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Impacts of inclusion of column feeder rohu (*Labeo rohita*) at different stocking densities on growth, production and environment in freshwater prawn-carp-mola polyculture system

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Abstract

The research investigated the impacts of inclusion of column feeder rohu (*Labeo rohita*) on growth and production in freshwater prawn-carp-mola polyculture system for a period of 172 days. Four stocking densities of Rohu were maintained as 500, 1,000, 1,500 and 2,000 ha^{-1} in treatment R_{500}, R_{1000}, R_{1500} and R_{2000}, respectively in triplicates. All ponds each 120 m^2 were stocked with juvenile freshwater prawn (*Macrobrachium rosenbergii*), silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*) and small fish mola (*Amblypharyngodon mola*) at the fixed stocking densities of 20,000, 1,500, 1,000 and 20,000 ha^{-1}, respectively. Prawns were fed with pelleted feed twice daily started with 10% and gradually reduced to 3% of body weight and continued throughout the study period. All fish were fed with mixture of soaked rice bran and mustard oilcake (2:1) at the rate of 3% of the body weight daily. All the water quality parameters and chlorophyll-a were measured. The density of rohu significantly ($P<0.05$) influenced the survival rate, growth and production of freshwater prawn. Catla and Mola production were affected adversely with increasing rohu density. The production of rohu increased with increasing density although the individual weight decreased. The combined production of all finfish was significantly lower in R_0 whereas, the combined production of all species including prawn did not differ significantly ($P<0.05$) among the treatments. The treatments R_0 and R_{500} fetched higher net profit without significant difference between them. Therefore, inclusion of rohu at a density of 500 ha^{-1} may be recommended for prawn-carp-mola polyculture.

***Keywords**: Rohu (Labeo rohita), growth, production, prawn-carp-mola polyculture.*

1 Introduction

Polyculture of prawn with finfish has the potential of increasing total yield as well as income, particularly as prawns have higher commercial value than most finfish (Zimmerman and New, 2000). In Bangladesh, several species, usually 5-7 of large carps are stocked in the polyculture systems. Both native and exotic species are stocked together, many of them have been found antagonistic to each other (Wahab and Ahmed, 1991). Prawns are omnivorous (Ling, 1969) and eat algae, aquatic plants, mollusks, aquatic insects, worms and other crustaceans. Cohen and Ra'anan (1983) have classified prawn as a benthopelagic omnivore. Silver carp is an important candidate species in the polyculture systems in Bangladesh (Wahab et al., 1995). Catla is the fastest growing fish among the three Indian major carps and a suitable species for polyculture. Rohu (*Labeo rohita*) is a herbivorous carp fish of family cyprinidae. Mola, *Amblypharyngodon mola*, is rich in micronutrients and vitamin-A content (Thilsted et al., 1997) and easily be consumed as food fish by the farmers for their family nutrition. Mola is particularly important as the fish contains more available vitamin A than any other edible fish species in this country (Ahmed 1981). Zafri and Ahmed (1981) reported that mola contains 200 IU of vitamin A per gram of edible protein. A medium size mola fish contains about 2.0 g edible protein in its muscles, which contain 400 IU of vitamin A. This means that four mola if eaten daily may provide more than 1500 IU of vitamin A, sufficient to save a child from night blindness caused by shortage of vitamin A. Development of appropriate culture technologies is one of the most important issues in Bangladesh to contribute to the national economy and to improve the standard of living of people through production of freshwater prawn along with high valued carps and nutrient rich small fish. To address this issue present study was designed to investigate the impacts of inclusion of column feeder rohu, *Labeo rohita*, an important major carp on growth and production and pond ecosystem in prawn-carp-mola polyculture system.

