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The potential of mixed culture of freshwater giant prawn *Macrobrachium rosenbergii* de Man and tiger shrimp *Penaeus monodon* Fab. at Khulna region, Bangladesh

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Abstract
The freshwater giant prawn (golda), *Macrobrachium rosenbergii* and tiger shrimp (bagda), *Penaeus monodon* were stocked together with or without fin fishes at different stocking rates in semi-saline waters at Khulna region and their growth, survival, yield and cost-return analysis were made. Survival rate of golda and bagda ranged from 23.0 to 36.8% and 8.2 to 24%, respectively. The both species were significantly affected by their own stocking density. The average final weight of golda and bagda ranged from 62.4 to 73.3 g and 32.0 to 66.4 g. The bivariate analysis of average final weight of both golda and bagda revealed that golda positively and bagda negatively influenced by the total stocking density. However, the results of the individual sizes of both golda and bagda showed an increase in the proportions of smaller animals and a decrease in the proportion of larger ones with increasing stocking rates. The harvesting weights of all animals in the experimental ghers were in marketable sizes although their prices varied with the individual size. The total production comprised of both golda and bagda ranged from 514.6 to 952.8 kg ha^{-1}, over a culture period of 10 months. Return on investment ranged from 51.0 to 125.7%.

Key words : Polyculture, *Macrobrachium rosenbergii*, *Penaeus monodon*, Cost-return

Introduction

The rapid expansion of shrimp culture over the last decade and its contribution to foreign exchange earnings has been quite remarkable. Shrimp culture covered an area of 1.4 lakh ha in 1995-'96 in contrast to 0.87 ha in 1985-'86 (DoF 1998). The biology of these two species are mostly associated with the salinity of the environment. The former is regarded as the marine or brackishwater species and the latter as freshwater species depending on their environment. In most cases, monoculture of both the species are being practiced and recently, polyculture with fin fish has been started (Hoq *et al.* 1996). However, as the market price of fin fish is much lower than that of shrimp, farmers could not show interest to practice polyculture with fin fish rather than mixed culture of both marine and freshwater shrimp species in the same ghers or ponds. There are a vast area of semi-saline waters in wide-spread coastal belt of Bangladesh in which salinity

fluctuate from about 0 to 20 ppt. This type of waterbodies could be used for culturing of both golda and bagda. However, farmers in this region is practicing mixed culture of golda and bagda round the year without comprehensive study on their biological characteristics, inter-species relationship, stocking ratios and production performance. Under the Aquaculture Research for Sustainable Development Project, Bangladesh Fisheries Research Institute (BFRI) undertook this study to determine growth, survival, yield and economics of golda and bagda in polyculture system.

Materials and methods

Experimental site and gher preparation

The experiment was conducted for a period of 10 months from April'97 to January '98 in four farmer's ghers at Dumuria Thana of Khulna district. All ghers were newly constructed and equal in size and depth with an area of 0.5 ha and an average depth of 1.0 m. The experimental area was low-land floodplain area beside the river Hamkura which is a dead one, flowing only in the rainy season. Lands of gher were leased from land owner for a period of 10 years except gher 4. In December-January, embankments of the ghers were constructed. Each gher was made in such a way that a deep drain (about 2.5 m) at the two border side of the ghers were made and the soil was used to make the embankment. Embankments were made wider (1 m) for escaping break down during the rainy season. Different types of vegetables were cultured on to the embankment.

The ghers were ploughed and treated with lime (80 kg/gher) and cowdung (500 kg/gher) in February. In March, the ghers were filled up with water by low-lift pump and afterwards ghers were received rain water.

Stocking of shrimp and fish

Stocking of shrimp and fish seeds started from April and continued up to June, 1997 on an irregular basis in all of the experimental ghers. As practiced, farmers did not agree to stock fin fish alongside the shrimp, but they were motivated to stock few fin fish in the experimental ghers except gher 4. However, farmers had the freedom to maintain all aspects of stocking and management practices with a little suggestion from the respective scientist. Fry *Macrobrachium rossenbergii* (locally called golda) and *Penaeus monodon* (locally called bagda), and fingerlings of fin fish were procured from natural sources through local traders. Detailed species combinations and stocking densities in different ghers are presented in Table 1.

Table 1. Species combinations and stocking densities in different experimental ghers

Species	Gher 1	Gher 2	Gher 3	Gher 4
Macrobrachium rossenbergii	27,600	9,250	8,500	16,500
Penaeus monodon	6,900	9,250	8,500	1,000
Fin fish	500	1500	500	--
Total	35,000	20,000	17,500	17,500

Gher management

A feeding programme was maintained to each pond on more or less regular and daily basis as appeared in Table 2. A mixture of rice bran and fish meal with or without mustard oil cake was supplied in the morning and snail meat in the evening to the experimental ghers. No fertilizer was applied to the ghers during the culture period.

