Bangladesh J. Fish. Res., 5(2), 2001: 135-144

Polyculture of freshwater prawn, *Macrobrachium rosenbergii*, de Man with carps: effects of prawn stocking density

M.J. Alam*, D.A. Jahan, W.A. Pramanik and M.E. Hoq
Bangladesh Fisheries Research Institute, Mymensingh 2201, Bangladesh
*Corresponding author

Abstract

Effects of three stocking densities, *viz.*, 35, 50 and 65/*decimal* (1 decimal = 40.48 m^2) of juvenile freshwater prawn (*Macrobrachium rosenbergii*) on prawn and fish production were tested in a polycuture system with silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*), Grass carp (*Ctenopharyngodon idella*) and silver barb (*Barbodes gonionotus*). The fish stocking density was 19/*decimal* with the species combination of silver carp-10, catla- 6, grass carp- 1 and silver barb- 2. In a 8-month culture period, the prawn yield 423 ± 144 kg/ha was significantly lower ($P < 0.5$) with the prawn stocking density of 35/decimal than that of 548 ± 178 kg/ha and 662 ± 243 kg/ha with 50 and 65/*decimal* respectively. The fish production (1844–1891 kg/ha) did not differ significantly ($p < 0.05$) among the three treatments indicating that prawn stocking densities had no influence on fish yield. The lower mean harvest weight (62 g) and survival rate (67 g) and higher yield (2.67 kg/*decimal*) with the highest stocking rate of prawn reveals that as density was increased, prawn survival and individual weight at harvest decreased but total yield increased.

Keywords: *M. rosenbergii*, Polyculture, Stocking density

Introduction

Polyculture of fishes in pond is a widespread practice in many countries where stocking strategies are determined by the feeding habits of fish, taking into account natural feeds available in the various ecological niches within the pond. The freshwater prawn, *Macrobrachium rosenbergii*, has attracted an enormous interest as an aquaculture species in many of the tropical and sub-tropical countries throughout the world (Perry and Tarver 1987) and particularly its benthophagic omnivore feeding habit makes the prawn a good candidate for polyculture. Prawns are self-limiting in respect to total production due to antagonistic interactions increasing the need for polyculture to maximize total pond efficiency (New 1990).

Prawn polyculture has a potentially higher net return than prawn monoculture (Rouse and Stickney 1982). Culture of prawn with fish also improves the ecological balance of the pond water, preventing the formation of massive algal blooms (Cohen *et* *al.* 1983). Besides these cultural benefits, a major advantage of prawn polyculture for developing nations like Bangladesh is that low-cost high quality protein (fish) is produced for local consumption simultaneously with a high value luxury protein product (prawns) that may be exported to generate foreign exchange. This development model has worked remarkably well in Israel, which produces some 50% of its total fish consumed and exports prawns to the high priced European market to generate foreign income (Cohen & Ra'anan 1983).

Although the traditional Chineese aquaculture system, consisting of polyculture of planktophagic, macrophytophagic, benthophagic and omnivorous fish species has been adapted extensively to Bangladesh aquaculture conditions, polyculture of fish and prawn has not yet been widely undertaken until recently. Polyculture of *M. rosenbergii* has been investigated with Chineese and Indian carps elsewhere (Malecha *et al.* 1981, Bian and Pang, 1982, Buck *et al.* 1983, Costa-Pierce *et al.* 1984), but no scientific study has been conducted to develop an appropriate fish-prawn polyculture system in Bangladesh conditions. Though Humayun *et al.* (1986), Hoq *et al.* (1995) and NFEP (2001) reported one species and three species carp-prawn polyculture system, respectively, but in a very crude way and nothing could be concluded from their results in establishing a viable prawn-fish polyculture system in Bangladesh. The present study was, therefore, undertaken to investigate the effects of stocking rate of prawn on the production performance of fish and prawn in a polyculture system considering fish as a marginal crop with an ultimate aim of developing an appropriate grow-out of freshwater prawn under a polyculture system.

Materials & methods

Previous year's hatchery produced nursed juvenile prawns were stocked at three different densities with silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*), grass carp (*Ctenopharyngodon idella*) and rajpunti (*Barbodes gonionotus*). Different prawn stocking densities of 35/*decimal*, 50/*decimal* and 65/*decimal* were considered as treatments. The stocking density of silver carp, catla, grass carp and rajpunti into each treatment pond was 10, 6, 1 and 2 per *decimal* respectively. Each of the treatments was assigned into three ponds as replication. The initial average weight of prawn was 1.8 g and that of silver carp, catla, grass carp and rajpunti was 3.6 g, 5.2 g, 50.7 g and 1.5 g, respectively.

