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Culture potential of fresh water giant prawn (*Macrobrachium rosenbergii*) with tiger shrimp (*Penaeus monodon*) and green back mullet (*Chelon subviridis*) in poly culture

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Abstract
To investigate the growth and production potentials of freshwater giant prawn (*Macrobrachium rosenbergii*) in polyculture with tiger shrimp (*Penaeus monodon*) and green back mullet (*Chelon subviridis*) a six month long experiment was conducted in six on-station ponds having an area of 0.1 ha each, with two replications in Brackish water station of Bangladesh Fisheries Research Institute. Overall stocking densities were different in three treatments. Stocking densities of shrimp and mullet were fixed in each treatment and that was 25,000 and 5,000 per hector respectively. Whereas, stocking density of prawn was maintained at 10,000, 15,000 and 20,000 per ha in T1, T2 and T3 respectively. After 90 days of culture final weight of shrimp was highest in T2 (30.77 g) while after 178 days of culture, final weights of prawn (64.73 g) and mullet (29.0 g) were highest in T1 than other treatments. Survival of shrimp (81.59%) and prawn (80.98%) was highest in T_2 whereas, survival of mullet (97.67%) was highest in T_1 than other treatments. Final weight (64.73 g) of prawn was found significantly (p<0.05) highest in T1 than other treatments. Total production was 1127.35, 1545.68 and 1449.92 kg/ha in T1, T2 and T3 respectively. Production of prawn (780.68 kg/ha) and total production (1545.68 kg/ha) were significantly (p<0.05) highest in T_2 than other treatments which suggest that the stocking density of 15000/ha of prawn and combine stocking density of 45,000/ha of shrimp, prawn and mullet in polyculture would be suitable for coastal aquaculture.

Keywords: Culture potentials, *Macrobrachium rosenbergii*, growth, production, stocking density

Introduction

Polyculture is a sustainable farming practice where combination of two or more complementary species, with different feeding habitat effectively utilizes nutrients resulting higher production compared with monoculture (Aubin *et al*., 2015; Milstein, 2005) [1, 2]. Polyculture plays a key role in nutrient recycling and environmental stability through effective utilization of nutrients derived from the inputs like fertilizers, unconsumed feed, excreta (Aubin *et al*., 2015) [1]. In the present scenario of shrimp farming where disease outbreak, environmental issues and market unpredictability are becoming major challenges, polyculture forms an ideal sustainable alternative to single species monoculture. Euryhaline fish form an ideal and ecologically important species for polyculture owing to its lowest trophic level feeding habit (El-Dahhar *et al.*, 2006) [3] and ability to accept artificial supplementary diet. Herbivorous finfish such as green back mullet, *C. subviridis* forms compatible species for polyculture apart from its consumer preference and market price.

Shrimp, prawn and green back mullet are commercially important species. These species are contributing the coastal fisheries of Bangladesh to a great extent, both in point of commercial and local consumption view. Prawn and fish are harvested as by-catch from extensive shrimp *ghers.* Freshwater prawn farming in Bangladesh has a number of socio-economic advantages over shrimp farming. Unlike the shrimp farms which are normally large (average size above 10ha or 25 ha), and often pirated by non-resident elite owners, the prawn farms are mostly small (average size less than an acre) and operated by the landowners themselves (Alam *et al*., 2006a) [4]. It has been observed frequently that total farm output increases through the inclusion of suitable fish and/or prawn in rice fields (Alam *et al*., 2006b and Cai *et.al*., 1995) [5, 6]. Besides, prawn is yet not susceptible to the prevailing white spot virus disease (Hameed *et. al.,* 2000) [7], that causes huge economic losses to the shrimp. For all these reasons, prawn culture is socially more acceptable and economically viable. Green back mullet, *Chelon subviridis* (Val. 1836) is a brackish water mugilid fish with a tropical Indo-pacific distribution. It is a euryhaline and eurythermal fish. Considering its euryhaline nature, green back mullet has potential for culture with tiger shrimp and freshwater giant prawn in brackish water ponds. The high quality of flesh, high economic value and wide range of temperature and salinity tolerance capacity make this species popular for aquaculture in the intertidal ponds (Nlewadin and Deekae, 1997) [8]. The culture practice of this fish in the coastal impoundments (locally called *ghers*) of Bangladesh is getting much popularity. These three species are delicious in taste and have high market demand. Moreover, it has an emerging trend as an aquaculture species in the coastal Bangladesh for conservation and increasing supply of these fish species. Virtually these three species are not cultured with specific design. In contrast, polyculture practice of these three species has not yet been developed. Although a freshwater species, prawn needs higher salinity level from early stages to juvenile stage, it can survive and grow normally in salinity up to 8 ppt. The year-round salinity level of the South-West coastal region provides the opportunity for horizontal and vertically expansion of prawn farming is, therefore, enormous. If prawn and green back mullet could be cultured along with shrimp it would be an appropriate technique to minimize the production loss of farmers due to sudden disease outbreak in main crop of shrimp. By considering these backdrops, the current study was carried out to investigate the production performance of these three species in polyculture with different stocking densities.

