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Effects of addition of tilapia in carp-prawn-mola polyculture system

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Abstract

An experiment was conducted with or without addition of Tilapia (*Oreochromis niloticus*) at different stocking densities in a polyculture system. The polyculture consists of catla, rohu, silver carp, prawn and mola at a stocking density of 10, 30, 30, 40 and 100, respectively in 100m^2 ponds in each treatment with three replications. In treatment T_0, no tilapia was added; in treatment T_{10} and T_{20} tilapia were added at 10% and 20% of total number of catla, rohu, silver carp and prawn, respectively. Formulated feed was given twice daily (8.00 h and 16.00 h) at the rate of 1.5% body weight throughout the culture period. Water quality analysis showed that the mean values of water temperature, pH, dissolved oxygen, ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen, phosphate-phosphorus, chlorophyll-*a* were not significantly different among the treatments. Water transparency was found significantly different ($P<0.05$) among the experiments. A total of 45 genera of phytoplankton and 13 genera of zooplankton were identified from the pond water. The abundance of macrobenthic organisms was mostly dominated by Chironomidae. There was no significant difference in the total abundance of benthos among the treatments. The combined net yield increased significantly with the increasing stocking density of tilapia. A simple economic analysis revealed that higher cost-benefit ratio was obtained in treatment T_{20} followed by treatment T_{10} and treatment T_0. Therefore, it is concluded that the polyculture of carp, prawn and mola with 20% tilapia may be a better option considering the production and economic benefits.

Keyword: Carp, Tilapia, Prawn, Mola, Polyculture

Introduction

Fisheries sector plays an important role in the socio-economic development, nutrition supply, employment generation, poverty alleviation and foreign exchange earning of Bangladesh. Fish production from open water capture fisheries has gradually declined during 1985 to 1996 due to modification and reduction of fish habitats, loss of fish breeding and nursery grounds, blocking of migratory channels by construction of flood control drainage (FCD) and flood control drainage and irrigation (FCDI) schemes, water pollution and diseases like Epizootic Ulcerative Syndromes (EUS) etc. In response of gradual decline of inland capture fisheries, aquaculture has evolved to play an important role in the total fish production in this country. Among various aquaculture systems, polyculture is one of the common systems, in which fast growing compatible species of different feeding habits are stocked in different proportions in the same pond. While carps are the most commonly cultured groups in polyculture, some exotic carps have also been introduced in this system in this country for their favorable food habits and rapid growth. Traditional carp polyculture can not fulfill the increasing demand for fish, so culture technologies need to be modified and developed towards higher yields. Carp polyculture with freshwater prawn, mola and an addition of tilapia may be a better option than only carp polyculture. The omnivorous tilapia and other planktivore species might be able to potentially utilize remaining foods in freshwater prawn culture ponds. Therefore, it might have a good advantage to incorporate tilapia with freshwater prawn in carp-polyculture. The present study has been undertaken to achieve the following objectives:

- To assess the impacts of tilapia on some important water quality parameters of fish ponds.
- To determine the effects of addition of tilapia on the growth, survival and production of all species in carp-prawn polyculture system.
- To optimize of stocking density of tilapia in carp-prawn polyculture system.

Materials and Methods

Experimental design

An on station trial was conducted with three treatments with three replications for each. The treatments were T_0, T_{10} and T_{20} and the experimental ponds were randomly allocated for each treatment. The numbers of catla, silver carp, rohu, freshwater prawn, mola were same in all treatments. The variation among the treatments was in treatment (T_0), no tilapia was added; in treatment (T_{10}), tilapia was added at 10% of the total number of fish excluding mola and in treatment (T_{20}), tilapia was added at 20% of total number of fish excluding mola. The number of each fish in each of the ponds is in Table 1.

Table 1. Experimental design showed the number of fish species in each (100 m^2) pond

Fish Species	Treatments		
	T_0	T_{10}	T_{20}
Catla	10	10	10
Silver carp	30	30	30
Rohu	30	30	30
Prawn	40	40	40
Mola	100	100	100
Tilapia	0%	10%	20%

Experimental site

The experiment was carried out for a period of 105 days between November 2006 to February 2007 at the Fisheries Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh. Nine similar sizes (100 m^2) earthen ponds were used for this experiment. The ponds were rectangular in shape, well exposed to sunlight and completely free from aquatic vegetation. The pond embankments were well protected and covered with grasses. The main source of water of these ponds was rainfall, but there was a provision for water supply from a deep tube-well whenever needed. The water depth was maintained to maximum 1m throughout the study period.