Some shelters made of coconut branches and plastic pipe were kept on the bottom of ghers so that the shrimps could take shelter during their molting. Shrimp and fish samples were collected monthly with a cast net to check up their health condition.

Table 2. Summary of the feeding programme applied to the experimental ghers

Food Item	Gher 1	Gher 2	Gher 3	Gher 4
Rice/wheat bran (kg)	1.0	2.0	3.5	1.0
Mustard oil cake (kg)	1.0	Nil	Nil	Nil
Fish meal (kg)	0.5	1.0	1.0	1.0
Snail meat (kg)	2.5	3.5	4.0	4.0
Total	5.0	6.5	8.5	6.0

Study of water quality parameters

Some water quality observations – temperature, pH, salinity, Dissolved Oxygen (DO) and total hardness were recorded during 1000-1100 h at monthly intervals using a HACH kit (FF-2).

Harvesting

The farmers started harvesting of farmed animals in irregular basis from August 1997 to January 1998 with a seine net and sold the products to the local depot. The grade (size) of shrimp, quantity, respective price and total cost were recorded regularly. In January, all the ghers were de-watered and all the marketable animals were harvested.

Results and discussion

Physico-chemical parameters of the experimental ghers are shown in Table 3. Temperature varied from 18.5 to 33.5^{0}C with the mean values of 31.1, 30.2, 29.6 and 30.5^{0}C in ghers 1, 2, 3 and 4, respectively. Ling (1969) recommended the range of temperature from 22-32^{0}C for optimum growth of freshwater prawn which was the case in the present study. The pH of water was almost around the neutral and ranged from 7.0 to 8.5 in gher 1, 6.5 to 8.5 in gher 2, 7.0 to 8.5 in gher 3 and 7.0 to 8.0 in gher 4. The trend of salinity of the gher was almost same in all the experimental ghers. It ranged 0-15 ppt with the mean values of 10.3, 9.5, 8.8 and 9.8 ppt in ghers 1, 2, 3 and 4, respectively. The salinity was higher at the beginning of the experiment and gradually declined with the rainfall. Siddiqui *et al.* (1997) reported 5 ppt salinity for prawn culture in their study. Dissolved oxygen (DO) varied from 4.0 to 7.1 mg l^{-1} with the mean values of 5.1, 5.8, 6.0 and 6.1 in ghers 1, 2, 3 and 4, respectively. Total hardness varied from 40.0 to 80.0 mg l^{-1}

with the highest mean value in gher 4. However, mean total hardness content of water of gher 1, 2, 3 and 4 were 54.8, 55.6, 54.0 and 74.0 mg l^{-1}, respectively. New (1995) recommended the total hardness level for prawn culture is 40-60 mg $CaCO_3$ /l which agreed with the present study. However, all the water quality parameters were within the acceptable range for prawn culture (Ling, 1969; New, 1995; Siddiqui *et al.*, 1997).

Table 3. Mean values of water quality parameters of different ghers during the study period

Parameters	Gher 1	Gher 2	Gher 3	Gher 4
Temperature (^{0}C)	31.1	30.2	29.6	30.5
	(18.5-33.5)	(19.0-32.5)	(18.5-33.0)	(19.5-33.0)
pH	(7.0-8.5)	(6.5-8.5)	(7.0-8.5)	(7.0-8.0)
Salinity (g/ l)	10.3	9.5	10.8	9.8
	(0.5-15.0)	(0.0-14.0)	(0.5-14.5)	(0.0-15.0)
Dissolved Oxygen (mg/l)	5.1	5.8	6.0	6.1
	(4.5-6.0)	(4.0-6.5)	(4.0-6.6)	(4.5-7.1)
Total Hardness (mg/l)	54.8	55.6	54.0	74.0
	(44.0-63.5)	(45.0-71.5)	(40.0-65.0)	(45.0-80.0)

The yield parameters of the two shrimp species in different ghers are shown in Table 4. The farmers used the fin fish for self consumption, hiring the labour to catch prawn and giving the relatives. For this reason, the account of the fin fish was not considered in this study.