The experiment was carried out into three earthen ponds, which were partitioned into three compartments having a water surface area of 7 *decimal* each and a mean effective water depth of about 1 m. The pond were partitioned using bamboo fetching covered with nylon mosquito net. The ponds were drained out and treated with lime and cowdung at the rate of 1 and 12 kg/*decimal*, respectively. The ponds were filled in with underground water and fertilized with 100 g urea/decimal and 50 g TSP/decimal for enhancing the natural food production prior to stocking. Fish and prawns were stocked into pond compartments in January'96 and the experiment was continued up to August'96.

The nutrient management included fortnightly manuring/fertilization and daily feeding. Dry cowdung, urea and TSP were applied fortnightly at the rate of 5 kg, 100 g and 50 g/decimal, respectively. The use and amount of fertilizer varied depending on the productivity status of ponds. Only prawns were fed with a SABINCO commercial grower pellet feed at 5% of biomass for initial 3 months and at 3% for the rest of rearing period. The feed contained 38% crude protein, 5% crude lipid, 6% crude fibre, 18% ash and 12% moisture. The pellets were applied at every evening using feeding trays hung in each pond compartment. Shelters were provided in each pond compartment with dry coconut leaves.

Gain in growth (total length and weight) of fish and prawn was recorded from seined netted samples (n=25) once in a month. At the end of the experiment, ponds were drain harvested, fish and prawns caught, total number counted for survival, measured and weighed, and gross yield computed. Among the water quality parameters, temperature was measured every day between 09.00 – 10.00 hrs using a centigrade thermometer. Dissolved oxygen, pH, ammonia and alkalinity were measured every week in between 08.00 – 09.00 hrs. Dissolve oxygen and pH were measured with a YSI model 54 oxygen analyzer and OSK-11475 pH meter respectively. Determination of ammonia and total alkalinity was performed according to the procedures outlined by AOAC (1990).

One-way analysis of variance (ANOVA) was performed on the yield data to determine treatment effects. Significant differences between treatments were isolated using Duncan's multiple range test (DMRT) at 5% level of significance. All analyses were done using on PC using Statgraphics *Version 7.0.*

Results

The final weight, survival rate, and yield of fish and prawns in each treatment are shown in Table 1. The growth of silver carp, catla, grass carp and silver barb ranged from 457-460 g, 347 – 388 g, 718 – 825 g and 185 – 202 g, respectively. The growth of each fish species was similar ($P < 0.05$) in all treatments, except catla and grass carp in T_2. The significantly higher growth of grass carp (825.28 ± 30.60 g) and lower of catla (347.09 ± 34.72 g) in T_2 might have due to some unknown reasons other than any interspecies interactions. The survival rate of each fish species was also similar ($P < 0.05$) among the all treatments. Neither the individual fish yield nor the total yield of 1891 ± 153 kg/ha in T_1, 1844 ± 162 kg/ha in T_2 and 1887 ± 186 kg/ha in T_3 were not significantly different ($P < 0.05$). Prawn with the highest stocking density of 65/decimal (T_3) showed significantly lower ($P < 0.05$) growth (61.61 ± 20.72 g) and survival rate (65.92 ± 2.27%), but higher yield of 2.67 ± 0.98 kg/decimal i.e. 662 ± 243 kg/ha than the lowest density of 35/decimal (T_1). Similarly, the weight gain and survival rate of prawns at harvest with T_2 (50/decimal) were higher but the yield was lower than that of prawns with T_3, although not significantly different (Table 1).

The monthly mean weight gain of prawn in all treatments is shown in Fig. 1. The prawns at all stocking rates gained in weight progressively with increment of rearing period. The prawns at the lowest stocking rate of 35/decimal (T_1) gained higher weight all through the study period. As the stocking rate increased, the prawns gained their weight at lower rates. The results indicate that individual weight of prawn negatively correlated with increasing stocking rate. The weight of prawns in all treatments sharply increased from April, possibly due to increase in temperature.