Materials & Methods

Study area and Duration

The study was conducted in the pond complex of the Bangladesh Fisheries Research Institute (BFRI), Brackish water station, Paikgacha which is located at 22° 28-22° 43' N, 89° 09'- 89° 23' E in Khulna district of Bangladesh. The experiment was carried out in nine earthen ponds of 0.1 ha each for 90 days in shrimp and 178 days for mullet and prawn.

Pond Preparation

Ponds were prepared following drying, liming (CaO, 250 kg/ha) and then filling with tidal water up to a depth of one meter. The water of the ponds was treated with chlorine at the rate of 20 ppm. The buffering capacity of water of the ponds was strengthened by applying dolomite at the rate of 20 ppm. Fertilization with urea, TSP and molasses was done at the rate of 2.5 ppm, 3.5 ppm and 3.0 ppm respectively.

Stocking

On 30 April 2018, after production of sufficient plankton required quantity of specific pathogen free (SPF) shrimp post larvae (PL) was acclimatized with the pond water and stocked to the in-pond nursery made up of nylon net and bamboo frame. Shrimp and green back mullet were stocked at a rate of 25,000 and 5,000 individuals/ha respectively in each pond whereas prawn were stocked at a rate of 10000, 15000 and 20000 individuals/ha under treatment-1 (T1), treatment-2 (T2) and treatment-3 (T3), respectively. Green back mullet and prawn were stocked in 27 may, 2018 when salinity was decreased. Before stocking the initial mean weights of the fingerlings were measured using sensitive balance (OHAUS Model CS-2000).

Feeding

In the nursery, the stocked PL and fries were fed with CP nursery feed. Feed was supplied by spreading at the rate of 100%, 80% and 60% of their estimated biomass on daily basis at 6h intervals in the 1st, 2nd and 3rd week respectively. Shrimp and prawn were fed with commercial CP shrimp feed and green back mullet were fed with commercial CP carp feed at the rate of 10-3% of their estimated body weight.

Growth measurement

The growth of experimental fishes was observed weekly basis for each pond by adopting simple random sampling method. At least 30 fishes were sampled with the help of a cast net to measure the growth to assess the health status and to adjust the amount of feed supplied to the fishes.

Physico-chemical properties

Water quality parameters such as temperature, water depth, transparency, dissolved oxygen (DO), salinity and pH were determined weekly basis using a Celsius thermometer, a graduated pole, a Secchi-disk, a portable dissolved oxygen meter (HI 9142, Hanna Instruments, Portugal), refractometer and a portable pH meter (HI 8424, Hanna Instruments, Portugal), respectively. Water quality parameters were determined following standard methods (APHA, 1992) [9]. Total alkalinity was determined following the titrimetric method according to the standard procedure and methods (Clesceri *et al*., 1992) [10].

Harvesting

After 90 days of culture, shrimp were harvested by netting and after 178 days of culture each pond was pumped out and all prawn and green back mullet were harvested. After harvesting growth and production of all fishes were estimated and compared.

Data Analysis

The mean values for growth, survival and production were tested using one-way analysis of variance (ANOVA), followed by testing of pair-wise differences using Duncan's Multiple Range Test (Vann, 1972) [11]. Level of significance was fixed at the 5%. All statistical analysis was done by using the SPSS (Statistical Product and Service Solutions) version-21.5. The graphs of water quality parameters were performed using Microsoft Excel.

Results & Discussion

Water quality parameters

Water temperature of different ponds varied from 25-33ºC. Salinity of water was almost same in all ponds which varied from 05-13 ppt (Table-1). Salinity steadily increased from April until reached its peak at June (13 ppt) then it showed sharp fall till October (5 ppt) due to the onset of monsoon. Depth of water was recorded 85-102 cm in T1, 81-102 cm in T2 and 82-105 cm in T3. Water transparency varied from one pond to another. Transparency of water was recorded 28-89 cm in T1, 18-63 cm in T2 and 18-65 cm in T3 which indicate the prevalence of sufficient plankton. Dissolved oxygen was congenial throughout the culture period and varied from 5.82-9.47 mg/l, 6.07-8.85 mg/l and 5.37-9.89 mg/l in T1, T2 and T3 respectively.