2 Materials and methods

The experiment was carried out for a period of six months from 15 June and 3 December, 2009 at the Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. Fifteen earthen ponds with an area of 120 m^2 each and an average depth of 1 m were used for this study. Four treatments named as R_{500}, R_{1000}, R_{1500} and R_{2000} with inclusion of rohu at different stocking densities (500, 1,000, 1,500 and 2,000 ha^{-1}, respectively) were compared with a control devoid of rohu (R_0) each with three replications. All ponds were stocked with juvenile freshwater prawn (*Macrobrachium rosenbergii*), silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*) and small fish mola (*Amblypharyngodon mola*) at the fixed stocking densities of 20,000, 1,500, 1,000 and 20,000 ha^{-1}, respectively as well. All ponds were drained out and prepared by removing weeds, predators and other fishes from the ponds. Afterwards, the ponds were treated with agricultural lime @ 2.5 kg/pond (250 kg ha^{-1}). To promote algal growth ponds were fertilized with organic and inorganic fertilizers. Urea, TSP (Triple Super Phosphate) and cowdung were applied @ 250g, 250g and 7.5 kg/pond (750 kg/ha) respectively. Fresh water prawns were fed with pellets (28% crude protein) daily at a rate of 10% for first month, 8% for the second month, 6% for the third month and 3% for rest of the culture period. Half of the daily feed was applied in the morning and rest half in the evening. Rohu were fed with mixture of rice bran and mustard oilcake (2:1) at the rate of 3% of the body weight daily. All ponds were fertilized with organic (cow manure) and inorganic fertilizer (urea and TSP) in each 15 days interval. A number of water quality parameters such as temperature (°C), transparency (cm), pH and dissolved oxygen (mg/l) were recorded weekly using a commercial kit box (Model: FF-3, USA). Total alkalinity, NH_3-N, NO_2-N, NO_3-N, PO_4-P, and chlorophyll-a were monitored fortnightly by using HACH kit (DR 2010). Fish were sampled monthly by using a seine net. Weight of 10 fishes of each species was measured separately to assess the health condition and growth of fishes using a portable balance (OHAUS, model No.CT-1200-S). Final harvesting was done by de-watering the ponds. During harvesting all fishes of each pond were collected and weighed individually to assess the survival rate and production.
Specific growth rate (SGR) was estimated as;
SGR = [Ln (final weight)-Ln (initial weight) x 100]/ culture period (days).
For the statistical analysis of the data, a one-way ANOVA (Analysis of Variance) and Tucky's test were done by using the SPSS (version-12.0) and the significance was assigned at 5% level.

3 Results

3.1 Water quality parameters

Temperature, transparency, pH and Dissolved oxygen (DO) concentration of pond water, measured weekly throughout the experimental period, were found almost identical in all treatments in every sampling dates without showing significant difference (P>0.05) among the treatments (Table 1). Water transparency in terms of Secchi disk readings ranged within 25 and 46 cm. Temperature of pond water was found to be more or less similar in different treatments. Water temperature ranged from 28 – 32ºC. Water pH ranged within 6.4 and 8.7. Dissolved oxygen concentration ranged within 4.65 and 5.89 mg l^{-1}.

Table 1: Mean (±SD) of Water quality parameters as obtained under 5 treatments.

Parameters	Treatments					F value	Level of significance
	R_0	R_{500}	R_{1000}	R_{1500}	R_{2000}		
Transparency (cm)	34.52± 5.84	34.53± 5.95	34.47± 6.43	36.20± 5.32	36.13 ± 5.84	1.435	NS
Temperature (ºC)	30.23± 0.91	30.25± 0.92	30.21± 0.94	30.15± 0.89	30.17 ± 0.89	0.134	NS
Total Alkalinity (mg l^{-1})	59.33± 15.24^{ab}	65.50± 13.94^{a}	65.70± 18.36^{a}	53.70± 13.56^{b}	61.13± 13.61^{ab}	3.257	*
pH	7.23± 0.41	7.17± 0.37	7.17± 0.40	7.09± 0.54	7.13± 0.34	0.949	NS
Dissolved Oxygen (mg l^{-1})	5.34± 0.57	5.36± 0.53	5.36± 0.52	5.38± 0.52	5.35± 0.48	1.435	NS

Means with the different superscripts in same row are significantly different (P< 0.05).
Total alkalinity of water was found to be ranged from 38 to 104 mgl^{-1} and there was no significant difference (P>0.05) among treatment R_0, R_{500}, R_{1000}, R_{1500} and R_{2000} but significant difference was observed in treatment R_{500} with treatment R_{1500} (Table 1). There were no treatment effects (P>0.05) on overall mean concentrations of inorganic nutrients (nitrate, nitrite and phosphate, except ammonia) but significant effects (P<0.05) of different sampling dates (time effects) on those were observed (Fig.1).

