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# Culture potentials of brown shrimp, *Metapenaeus monoceros* (Fab.) under different stocking densities in south-western region of Bangladesh

**NILUFA BEGUM*, SYED LUTFOR RAHMAN AND YAHIA MAHMUD[1]**
Bangladesh Fisheries Research Institute, Brackishwater Station. Paikgacha, Khulna 9680, Bangladesh
[1] Bangladesh Fisheries Research Institute, Mymensingh
*Email:bfri.fpss@yahoo.com

**Abstract.** An experiment was conducted to evaluate the production potentials of brown shrimp, *Metapenaeus monoceros* under three different stocking densities such as 10, 20 and 30 /m$^2$ in treatments $T_1$, $T_2$ ,and $T_3$ in brackishwater ponds. After 90 days of culture total production was recorded as 577, 608 and 764 kg/ha in $T_1$, $T_2$ and $T_3$ respectively. Total production was significantly higher *($p<0.05$)* in $T_3$ compared to $T_1$ and $T_2$. Net benefit was recorded as BDT 143,109/ha, BDT 121,825/ha and BDT 162,516/ha in $T_1$, $T_2$ and $T_3$ respectively. Cost benefit ratio was 2.23, 1.80 and 1.91 in $T_1$, $T_2$ and $T_3$ respectively. Net benefit in $T_3$ (BDT 162,516/ha) was higher than $T_1$ and $T_2$. The brown shrimp have high rates of growth, together with that they tolerate wide ranges of salinity and environmental parameters, makes them highly attractive for culture purposes.
**Keywords:** Brown Shrimp, *Metapenaeus monoceros,* Brackishwater

## Introduction

Black tiger shrimp (*Penaeus monodon*, locally called *Bagda*) is particularly stocked in these *ghers*. But due to frequent mass mortality of this shrimp caused by invasion of virus and EMS (Early Mortality Syndrome), farmers have become very much cautious about stocking of this shrimp in their *ghers* and many of the *bagda* farmers have already intended to shift their culture pattern and searching for suitable species for stocking to their *ghers.* In this context, the brown shrimp, *Metapenaeus monoceros* (locally called *Harina chingri*) can be a suitable candidate for culture in the brackish water *ghers.* This shrimp offers a good potential for large scale commercial aquaculture primarily because of available natural seed and demand in the international market. The severity of disease incidence in this shrimp is not so alarming like that of *P. monodon.* Requirement of oxygen of this species is also low and increases with the increase in salinity. It is a continuous breeder with two major spawning periods during December-April and August-September. Growth rate of this species as observed in the traditional culture system indicates that this shrimp was attain marketable size within three months, which is less than that other commercial shrimp species. It is obvious that stocking density is an important factor affecting the survival and growth of crustaceans including shrimp (Dong *et al.* 2007, Saha *et al* (2009a). On the other hand, the use of lower densities results in lower productivity affecting the feasibility of the water body. Therefore, there is no alternate of increasing stocking density for achieving higher production. In spite of having many advantages of production, the culture technology of the species has not yet developed. Considering the above, the present study aimed to investigate the growth and production performance of brown shrimp (*M. monoceros*) with different stocking densities under 90 days culture period.

## Materials and Methods

***Study area and experimental design***: The present study was conducted in the pond complex of Bangladesh Fisheries Research Institute, Brackish water Station, Paikgacha Upazilla (22°35.3'N 89°20.2'E) under Khulna district, Bangladesh. The study was conducted in nine on-station earthen ponds of 0.1 ha each. The experiment was designed in three treatments for three stocking densities with three replications for each. The stocking densities for T1, T2, and T3 were 10, 20, and $30/m^2$ respectively.

***Pond preparation***: Ponds were prepared following drying, liming (Cao@ 250 kg/ha) of soil and then filling with tidal water up to a depth of one meter. The water of the ponds was treated with chlorine @ 20 ppm to disinfect water and kill all animalcules those are the potential carrier of pathogen and disease. The buffering capacity of water of the ponds was strengthened by applying dolomite @ 20 ppm. Fertilization with urea and TSP was done @ 2.5 ppm and 3.0 ppm, respectively for quick development of colour of water and production of plankton.

***Nursery preparation and stocking***: An in-pond nursery was constructed at one corner of each pond made of nylon net fastened in bamboo frame. After $4^{th}$ days of fertilization and production of sufficient plankton, required quantity of *Harina* PL were acclimatized with the pond water and stocked on March 2019. Before stocking the initial mean length of the PL was measured with a millimeter scale and weight measured using sensitive balance (OHAUS Model CS-2000).