Pond preparation

At the beginning, ponds were renovated and cleaned of aquatic vegetation. All unwanted fishes and other aquatic organisms were eradicated by dewatering. Pond dikes were repaired using the excavated bottom soils. The weeds of embankment were also cleaned manually. Quicklime (CaO) was applied to the pond bottom at the rate of 250 kg ha^{-1}. The ponds were filled with water after seven days of liming from adjacent deep tube well. All ponds were fertilized with semi-decomposed cattle manure, urea and Triple Super Phosphate (TSP) at the rates of 3,000 kg ha^{-1}, 25 kg ha^{-1} and 25 kg ha^{-1}, respectively. Semi-decomposed cow manure was applied in each pond mixing with urea and TSP by spreading methods. After the first fertilization and before fish stocking, the ponds were left 10 days to allow plankton development.

Stocking and post stocking management

The fish fry and prawn juveniles were purchased from a commercial hatchery in Mymensingh. Before stocking, all fish fry and prawn juveniles were kept in a hapa for conditioning. The average mean initial weight of catla was 75.9 g, silver carp 86.07 g, rohu 51.6 g; prawn 3.5 g, and mola 0.99 g, in all treatments. In case of tilapia, the average mean initial weight was 9.75 g in the treatment of T_{10} and T_{20}. After stocking of fish and prawn, feeding, fertilization, fish sampling and pond water quality were monitored regularly during the culture period. As the experiment was conducted during the winter season, fish were fed daily at the rate of 1.5% body weight throughout the study period. Half of the required food was applied evenly over the surface of the ponds, in the morning and the rest half in the evening. To keep natural food available in the water, interim fertilization with urea and TSP were done at the rate of 12.5 kg ha^{-1} at every 15 days interval.

Water quality monitoring

Water quality measurements and sample collection were made between 9.00 h and 10.00 h on each sampling day. Water temperature (°C), Transparency (cm), pH and dissolved oxygen (mg l^{-1}) were measured every week in the morning. Total alkalinity, NH_3-N (mg l^{-1}), NO_2-N (mg l^{-1}), NO_3-N (mg l^{-1}), PO_4-P (mg l^{-1}) and Chlorophyll-*a* (µg l^{-1}) were measured on monthly basis. Plastic bottles with stopper having a volume of 250 ml each were used for collection of water samples. Water samples were collected covering all layers of the water using a tube sampler. Then water samples were carried to the laboratory for chemical analysis. Total alkalinity was measured with 50 ml of water sample by 0.02 N Sulfuric Acid (H_2SO_4) titrant and methyl orange as an indicator. 100 ml of water sample from each bottle was filtered through high quality glass micro fiber filter paper (Whatman GF/C) with the help of vacuum pressure air pump for nutrients and chlorophyll-*a* analysis. The filter paper was kept in a test tube containing 10 ml of 90% acetone, ground with a glass rod and preserved in a refrigerator for 24 h. Later, chlorophyll-*a* was determined using a spectrophotometer (Milton Roy Spectronic, model 1001 plus) at 750 nm and 664 nm wave length, following Boyd (1990).

Table 2. Mean values of water quality parameters from three different treatments

Variables	Mean		
	T_0	T_{10}	T_{20}
Temperature (°C)	17.77 ± 0.12	17.92 ± 0.10	17.84 ± 0.12
Transparency (cm)	29.17 ± 0.75	25.75 ± 0.70	27.15 ± 0.44
pH	7.85	7.80	7.79
Dissolved oxygen (mg l^{-1})	6.45 ± 0.03	6.41± 0.03	6.42 ± 0.04
Total alkalinity (mg l^{-1})	110.83 ± 11.79	116.50 ± 9.93	130.67 ±10.01
Ammonia (mg l^{-1})	0.58 ± 0.19	0.56 ± 0.13	0.51 ± 0.14
Nitrite-nitrogen (mg l^{-1})	0.006 ± 0.0005	0.005 ± 0.001	0.005 ± 0.002
Nitrate-nitrogen (mg l^{-1})	0.05 ± 0.016	0.04 ± 0.009	0.02 ± 0.004
Phosphate-phosphorus (mg l^{-1})	2.05 ± 0.39	1.99 ± 0.37	1.81 ± 0.34
Chlorophyll-*a* (µg l^{-1})	142.20 ± 19.49	150.14 ± 22.49	147.56 ± 12.15

