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# Use of artificial substrate in pond culture of freshwater prawn (*Macrobrachium rosenbergii*): a new approach regarding growth performance and economic return

**Dilshad Milky Tuly • Md. Sherazul Islam • Mst. Hasnahena • Md. Rezwanul Hasan • Md. Tawhid Hasan**

*Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology, Jessore-7408, Bangladesh*

Correspondence: Md. Sherazul Islam, Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology; Email: tuhinkk@ahoo.com

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**Abstract**

An experiment was conducted for six months to evaluate the effects of artificial substrates on the survival, growth and production of *Macrobrachium rosenbergii* juveniles. The $T_1$ contained locally available bamboo-made substrate both vertical and horizontal and $T_2$ received no substrate. Juvenile prawns (0.40±0.13 g) were stocked at the rate of 19,760 prawns ha$^{-1}$. The water quality parameters range such as temperature, pH and DO were 22.06-33.45°C, 7.70-8.40 and 4.75-6.15 mgl$^{-1}$ respectively which was no significant difference ($P$<0.05) between two treatments. The final weight was 56.48±6.56 g and 45.03±2.11 g in $T_1$ and $T_2$ respectively. The survival rate of $T_1$ was 63.12% which was significantly higher ($P$>0.05) than $T_2$ (56.87%). The specific growth rate, food conversion ratio and protein efficiency ratio were 1.19 % and 1.14 %, 3.15 and 4.39, 0.98 and 0.71 in $T_1$ and $T_2$ respectively which were not significantly different ($P$<0.05) between treatments. The total production and net profit in $T_1$ was 1408 kgha$^{-1}$ and BDT 117,325 ha$^{-1}$ which was significantly higher ($P$>0.05) than $T_2$. Thus growth and survival of prawn juveniles improved in presence of artificial substrate which could be economically viable technique for the freshwater prawn culture.

**Keywords:** Artificial substrate, freshwater prawn, pond culture, growth performance, economic return

## INTRODUCTION

The freshwater prawn (*Macrobrachium rosenbergii*) is one of the high value aquaculture products emerging from Asia. It can easily adapt with wide range of temperature from 15°C to 35°C (Humayan and Alam 1988). This fast growing individual of the species can reach the marketable size in about six to seven months (Paul 1994). Its nutritional value and omnivorous habit has made the species an excellent candidate for aquaculture (Chen and Chen 2003). Since it's most successful domestication the culture of freshwater prawn has gained great popularity worldwide, especially in the tropics and subtropical regions (Ling 1969).

The freshwater prawn was introduced in the aquaculture system in Bangladesh during 1970s. Twenty four species of freshwater prawns, including 10 species of *Macrobrachium* are found in Bangladesh. However, only *M. rosenbergii* has significant aquaculture potential and is commercially cultured (Akand and Hasan 1992, Ahmed 2001). Approximately 71% of farmers are involved in *gher* systems and the remainder in pond systems (Muir 2003). The farmers practice monoculture, polyculture with fin fishes, as well as concurrent and crop-rotation with rice in rice fields.

As prawns are primarily benthic animals, their growth are mostly constrained by the availability of two-dimensional area rather than a three-dimensional volume in the pond. This limitation on production is further exacerbated by the fact that they are territorial and cannibalistic (Cohen *et al.* 1981). Therefore, it may be possible to increase production of prawns from a pond by increasing the amount of surface area available within the pond.