***Feeding and growth measurement***: In the nursery, the stocked PL was fed with CP (Charon Pokphand) nursery feed (40% protein) @ 100, 80 and 60% of estimated PL biomass for the $1^{st}$, $2^{nd}$ and $3^{rd}$ weeks and thrice daily. After 3rd week of nursery rearing, the juveniles were released to the whole pond by up-folding the nylon net of the nursery enclosure. The rate of feeding was gradually reduced with the growth of *Harina* and feed was supplied @ 2% of *Harina* chingri biomass in the last month of culture. The feeding behavior and well-being of harina were checked every 1-2 days intervals by cast netting. The growth of *Harina* of all ponds were monitored fortnightly by using random sampling method. At least 50 shrimps were sampled with the help of a cast net to measure the growth and assess the health status. Accordingly feeding rates were adjusted.

***Monitoring of water quality***: The pond parameters such as depth, salinity, pH, transparency, free carbon dioxide and alkalinity were determined at weekly intervals and dissolved oxygen and temperature were determined frequently. Temperature was monitored by a mercury thermometer in the morning, depth of water by a depth gauge at noon, transparency by a Secchi disk at noon, pH by a digital pH meter in the morning, salinity by an optical Refractometer (Atago, Japan) at noon, total alkalinity by titrimetric method in the morning and DO was monitored by Knuden's titrimetric method as mentioned in APHA (2005) just before sunrise.

***Harvesting of shrimp***: After three months of culture, the shrimps were harvested by dewatering the ponds. During harvest, they were counted and individually weighted to assess survival, growth and production.

Specific growth rate was estimated as:

SGR (%bw/d) = [(final weigh)-(initial weight)]/culture period(days)x100.

***Data analysis***: Comparison of treatment mean was carried out using one-way analysis of variance (ANOVA), followed by testing of pair-wise differences using Duncan's Multiple Range Test. Significance was assigned at the 5% level *($p<0.05$)*. All statistical analysis was done by using the SPSS (Statistical Package for Social Science) version-16.5.

## Results and Discussion

***Physico-chemical parameters of pond water***: The physico-chemical parameters of water v*iz.* transparency, temperature, dissolved oxygen; pH, salinity, alkalinity and free $CO_2$ (mg/l) recorded during the study period were found within optimal ranges. The mean values of water quality parameters in three treatments are presented in Table I. The observed temperature and salinity range of water during the study period were 29.5 to 35.0$^o$ C. and 04 to 18ppt that were almost same in all ponds with mean values was 32$\pm$0.69, 32.05$\pm$0.75, 32.05$\pm$0.78 and 10.5$\pm$0.22, 10.8$\pm$0.34 and 10.58$\pm$0.42 in $T_1$, $T_2$ and $T_3$ respectively (Table I).

**Table I. Water quality characteristics of pond water under different treatments**

| Parameters | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Temperature (°C) | 29.5-34.5<br>$32.0\pm0.69^a$ | 30.0-35.0<br>$32.5\pm0.75^a$ | 29.5-35.0<br>$32.5\pm0.78^a$ |
| Salinity (ppt) | 4 -18<br>$10.5\pm0.2^a$ | 4-17<br>$10.8\pm0.3^a$ | 5-18<br>$10.6\pm0.4^a$ |
| Depth (cm) | 90-110<br>$105.3\pm10.10^a$ | 95-100<br>$100.7\pm12.5^a$ | 92-105<br>$102.5\pm11.5^a$ |
| Transparency (cm) | 21-30<br>$25.4\pm2.9^b$ | 30-40<br>$36.4\pm4.7^a$ | 21-34<br>$29.7\pm3.3^{ab}$ |
| pH | 7.8- 8.2<br>$7.8\pm0.6^a$ | 7.9- 8.2<br>$8.0\pm0.5^a$ | 7.9- 9.0<br>$8.2\pm0.8^a$ |
| Alkalinity (mg/l) | 124.0-160.0<br>$152.5\pm12.7^a$ | 128.0-150.0<br>$146.4\pm11.5^b$ | 130.0- 160.0<br>$132.0\pm15.1^c$ |
| Dissolved oxygen (mg/l) | 6.1-7.2<br>$6.8\pm0.5^a$ | 5.1-7.0<br>$6.6\pm0.7^a$ | 5.3-7.2<br>$5.9\pm1.4^b$ |
| Free $CO_2$ (mg/l) | 0.0-0.0 | 0.0-0.0 | 0.0-0.0 |

*Different letter superscripts in the same row indicate significant difference ($p<0.05$).