Enumeration of plankton abundance

Plankton samples were collected monthly from each pond. For the study of plankton, 10 liters of water sample was taken from different places and depths of the pond and passed through fine (45 µm) mesh plankton net. Filtered samples was taken into a measuring cylinder and carefully made up to a standard volume of 45 ml. Then the collected plankton samples were preserved in 10% buffered formalin (i.e. 5 ml) in each small plastic bottle for subsequent studies. From each 50 ml preserved sample, 1 ml sub-sample was examined using a Sedge wick-Rafter cell (S-R cell) and a binocular microscope (Olympus CH-40) with phase contrast facilities. One ml sub sample from each sample was transferred to the cell and then all planktonic organisms present in 10 squares of the cell chosen randomly were identified and counted. Plankton identification was performed following APHA (1992) and for each pond; mean number of plankton was recorded and expressed numerically per liter of water. The quantitative estimation of plankton was done using the following formula:

$N = (P \times C \times 100)/L$ (Azim et at., 2001)

Where,

N = the number of plankton cells or units per litter of original water
P = the number of plankton counted in ten fields
C = the volume of final concentrate of the sample (ml)
L = the volume (liters) of pond water sample

For each pond, mean number of plankton was recorded and expressed numerically in per liter of water.

Table 3. Mean values of total plankton abundance (cells 1^{-1}) in different treatments

Variables	Mean		
	T_0	T_{10}	T_{20}
Bacillariophyceae	36000.00 ± 13.0	16300.00 ± 4.9	12500.00 ± 3.2
Chlorophyceae	30000.00 ± 3.4	26500.00 ± 3.7	19900.00 ± 4.2
Cyanophyceae	4600.00 ± 0.8	2300.00 ± 0.6	3300.00 ± 0.8
Euglenophyceae	11600.00 ± 3.6	7900.00 ± 2.1	5100.00 ± 1.4
Rotifera	2500.00 ± 0.7	2600.00 ± 0.5	2300.00 ± 1.0
Copepoda	600.00 ± 0.1	300.00 ± 0.1	300.00 ± 0.1
Cladocera	500.00 ± 0.1	1000.00 ± 0.4	800.00 ± 0.2
Crustacean larvae	1100.00 ± 0.2	600.00 ± 0.1	800.00 ± 0.2
Total plankton	87100.00 ± 16.9	57800.00 ± 7.8	45400.00 ± 9.1

The mean values of total plankton (cells l^{-1}) in three different treatments were recorded on monthly basis.

Determination of benthos fauna

Macrobenthos samplings were carried out monthly by using Ekman dredge (covering an area of lower month 225 cm^2). The dredge was allowed to settle on the bottom, the jaws were closed using a metallic messenger and sample was drawn up to the surface. Each sample was washed through a series of standard brass sieves of mesh sizes 0.2 mm for a preliminary separation of benthos and larger particles from mud and water. Three samples were taken from three random site of each pond. Collected organisms were preserved in 10% formalin for laboratory analysis. The organisms were classified and counted according to different taxonomic groups. The abundance of macroscopic organisms was expressed as density (individuals m^{-2}) following Welch (1948):

$$N = [O/ (A \times S)] \times 10000$$

Where,

N = number of macroscopic organisms in 1 square m of profundal bottom.
O = number of organisms actually counted.
A = transverse area of Ekman dredge in square cm.
S = number of samples taken at one sampling station.

