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Potential and Economic Viability of Freshwater Prawn *Macrobrachium rosenbergii* (de Man, 1879) Polyculture with Indian Major Carps in Northwestern Bangladesh

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Abstract
This study was conducted to assess the aquaculture potential of the freshwater prawn *Macrobrachium rosenbergii* (de Man, 1879) with the Indian major carps (Catla, *Catla catla*; Rui, *Labeo rohita* and Mrigal, *Cirrhinus mrigala*) and silver carp, *Hypophthalmichthys molitrix* in northwestern Bangladesh. Further, the effect of the culture system on overall production and economic feasibility was evaluated. A 3×2 (treatment×replicate) experimental setup was conducted using six earthen ponds measuring 100 m^2 each for a culture period of six months from September, 2007 to February, 2008. The treatments were as follows: T_1 was stocked with only carps (catla, rohu, mrigal and silver) at the 3000 (catla), 2000 (ruhu), 3000 (mrigal) and 2000 (silver) ha^{-1}; T_2 and T_3 were stocked with catla and silver carp were 3000 and 2000 ha^{-1}, respectively; and additionally *M. rosenbergii* (juvenile) was stocked at 15000 and 20000 ha^{-1} in T_2 and T_3, respectively. All the ponds were subjected to the same fertilization treatment. Fish were fed twice per day at a rate of 5-12% of the prawn and fish body weight. The net weight gain of catla and silver carp were 69.08±11.63 and 108.67±15.00 g in T_1, 61.76±12.58 and 98.80±17.05 g in T_2, while 58.11±12.51 and 93.09±14.84 g in T_3, respectively. The mean individual weight of harvested prawn was significantly higher in T_2 (14.61±02.06 g) than T_3 (14.04±01.83 g) ($P<0.05$). Also the survival rate of prawn was higher in T_2 (74.15%) than T_3 (69.25%) ($P<0.05$). The net production of prawn was higher in T_3 (1141.28±46.35 kg ha^{-1}) than T_2 (964.54±25.53 kg ha^{-1}), but the specific growth rate was significantly higher in T_2 (2.07%) than T_3 (1.99%) ($P<0.05$). Higher profit was obtained in T_3 (35682.18 Tk ha^{-1}) than T_1 (8537.53 Tk ha^{-1}) and T_2 (30801.56 Tk ha^{-1}); however, cost-benefit ratio (CBR) was significantly higher in T_2 (3.19) where stocking densities of prawn was 15000 ha^{-1} than T_1 (2.92) and T_3 (2.47). The results of this experiment indicate that the polyculture of the freshwater prawn with the Indian major and Chinese carp present a more profitable venture which is more economically feasible than the monoculture of the freshwater prawn.

Key words: Prawn, growth, *Macrobrachium rosenbergii*, production, economics, carp polyculture

Introduction

Over the last century, aquaculture has proved to be the fastest growing food-producer in the World and total production has recorded an upward trend over the last decades (Khondker *et al*., 2010). In 2005, Asia dominated aquaculture production in the world, contributing 87% to the global cultured fin-fish production, estimated at 25.7 million tons (De Silva *et al*., 2006). Two leading producers of freshwater aquaculture species; India and Bangladesh produced 45% of the world's total freshwater aquaculture production (FAO, 2008). In Bangladesh, aquaculture is mainly a rural activity where an estimated 73% of rural households are involved in some form of freshwater aquaculture (Mazid, 1999). The majority of this production is earthen-ponds based under semi-intensive polyculture systems consisting of fast growing fish species. The cultured species are fed using supplementary diets aimed at improving on the fish production in the earthen ponds, and if possible, to benefit from synergic effect between the different fish species. In the South Asian region, traditional semi-intensive carp polyculture is a combination of indigenous and exotic carp species (Uddin *et al*., 1994; Miah *et al.*, 1997). However, in Bangladesh, polyculture of three Indian major carps including *Catla catla* (Hamilton, 1822), *Labeo rohita* (Hamilton, 1822) and *Cirrhinus mrigala* (Hamilton, 1822), or occasionally with other exotic carps such as *Hypophthalmichthys molitrix* (Valenciennes, 1844), *Ctenopharyngodon idella* (Valenciennes, 1844) and *Cyprinus carpio* (Linnaeus, 1758) (Azim and Wahab, 2003) has been the preferred traditional systems of aquaculture.