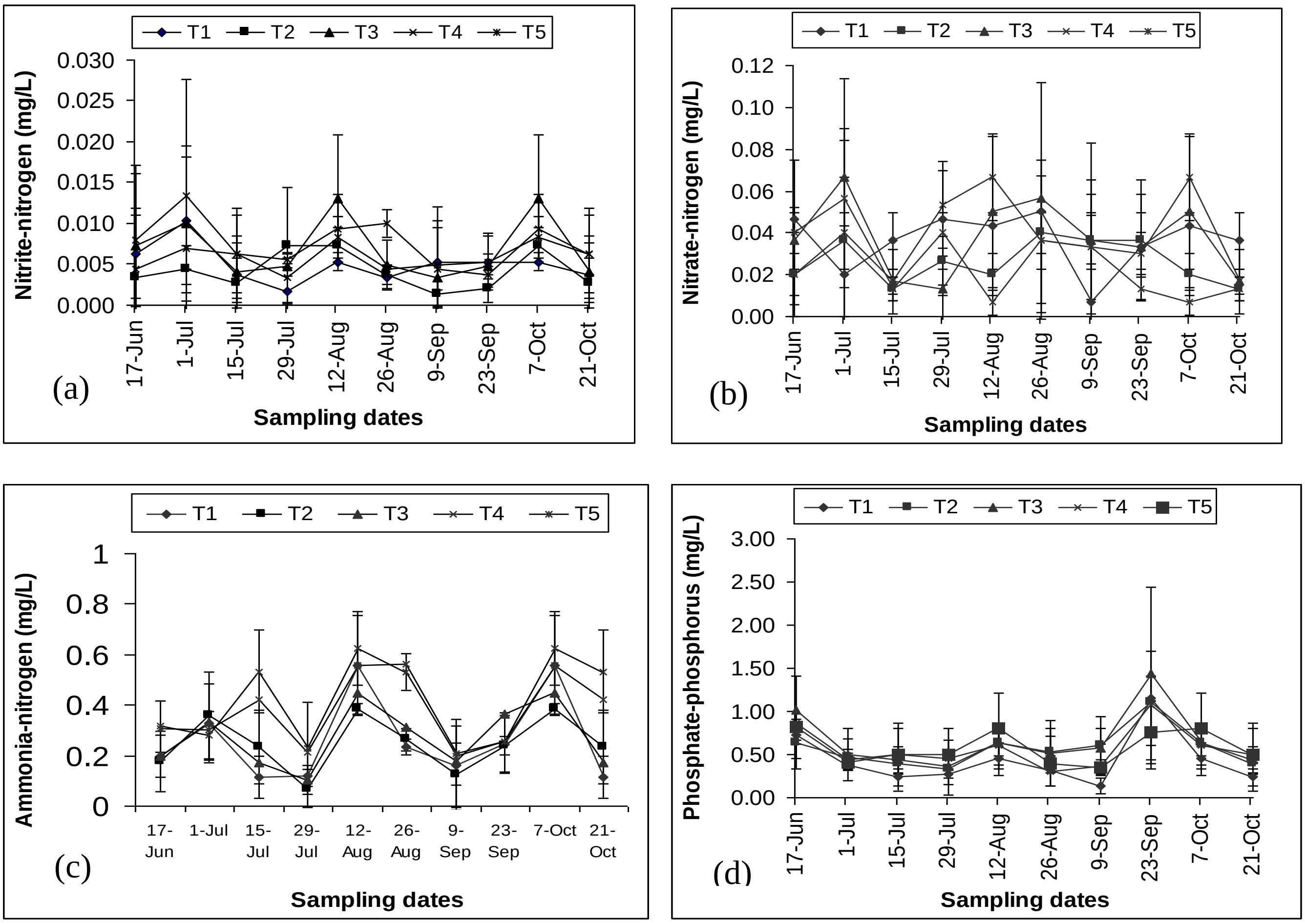

Fig. 1: Concentrations of (a), nitrite (b) nitrate, (c) ammonia, and (d) phosphate in different treatments. Values are means (± SD) at bi-weekly sampling dates throughout the experimental period.

3.2 Growth and production performance of fish:

Growth and production of prawn and fish were varied from treatment to treatment. Gross and net production of prawn (553 kg and 534 kg ha^{-1}, respectively) was significantly higher (P<0.05) in control i.e. in absence of rohu (R_0) (Table 2). Prawn production decreased gradually with increased rohu density. Silver carps growth and production did not vary significantly (P>0.05) among treatments regardless of rohu density. The gross production of silver carp ranged from 789 kg to 879 kg ha^{-1}. Catla performed higher gross production (287 kg ha^{-1}) in R_0 and lower in R_{2000} (184 kg ha^{-1}). Gross production of mola ranged from 86 kg to 105 kg ha^{-1} (Table 2).