In ponds without natural (perimeter vegetation) or artificial substrate, the territorial prawns are confined to benthic (bottom) area of a pond. Therefore, as the growing season progresses, the total weight (biomass) of the prawns in a pond increases and the corresponding amount of bottom area available per unit of body weight decreases. As a result, growth rates decrease and mean individual weights at harvest are lower in ponds with comparatively higher densities of prawns. Adding substrates to a pond changes it from a two-dimensional area to a three-dimensional area (D'Abramo *et al.* 2006) and provides a greater area for the prawns within the pond. Several studies have documented benefits of adding different artificial substrate to production units (e.g. tanks and ponds) to increase available surface area. PVC frame with plastic mesh and suspended seine were used by Tidwell *et al.* (1998) and later Tidwell *et al.* (1999) used plastic mesh and strips of oyster netting. Bamboo poles, PVC pipes and sugarcane bagasse bundles were used by Keshavanath *et al.* (2001). Hollow PVC pipe, high density polyethylene (HDPE) and black nylon netting were used by Mamun *et al.* (2010). Sandifer and Smith (1977) reported that the addition of substrate in nursery tanks allowed prawns to use the entire water column and reduced mortality. Cohen *et al.* (1983) reported that added substrate in ponds increased prawn production by 14% and average size by 13%. Tidwell *et al.* (2000) found that prawns provided with an 80% increase in pond bottom surface area by inclusion of orange mesh (safety fence) were 33% larger, with a 24% increase in total yield, compared to those without substrate.

Although considering reports are available on the use of different artificial substrate, reports on improvement in grow out of freshwater prawn *M. rosenbergii*, using bamboo-made substrate (as it is available and cheap) is scanty. Moreover, systematic studies for developing suitable substrates to produce more advances of *M. rosenbergii* juveniles have not been so wide. Therefore, investigation into potential benefits derived from using different artificial substrates for freshwater prawn growout is necessary. Considering the above circumstances, the present study was designed to attain potential benefits by using locally available bamboo-made substrate in prawn growout system in pond condition.

## METHODOLOGY

***Experimental site and preparation of ponds:*** The present experiment was conducted in four experimental earthen ponds (0.004 ha each) at the field complex of the Fisheries and Marine Bioscience Department, Jessore University of Science and Technology, Jessore, Bangladesh. Lime was applied at the rate of 250 kgha$^{-1}$. After four days of liming, cow dung, urea and triple super phosphate (TSP) were used at the rates of 1,250 kg, 25 kg and 12.5 kg per ha respectively. Organic and inorganic fertilizations were used to increase natural feed and productivity. A deep tube well was fitted to supply water using a PVC pipe and the water depth was maintained to a maximum of 1.5 m.

***Experimental design:*** The experiment consisted of two treatments ($T_1$ and $T_2$) with two replications of each treatment. $T_1$ considered the using substrates while $T_2$ was considered without substrates. For the substrates, two bamboo-mats (229 cm × 137 cm) were used in $T_1$. The two unit placed as vertically and another horizontally along the side. The horizontal unit floated approximately 6 inches above the pond bottom so that three levels (including the pond bottom) were actually available. The juveniles were collected from a commercial hatchery and stocked on May 15 at a rate of 19,760 individualsha$^{-1}$ with mean lengths and weights of 4.01±0.09 cm, 0.40±0.13 g and 4.34±0.11 cm, 0.40±0.13 g in $T_1$ and $T_2$ respectively.

***Feed and mode of feeding:*** A compound commercial fish feed was used, with proximate composition of 31.76±0.04% protein, 7.4% lipid, 18.62% ash and 9.84±0.03% moisture. Feed was supplied twice daily and the amount of feed was determined according to the rate of feed consumed that was regularly checked using feed sampling trays. It was noticed that the initial feeding rate was high (10% of body weight) that gradually decreased to 4% with increasing prawn body weight.

***Hydrographical parameters:*** Water quality parameters such as temperature, dissolved oxygen (DO) and pH were measured fortnightly. Water temperature and DO were measured with a DO meter (Digital Oxygen meter, model DO-5510, Lutron electronic, PA, and USA) and pH was determined with a digital pH meter (HANNA, RI 02895, Portugal).

***Fish sampling:*** Experimental prawns were sampled monthly at the rate of 20% of the total stock. Substrates were not removed and only open areas were seined. Prawns were caught with a cast net and kept in water bowl. Prawns were released to the ponds immediately after measuring the length-weight of each individual sample. Total lengths were recorded to the nearest centimeter using the ordinary scale and weight was recorded to the nearest gram with an electric balance (EK 1200 I, A&D company, Japan). At the final harvest, the survival rate, the survival rate (%), net weight gain, mean daily weight gain (MDW), percentage of increment in weight and length and specific rate (SGR) were calculated.