Table 4. Mean values of different groups of benthic fauna (individual's m^{-2}) from three different treatments

Variables	Mean		
	T_0	T_{10}	T_{20}
Chironomidae	659.26 ± 71.01	693.83 ± 145.74	695.47 ± 136.26
Oligochaeta	211.52 ± 41.09	362.14 ± 51.63	358.03 ± 63.63
Molluscs	24.69 ± 4.48	28.81 ± 5.92	142.39 ± 37.69
Miscellaneous	155.56 ± 17.89	153.91 ± 27.29	114.40 ± 12.66
Total benthos	1051.03 ± 85.36	1238.68 ± 176.05	1310.29 ± 171.38

The mean values of different groups of benthic fauna (individual's m^{-2}) in three different treatments were recorded on monthly basis. Values are means of 4 sampling dates and three ponds (N=12).

Sampling and harvesting of fish and prawn

Monthly sampling of fish and prawn was done to check the health condition of fish and prawn. Feeding rate was calculated from the average weight of fish and prawn for each period. Ten random samples of fish and prawns were taken to make some rough assessment of growth trends. At the end of the experiment, fish and freshwater prawn were harvested and counted for total number separately. The individual length and body weight of fishes recorded by a wooden measuring board with precision of 0.1 cm and a digital balance (Denver-xp-3000; precision = 0.1g), respectively. Specific growth rate (SGR), food conversion ratio (FCR), and net yields were calculated as follows:

SGR = [Ln (final weight – Ln (initial weight)] ×100/ No. of days of the experiment
FCR = Feed applied (dry weight)/ Live weight gain
Net yield = total biomass at harvest – total biomass at stocking

Statistical analysis

For the statistical analysis of the data, a one-way ANOVA and DMRT were done by using the SPSS (Statistical Package for Social Science) version 11.5. Significance was assigned at the P<0.05 level of significance. Duncan's test was used to determine the results of multiple ranges for comparisons of averages.

Results and Discussion

Water quality parameters

Water quality parameters of a large number of samples were analyzed (Table 2) in this experiment to observe any appreciable changes that might have occurred. The water temperature, dissolved oxygen (DO), pH, NH_3-N, NO_2-N, NO_3-N and PO_4-P of the experimental ponds did not show any significant difference (*P>0.05*) among the treatments. Water transparency varied in different ponds under different treatments. The significantly higher values were observed in treatment T_0 and than treatments T_{10} and T_{20}. Alkalinity in pond-water of different treatments ranged from 42 mg l^{-1} to 184 mg l^{-1} with the highest in T_0 and lowest in T_{10}. The concentrations of chlorophyll-*a* in ponds ranged from 14.28 µg l^{-1} to 271.32 µg l^{-1}. The highest (271.32 µg l^{-1}) and the lowest (14.28 µg l^{-1}) chlorophyll-*a* concentrations were recorded in T_0 and T_{20}, respectively.

Plankton abundance

Forty five genera of phytoplankton belonging to different groups with Chlorophyceae (22), Bacillariophyceae (12), Cyanophyceae (08) and Euglenophyceae (03) were found in the experimental ponds. The mean abundance of plankton under different treatments are shown in Table 3. Among 4 groups of phytoplankton, Chlorophyceae was the dominant group in all treatments, Bacillariophyceae was the second and Euglenophyceae ranked third in respect of abundance. A total of 13 genera of zooplankton belonged to the groups of Rotifera, Copepoda, Cladocera and Crustacean larvae (nauplius) were found in the ponds. *Brachionus, Cyclops* and *Sida* were the dominant zooplankton among all zooplankton.

Benthos production

Three diverse groups such as Chironomidae, Oligochaeta, Molluscs and other unknown species named as miscellaneous group were found in the pond mud during the study period. The abundances of different groups of benthic organism are presented in the Table 4. The mean number of benthic population found in different treatments were 37.2±3.2 individuals m^{-2}, 42.8±4.4 individuals m^{-2} and 33.2±2.7 individuals m^{-2} in T_0, T_{10} and T_{20}, respectively. The Chironomidae was found as the dominant group of benthic fauna, Oligochaeta was found as the second dominant group and the Molluscs was found as minor group among the four different groups of benthic fauna.