3.3 Performance of fresh water prawn:

The growth performances of fresh water prawn in all treatments are shown in Table 2. The yields of prawn were significantly different among the treatments (P<0.05). The highest yield of prawn was resulted in treatment R_0 (534 ± 4 kg ha^{-1}) and the lowest yield was resulted in treatment R_{2000} (368 ± 4 kg ha^{-1}). Survival rate, mean weight at harvest and net production were significantly different among the treatments (P<0.05). The net production of prawn in different treatments was significantly different (P<0.05). There was a strong negative relation (R^2 = 0.943) between rohu density and prawn production (Fig. 2).

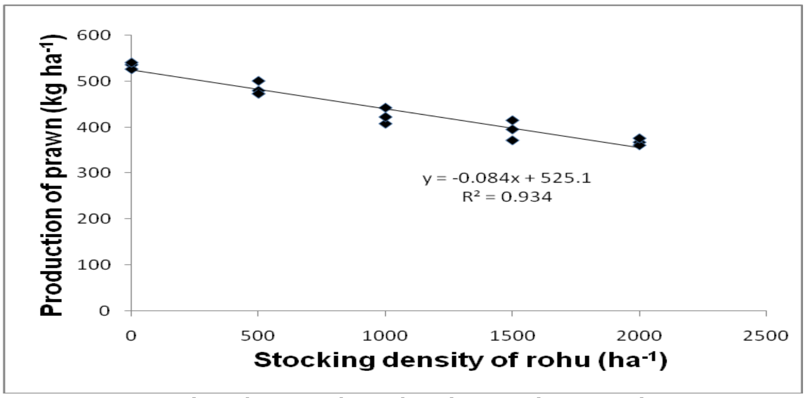

Fig. 2: Relation between rohu stocking density and prawn production

3.4 Performance of rohu:

The stocking density of rohu (0, 500, 1000, 1500 and 2000 ha^{-1}) in different treatments was the variable in the study. The highest yield of rohu 353 ± 17 kg ha^{-1} was observed in treatment R_{2000} due to highest stocking density of rohu. The lowest yield was observed in treatment R_{500} (175 ± 8 kg ha^{-1}). Individual growth performance of rohu was better in R_{500} (185 kg ha^{-1}) whereas, higher gross and net productions of this fish were resulted in the treatment R_{2000} (353 kg ha^{-1}) where stocking density of the species was higher. The yields were significantly different among treatments (P<0.05).

3.5 Performance of catla:

Catla reached an average weight of 305.2±17g in treatment R_0, 286.3±12g in treatment R_{500}, 249.6±14.4g in treatment R_{1000}, 265.9±9.7g in treatment R_{1500} and 214.4±16.1 in treatment R_{2000}. Mean harvesting weight, SGR (Specific Growth Rate) and net production were significantly different (P<0.05) among different treatments (Table 2).

3.6 Performance of silver carp:

The highest growth of silver carp was recorded in treatment R_0 and lowest growth was recorded in treatment R_{2000}. Mean harvesting weight, SGR and net production were not significantly different (P<0.05) among the treatments. The growth performance of Silver carp in all treatments is shown in Table 2.

3.7 Performance of mola:

The small indigenous fish species, mola was stocked at a rate of 20,000 ha^{-1}. Mola bred in July in all ponds and larger mola were then harvested partially with 15 days intervals. Mola production differed significantly (P<0.05) among the treatments with lower production in treatment R_{2000} (Table 2).

3.8 Combined production:

The combined net production of all species (prawn, carps and mola) did not vary among the treatments. The net production of all species were 1726 kg ha^{-1}, 1783 kg ha^{-1}, 1803kg ha^{-1}, 1790 kg ha^{-1} and 1700 kg ha^{-1} in 172 days culture period in treatment R_0, R_{500}, R_{1000}, R_{1500} and R_{2000} respectively. The combined production figures in all treatments are shown in Table 2.

3.9 Economics of different treatments:

Economic analysis was performed to estimate the net profit derived from the experiment. Total cost of the experiment was Tk. 1,84,049, 1,93,664, 1,98,356, 2,03,979 and 2,08,834 (Tk./ha/172days) in treatment R_0, R_{500}, R_{1000}, R_{1500} and R_{2000}, respectively. The highest net profit of Tk. 1, 20,359 ha^{-1} 172 d^{-1} was achieved with treatment R_0 and the lowest Tk. 50,068 ha^{-1} 172 d^{-1} with treatment R_{2000}. Net profit derived from different treatments is shown in Table 2.