Table 1: Water quality parameters under different treatments during rearing period

Parameters	T1	T2	T3
Temperature (°C)	25-33	25-33	25-33
Salinity (ppt)	5-13	5-13	5-13
Depth (cm)	85-102	81-102	82-105
Transparency (cm)	20-89	18-63	18-65
pH	8.0-9.2	8.0-9.2	8.1-9.3
Total Alkalinity (mg/l)	91-148	97-133	90-171
Dissolved oxygen (mg/l)	5.82-9.47	6.07-8.85	5.37-9.89
Free CO_2(mg/l)	0.0-0.0	0.0-0.0	0.0-0.0

Total alkalinity level of water was suitable to support the primary production for all ponds, found to vary from 91-148 mg/l in T1, 97-133 mg/l in T2 and 90-171 mg/l in T3. Water pH of all ponds slightly decreased with the progress of culture period but it did not decrease below critical value and was always alkaline. The pH value varied from 8.0 to 9.2 in T1, 8.0 to 9.2 in T2 and 8.1 to 9.3 in T3. Free carbon dioxide of water of all ponds was recorded 0.0 mg/l.

Temperature is one of the critical physical modifiers that influence on energy flow, growth and biological effects in marine organisms (Brett, 1979) [12]. Defective production will be occurred when the water temperature falls out of optimum temperature range for significant epoch. Wickins and Lee (2008) [13] suggested that more than 30 °C temperature is optimum for small shrimp (<5 g) while for large shrimp; the optimum temperature is about 27 °C. Similarly shrimp yield was found increased in pond between 26 °C and 28 °C temperatures and yield was impaired when temperature was above 33 °C (Abdelrahman *et al*., 2018) [14]. The optimum range of water pH for shrimp culture is 7-9 (Boyd, 1982) [15]. Besides, several authors have reported a wide variation in pH (7.5-9.2) (Hoq, 2002) [16] and 7.68-8.35 (Shofiquzzoha *et al*., 2001)[17] in shrimp farms and found the ranges favorable for shrimp culture. Hence, pH values in all the shrimp *ghers* were observed within these ranges. The transparency is mainly depends on the presence of phytoplankton population. Wahab *et al*., (1994) [18] found transparency depth ranging from 15.0 to 74.0 cm in polyculture ponds whereas the transparency of present study was between the ranges of 18-89 cm. The recorded alkalinity of the selected ponds was between the ranges of 90-171 mg/l which is closely similar as (Debnath *et al*., 2013) [19]. DO is considered as one of the crucial factor for shrimp culture (Lin *et al*., 2003; Cobo *et al*., 2014) [20, 21]. The DO level of the experimental ponds varied between 5.37-9.89 mg/l whereas, Banerjea (1967) [22] considered 4-8 ppm of DO as favorable range for shrimp culture and (Zhang *et al*., 2006) [23] reported that dissolved oxygen content of a shrimp farm should be >4.0 mg/I.

Growth and Production Performance

Growth performances of prawn at different stocking densities during 178 days of rearing period are given in figure-1.