Growth and production of fish

The growth performance of fish and prawn in three treatments has been shown in Tables 5. There were no significant difference of initial weights of fish and prawn among the treatments. The average mean initial weights of rohu, catla, silver carp, mola, tilapia and prawn were 51.63±3.33 g, 75.93±2.43 g, 86.07±2.67 g, 1.01±0.02 g, 9.76±0.8 g and 3.47±0.2 g, respectively. The final weight of rohu ranged from 84.4 g to 121.3 g, catla 190.4 g to 208.9 g, silver carp 161.5 g to 221.8 g, mola 1.84 g to 2.13 g and prawn 33.8 g to 42.5 g, respectively. The mean final weights of tilapia were 128.7±15.8 g and 114.6±7.5 g in T_{10} and T_{20}, respectively. The ANOVA showed that there was no significant difference of mean values of Specific Growth Rate (SGR) of all fish among the treatments. The mean survival of rohu, catla, tilapia and prawn were not significantly, different but the mean survival values of silver carp and mola showed significant difference among the treatments. The average mean gross yield (kg ha^{-1}) of rohu, catla, silver carp, mola, tilapia and prawn over 105 days were 287.43±25.03, 198.87±3.33, 523.87±16.0, 15.0±0.57, 168.85±18.65 and 124.27±6.9 kg ha^{-1}, respectively.

Table 5. Comparison of mean (±SE) values of yield parameters of rohu, catla and silver carp in three different treatments

Growth Parameters	Mean		
	T_0	T_{10}	T_{20}
Rohu			
Individual stocking weight (g)	50 ± 1.2	53.8 ± 4.3	51.1 ± 4.5
Individual harvesting weight (g)	106.8 ± 7.5	128.7 ± 6.0	114.6 ± 5.2
Average daily gain (g day^{-1})	0.5 ± 0.07	0.4 ± 0.09	0.5 ± 0.09
Specific growth rate (% day^{-1})	0.72 ± 0.08	0.55 ± 0.14	0.67 ± 0.13
Net yield (kg ha^{-1} $105d^{-1}$)	135.5 ± 38.3	123.4 ± 30.3	138.6 ± 30.9
Gross yield (kg $ha^{-1}105d^{-1}$)	285.5 ± 39.5	284.9 ± 17.5	291.9± 18.1
Survival %	88.9 ± 9.5	98.9 ± 1.1	94.4 ± 1.1
Catla			
Individual stocking weight (g)	75.9 ± 2.4	76.1 ± 3.0	75.8 ± 1.9
Individual harvesting weight (g)	203.9 ± 2.2	198.7 ± 5.4	194.0 ± 2.3
Average daily gain (g day^{-1})	1.2 ± 0.01	1.2 ± 0.03	1.1 ± 0.03
Specific growth rate (% day^{-1})	0.9 ± 0.02	0.9 ± 0.01	0.9 ± 0.03
Net yield (kg ha^{-1} $105d^{-1}$)	128.1 ± 1.9	122.5 ± 3.0	118.25 ± 3.4
Gross yield (kg $ha^{-1}105d^{-1}$)	203.9 ± 2.3	198.7 ± 5.4	194.0 ± 2.3
Survival %	100.0	100.0	100.0
Silver carp			
Individual stocking weight (g)	82.2 ± 3.5	88.3 ± 2.7	87.7 ± 1.8
Individual harvesting weight (g)	175.2 ± 6.8	191.6 ± 16.0	186.4 ± 3.3
Average daily gain (g day^{-1})	0.89 ± 0.09	0.98 ± 0.17	0.94 ± 0.03
Specific growth rate (% day^{-1})	0.7 ± 0.08	0.7 ± 0.09	0.7 ± 0.02
Net yield (kg ha^{-1} $105d^{-1}$)	225.7 ± 21.6	281.4 ± 32.6	289.8 ± 12.0
Gross yield (kg $ha^{-1}105d^{-1}$)	472.3 ± 11.1^b	546.4 ± 28.3^a	552.9 ± 8.6^a
Survival %	90.0 ± 1.9^b	95.6 ± 2.9^{ab}	98.9 ± 1.1^a