The food conversion ratio (FCR) expressed by the rate of food consumed to weight gain was determined through dividing the dry weight of food fed by the live weight gain of fish and multiplied by 100. Protein efficiency ratio (PER) is defined as the weight gain of fish with a unit weight (g) of crude protein fed that is calculated as dividing the live weight gain of fish by the crude protein fed and multiplied by 100.

***Data analysis:*** Regression analysis was performed to determine the relation of growth performance with growth effective parameters (temperature, pH, DO etc.). One-way analysis of variance (ANOVA) and t-test were used to determine the significance of variation among the treatments average. A significant level of $P>0.05$ was considered.

## RESULTS

***Hydrological parameters:*** The mean values of water quality parameters such as temperature, pH and dissolved oxygen with standard deviation (SD) in the different treatments are shown in Table 1. During the study period, the maximum temperature of 33.45°C recorded in September and the minimum (22.06°C) was in December in $T_2$. Water parameters were not significantly different between the treatments.

**Table 1:** Mean values (±SD) of water quality parameters

| ***Treatment*** | ***Temperature (°C)*** | ***pH*** | ***Dissolved oxygen (mg/l)*** |
|---|---|---|---|
| $T_1$ | 26.88±0.24 | 8.08±0.12 | 5.47±0.28 |
| $T_2$ | 26.66±0.61 | 8.13±0.34 | 5.68±0.79 |

Parameters were not different significantly ($P>0.05$) between two treatments

***Growth performance:*** The stocking density ($ha^{-1}$), survival rate (%), growth performance in terms of length (cm) and weight (g), NW, MDW gain, SGR, FCR and PER of M. rosenbergii in the two treatments are given in Table 2. On harvesting of fish after rearing six months, the mean survival rates of *M. rosenbergii* was significantly ($P<0.05$) higher in $T_1$ than $T_2$. The mean daily weight gain, specific growth rate and protein efficiency ratio did not differ significantly ($P>0.05$) between two treatments. However, percentage of growth increment in terms of length (cm) and weight (g) and food conversion ratio showed significantly ($P<0.05$) lower in $T_1$.

The mean length gain of *M. rosenbergii*was 17.44±2.43 cm and 16.14±2.25 cm in $T_1$ and $T_2$ respectively. The mean weight gain during six months of the species was 56.48±25.90 g and 45.03±23.26 g in $T_1$ and $T_2$ respectively. The monthly mean weight gain was similar between two treatments (Figure 1). However, it is showed that during September the increments were higher in both treatments than other sampling months (Figure 1).

**Table 2:** The stocking density, survival rate, growth increment in terms of length and weight, net wet gain (NW), mean daily weight gain (MDW), specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER), production and income generation of *Macrobrachium rosenbergii*

| ***Parameters*** | ***$T_1$*** | ***$T_2$*** |
|---|---|---|
| Stocking density (No$ha^{-1}$) | 19760 | 19760 |
| Survival (%) | $63.12^a$ | $56.87^b$ |
| Initial size (cm) | 4.01 | 4.34 |
| Final size (cm) | 17.44 | 16.14 |
| Percentage of increment | $325.36^a$ | $271.88^b$ |
| Initial weight (g) | 0.4 | 0.4 |
| Final weight (g) | 56.48 | 45.03 |
| Net weight gain (g) | $56.08^a$ | $44.63^b$ |
| Mean daily weight gain (g) | $0.31^a$ | $0.25^a$ |
| Percentage of body weight | $14020.00^a$ | $11157.50^b$ |
| SGR | $1.19^a$ | $1.14^a$ |
| FCR | $3.15^a$ | $4.39^b$ |
| PER | $0.98^a$ | $0.71^a$ |
| Production (kg$ha^{-1}$) | $1407.9^a$ | $1012.7^b$ |
| Money value (BDT$ha^{-1}$) | $915135^a$ | $506350^b$ |