The freshwater prawn (*M. rosenbergii*) is considered a popular and prime candidate species for freshwater aquaculture worldwide due to its distinctive taste, rapid growth rate, larger market size, high resistance to diseases compared to other marine species, and high demand in both domestic and international markets (Hossain and Islam, 2006; Kunda *et al.*, 2008). Ling (1969) earlier recommended polyculture of *M. rosenbergii* with non-carnivorous freshwater fish such as carps and tilapia. Moreover, the polyculture of *M. rosenbergii* with Chinese and Indian major carps has been reported from different parts of the world in recent years (Malecha *et al*., 1981; Costa-Pierce *et al*., 1984; Hoq *et al*., 1996; Alam *et al*., 2001). Similarly, the polyculture of freshwater prawns with carnvirous species including the channel cat fish, *Ictalurus punctatus* (Pavel, 1985), or with a combination of channel catfish, grass carp, *Ctenopharyngodon idella* and silver carp, *Hypophthalmichthys molitrix*, has also been tested (Miltner *et al*., 1983). Ranjeet and Kurup (2002) reported that *M. rosenbergii* is one of the most desirable candidate species for freshwater aquaculture in different parts of the Indo-Pacific region.

The attractiveness of this freshwater species has gained significance day by day in terms of developing its culture technology (New, 2002). The species exhibits fast growth and attains market size within a short period of 6 months compared to the major carps which require about one year to attain market size (Hossain and Islam, 2006). Mitra *et al*. (2005) recognized *M. rosenbergii* as an economically valued species for aquaculture due to its big market size, fast growth rate, wide range of foods and feeding habits, tolerance to wide range of environmental parameters, ease of controlled production and breeding under hatchery conditions and higher survival rates from stocking to harvest. Moreover, culture of the freshwater prawns with fish has been reported to improve the ecological balance of the pond environment and keeps the proliferation of massive algal blooms in check (Cohen *et al*., 1988).

In Bangladesh, *M. rosenbergii* is commonly known as 'Golda'. Fleming (2004) reported that commercially cultured with Golda in ponds has increased quite rapidly in Bangladesh including the coastal districts of Khulna, Bagherhat, Satkhira and Cox's Bazar. In recent years, prawn cum carp polyculture in earthen ponds, especially the Indian and Chinese major carps, has gained importance in the Mymensingh region of Bangladesh (Hossain and Islam, 2006). However, information on the polyculture of the *M. rosenbergii* with the Indian major carps or the silver carp at the famers' level in rural northwestern Bangladesh is clearly lacking. Nevertheless, several studies have been conducted in Bangladesh on optimum stocking densities of *M. rosenbergii* for monoculture systems (Hossain and Paul, 2007) as well as polycutlre sytems with carps (Siddique *et al*., 1999; Haque *et al*., 2003; Hossain and Islam, 2006; Hossain and Kibria, 2006; Hossain *et al*., 2007; Kunda *et al*., 2008) on experimental basis in northwestern Bangladesh. The present study aimed to assess the aquaculture potential of the freshwater prawn (*M. rosenbergii)* with the Indian major carp (*C. catla*) and silver carp (*H. molitrix*). Further, the study evaluated the overall effect on pond biomass production, harvest size and the economic feasibility in a polyculture system. Specifically, the study analyzed the growth performance in terms of net weight gain of the cultured species, their specific growth rate (SGR), survival rates (SR), overall pond biomass and yields, cost-benefit ratios (CBR) and net returns on investment.

Materials and methods

Study site and experimental setup

The study was conducted over a culture period of six months during September, 2007 to February, 2008 using six 100 m^2 earthen ponds located at the Merherchandi of Boalia Upazilla in Rajshahi district of northwestern Bangladesh. The preparation of the ponds was conducted as follows. The ponds were initially drained and sun dried for a fallow period of one month. The ponds were limed using calcium oxide at the rate of 250 kg ha^{-1}, and filled up to 1.5 m depth using canal water filtered through a fine-mesh net at the inlet. The ponds were then left for seven days to mature, and then fertilized to enhance pond productivity, using animal manure, Urea, and Triple super phosphate (TSP) at the rate of 2500 kg ha^{-1}, 50 kg ha^{-1} and 50 kg ha^{-1}, respectively. A deep tube well was fixed to supply water using a PVC pipe to retain the water depth up to 1.5 m level. A fine synthetic net (1.0 mm mesh size) was used to fence around the ponds to prevent prawn escape. Shelters were made using dried branches of bamboo and the leaf of palm at each pond.