Table 1. Yield data of different fish species and *M. rosenbergii* in fish-prawn polyculture system (means with same superscripts letter are not significantly different at 5% level of significance)

Species combination	Stocking (no/*dec.*)	Final weight (g)	Survival rate (%)	Yield (kg/*dec.*)*	Total yield (kg/ha)
Treatment I					
H. molitrix	10	460.50 ± 29.04	96.42 ± 0.71	4.44 ± 0.31	
C. catla	6	388.50 ± 24.82[a]	92.86 ± 2.38	2.17 ± 0.20	Fish: 1891 ± 153[a]
C. idella	1	717.65 ± 64.32[b]	100 ± 0.00	0.72 ± 0.07	Prawn: 423 ± 144[b]
P. gonionotus	2	185.25 ± 26.75	82.14 ± 3.57	0.31 ± 0.05	
M. rosenbergii	35	67.85 ± 19.05[a]	70.22 ± 4.73[a]	1.70 ± 0.58[b]	
Treatment II					
H. molitrix	10	457.86 ± 30.43	93.58 ± 0.72	4.29 ± 0.32	
C. catla	6	347.09 ± 34.72[b]	95.24 ± 2.38	1.99 ± 0.25	Fish: 1844 ± 162[a]
C. idella	1	825.28 ± 30.60[a]	100 ± 0.00	0.83 ± 0.04	Prawn: 533 ± 178[ab]
P. gonionotus	2	201.64 ± 23.42	83.34 ± 3.21	0.34 ± 0.06	
M. rosenbergii	50	64.04 ± 18.28[ab]	68.86 ± 2.85[a]	2.23 ± 0.72[ab]	
Treatment III					
H. molitrix	10	466.50 ± 33.51	94.29 ± 1.42	4.41 ± 0.39	
C. catla	6	388.75 ± 35.09[a]	91.67 ± 3.57	2.15 ± 0.28	Fish: 1887 ± 186[a]
C. idella	1	739.28 ± 36.44[b]	100 ± 0.00	0.74 ± 0.04	Prawn: 662 ± 243[a]
P. gonionotus	2	195.50 ± 20.65	85.72 ± 7.14	0.34 ± 0.07	
M. rosenbergii	65	61.61 ± 20.72[b]	65.92 ± 2.27[a]	2.67 ± 0.98[a]	

* 1 decimal = 40.48 m^2

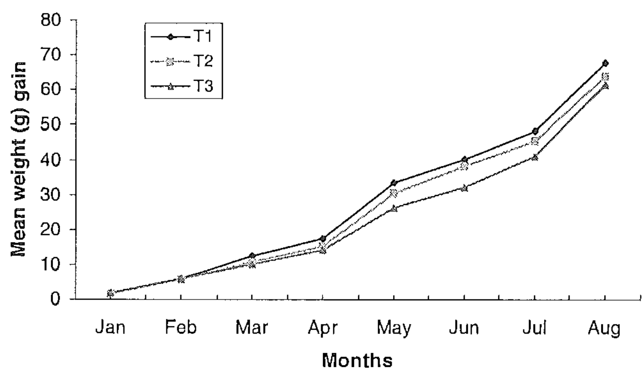

Fig. 1. Monthly mean weight gain of *M. rosenbergii* in fish-prawn polyculture ponds.

Fig. 2 shows the percent occurrence of prawn in different weight class at harvest. The occurrences of prawn in higher weight-class prawn were more than that in lower weight-class at lower stocking densities. The highest occurrence of 32.3% prawns in T_3 with 65/decimal was at 50-60 g weight class and that of 30.9% in T_1 with 35/decimal was at 60-70 g weight-class. The occurrence of prawn at 50-60 g and 60-70 g weight-class in T_2 with 50/decimal was 26.6% and 28.2%, respectively. While in T_1, 56.1% of prawns were at higher weight-class of 60-80 g, 54.8% and 55.9% of prawns were at 50-70 g in T_2 and T_3, respectively. Again, when prawns of more than 80 g of weight were 13.8% in T_1, those were 11.8% in T_2 and 5.4% in T_3. All prawns at 35 and 50/decimal were more than of 40 g. These indicate that an increase in stocking rates resulted in a decrease of occurrence of higher weight-class prawn.

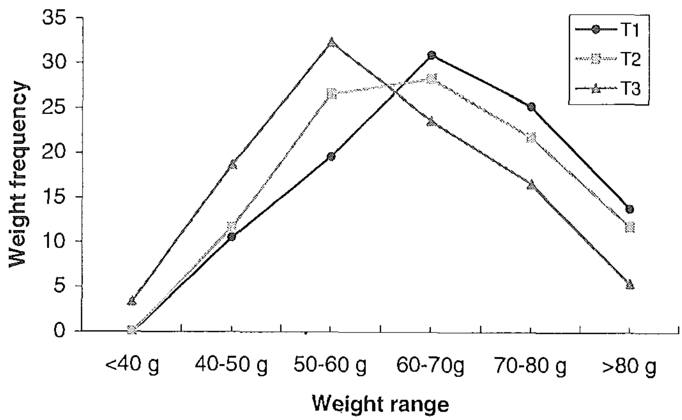

Fig. 2. Occurrence of *M. rosenbergii* at different weight-class in fish-prawn polyculture ponds.