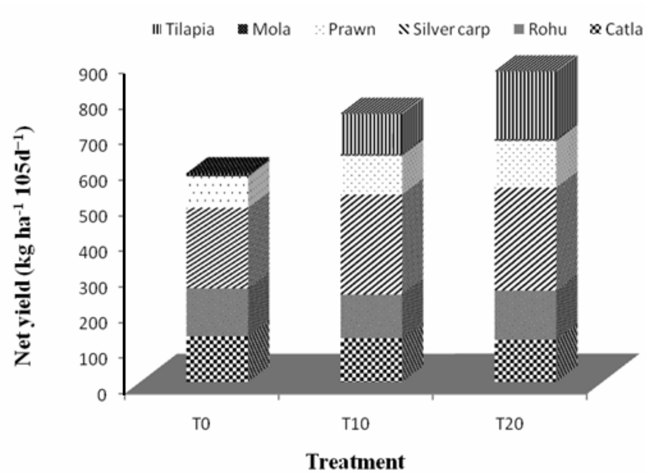

Fig. 1. Net yield (kg ha^{-1} $105days^{-1}$) in all treatments

Economics comparisons

The economic analysis of fish production of each treatment was given in Table 8. The analysis was based on the local market price for fish, prawn and all other items, expressed in Bangladesh Taka (BDT). The economic analysis revealed that significantly higher net return was observed in T_{20} treatment compared to other treatments.

Water quality parameters

The growth and performance of aquatic organisms depend on the water quality of a water body. Water quality includes all physical and chemical parameters that may affect aquatic production. Temperature is an important water quality parameter which was found to vary from 16.1 °C to 19.4 °C in ponds. Wahab *et al*. (1995) recorded the water temperature from 27.2 °C to 32.4 °C in their experimental ponds. Kohinoor (2000) recorded a temperature range of 18.5 °C to 33.3 °C in SIS mola, chela and punti culture in BAU, Mymensingh, which are higher than the present study. The experiment was conducted in winter season, therefore water temperature remained below 20 °C. Boyd (1982) suggested that transparency range from 15 cm to 40 cm is good for fish culture. Rahman (1999) recorded transparency ranged from 12 cm to 46 cm in his experiment in BAU campus, Mymensingh, which is similar to the results of present study. Rahman (1992) reported that the range of pH of a suitable water body for fish culture would be 6.5 to 8.5. pH values in the experimental ponds varied from 6.8 to 8.8, which were similar to the findings of Hossain *et al.* (1997). Total alkalinity more than 20 ppm in fertilized ponds is good for fish culture (Boyd, 1982). Banerjea (1967) and Bhuiyan (1970) recorded alkalinity in their experiments which ranged from 20 to 200, 25 to 100 ppm, respectively. The range of total alkalinity in present study found to vary 42 to 184 ppm. These values are almost similar to the findings of previous studies.

DoF (1996) reported that the range of dissolved oxygen suitable for fish culture should be 5.0 mg l^{-1} to 8.0 mg l^{-1}. The concentration of dissolved oxygen in the experimental ponds ranged from 5.78 mg l^{-1} to 6.83 mg l^{-1}, which was also similar to Alim *et al*. (2003). In culture condition, the lower the value of total ammonia, the better the quality of water for fish. In the present study, concentration of total ammonia ranged from 0.01 mg l^{-1} to 2.31 mg l^{-1}. Wahab *et al*. (1995), Kohinoor *et al.* (1998) recorded NH_3-N from 0.07 mg l^{-1} to 0.23 mg l^{-1} and 0.05 mg l^{-1} to 0.25 mg l^{-1}, respectively in ponds in the BAU campus, Mymensingh, which are similar to the present study.

Available information on safety limits of nitrite-nitrogen is very limited; the suggested maximum level for prolonged exposure in hard fresh water is 0.1 mg l^{-1}. Nitrite-nitrogen in this study remains within desirable ranges (0.001 mg l^{-1} to 0.026 mg l^{-1}) of fish culture. Nitrate-nitrogen (NO_3-N) is the available form of nitrogen to phytoplankton and other aquatic plants, the range of nitrate-nitrogen was 0.01 mg l^{-1} to 0.2 mg l^{-1} which were suitable for pond ecosystem. In the present study, PO_4-P ranged from 0.4 mg l^{-1} to 4.68 mg l^{-1}, which was good for biological production. Chlorophyll-*a* values ranged from 14.28 µg l^{-1} to 271.32 µg l^{-1} similar to the findings of Ahmed (1993), Hassan (1998), Kohinoor (2000), Alim (2005) and Rahman (2005) who recorded chlorophyll-*a* and found to vary from 10 µg l^{-1} to 200 µg l^{-1}; 0.0 µg l^{-1} to 2224.1 µg l^{-1}; 1.2 µg l^{-1} to 1178.1 µg l^{-1} and 33.3 µg l^{-1} to 699.7 µg l^{-1}, respectively, which are almost similar to the present study.