The mean range of temperature was 29.5 to 35.0$^o$ C in the experimental ponds which is similar to the observation of Saha *et al.* (2016) and Chiu (1988). Salinity steadily increased from April until reached its peak in June (18ppt) then it showed sharp fall. Salinity level (4-18ppt) in the present study was closely similar with the report of Washim *et al.* (2016). Shivappa (1997) and Collins and Russel (2003) stated that *P. monodon* adapted quite well in freshwater conditions (salinity level 5-18ppt). Gunarto and Muharijadi (2006) showed wide range of salinity tolerance from 5 ppt to 35 ppt. The mean depths recorded during the study period were 105.28$\pm$10.10, 98.66$\pm$12.45 and 102.52$\pm$11.45 in $T_1$, $T_2$ and $T_3$ respectively. However, no significant difference was observed ($p>0.05$) in their water depth and temperature among the treatments. Transparency of water was initially higher in all ponds and gradually decreased with the progress of culture period. The observed transparency ranged from 20 to 40 cm with mean values of 25.40±2.98, 36.35±4.65 and 29.78±3.25 in $T_1$, $T_2$ and $T_3$ respectively (Table I). The transparency of water showed significant difference *($p<0.05$)* among the treatments, which might be due to variations in abundance of plankton. (Washim *et al.* 2016) reported transparency ranges was 25 to 40 cm. over the study period, which are strongly supported in this result. The mean values of pH were 7.80±0.62, 8.00±0.48 and 8.2± 0.78 in $T_1$, $T_2$ and T3 were no significant differences among the treatments (Table I). The pH values in all pond water was alkaline throughout the experimental period. According to (Saha *et al.* 2016) pH 7 to 9.2 and (Washim *et al.* 2016) stated that pH 7.50 to 9.10 is suitable for shrimp culture which agreed to the present study. Boyd and Fast, 1992 reported for shrimp culture pH 7 to 9 is best range of water. The mean dissolved oxygen (DO) concentrations in the morning hours were significantly (*$p<0.05$*) higher in $T_1$ (6.82±0.48 mg/1) and $T_2$ (6.58±0.72 mg/1) than $T_3$ (5.87±1.40 mg/1) (Table 2). Dissolved oxygen (DO) concentrations higher in present study than (Washim *et al* 2016) observation. (Rahman *et al.* 1982) have reported that dissolved oxygen content of a productive pond should be 5.00 mg/1 or more. The values in the present experiment were found around 6.0 mg/l. Mean total alkalinity levels were 152.50±12.70, 146.42±11.50 and 132.00±15.12 mg/1 in $T_1$, $T_2$ and T3 respectively. Total alkalinity was significantly ($p<0.05$) highest in $T_1$ followed by $T_2$ and lowest in $T_3$ (Table I). The variations in total alkalinity in all the treatments were within the productive range for aquaculture ponds. Although the variations among the treatments were statistically significant ($p<0.05$).

***Growth and survival of Harina***: As mentioned in materials and methods, initial weight of post-larvae of Harina were more or less same 0.016g in all treatments. After 90 days of culture, Harina attained the highest ABW of 8.2g±1.6 with a daily weight increment of 0.09g±0.05 in ponds stocked with Harina at a density 10/m$^2$. This was followed by 20/m$^2$ and 30/m$^2$ density with the ABW of 7.3g ±2.4 with a daily weight increment of 0.08g±0.1 and 5.1g±2.8 with a daily weight increment of 0.06g±0.2 respectively (Table II). The ABW of Harina at the lowest stocking density of 10/ m$^2$ was significantly higher than that of Harina at the highest stocking density of 30/ m$^2$ ($p<0.05$). But the difference in ABW of Harina between medium stocking density 20/m$^2$ and lowest or highest stocking density was not significant. Saha *et al.* (2009a) after 120 days of culture of shrimp observed a final weight 25.7g when stocking density was 15/m$^2$. Washim *et al.* (2016) showed after 63 days of culture of shrimp final weight 15.2g when stocking density was 7/m$^2$ and daily weight increment of 0.23g. The specific growth rate (SGR% day) were more or less same in all the treatments. However, the highest SGR in $T_1$ (6.9±1.6±0.2) than those obtained in $T_2$ (6.8±0.4) and $T_3$ (6.5±0.1) and which showed insignificant difference among the treatments. The percentage survival of Harina was variable at different stocking densities. The percentage survival of Harina at the lowest stocking density of 10/m$^2$ was significantly higher than those at the medium and highest stocking density of 20/ m$^2$ and 30/ m$^2$ ($p<0.05$). But difference between the medium and highest stocking density was not significant. The mean FCR value (Food Conversion Ratio) of $T_3$ (1.1±0.1) was significantly ($p<0.05$) lower than $T_2$ (1.2±0.3). But no significant difference was found between $T_1$ and $T_2$ and between $T_1$ and $T_3$. This results closely agrees with the findings of Washim *et al.* (2016).