Survival rate of golda and bagda ranged from 23.0 to 36.8% and 8.2 to 24%, respectively in this study. The highest survival of golda was observed in the gher 2 where the medium stocking density (40,000 ha^{-1}) and equal ratio of golda and bagda along with fin fish at the rate of 3000 ha^{-1} was maintained. However, the lowest survival rate was recorded from gher 1 where the highest stocking density (70,000 ha^{-1}) and four times higher number of golda in comparison to bagda along with fin fish at the rate of 1000 ha^{-1} was cultured. On the other hand, bagda showed the higher survival rate in the gher 4 where the lowest density of bagda and no fin fish stocked. However, the lowest survival rate of bagda was observed in the gher 2 where golda showed the highest survival indicating that the both species were affected by increasing stocking density and there was an antagonistic relationship between the two species. Hoq *et al.* (1996) reported that the survival rate of prawn ranged from 32.2 to 75.7% (mean 51.1%) in a polyculture with fin fish which is quite higher than that of the present study. Scott *et al.* (1988) found an average 63% survival of golda in a polyculture with golda and gold shiner. The lower survival of the present study might be due to stocking of fry rather than juveniles in the present study which are available and cheaper in comparison to juvenile ones. It is fact that availability of shrimp seeds both of golda and bagda mainly depends on the natural sources and is decreasing day by day. Juveniles prawn are scarce and expensive in this region. The regressions of survival rate of both golda and bagda on total stocking density

Table 4. Yield parameters of Golda and Bagda in different ghers

Gher/Pond	Gher 1				Gher 2				Gher 3						
Species	Golda	Bagda	Fish	Total	Golda	Bagda	Fish	Total	Golda	Bagda	Fish	Total	Golda	Bagda	Total
No. stocked	55200	13800	1000	70000	18500	18500	3000	40000	17000	17000	1000	35000	33000	2000	35000
No. harvest	12696	2622	-	14700	6808	1517	-	9000	6069	3825	-	10185	7821	480	8330
Survival (%)	23.0	19.0	-	21.0	36.8	8.2	-	22.5	35.7	22.5	-	29.1	23.7	24.0	23.8
Av. final wt (g)	68.44	32.0	-	41.8	73.3	49.8	-	61.5	70.6	22.5	-	46.6	62.4	66.4	64.4
Production (Kg/ha)	868.9	83.9	-	952.8	499.0	75.5	-	574.5	428.5	86.1	-	514.6	488.0	32.0	520

are slightly negative but not significant (Fig. 1). Whereas, the survival affected by their own stocking density (Golda r = -0.87; Bagda r = -0.63). Wohlfarth *et al.* (1985) reported that prawns were influenced only by their own stocking ratio which correlated positively with yield and negatively with individual growth in a polyculture trial with fin fishes.

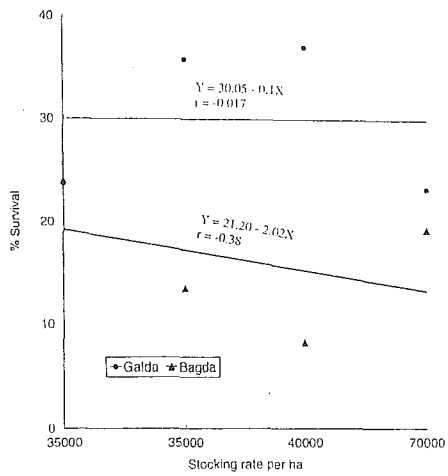

Fig. 1. Bivariate analysis of survival on total stocking density.

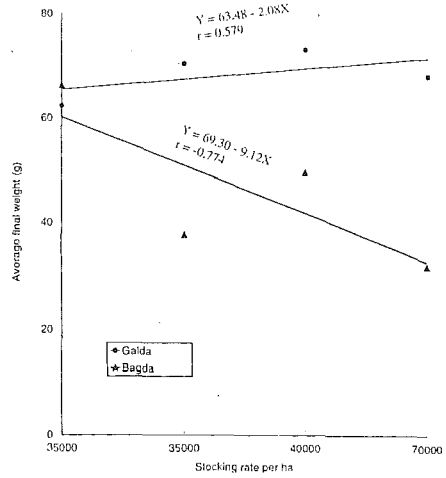

Fig. 2. Bivariate analysis of final weight on total stocking density.

A clearly distinguishable growth was observed among the ghers when final weight of golda and bagda was taken into consideration. Average final weight of golda were 68.4, 73.3, 70.6 and 62.4 g in Ghers 1, 2, 3 and 4, respectively. Whereas, average final weight of bagda were 32.0 g in Gher 1, 49.8 g in gher 2, 37.8 g in gher 3 and 66.4 g in gher 4. The bivariate analysis of average final weight of both golda and bagda (Fig. 2) revealed that golda positively and bagda negatively influenced by the total stocking density. The average highest final weight of golda and bagda in the gher 2 and 4 respectively, are attributed to be the lower stocking density of the species resulting less intra-species competition for food and space. Siddiqui *et al.* (1997) cultured *M. rosenbergii* at a stocking density of 100,000 ha^{-1} in concrete tank and reported that the final mean body weight decreased with the increasing stocking density. The positive correlation between stocking rate and final weight of golda in the present study indicated that the stocking density might be increased within a certain limits without hampering growth rate.