Plankton production

Plankton, especially phytoplankton is an important food component of the aquaculture pond environment. During the study period, a total of 45 genera of phytoplankton and 13 genera of zooplankton were identified. Dewan *et al*. (1991) recorded 27 genera of phytoplankton and 9 genera of zooplankton, and Kohinoor (2000) recorded 34 genera of phytoplankton and 12 genera of zooplankton from BAU campus ponds, Mymensingh which are similar to the present study. The mean abundance of total plankton in different groups was significantly different among three treatments. Chlorophyceae was the most abundant phytoplankton community in treatment T_{10} and T_{20} and Bacillariophyceae was abundant group in treatment T_0. Chowdhury (1999) studied the plankton population in ponds and found Chlorophyceae as the most dominant group. The number of zooplankton was more or less similar in all treatments.

Benthos production

The major groups of benthic fauna recorded from three treatments were Chironomidae, Oligochaeta, and Molluscs. All other unidentified species are grouped into miscellaneous organisms. Chironomidae was the dominant group in this study which might be due to the ecological stability, food availability and sediment characteristics, which were more suitable than other groups. Bose and Lakra (1994) worked on the comparative study of macro benthos of two freshwater ponds in Rachi and found Chironomidae, Oligochaeta, Molluscs in their experiment and Chironomidae was the dominant group. Hirabayashi and Hayashi (1994) worked on horizontal distribution of benthic organisms in lake Kizaki, Japan and observed that the Oligochetes inhibit the entire lake bottom. Singh and Singh (1996) identified Oligochaetes, Hirudineans, Gastropodes and Polecypods in their experiment all ponds in Bihar, India. This study was almost similar to the previous studies in relation to the abundance of benthic organisms.

Growth and production of fish and prawn

The productions of fishes and freshwater prawn in different treatments were found to vary among treatments due to difference in survival and growth rate. The survival of rohu, catla, silver carp and tilapia were higher might be due to the good quality seed and stocking of larger fingerlings. The survival of mola and prawn were relatively lower. Prawn is known to be a sensitive species to the environment and it requires suitable pond ecology for their growth. A significant difference was observed among the combined net and gross yield in different treatments. The yield was calculated on per hectare basis over a 105 days culture period. The highest net and gross yields were found in T_{20} may be due to proper food utilization, most suitable water quality condition in different water strata. Lower yield of catla fish in the present study was found due to its short culture period and winter season. On other, the highest yield of silver carp was found in all treatments where the lowest production of catla was recorded and vice-versa (Paul, 1998 and Hossain, 2006).

The highest number and production of mola was found in T_0 and the lowest number in $T_{20,}$ it indicates that tilapia may have competed for food with mola (Islam, 1997 and Kadir et al., 2006). The highest net and gross yield of tilapia was obtained in T_{20} and the lowest in T_{10}. Tilapia production in the present study was lower in comparison to Fatema (2004), Uddin *et al*. (2004) and Rahman (2005). Because the stocking density of tilapia was lower and the experiment was done during the winter season.

Table 6. Comparison of mean (±SE) values of yield parameters of mola and tilapia in three different treatments