**Table II. Growth and survival of *P. monoceros* under three different stocking densities**

| Parameters | Treatments | | |
|---|---|---|---|
| | $T_1$ (10 Nos/m$^2$) | $T_2$ (20 Nos/m$^2$) | $T_3$ (30 Nos/m$^2$) |
| Initial length (cm) | 1.8±0.02 | 1.8±0.43 | 1.8±0.22 |
| Initial weight (g) | 0.016±0.04 | 0.016±0.35 | 0.016±0.28 |
| Final length (cm) | 10.1 ±0.7 | 9.2 ±1.9 | 8.2 ±2.6 |
| Final weight (g) | 8.2 ±1.6$^a$ | 7.3 ±2.4$^{ab}$ | 5.1 ±2.8$^b$ |
| % wt gain | 50838±432 | 45275±377 | 31588±250 |
| Specific growth rate (SGR) (%day) | 6.9±0.2$^a$ | 6.8±0.4$^a$ | 6.5±0.1$^a$ |
| ADG (g/pcs/day) | 0.09±0.05 | 0.08±0.08 | 0.06±0.2 |
| Feed conversion ratio (FCR) | 1.2±0.2$^a$ | 1.2±0.2$^a$ | 1.1±0.1$^b$ |
| Survival (%) | 70.8±4.6$^a$ | 48.6±9.4$^b$ | 50.2±13.6$^b$ |

*Different letter superscripts in the same row indicate significant difference ($p<0.05$).

***Production and cost-benefit analysis***: The significance of any culture management apparently depends on total production but profit must also be considered for the ultimate adoption of that management technique. Highest production was recorded in $T_3$ (764.0±72.0) kg/ha and the lowest was produced in $T_1$ (577.0±48.0) kg/ha but the variation was significant ($p<0.05$) among the treatments (Table III). Saha *et al.* (2009b) found total production 699 kg/ha shrimp using commercial feed (Quality) at 50,000/ha density in 120 days culture period. The total cost of production was recorded BDT 116,550/ha, Tk 151,550/ha and BDT 179,550/ha in $T_1$, $T_2$ and $T_3$ respectively and the net benefit was BDT 143,109/ha, BDT 121,825/ha and BDT 162,515.92/ha in $T_1$, $T_2$ and $T_3$ respectively.

**Table III. Production performance and cost benefit ratio of brown shrimp under three different stocking densities**

| Treatments | Stocking densities (No/m$^2$) | Culture period (days) | Production (kg/ha) | Cost of production (BDT/ha) | Gross income (BDT/ha) | BCR |
|---|---|---|---|---|---|---|
| $T_1$ | 10 | 90 | 577.0$^c$ | 116550 | 259659 | 2.23$^a$ |
| $T_2$ | 20 | 90 | 608.0$^b$ | 151550 | 273375 | 1.80$^{ab}$ |
| $T_3$ | 30 | 90 | 764.0$^a$ | 179550 | 342066 | 1.91$^a$ |

*Different letter superscripts in the same column indicate significant difference ($p<0.05$).

The cost and economic benefit analysis showed that the higher net return was achieved in treatment $T_3$ (where stocking density was 300000/ha) than $T_1$ and $T_2$ (Table III). Cost benefit ratio BCR 2.23, 1.80 and 1.91 in $T_1$, $T_2$ and $T_3$ respectively. BCR value of $T_1$ was significantly higher than $T_2$ but no significant difference were recorded between $T_1$ and $T_3$. Though net return was higher at higher stocking densities. BCR value $T_1$ was higher due to feed quantity, because density was lower. Washim *et al.* (2016) found net benefit BDT. 106,484 after 63 days of culture of shrimp where stocking density was 7/m$^2$ and BCR value was 1.41. Saha *et al.* (2016) also found net benefit BDT 79368 at 50000/ha density in 120 days culture period and BCR value was 1.29. Net benefit in $T_3$ (BDT 162,516/ha) is higher than $T_1$ and $T_2$ which implies that net economic return is higher in 300,000/ha densities shrimp. So it is understood that mono culture of Harina with a stocking density of 300,000/ha would be environment friendly and economically viable for coastal areas of Bangladesh. Indeed, further study is needed to validate the present findings before planning for extension to the farmers.

Harina is an attractive and popular species to the people of Bangladesh due to its delicious and nutritious food value. The present study provides empirical evidence on the effects of Harina stoking density on its growth, survival and production. There are no previous studies comparing the effects of Harina density on its growth and survival in aquaculture ponds especially in the southern region of Bangladesh. There are many Factors that affect the production of Harina. Stoking density is one of the most important factors for the production of Harina. So, the present study was very important to know the proper stoking densities of the Harina to get the optimum production. However, further research should be performed about optimum stocking density, culture period and performance in different culture types likewise traditional, other modified and intensified culture system before planning for massive to farmer level.

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