The mean with different superscripts in the same row are significantly different ($P<0.05$)

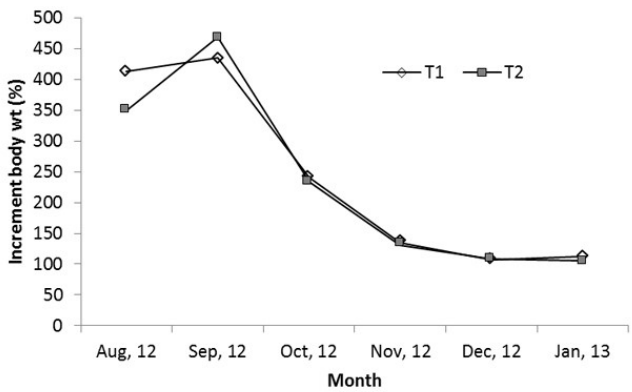


**Figure 1:** The body weight increment of *Macrobrachium rosenbergii* in two treatments

***Economic aspects:*** A simple economic analysis was performed to estimate the net profit derived from with and without substrate used in the culture of *M. rosenbergii*. The total productions were 1,407.9 and 1,012.7 kg$ha^{-1}$ in $T_1$ and $T_2$ respectively (Table 3). The total production was significantly higher in the substrate used treatment than without substrate culture system. The cost-benefit analysis of two treatments is presented in Table 3. The net profits were BDT 117,325 and 64,220 $ha^{-1}$ in $T_1$ and $T_2$ respectively, and these were significantly different between two treatments.

**Table 3:** A comparisons of economic returns between two different culture of freshwater prawn ($T_1$ is culture with substrate and $T_2$ culture without using substrate)

<table>
<tr><th colspan="4">Treatment T<sub>1</sub></th><th colspan="4">Treatment T<sub>2</sub></th></tr>
<tr><th colspan="2">Cost</th><th colspan="2">Income</th><th colspan="2">Cost</th><th colspan="2">Income</th></tr>
<tr><td>Items</td><td>BDT</td><td>Items</td><td>BDT</td><td>Items</td><td>BDT</td><td>Items</td><td>BDT</td></tr>
<tr><td>Substrate*</td><td>240x6=1440</td><td rowspan="5">5.7x650</td><td rowspan="5">3,705</td><td>-</td><td>-</td><td rowspan="5">4.1x500</td><td rowspan="5">2,050</td></tr>
<tr><td>Prawn seed**</td><td>160x6.5 = 1040</td><td>160x6.5</td><td>1040</td></tr>
<tr><td>Fish feed‡</td><td>18x30 =540</td><td>18x30</td><td>540</td></tr>
<tr><td>Fertilization</td><td>3x20 =60</td><td>3x20</td><td>60</td></tr>
<tr><td>Others</td><td>150</td><td></td><td>150</td></tr>
<tr><td>Total cost</td><td>3230</td><td>Total income</td><td>3705[a]</td><td>Total cost</td><td>1790</td><td>Total income</td><td>2050[b]</td></tr>
<tr><td colspan="4">Net profit: BDT 117,325 ha<sup>-1</sup></td><td colspan="4">Net profit: BDT 64,220 ha<sup>-1</sup></td></tr>
</table>

Calculation was done based on 0.008 ha in each treatment and 6 months experimental period
BDT, Bangladeshi currency (1 BDT = 0.016 US$)
*Mentioned as number of substrate x price of each unit
** Mentioned as number of seed x price of each seed
‡ Mentioned as total kg of feed or fertilizer or fish x price of each kg
The mean with different superscripts in the same row are significantly different ($P<0.05$).