Fingerlings of *C. catla*, *L. rohita*, *C. mrigala*, *H. molitrix* of mean weight of 28.2 g, 24.7 g, 22.3 g, 22.2 g, respectively and 5.5 g post larvae of the freshwater prawn *M. rosenbergii* were stocked at the beginning of September, 2006 after completion of the initial pond preparations. The experiment employed a 3×2 treatment-replicate setup as follows. Treatment (T_1) was an all-carp treatment, stocked with catla, rohu, mrigal and silver at the rate of 3000 fingerlings ha^{-1} for catla and mrigal and 2000 fingerlings ha^{-1} for rohu and silver, respectively. In treatments T_2 and T_3, a polyculture setup was designed with varied stocking density for the catla and silver carp, at 3000 fingerlings ha^{-1} in treatment T_2 and 2000 fingerlings ha^{-1}, in T_3. The stocking density for the freshwater prawn *M. rosenbergii* post larvae in treatments T_2 and T_3 was 15000 and 20000 ha^{-1}, respectively.

Feed preparation and feeding

The cultured species were fed on pelleted feed prepared using rice bran (50%), fish meal (20%) and mustard oil cake (30%) obtained from the Rajshahi local market. Proximate analyses of the composition of the pelleted feed confirmed the protein content as 30%. Feeding was conducted twice a day based satiation feeding, and the amount of feed consumed was checked after each feeding using feed sampling trays., and thereafter, the feeding rates adjusted accordingly. The initial feeding rate was set as 12% of body weight and gradually adjusted to 5% of body weight after several samplings as the culture period progressed.

Water quality parameters

Water quality was monitored throughout the study period to ensure optimal conditions for the cultured species my routine measurements of water temperature, dissolved oxygen (DO) and pH. Dissolved oxygen was measured using a DO (DO-5510, Lutron electronic, USA) while temperature and pH were measured using a portable meter (EC10-50050, Hach, USA) between 10:00 and 11:00 h.

Prawn and fish harvesting

The total culture period was 173 days. All the ponds were harvested separately by repeated netting and complete draining, and the harvests of Catla, rohu, mrigal, silver carp and prawn from each pond were counted and weighed to get the total numbers and biomass for each pond, and the data later pooled by treatment. The sizes at harvest were assessed by measuring the total length (TL) of each individual to the nearest 0.01 cm using digital slide calipers, and whole body weight (BW) was taken on a digital balance with 0.01 g accuracy. The survival rate (%) was calculated as [(total numbers at harvest / total numbers stocked) ×100]; net weight gain (g) as [mean weight (g) at harvest -mean weight (g) at stocking]; specific growth rate (%) as [{(log BW_d - log BW_0)/ (t_d-t_0)} × 100], where, t_0 is day of stocking, t_d is the day of harvest, BW_d is the body weight at harvest, day t_d and BW_0 the initial body weight, day t_0] while pond yields (kg/ha) were calculated as the biomass at harvest (kg) -biomass at stocking .

Economic analyses

A simple economic analysis was performed to estimate the net profit (total returns from harvest - total cost of production) and cost-benefit-ratio (CBR = total benefit - total cost) from polyculture of prawn with Indian major carps and silver carp for different treatments, separately. The cost of production was based on the whole sale market prices of the inputs used during the 2006-2007 period. The cost of feed ingredients, post larvae and fingerlings of the fish species and the sale price of harvest of fish and prawn as well as the rent costs for the earthen ponds used in the study.

Statistical analysis

Statistical analyses were performed using Microsoft® Excel-add-in-DDXL and GraphPad Prism 5 software. All data was checked for homogeneity of variance. Tests for normality of each group were conducted by visual assessment of histograms and box plots and confirmed with the Kolmogorov-Smirnov test. Where test for normality assumption was not met, then the non-parametric Kruskal-Wallis test was used to compare the mean value among treatments, and if it indicated significant differences, then followed by a post hoc Dunns Multiple comparison test. But in case of two treatments, Mann-Whitney U test was applied to compare the mean value. In addition, Chi-square test was used to compare the survival rate of fish and/or prawn among treatments. All statistical analyses were considered significant at 5% ($P<0.05$).

