AKM, Haque A, Haq MS. limnological studies of four ponds Bangladesh. J. Fish. 1982;2-5(1-2):25-35.
20. Haider MA, Shahriar SIM, Hosen MHA, Chanda MS, Khatun MM. A study on water quality parameters and benthos abundance in freshwater homestead ponds of Dinajpur, Bangladesh. International Journal of Fisheries and Aquatic Studies. 2017;5(2):27-32.
21. Monir MS, Rahman S. Effect of stocking density on growth, survival and production of shing Heteropneustes fossilis fingerlings under nursery ponds in northern region of Bangladesh. International Journal of Fisheries and Aquatic Studies. 2015;2(3):81-86.
22. Asadujjaman M, Wahab MA, Fatema MK, Hossain MB and Azam AKMS. Effects of stocking density on growth performance and production of mola, *Amblypharyngodon mola*. Sains Malaysiana. 2013;42(9):1231–1235.
23. Boyd CE. Water quality management for pond fish culture. Elsevier science publisher B.V., 1000 AH Amsterdam. The Netherlands. 1982;318.
24. Hosen MA, Shahjahan M, Rahman MS and Alam MJ. Effects of artificial feeds on growth and production of fishes in polyculture. Int. J. Agril. Res. Innov. & Tech. 2014;4(2):11-15. Available:http://www.ijarit.webs.com
25. Uddin MM. Effects of addition of small fish on pond ecology and production in polyculture. MS dissertation. Dept. of Fisheries Management, Bangladesh Agricultural University, Mymenshing, 2002;91 .
26. Swingle HS. Standardization of chemical analysis for waters and pond mud. FAO. Fisheries Res. 1969;4(2):397-421.
27. Real HK, Khanam N, Mia MY, Nasreen M. Assessment of water quality and microbial load of Dhaleshwari River Tangail, Bangladesh. Adv. Microbiol. 2017;7:523-533.
28. Rumpa RJ, Haque MM, Alam MM, Rahamatullah SM. Growth and production performance of carps in shaded pond in Barisal, Bangladesh. J. Bangladesh Agril. Univ. 2016;14(2):235–241.
29. Munni MA, Fardus Z, Mia MY, Afri R. Assessment of pond water quality for fish culture: A case study of santosh region in Tangail, Bangladesh . J. Environ. Sci. & Natural Resources. 2013;6(2):157-162.
30. Islam MS. Effect of stocking density on the growth and production of GIFT Tilapia (*Oreochromis niloticus*) in ponds. MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh. 2007;48.
31. Chakraborty BK, Miah MI, Mirza MJA, Habib MAB. Rearing and nursing of endangered sarpunti, *Puntius sarana* (Ham.) with tree supplementary feeds. J. Asiat. Soc. Bangladesh, Sci. 2006;32(1):33–41.
32. Rahman MR, Rahman MA. Studies on the growth, survival and production of calbasu (*Labeo calbaus* Ham.) at different stocking densities in primary nursing. Bull. Fac. Sci. Unv. Ryuyus, Jpn. 2003;76:245–255.
33. Kohinoor AHM, Khan, MM, Ahmed SU, Hussain MG. Culture potentials of climbing perch (*Anabas testudineus*, Bloch) under different stocking densities at semi-intensive management. Bangladesh Journal of Fisheries Research 2009;2:115-120.
34. Rahman MA, Mazid MA, Rahman MR, Khan MN, Hossain MA, Hussain MG. Effect of stocking density on survival and growth of critically endangered mahseer, *Tor putitora* (Hamilton), in nursery ponds Aquaculture. 2005;249:275-284.
35. Powell MR. Cage and race way culture of stripped bass in brackish water in Alabama. Proc. 26 Ann. Conf. South East Assoc. Game Fish Comm. 1972;553-565.
36. Haque MZ, Rahman MA, Hossain MM, Rahman MA. Effect of stocking densities on the growth and survival of mirror carp, *Cyprinus carpio* var. specularis in rearing ponds. Bangladesh J. Zool. 1994;22:109-116.
37. Jiwyam W. The effect of stocking density on yield, growth, and survival of Asian river catfish (*Pangasius bocourti* Sauvage, 1880) cultured in cages. Aquacult Int 2011;19:987–997.
38. Shiremen JV, Colle DE, Rattman RW. Intensive culture of grass carp, *Ctenopharyngodon idella*, in circular tanks. J. Fish Biol. 1977;2: 267-272.

39. Ahmed GU, Haque AKMA, Islam MA, Haque MM. Intensive culture of *Labeo rohita* (Hamilton) in floating ponds with special reference to different stocking densities. Bangladesh J. Fish. 1983;6(1-2):11-17.

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