## DISCUSSIONS

The major hydrological parameters that were recorded during the study period were similar to data reported in other such studies. The adult prawns are tolerant of wide range of water temperature such as 18-34°C (Tidwell *et al.* 2005) but the optimum temperature range is 27-32°C (Maclean *et al.* 1989, Hoq *et al.* 1996, Tidwell *et al.* 2005). In the present study, temperature showed below 27°C during December. However, the mean temperature was about 27°C in both treatments. The optimum pH and DO for the species mentioned 7-9 and 4-7 $mgl^{-1}$ (Hoq *et al.* 1996, D'Abramo *et al.* 2006, Tidwell and Coyle 2008). Although prawns can survive when DO is below 2 $mgl^{-1}$, at least 3 $mgl^{-1}$ should be maintained to avoid stress and achieve the highest growth rate (D'Abramo *et al.* 2006).

The significant impact showed on the survival of freshwater prawn by adding bamboo-made substrate. The substrate added ponds showed higher (63%) survival than without substrate ponds (57%). However in both cases ($T_1$ and $T_2$) the survival rate of prawn were quite lower than other such reported. Tidwell *et al.* (1999) reported 77% in substrate added ponds and 74.5% in without substrate ponds. D'Abramo *et al.* (1989) found that the survival rate of prawn in earthen ponds varied from 54.3 to 89%. The present study indicated that use of substrates improved survival which differs from the findings of Posadas *et al.* (2003) and Tidwell *et al.* (2000) who reported that addition of increasing amounts of substrate had no significant impact on survival of freshwater prawn.

The FCR in the present study was higher in both treatments compared to other experiments of *M. rosenbergii*. It has been reported that the FCR in substrate used pond was 2.33 (Tidwell *et al.* 1998) and 2.9 (Tidwell *et al.* 1999) where as in without substrate pond it were 2.48 (Tidwell *et al.* 1998), 2.4 (Tidwell *et al.* 1999) and 1.88 (Mamun *et al.* 2010). It is showed that added substrate improved the food conversion efficiencies of the species. The same also reported by Tidwell *et al.* (2000). This is probably due to the increase in periphyton production and the resulting increase in natural food availability associated with the increased amount and complexity of benthic substrate. On the other hand, Posadas *et al.* (2003), Gwak (2003) and Tidwell *et al.* (2000) showed substrates had no statistically significant impact ($P<0.05$) on feed conversion ratios. In aspect of PER, $T_1$ showed little higher than $T_2$ but it was lower to compare Asadujjaman *et al.* (2006) who recorded 1.25 to 1.60.

***Growth performance:*** The growth performance in terms of both length and weight increment was significantly higher in $T_1$. The SGR and MDW gain of *M. rosenbergii* in the different treatment was not significantly different between two treatments. The SGR in the present experiment was lower than Hossain (2007) who reported 2.74 to 3.12. The SGR in the nursery ponds reported 4.72 to 5.19 (Mitra *et al.* 2005) and 2.93 to 3.32 (Hossain and Islam 2007).

The body weight increment showed similar pattern between two treatments throughout the culture period. The highest increment (about 350-450% of the body weight) occurred in August and September in both treatments while the lowest (about 125%) was in December due to fall down of temperature. The net weight gain was comparatively higher in $T_1$ (about 56 g) than $T_2$ (45 g) and these values were much lower than other experiments monoculture or mixed culture like 92 g in 7 months (Islam *et al.* 2008), 60 g in 7 months (Chand *et al.* 2002). The bamboo-made substrate in the present study was significantly influenced on the growth of *M. rosenbergii*. The final weight increment increased by about 25% than the without substrate ponds. Similar improved growth was also reported elsewhere (23% by using PVC substrate, Tidwell *et al.* 1998; 21-32% by using different artificial substrate, Mamun *et al.* 2010).