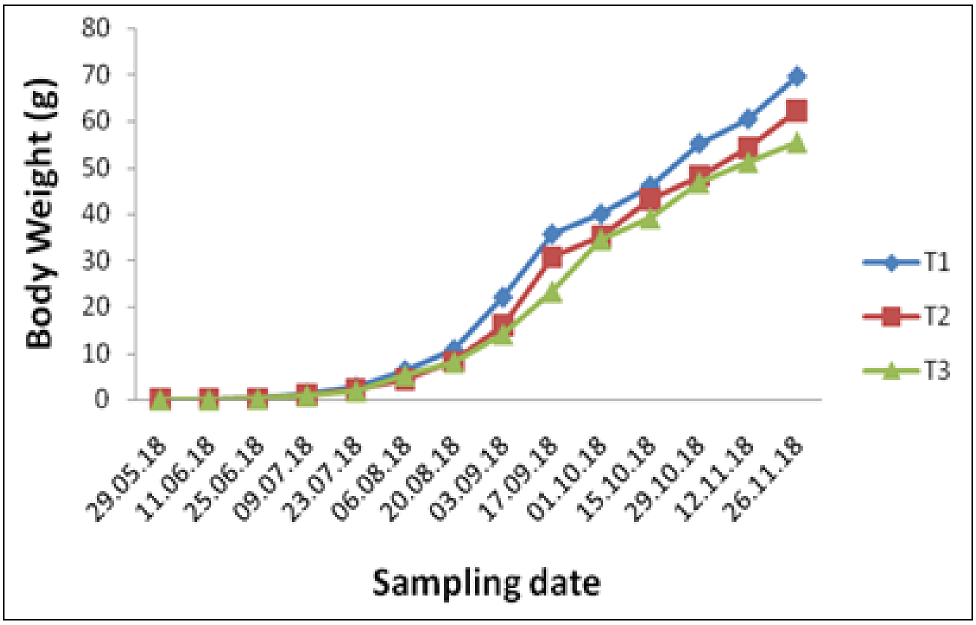

Fig 1: Growth trend of prawn in polyculture with different stocking densities during rearing period

Final weight of prawn and green back mullet was highest in T1 while final weight of shrimp was highest in T2 than other treatments (Table 2). Stocking density is an important parameter which directly affects the growth of fish and its production (Backiel and Lecren, 1978) [24].

Table 2: Details of Stocking density, growth, survival rate and production of shrimp, prawn and green back mullet under different treatments during rearing period.

Treatment	Species	Stocking density/ha	Initial weight (g)	Final weight (g)	Survival (%)	Production (Species wise, kg/ha)	Total production (kg/ha)
T_1	Shrimp	25000	0.007	30.68±1.86	74±4.6	567.58±7.65	1127.35[c]
	Prawn	10000	0.007	64.73±12.45[a]	64.57±2.8	418.15±24.78[b]	
	mullet	5000	0.18	29.0±2.56	97.67±4.3	141.62±7.12	
T_2	Shrimp	25000	0.007	30.77±1.76	81.59±4.8	627.63±8.42	1545.68[a]
	Prawn	15000	0.007	64.27±12.32[a]	80.98±4.7	780.68±111.18[a]	
	mullet	5000	0.18	28.76±4.67	95.53±6.3	137.37±15.32	
T_3	Shrimp	25000	0.007	30.40±2.44	72.72±2.7	552.67±8.77	1449.92[b]
	Prawn	20000	0.007	63.31±15.24[ab]	60.0±3.6	759.72±134.35[a]	
	mullet	5000	0.18	28.30±7.58	97.2±4.1	137.53±8.9	

Different superscript differ significantly ($P<0.05$).

These phenomena indicated that lower stocking density reduces competition among the fishes which influenced them to take feed properly and it might be absent in the treatments with higher stocking densities. The present results coincide with the findings of Kawamoto *et al*. (1957) [25] who achieved best growth at lower stocking densities in *Heteropneustes fossilis* farming. Survival rate of shrimp (81.59%) and prawn (80.98%) was highest in T2 whereas, survival rate of green back mullet (97.67%) was highest in T1 among all treatments. On the contrary, lower survival rate of shrimp and prawn might be happened due to transportation stress. However, Mollah (1985) [26] reported that bigger size and higher survival rate was found in the lower density in *Clarias macrocephalus*. Final weight of mullet was 29.0 g, 28.76 g and 28.30 g in T1, T2 and T3 respectively. This lower growth might be found probably due to interspecies interaction of green back mullet when it attained juvenile stage. Final weight (64.73 g) of prawn was found significantly ($p<0.05$) highest in T1 after 178 days of culture among other treatments which was similar with the findings of Islam *et al.* (2015) [27] where they found 48.2 g after 225 days of culture of prawn. Total production was 1127.35, 1545.68 and 1449.92 kg/ha at T1, T2 and T3 respectively where T2 showed significantly ($p<0.05$) highest total production among others. Production of prawn was significantly ($p<0.05$) highest (780.68 kg/ha) in T2 than other treatments. It might be due to the highest survival in T2 than other treatments. The present result supports the findings of Kohinoor *et al.* (2012) [28] who achieved the best production from higher stocking densities compared to that achieved with the lower ones. In this experiment, prawn showed higher survival with the stocking density of 15000/ha. Therefore, it can be concluded that polyculture of shrimp, prawn and green back mullet with a combine stocking density of 45,000/ha would be suitable for coastal aquaculture.

Conclusion

Considering the survival, final weight and production of prawn as well as overall production in this study, it can be concluded that 15,000 PL/ha stocking density of prawn can be recommended for polyculture of *M. rosenbergii* with *P. monodon* and *C. subviridis* in southwest coastal Bangladesh. Therefore, these will pave the way to the coastal shrimp farmers to minimize the production loss due to sudden crop failure for viral diseases and to expand the cost effective culture of these species in the coastal area of Bangladesh.

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