Results

Water quality parameters

The temperature, DO and pH of pond water did not vary significantly among the treatments (Tab. 1). However, there were significant temporal effects on temperature, transparency and DO. The highest temperature was recorded in September (30.31°C) and the lowest in January (19.11°C). Water pH ranged from a neutral to an alkaline level (7.1- 9.1) throughout the study period.

Growth performance and survival rate

The growth performance in terms of net weight gain of catla, and silver carp were 69.08±11.63 g and 108.67±15.00 g in T_1, 61.76±12.58 and 98.80±17.05 g in T_2, while 58.11±12.51 and 93.09±14.84 g in T_3, respectively (Tab. 2). The growth performances were significantly different in both carps (Kruskal-Wallis test, $P <0.05$) among treatments. In addition, the average individual weight of harvested prawn was significantly higher in treatment T_2 (14.61±02.06 g) than T_3 (14.04±01.83 g) (Mann-Whitney test, $P <0.05$). The survival rate of prawn in both treatments was calculated on the basis of accumulative harvests (Tab. 3). The survival of prawn was also higher in treatment T_2 (74.15%) than T_3 (69.25%) ($\chi^2 = 3.69$; $P <0.05$).

Values are expressed as mean ±SD and values in the same row having same superscripts are not significantly different ($P>0.05$). Survival rate (%) = 100 × (Number of fish harvested/Initial number of fish)

Specific growth rate (SGR) and yield

The SGR was significantly lower in treatment T_3 (1.99%) than T_2 (2.07%) (Mann-Whitney test, $P<0.05$) (Tab. 4). However, the net production of prawn differed significantly among the treatments, with better performance in treatment T_3 (1141.28±46.35 kg ha^{-1}) than T_2 (964.54±25.53 kg ha^{-1}) (Tab. 5).

Economic analysis

The cost of the inputs including seed, lime, feed and fertilizer was based on the price of the Rajshahi market during 2007-2008. The fish and prawn were sold in the local markets through whole sellers. The total input cost was Tk. 2921.90±374.34 ha^{-1} (T_1)

Table 1. The water quality parameters (Mean ±SD) observed in different treatments during the experimental period.

Parameters	**Treatments**		
	T_1	**T_2**	**T_3**
Temperature (^oC)	24.17 ± 4.71^a	24.14 ± 4.69^a	24.11 ± 4.6^a
Dissolved Oxygen (DO)	4.55 ± 0.26^a	4.35 ± 0.22^a	4.34 ± 0.20^a
p^H	7.32 ± 0.99^a	7.30 ± 0.94^a	7.27 ± 0.91^a

Values are expressed as mean ± standard deviations; and values in the same row having same superscripts are not significantly different (P > 0.05).

Table 2. Growth performance (weight gain) of Golda (*M. rosenbergii*), silver carp (*H. molitrix*), catla (*C. catla*), rohu (*L. rohita*), and mrigal (*C. mrigala*) in polyculture with different stocking density during September 2007 to February 2008.

Species	**Treatments**		
	T_1	**T_2**	**T_3**
M. rosenbergii	-	14.61 ± 02.06^a	14.04 ± 01.83^b
H. molitrix	108.67 ± 15.00^a	98.80 ± 17.05^b	93.09 ± 14.84^c
C. catla	69.08 ± 11.63^a	61.76 ± 12.58^b	58.11 ± 12.51^c
L. rohita	57.24 ± 08.73	-	-
C. mrigala	51.26 ± 07.71	-	-

Values are expressed as mean ±SD and values in the same row having same superscripts are not significantly different (P>0.05). Weight gain (g) = Mean final weight (g) - Mean initial weight (g).

Table 3. Survival rate (SR) of Golda (*M. rosenbergii*), silver carp (*H. molitrix*), catla (*C. catla*), rohu (*L. rohita*), and mrigal (*C. mrigala*) in polyculture with different stocking density during September 2007 to February 2008.