Growth Parameters	Mean		
	T_0	T_{10}	T_{20}
Mola			
Individual stocking weight (g)	0.99 ± 0.02	1.05 ± 0.04	0.98 ± 0.01
Individual harvesting weight (g)	2.03 ± 0.08	1.93 ± 0.05	1.97 ± 0.04
Average daily gain (g day^{-1})	1.03 ± 0.08	0.87 ± 0.05	0.99 ± 0.03
Net yield (kg ha^{-1} 105d^{-1})	8.2 ± 0.8^b	3.2 ± 0.7^b	3.4 ± 0.2^a
Gross yield (kg ha^{-1}105d^{-1})	18.1 ± 0.9^b	13.7 ± 0.7^b	13.2 ± 0.1^a
Survival %	89.33 ± 1.5^b	71.1 ± 1.5^b	67.0 ± 1.0^a
Tilapia			
Individual stocking weight (g)	-	9.22 ± 0.9	10.3 ± 0.7
Individual harvesting weight (g)	-	128.7 ± 15.9	114.6 ± 7.6
Average daily gain (g day^{-1})	-	1.1 ± 0.15	0.99 ± 0.07
Specific growth rate (% day^{-1})	-	2.5 ± 0.18	2.3 ± 0.03
Net yield (kg ha^{-1} 105d^{-1})	-	113.9 ± 15.9^b	191.1 ± 22.2^a
Gross yield (kg ha^{-1}105d^{-1})	-	124.0 ± 15.0^b	213.7 ± 22.3^a
Survival %	-	87.9 ± 6.1	84.8 ± 7.6

Prawn was found higher in T_{20} where there was 20% of tilapia and it indicated that tilapia might have number improved the water quality of the ponds and provided its excreta as an extra food to prawn.

Table 7. Comparison of mean (±SE) values of yield parameters of prawn in three different treatments

Growth Parameters	Mean		
	T_0	**T_{10}**	**T_{20}**
Individual stocking weight (g)	3.5 ± 0.1	3.2 ± 0.4	3.7 ± 0.1
Individual harvesting weight (g)	36.1 ± 1.2	38.3 ± 2.2	41.2 ± 0.4
Average daily gain (g day^{-1})	0.31 ± 0.01	0.33 ± 0.02	0.36 ± 0.01
Specific growth rate (% day^{-1})	2.2 ± 0.06	2.4 ± 0.16	2.3 ± 0.04
Net yield (kg ha^{-1} $105d^{-1}$)	89.3 ± 8.5^{b}	109.8 ± 5.3^{b}	132.1 ± 4.8^{a}
Gross yield (kg $ha^{-1}105d^{-1}$)	103.1 ± 9.1^{b}	122.7 ± 6.8^{ab}	147.0 ± 4.8^{a}
Survival %	71.7 ± 7.12	80.8 ± 7.95	89.2 ± 3.33

Table 8. Comparisons of economics among different treatments based on 1 hectare culture over area 105 days culture period (all figure in BDT)

Variables	Mean		
	T_0	T_{10}	T_{20}
Urea	800.0	800.0	800.0
TSP	2500.0	2500.0	2500.0
Lime	2000.0	2000.0	2000.0
Feed	18000.0	20000.0	21000.0
Carp seeds	21000.0	21000.0	21000.0
Mola seeds	3000.0	3000.0	3000.0
Prawn seeds	24000.0	24000.0	24000.0
Tilapia seeds	-	2200.0	4400.0
Total investment cost (Tk. ha^{-1} 105 d^{-1})	**71300.0**	**75500.0**	**78700.0**
Carps sale	63000.0	62800.0	63200.0
Prawn sale	43300.0	46000.0	49500.0
Mola sale	2500.0	2300.0	1900.0
Tilapia sale	-	7000.0	12400.0
Total returns (Tk. ha^{-1} 105 d^{-1})	**108800.0**	**118100.0**	**127000.0**
Net benefit (Tk. ha^{-1} 105 d^{-1})	**37500.0**	**42600.0**	**48300.0**
Cost-benefit ratio	**1:1.53**	**1:1.56**	**1:1.61**

It may be concluded that, though rohu, catla, mola yields were lower in presence of tilapia but tilapia addition into the polyculture led to higher total yields. The phytoplankton abundance was very dominant in treatment T_0 indicated that without tilapia other species was not able to fully utilize the natural food organisms.

Gross yield of silver carp, tilapia, and prawn in treatment T_{20} was significantly higher than T_0 and T_{10} indicated that it is suitable species combination for pond aquaculture. It also indicated that feed efficiency was maximum and net return was significantly higher in treatment T_{20} compared to other treatments. From this research it was revealed that the culture of carps, prawn, mola and tilapia may be a suitable polyculture technology for rural poor and it would allow simultaneous production of mola for family consumption and large carps, prawn and tilapia as cash crop.

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