Table 2: Growth, survival, production and profit derived from different treatments

Treatments	Name of Species	Fish stocked: Mean wt (g)	Fish harvested: Mean final wt (g)	Survival (%)	Yield kg/ha/176 days: Species wise	Net production of all fish	Net profit (BDT)
R_0	Prawn	0.94±0.04	43.4±0.4	63.6±1.1[a]	534±4[a]	1726±32	120359±7094[a]
	Rui	-	-	-	-		
	Catla	20.4±0.1	305.2±17[a]	94.4±2.8	267±8[a]		
	Silver carp	22.4±0.3	608±8	96.3±1.8	845±28		
	Mola	1.25±0.03	-	-	80±4a		
R_{500}	Prawn	0.96±0.02	42.9±0.3[a]	58.6±1.0[a]	484±8[a]	1783±39	103183±9834[a]
	Rui	20.2±0.2	392.4±7.9[a]	94.4±5.6	175±8[c]		
	Catla	20.2±0.2	286.3±12.1[a]	88.9±2.8	235±18[ab]		
	Silver carp	22.5±0.1	568±18	96.3±1.8	812±21		
	Mola	1.26±0.01	-	-	78±1[a]		
R_{1000}	Prawn	0.92±0.02	40.4±0.5[a]	54.7±0.8[bc]	424±10[c]	1803±33	82510± 8587[b]
	Rui	20.0±0.3	319.4±19.9[b]	91.7±4.8	271±9[b]		
	Catla	20.4±0.1	249.6±14.4[ab]	88.9±2.8	201±5[bc]		
	Silver carp	22.7±0.2	601±14	96.3±1.8	834±23		
	Mola	1.28±0.04	-	-	75±2[a]		
R_{1500}	Prawn	0.96±0.01	39.8±0.42[b]	51.8±1.6[cd]	394±13[cd]	1790±34	69170± 7579[bc]
	Rui	20.0±0.1	268.3±7.7[c]	87.0±1.8	321±17[ab]		
	Catla	20.5±0.2	265.9±9.7[ab]	88.9±2.8	208±3[bc]		
	Silver carp	22.8±0.2	598±7	92.6±1.8	797±25		
	Mola	1.28±0.03	-	-	71±2[ab]		
R_{2000}	Prawn	0.96±0.01	39.8±0.4[b]	78.6±0.9[b]	368±4[d]	1700±23	50068± 1818[c]
	Rui	20.1±0.1	231.8±8.5[c]	84.7±14	353±17[a]		
	Catla	20.5±0.1	214.4±16.1	8601±2.8	164±10[c]		
	Silver carp	22.6±0.1	580±4	90.7±1.8	755±17		
	Mola	1.27±0.01	-	-	61±3[b]		

Means with the different superscripts in same column are significantly different (P< 0.05)

4 Discussion

A number of water quality parameters such as temperature, transparency, pH and dissolved oxygen were monitored weekly. Total alkalinity, NH_3-N, NO_2-N, NO_3-N, PO_4-P, and chlorophyll-a were monitored fortnightly and fish growth was monitored at monthly interval. Significant variations (P<0.05) were observed for total alkalinity, NH_3-N and chlorophyll-a among the treatments. Boyd and Zimmerman (2000) suggested the ideal ranges of water temperature as 28 – 32 ºC for grow out phase of M. rosenbergii. Azim et al. (2004) observed water temperature ranged from 28 to 33.1 ºC was suitable for tropical fish culture. Water temperature in the present study varied from 28 – 34 ºC with overall mean of 30.2 ºC in all treatments, which was suitable for prawn and finfish culture. Secchi disk reading becomes lower when the abundance of phytoplankton increases into a water body and vice-versa. Secchi disk visibilities in fertilized ponds fluctuate over time and a transparency between 15 and 40 cm is good for fish culture (Boyd, 1982). In the present study, the water transparencies were found to vary from 25 to 46 cm in different treatments which were similar to the observations of Wahab et al. (1995) and Kohinoor (2000) in Bangladesh. Water pH less than 6.5 or more than 9 - 9.5 for long periods is harmful to reproduction and growth of fish (Mount 1973). According to Boyd and Zimmerman (2000) ideal range of pH for the grow-out phase of *M. rosenbergii* is 7. 8.5. Water pH in the different treatments of present study varied from 7.1 to 8.7, in which only in a few instances pH values exceeded 9.0. Dissolved oxygen (DO) concentration at 9:00 to 10:00 hours ranged from 4.65 – 5.89 mg l^{-1} in different treatments throughout the study period with the mean values of nearly 5.8 mg l^{-1}, which were within the ideal range (3 – 7 mg l^{-1}) recommended by Boyd and Zimmerman (2000). Alkalinity below 30 mg l^{-1} limits primary production in well fertilized ponds (Boyd, 1990). In the present study alkalinity of pond water in all treatments were suitable for the primary production throughout the study period. Nitrogenous compounds such as nitrate, nitrite, phosphate and ammonia were within the recommended ranges for freshwater prawn culture (Boyd and Zimmerman, 2000).