***Production and income generation:*** The total production and money values were significantly influenced by the presence of added substrate. Ponds provided with substrate produced prawns about 25% larger and production 39% greater than ponds without substrate. Similar improved growth and productions were also reported elsewhere. Tidwell *et al.* (1998) found 1268 kgha$^{-1}$ with substrate added pond and 1,060 kgha$^{-1}$ in without substrate, an increased by 20%. Tidwell *et al.* (1999) reported 1469 kgha$^{-1}$ from added substrate ponds and 1,244 kgha$^{-1}$ from without substrate ponds, an 18% increase. This higher production probably resulted from an increased periphyton or biofilms growing on the substrates which acted as food and use of substrate as refuge by *M. rosenbergii*. In ponds without natural or artificial substrate, the territorial prawns are confined to the benthic (bottom) area of a pond. Therefore, as the growing season progresses, the total weight (biomass) of the prawns in a pond increases and the corresponding amount of bottom area available per unit of body weight decreases. As a result, growth rate decreases which causes low production. Because of added substrate, this problem is not so significant in $T_1$. This might be the cause of higher production of $T_1$ than $T_2$. In net profit analysis it is showed that significantly higher income generated from the ponds of added substrate than the without substrate ponds.

Results of the present study indicated that growth, survival, production and net profit of freshwater prawn improved in the presence of substrate. As a consequence, it might be said that in growout culture of *M. rosenbergii*, using substrate is economically more convenient.

## CONCLUSION

Present study shows that using substrate in the freshwater prawn culture ponds increase the survival, growth and production of the species. Bamboo-made substrate can be recommended for use in prawn grow-out system in Bangladesh as it is locally available and comparatively low cost material. However, further studies using different substrate should be carried out in growout ponds to ascertain the usefulness of the different substrates for growout of *M. rosenbergii* juveniles which could be flourished the prawn culture of the country.

## REFERENCES

Ahmed N (2001) Socio-economic aspects of freshwater prawn culture development in Bangladesh. PhD Thesis, Institute of Aquaculture, University of Starling, Scotland, UK.

Akand AM and Hasan MR (1992) Status of freshwater prawn culture in Bangladesh. In: Freshwater prawns (ed. By E.G. Silas) 31-41.

Asadujjaman M, Salam MA, Wahab MA, Kunda M andRahman MB (2006) Effects of control of Carbon/Nitrogen ratio by low cost carbohydrate addition on water quality and pond ecology in fresh water prawn *M. rosenbergii* post-larvae nursing system. Bangladesh Journal of Fisheries Research 10(2): 121-130.

Chand BK, Patra BC and Das SK (2002) Growth and production of freshwater prawn and carp under polyculture system. West Bengal University of Animal and Fishery Sciences. Journal of Interacademicia 6: 210-215.

Chen SM and Chen JC (2003) Effects of pH on survival, growth, molting and feeding of giant freshwater prawn *Macrobrachium rosenbergii*. Aquaculture 218: 613-623.

Cohen D, Ra'anan Z and Brody T (1981) Population profile development and morphytic differentiation in the giant freshwater prawn *Macrobrachium rosenbergii*. Journal of World Mericulture Society 12: 213-234.

Cohen D, Ra'anan Z, Rappaport U and Arieli Y (1983) The production of freshwater prawn *Macrobrachium rosenbergii* in Israel: improved condition for intensive monoculture. Bamidegh 35: 31-37.

D'Abramo LR, Heinen JM, Robbinette HR and Collins JS (1989) Production of freshwater prawn, *Macrobrachium rosenbergii* stocked as juveniles at different densities in temperate zone ponds. Journal of the World Aquaculture Society 20: 81-89.

D'Abramo LR, Tidwell JH, Fondren M and Cortney LO (2006) Pond production of the freshwater prawn in temperate climates. Southern Regional Aquaculture Center, SRAC Publication No. 484.

Gwak SW (2003) Effects of shelter on growth and survival in age-0 black sea bass, *Centropristis striata* (L.). Aquaculture Research 34: 1387-1390.

Hoq ME, Islam MM and Hossain MM (1996) Polyculture of freshwater prawn (*Macrobrachium rosenbergii*) with Chinese and Indian carps in farmer's pond. Journal of Tropical Aquaculture 11: 135-141.