Species	**Treatments**		
	T_1	**T_2**	**T_3**
M. rosenbergii	-	74.15 ± 0.85^a	69.25 ± 1.25^b
H. molitrix	74.00 ± 1.50^a	83.34 ± 8.03^b	72.16 ± 1.17^a
C. catla	68.75 ± 6.25^a	74.50 ± 0.70^b	64.83 ± 4.17^a
L. rohita	74.50 ± 1.50	-	-
C. mrigala	75.00 ± 3.00	-	-

Table 4. Specific growth rate (SGR) of Golda (*M. rosenbergii*), silver carp (*H. molitrix*), catla (*C. catla*), rohu (*L. rohita*), and mrigal (*C. mrigala*) in polyculture with different stocking density during September 2007 to February 2008.

Species	**Treatments**		
	T_1	**T_2**	**T_3**
M. rosenbergii	-	2.07 ± 0.76^a	1.99 ± 0.72^b
H. molitrix	1.40 ± 0.62^a	1.67 ± 0.85^b	1.26 ± 0.55^c
C. catla	1.19 ± 0.50^a	1.21 ± 0.55^b	1.21 ± 0.57^b
L. rohita	1.19 ± 0.50	-	-
C. mrigala	1.13 ± 0.45	-	-

Values are expressed as mean ±SD and values in the same row having same superscripts are not significantly different (P>0.05). Specific growth rate (SGR% day $^{-1}$) = 100 × (log final body weight - log initial body weight)/total number of experimental days.

Table 5. Yield of Golda (*M. rosenbergii*), silver carp (*H. molitrix*), catla (*C. catla*), rohu (*L. rohita*), and mrigal (*C. mrigala*) in polyculture with different stocking density during September 2007 to February 2008.

Species	Treatments		
	T_1	T_2	T_3
M. rosenbergii	-	964.54 ± 25.53 [a]	1141.28 ± 46.35 [b]
H. molitrix	1565.21 ± 44.90 [a]	1541.43 ± 43.00 [a]	1304.55 ± 03.28 [b]
C. catla	618.14 ± 91.29 [a]	615.10 ± 11.93 [a]	590.73 ± 11.93 [b]
L. rohita	662.50 ± 34.67	-	-
C. mrigala	590.23 ± 42.29	-	-

Values are expressed as mean ±SD and values in the same row having same superscripts are not significantly different (P>0.05). Yield (kg^{-ha}) = Biomass at harvest time - Biomass at stocking time.

Table 6. Economic analysis of the cost of production for polyculture of *Macrobrachium rosenbergii* with carps in earthen ponds during September 2007 to February 2008.

Items		T_1	T_2	T_3
Seed cost	Carp fingerling	868.50 ± 106.50	567.00 ± 49.00	682.50 ± 157.50
	Prawn juvenile	-	6075.00 ± 525.00	7912.50 ± 1419.56
Lime		71.875 ± 9.38	101.25 ± 8.75	121.50 ± 28.50
Feed cost	Rice bran	157.32 ± 20.52	272.160 ± 23.52	462.15 ± 106.56
	Mustard oilcake	125.120 ± 16.320	246.240 ± 21.28	390.00 ± 90.00
	Fish meal	181.125 ± 23.63	255.31 ± 22.21	494.82 ± 114.19
Fertilizer cost	Cowdung	310.50 ± 40.50	437.40 ± 37.80	526.50 ± 121.50
	Urea	80.50 ± 10.50	113.40 ± 9.80	136.50 ± 31.50
	TSP	207.00 ± 27.00	291.60 ± 25.20	351.00 ± 81.00
Labour cost (harvesting and neeting)		287.50 ± 37.50	405.00 ± 35.00	487.50 ± 112.50
Land rental cost		575.00 ± 75.00	810.00 ± 70.00	975.00 ± 225.00
Other cost		57.50 ± 7.50	81.00 ± 7.00	97.50 ± 22.50
Total input cost		2921.90 ± 374.34 [a]	9655.36 ± 834.56 [b]	14474.97 ± 3340.84 [c]
Total income (from carp sale)		11459.47 ± 1494.72 [a]	10000.92 ± 860.00 [b]	9831.14 ± 2268.70 [b]
Total income (form prawn sale)		-	30456.00 ± 2632.00 [a]	40326.00 ± 9306.00 [b]
Total revenue		11459.47 ± 1494.72 [a]	40456.92 ± 3496.00 [b]	50157.14 ± 11574.70 [c]
Net profit (Tk/ha)		8537.53 ± 7417.15 [a]	30801.56 ± 2661.45 [b]	35682.18 ± 8233±87 [c]