The mean survival rate of prawn in the present study was significantly higher in treatment R_0 (63.6 ± 1.1 %). The overall survival of prawn (50 to 64%) in the present experiment was more or less similar to the reported values in earthen ponds: 62% (Kumar et al., 2000), 52 to 55% (Mazid and Mahmud, 1994) and 57 to 66% (Uddin et al., 2006).

The net production of prawn in the present study ranged between 361- 540 kg ha^{-1} which was higher than those reported by Haque et al. (2003) and Mia (2004). However, Kunda et al. (2008) found net production of freshwater prawn ranged from 268 to 570 kg ha^{-1} 120 $days^{-1}$ which is similar with the present study.

The harvesting weight of rohu was found 216 to 408g which is more or less similar to Azim et al. (2001). Individual growth performance of rohu was better in R_{500} whereas, higher gross and net productions of this fish were resulted in the treatment R_{2000} (393 and 353 kg ha^{-1}, respectively) where stocking density of the species was higher. The combined gross and net production of finfish and prawns did not differed significantly ($P<0.05$) among the treatments. The net production of rohu was 180 to 372 kg h^{-1} in 172 days culture period. The net production of rohu varied due to different stocking densities in different treatments.

The harvesting weight of silver carp was found 564.89 to 626.29 g which is higher than Ahmed (2005) who found mean weight ranged from 189.9 to 280.35 g. Final harvesting weight of catla ranged from 191.36 to 325.00g which is comparable to Islam (2005) and Nahid (2006) who found average weight of catla ranged from 406.19 to 528.43, 258 to 364.40 and 224.72 to 330.34 g. The production of mola in the present study (111to 142 kg ha^{-1}) was comparable to other reported values: 124 to 152 kg ha^{-1} 120 d^{-1}, stocked at a density of 20,000 ha^{-1} with freshwater prawn (Kunda et al., 2008), 52 to 84 kg ha^{-1} 138 d^{-1}, stocked at a density of 25,000 ha^{-1} with major carps (Kadir et al., 2006). The advantage of stocking mola in polyculture is that once stocked, no need of restocking because it breeds at least twice a year under natural conditions (Kohinoor, 2000). The combined net production of prawn and finfish ranged between 1696 to 1835 kg ha^{-1} 172 d^{-1} which is higher than the findings of Asaduzzaman et al. (2006) who reported annual production of freshwater prawn was 412 kg ha^{-1} in monoculture and 390 kg ha^{-1} in polyculture with finfish (660 kg ha^{-1}) in the southeast region of Bangladesh. However, Kurup and Ranjeet (2002) reported that production from polyculture system ranged from 70 to 500 kg ha^{-1} of freshwater prawn and 200 to 1200 kg ha^{-1} of fish.

The net profits were 1, 20,359, 1, 03,182, 82,510, 69,170 and 50,068 (Tk. ha^{-1} $crop^{-1}$) in treatment R_0, R_{500}, R_{1000}, R_{1500} and R_{2000}, respectively. The higher BCR was obtained in treatment R_0 (1.65) followed by R_{500} (1.53), R_{1000} (1.42), R_{1500} (1.34) and R_{2000} (1.24), respectively which indicate that rohu affect the economic return negatively.

5 Conclusion

Inclusion of rohu did not affect the growth and production of silver carp and mola, but catla production was adversely affected. Prawn survival, growth and production were decreased with increasing density of rohu. The overall production of prawn was higher in treatment R_0, but combined production of prawn and finfish was better in treatment R_{500}. Net profit derived from the experiment was high and equal in treatment R_0 and R_{500}. Therefore, inclusion of rohu at a density of 500 ha^{-1} may be recommended for higher production and economic return in prawn-carp-mola polyculture system.

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