Hossain MA and Islam SF (2007) Meat and bone meal as substitute for fish meal in nursery diet for giant freshwater prawn, *Macrobrachium rosenbergii* (de Man). Journal of the World Aquaculture Society 38(2): 272-280.

Hossain MA (2007) Freshwater Prawn farming: search for new technology. In: Wahab MA and Faruk MAR (eds).

2007. Abstract- National Workshop on "Freshwater Prawn farming: search for new Technologies". Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. p. 28.

Humayan NM and Alam AN (1988) Observation of the pond growth rate of *M. rosenbergii* at different stocking density. Bangladesh Journal of Zoology. p. 48.

Islam MS, Huq KA and Rahman MA (2008) Polyculture of Thai pangus (*Pangasius hypophthalmus*, Sauvage 1878) with carps and prawn: a new approach in polyculture technology regarding growth performance and economic return. Aquaculture Research 39: 1620-1627.

Keshavanath P, Gangadhar B, Ramesh TJ, van Rooij JM, Beveridge MCM, Baird DJ, Verdegem MCJ and van Dam AA (2001) Use of artificial substrates to enhance production of freshwater herbivorous fish in pond culture. Aquaculture 32: 189-197.

Ling SW (1969) The general biology and development of FAO Fisheries Report 3: 589-606.

Maclean MH, Ang KJ, Brown JH and Jauncey K (1989) The effect of organic fertilizer and formulated feed in pond culture of the freshwater prawn *Macrobrachium rosenbergii* (de Man): prawn production. Aquaculture and Fisheries Management 20: 399-406.

Mamun MMA, Hossain MA, Hossain MS and Ali ML (2010) Effects of different types of artificial substrates on nursery production of freshwater prawn, *Macrobrachium rosenbergii* (de Man) in recirculatory system. Journal of Agricultural University 8(2): 333-340.

Mitra G, Mukhopadhyay PK and Chattopadhyay DN (2005) Nutrition and Feeding in Freshwater prawn (*Macrobrachium rosenbergii*) Farming. Aqua Feeds: Formulation and Beyond 2: 17-19.

Muir JF (2003) The features of Fisheries: economic performance. Fisheries Sector Review and Development Study, Bangladesh Ministry of Fisheries and Livestock and the Department of Fisheries, Dhaka. p. 772.

Paul SK (1994) Bangladesher Roptanijoggo Matsha Sampad (Exportable Fisheries in Bangladesh). Tuli-Mili Prokashini, Khulna p. 41.

Posadas BC, Walters SC and Long RD (2003) Effects of using artificial substrates on experimental freshwater prawn *Macrobrachium rosenbergii* pond production in Coastal Mississippi. World Aquaculture 34: 47-50.

Sandifer PA and Smith J (1975) Effects of population density on growth and survival of *Macrobrachium rosenbergii* reared in recalculating water management system. Proceeding of the World Mariculture Society 8: 225-235.

Tidwell JH, Coyle SD and Schulmeister G (1998) Effects of added substrate on the production population characteristics of freshwater prawn *Macrobrachium rosenbergii* in ponds. Journal of the World Aquaculture Society 29(1): 17-22.

Tidwell JH, Coyle S, Weibel C and Evans J (1999) Effects and interactions of Stocking density and added substrate on production and population structure of freshwater prawn *Macrobrachium rosenbergii*. Journal of the World Aquaculture Society 30(2): 174-179.

Tidwell JH, Coyle S, Van Arnum A and Weibel C (2000) Production response of freshwater prawn *M. rosenbergii* to increasing amounts of artificial substrate in ponds. Journal of the World Aquaculture Society 31(3): 452-458.

Tidwell JH, D'Abramo LR, Coyle SD and Yasharian D (2005) Overview of recent and development in temperate culture of the freshwater prawn (*M. rosenbergii* De Man) in the South Central United States. Aquaculture Research 36: 264-277.

Tidwell J and Coyle S (2008) Impact of Substrate Physical Characteristics on Grow out of Freshwater prawn *Macrobrachium rosenbergii*. Journal of the World Aquaculture Society 39: 406-413.