Values are expressed as mean ±SD and values in the same row having same superscripts are not significantly different (P>0.05). 1 US $ = Tk. 65.00 (2006-2007).

and Tk. 9655.36±834.56 ha^{-1} (T_2) and Tk. 12637.47±3340.84 ha^{-1}, respectively (Tab. 6). The total revenue was calculated Tk. 11459.47±1494.72 ha^{-1}, 40456.92±3494.00 ha^{-1} and 50157.14±11574.70 ha^{-1} in treatment $T_{1\ \mathrm{and}}$ T_2 and T_3, respectively. The economic analysis showed that the highest profit was obtained with treatment T_3 (35682.18 Tk. ha^{-1}) and the lowest was obtained with T_1 (8537.53 Tk. ha^{-1}). The cost-benefit-ratio (CBR) was calculated as 2.92±0.09, 3.19±0.00 and 2.46±0.00 in T_1, T_2 and T_3, respectively. The cost-benefit-ratio (CBR) differed significantly among the treatments (χ^2 = 3.77; P <0.05), with best performance in treatment T_2 (3.19) than T_1 (2.92) and T_3 (2.47) (Fig. 1).

Discussion

Information regarding the polyculture of *M. rosenbergii* with carps in the northwestern region (Rajshahi) of Bangladesh is quite insufficient. In this region, most of the culture is conducted in earthen ponds which often suffer low water levels especially during September to February dry season.

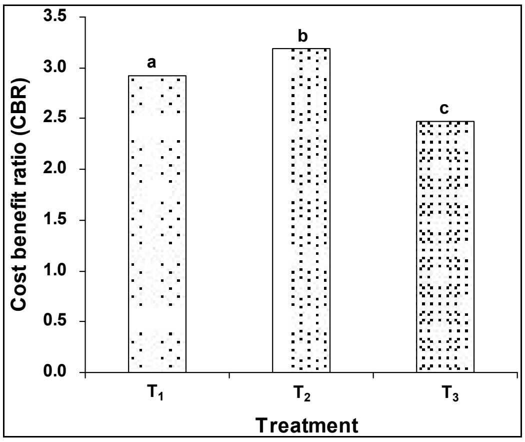

Figure 1. The cost-benefit-ration (CBR) of the production for polyculture of *M. rosenbergii* with carps in earthen ponds during September, 2007 to February, 2008.

Nevertheless, a number of experimental trials on the polyculture of the freshwater prawn with other species of fish has been reported elsewhere (Malecha *et al*., 1981; Costa-Pierce *et al*., 1984; Engle, 1987; Hoq *et al*., 1996; Alam *et al*., 2001; Hossain and Kibria, 2006). Water quality parameters in the ponds during the study period were within suitable range for prawn-carp polyculture (Tripathi *et al*., 2000; Jena *et al*., 2002, 2007; Das *et al*., 2004; Hossain *et al*., 2007; Sahu *et al*., 2007). In earthen ponds, the freshwater prawn *M. rosenbergii* has been shown to be an apposite candidate for commercial polyculture with carps in northwestern Bangladesh. Nevertheless, in a recent study, Hossain and Kibria (2006) reported that prawns are suitable candidates for earthen pond polyculture with fish. They also added that prawn and Indian carps are a suitable combination, at least for over-wintering. However, earlier, Ling (1969) suggested polyculture of *M. rosenbergii* with non-carnivorous freshwater fish including carps and tilapia. Additionally, Engle (1987) reported that polyculture of *M. rosenbergii* with *Colossoma* and grass carp are more profitable than monoculture. Polyculture of *M. rosenbergii* with Chinese and Indian carps has been reported by a number of authors (Malecha *et al*., 1981; Costa-Pierce *et al*., 1984; Hoq *et al*., 1996; Alam *et al*., 2001). The polyculture of *M. rosenbergii* is more preferable than the traditional and improved traditional polyculture system (Huq *et al*., 2004; Hossain and Islam, 2006).