Fig. 3 represents the sex ratio of harvested prawn at different stocking densities. The proportions of male prawns were lower than that of females in T_1 (46.2% M ; 53.8% F) and in T_2 (47.4% M ; 52.6% F). In T_3 the male population (52.3%) was higher than the female (47.7%).

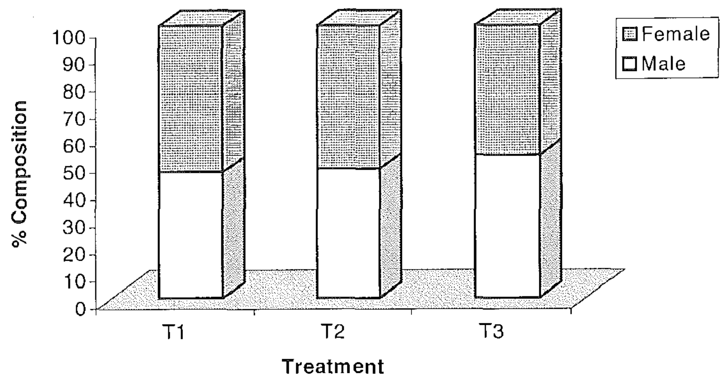

Fig. 3. Composition (%) of male and female *M. rosenbergii* in fish-prawn polyculture ponds.

The differences in sex ratio at varied stocking densities under the study were apparent, indicating that the abundance of one sex over the other one might have been occurred due to variation in stocking densities.

As the ponds were partitioned using bamboo fetch covered with nylon mesh net, water among the compartments in the same pond flowed with wind action. For this reason, water quality parameters were measured from each of three ponds, irrespective of treatment compartments. There were no significant differences in water quality parameters among three ponds. For this reason, all measured values for each parameter were averaged and are shown in the Table 2. Monthly variations in water quality values in all experimental ponds were within the acceptable limit of pond fish and prawn culture.

Table 2. Mean (range) values of water quality parameters in fish-prawn polyculture ponds

Water quality parameters	Months							
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Temperature (°C)	18.5 (16-20)	19.5 (18-20)	24.4 (23-25)	25.2 (24-27)	27.5 (24-29)	26.7 (25-28)	26.4 (25-29)	27.1 (26-30)
Dissolved oxygen (mg/l)	4.5 (3.5-5.2)	4.3 (3.2-5.0)	4.9 (3.8-5.3)	5.5 (4.4-6.2)	4.8 (4.2-5.7)	4.5 (3.9-5.7)	4.2 (3.7-5.0)	4.6 (3.9-5.3)
PH	7.8 (7.5-9.0)	7.2 (7.0-8.5)	7.6 (7.4-8.8)	7.5 (6.9-8.6)	7.7 (7.5-8.9)	7.6 (7.4-9.0)	7.9 (7.5-9.0)	7.5 (6.8-8.8)
Total ammonia (mg/l)	0.25 (0.2-0.3)	0.27 (0.2-0.3)	0.25 (0.2-0.3)	0.36 (0.3-0.4)	0.33 (0.3-0.4)	0.35 (0.3-0.4)	0.26 (0.2-0.3)	0.34 (0.3-0.4)

Discussion

A similar fish yield at three different stocking densities of prawn (Table 1) indicates that the growth and yield of fish do not appear to be affected by the prawn stocking density. The significant differences ($P<0.05$) in growth and yield of prawns were also not influenced by the type and stocking rate of fish, but by the stocking rate of prawn itself. The prawn weight decreased from 68 - 62 g and the yield increased from 423 – 662 kg/ha with increasing prawn density. The weight frequency data (Fig. 2) show an increase in the proportion of larger prawns with lower stocking rate and a decrease in that with higher stocking rate. This similar inverse relation in individual weight gain and positive relation in total yield with stocking rates of prawn in polyculture with carps and tilapia has been reported by (Cohen and Ra'anan 1983, Wohlfarth *et al.* 1985). In case of a variety of prawn monoculture conditions, Smith *et al.* (1976); Brody *et al.* (1980); Perry *et al.* (1982) also observed that stocking rates of prawn had a negative with weight gain but a positive correlation with yield. Similar survival rates of prawn in the present study indicate that a stocking rate of 35-65/decimal might have no effect on survival at harvest. While Wohlfarth, *et al.* (1985) observed a slightly negative, but not significant, correlation between survival rate and stocking density of prawn in a polyculture system, no any correlation was found by Cohen and Ra'anan (1983).