The growth increment data were extrapolated in order to express the result in hectare. The production of golda in ghers 1, 2, 3 and 4 were 868.9, 499.0, 428.5 and 488.0 kg ha^{-1}, respectively. Whereas, the production of bagda were 83.9, 75.5, 86.1 and 32.0 kg ha^{-1} in ghers 1, 2, 3 and 4, respectively. However, the total production comprised of both golda and bagda in ghers 1, 2, 3 and 4 were 740.3, 574.5, 514.6 and 520.0 kg ha^{-1}, respectively. The overall production of all the experimental ghers were satisfactory in comparison to shrimp production of about 70-100 kg/ha owing to the practice of

traditional extensive culture technologies in the experimental region (Wahab 1998). Hoq *et al.* (1996) reported the highest prawn production of 428.4 kg/ha in a polyculture system with golda and other fin fishes in the same region. However, the bivariate analysis of stocking density and total production as appeared in Fig. 3 revealed that the production was increased with the stocking density. Similar observation was reported by Hoq *et al.* (1996) in a polyculture of *M. rosenbergii* with the fin fishes. The results of the individual sizes of both golda and bagda as appeared in Table 4 showed an increase in the proportions of smaller animals and a decrease in the proportion of larger ones with increasing stocking rates. The harvesting weights of all animals in the experimental ghers were in marketable sizes although their prices varied with the individual size. However, since the marketable size of prawn had not been hampered by higher stocking density, we recommend the higher stocking density (70,000 ha^{-1}) with a ratio of 4:1 for golda and bagda with few fin fishes.

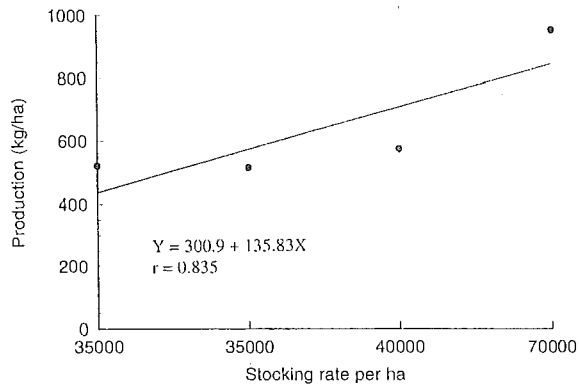

Fig. 3. Regression analysis of production and total stocking density.

Cost-return analysis of the experiments is presented in Table 5. The main items for expenditure were land rental value, gher construction and preparation, seeds, feeds, etc. Although gher 4 was not leased, same amount of rental value was supposed for comparing it to the others. A slightly higher amount of money was spent for construction and preparation of the gher 1. The large amount of money was used for feeding purpose in gher 3 followed by gher 2, 4 and 1. Cost-return analysis of the experimental ghers indicates that it is a highly profitable business. The analysis also revealed that the profit as well as production characteristics of shrimp were independent of supplemental feed. The growth of prawn mostly resulted from utilizing natural food components (Schroeder 1983) stimulated by the manure and its degradation products (Wohlfarth and Schroeder 1979). The soil fertility of the experimental ghers was very high and the decomposed products of plants and silts were observed during the construction of ghers. However, it might be better to apply the manure instead of supplemental feed to the ghers. Among the ghers, economic return was better in gher 1 followed by gher 2, 4 and 3. Return on investment in gher 1, 2, 3, and 4 were 125.7, 119.3, 61.3 and 51.0%, respectively.

Table 5. Cost-return analysis of experimental ghers

Gher/pond	Gher 1	Gher 2	Gher 3	Gher 4
Input costs (Tk.)				
Land rental value	10,000	10,000	10,000	10,000
Gher construction and preparation	17,400	13,365	13,600	13,030
Shrimp/fish seeds	19,534	12,646	17,816	12,906
Cowdung & Lime	680	680	680	680
Feed	8750	13,800	16,950	13,200
Total input cost	56,364	50,491	59,046	49,816
Total return	127,225	110,711	95,233	75,247
Net profit	70,861	60,220	36,187	25,431
Return on investment (%)	125.7	119.3	61.3	51.0

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