The mean SGR (% bwd^{-1}) of catla, silver carp and Golda in different treatments were 1.19 to 1.21, 1.26 to 1.40 and 1.99 to 2.07, respectively, which is higher than the findings reported by Hossain *et al*. (1997), Siddique *et al*. (1999) and Hossain and Islam (2006). In addition, the mean SGR of catla, rohu, mrigal and mahseer in different treatments under polyculture system were recorded as 1.09 to 1.12, 1.13 to 1.14, 1.10 to 1.12 and 1.15 to 1.16 (Rahman *et al*., 2007), which are lower than those of the present study. However, a comparatively higher SGR (8.89% bwd^{-1}) and final weight gain (88.75 g) obtained in summer period indicated that growth performance of prawn and carp was directly influenced by the effect of seasonal change and these findings were in conformity with those of Rahmatullah *et al*. (1983). Nevertheless, the weight gains in catla, and silver carp ranged from 58.11 to 69.08 and 93.09 to 108.67 g, respectively, which is lower than the findings reported by Siddique *et al*. (1999) and Hossain and Islam (2006). Furthermore, the weight gain of *M. Rosenbergii* among the treatments obtained as 14.61 and 14.04 g at stocking densities between 15000 and 20000 ha^{-1} respectively, which is also lower than the studies conducted by Hossain and Islam (2006), however it is almost similar to Siddique *et al.* (1999). The acceptable growth performance of *M. rosenbergii* in this study compared with the studies by Siddique *et al.* (1999) might be due to the absence of mrigal, *C. mrigala*, a bottom feeder, which compete for food and space with prawn.

During this study, the survival of prawn ranged from 69 to 74%, which is almost similar to the earlier studies conducted by Siddique *et al.* (1999), Ali *et al.* (2003) and Hossain and Islam (2006). However, the survival rate was higher than the studies done by Hoq *et al*. (1996), who recorded a survival of 32.2-75.5% of *M. rosenbergii* in polyculture system. In addition, the mean survival rate of silver carp, and catla varied from 74.00±1.50% (T_3) to 83.33±8.33%. (T_2) and 62.50±12.50% (T_3) to 75.00±0.00% (T_2), rui and mrigal was found 76.50±1.30% (T_1) and 77.50±2.50% (T_1) respectively. The average survival rate of carp in this study was above 62% which is more or less similar with Siddique *et al.* (1999).

In this study, significantly higher ($P<0.05$) productions of *M. rosenbergii* found in T_3 (1141.28 kg ha^{-1}) with prawn densities of 20,000 than T_2 (964.54 kg ha^{-1}) with prawn densities of 15,000. However this production was higher than those reported by Jose *et al*. (1992), Islam *et al.* (1999) and Haque *et al*. (2003). Jose *et al.* (1992) reported a gross production of 106-254 kg ha^{-1} of prawn for a 160 day period. In addition, Islam *et al*. (1999) reported a production of 172 kg ha^{-1} $year^{-1}$. Therefore, the present study indicated that higher stocking density increased the prawn yield without significant change in the carp production. It might be due to the significant role of the co-species in the present study. This might be supported by Malecha *et al*. (1981) and Cohen *et al*. (1988) who suggested for avoiding the bottom feeder like common carp and introducing the surface feeder like silver carp in prawn cum carp polyculture system to increase the prawn production.

Seeds (fish fry and PL) were the main investment and the profit was calculated from the value of the harvested fish and prawn. The production cost was comparative higher in T_3 because the seed price of prawn was comparatively higher. Without considering the seed costs, other input costs were more or less similar in different treatments. The highest net revenue was obtained from prawn carp poly culture system (T_2) and lower net revenue was obtained from only carp polyculture system (T_1). In addition, the highest benefit was obtained in T_3, where carps and prawn were stocked for polyculture and lowest benefit was obtained in T_1, where only carp was stocked for polyculture. However, the simple economic analysis showed that the cost-benefit ratio (CBR) was significantly higher in treatment T_2 (where prawn stocking density was 15000 ha^{-1}) than T_1 and T_3. Therefore, it could be concluded that of 15000 fingerlings ha^{-1} is the most suitable stocking density for culturing *M. rosenbergii* under a monoculture system with catla, and silver carp in the earthen freshwater ponds for better production as well as higher profit.

In conclusion, this study indicated the polyculture with prawn and carps are more profitable and economically feasible than only carp polyculture. This research would be useful for the sustainable aquaculture in Bangladesh as well as other countries.

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