A higher ($P < 0.05$) prawn yield of 2.76 kg/day/ha and a similar fish yield of 7.9 kg/day/ha (Table 1) reveals that stocking of 65 prawn/decimal (16000/ha) with 19 fish/decimal (4700/ha) may be practiced in Bangladesh aquaculture conditions for an optimum yielding crop in a fish-prawn polyculture system. When Brick and Stickney (1979) stocked juvenile prawns at 11000/ha with tilapia fry at 2000/ha, mean prawn survival, harvest weight and yield were 95%, 24.5 g and 2.1 kg/day/ha, respectively. The daily fish yield was 2.6 kg/ha. Miltner *et al.* (1983) reported mean prawn survival rate of 94%, harvest weight of 72.2 g and daily yield of 1.6 kg/ha at 2500/ha. The daily fish yield was 12.4 kg/ha at 8240 (catfish, silver carp and grass carp)/ha. High protein feed was used in both studies. The prawn yield of 1.76 – 2.76 kg/day/ha, in spite of at relatively low survival rate of 65 – 70%, in the present study is quite comparable to that of 1.6 – 2.1 kg/day/ha. However, Cohen and Ra'anan (1983) obtained an average daily yield of 3.9 kg/ha at a prawn stocking density of 15000/ha with above 85%of survival. The prawn survival rates in all treatments in the present study ranging from 66 – 70% are supposed to be of relatively low, which might be due to low temperature during the initial months of stocking (Table 2). Therefore, it leads to apprehend that the daily rate of prawn yield could have been more than that has been achieved, if the prawns are stocked at onset of summer and harvested at the onset winter months.

Although a commercial feed was used to feed the prawn only in the present study, certain amount of feed was also used by fishes and it is difficult to determine that which species actually consumed how much of feed. The fish and prawn yield was actually the result of combined effect of low rate of feeding and fertilization, as compared to high-level pond management, in terms of nutrient inputs, maintained by Cohen and Ra'anan (1983); Wohlfarth *et al.* (1985). It may, therefore, be presumed that a prawn stocking density of 16000/ha may be optimum one in polyculture system for having a good harvest at low input management. However, a higher stocking density of prawn and fish with high input management may result in high yield of both prawn and fish. A prawn yield of 3.7 – 7.2 kg/day/ha at a stocking density of 20000 - 40000/ha and fish (carps and tilapia) yield of 29.5 – 40.6 kg/day/ha at a stocking density of 13150- 13300/ha have been reported by Wohlfarth *et al.* (1985); Hulata *et al.* (1990).

Besides the relationship with growth and yield, stocking rates of prawn have also shown some effects on sex ratio. The females of harvested prawns had a higher percentage (54%) with the lowest test stocking density (35/decimal), whereas the males dominated with the highest stocking rate of 65/decimal (Fig. 3). Different authors have recorded different observations regarding the occurrence of sex ratio and stocking rate of prawn. Wang *et al.* (1975) found that the proportion of males exceeded that of females in the harvested populations from ponds stocked with relatively high densities. Smith *et al.* (1978) reported that sex ratios obtained in prawn monoculture systems were generally biased towards females (55-64%) without showing any relationship between sex ratio and stocking density. However, Cohen and Ra'anan (1983) observed, in ponds under fish-prawn polyculture system, a higher percentage (55%) of female prawns at a lower stocking density of 5000/ha and that (51%) of male at a higher stocking density of 15000/ha. However, it is beyond the capacity of the present report to explain the exact reasons of occurrence of sex ratio in harvested prawn population. It might be possible that certain environmental conditions within the pond, including stocking density, would favour the development of one sex over the other, as assumed by Cohen and Ra'anan (1983).

Finally, it can be concluded that proper stocking rates are of prime significance for aquaculture production in fish and prawn polyculture system. Though a prawn stocking rate of 16000/ha resulted in a good yield, higher stocking densities of both fish and prawn, along with better nutrient input and pond management, may tried for better yield. It, however, needs to take into account that an increase in stocking rate of prawn may increase in harvest yield, but decrease in individual weight gain. Therefore, any further study for optimizing the higher stocking rate of prawn for maximum yield should consider the rate of individual weight gain a major factor, as the market value of prawn highly depends on it.

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(Manuscript received 12 December 1999)