E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(4): 223-230

www.fisheriesjournal.com
Received: 17-05-2018
Accepted: 20-06-2018

M Abu Baker Siddique
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

M Shadiqur Rahman
Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Balaram Mahalder
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

M Shafiullah
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

M Musfikur Rahman
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

SM Rahmatullah
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Correspondence
M Shadiqur Rahman
Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Effects of different stocking ratios of carps and pangas on the plankton population of a pond system

M Abu Baker Siddique, M Shadiqur Rahman, Balaram Mahalder, M Shafiullah, M Musfikur Rahman and SM Rahmatullah

Abstract
An experiment was conducted to evaluate the effect of different ration of carps and pangas on the plankton population of a pond system in different three farmers ponds under semi intensive rearing system located at Shamgonj thana under Netrokona district from 01 June 2003 to 31 August 2003. The stocking ratio of rohu, catla, mrigal and pangas were 35:17.5:17.5:30, 30:15:15:40 and 25:12.5:12.5:50 in three treatments. The gut content of carps and pangas were analyzed. A total of 27 genera of phytoplankton under the groups of Bacillariophyceae (4), Chlorophyceae (14), Cyanophyceae (7) and Euglenophyceae (2) and 6 general of zooplankton under the groups of Cladocera (3) and Rotifera (3) were found. Among the phytoplankton groups Chlorophyceae was the dominant group in three treatments. During the study period, total abundance of plankton found higher (91.8×103 /L) in the month of August in T1. On the contrast, less abundance of plankton (56.7×103 /L) was found in the month of June in T3. Among the phytoplankton and zooplankton, Cyanophyceae and Cladocera were higher in the gut content of catla and rohu in T2 and T1 respectively than others treatments. In case of feeding habits, rohu, catla, mrigal and pangas were showed positive response to Bacillariophyceae, Euglenophyceae, Cladocera and Rotifera in three treatments and negative response to Chlorophyceae and Cyanophyceae in T1 and T2 respectively. The significantly highest total production of fishes 2627 kg/acre/90 days was recorded in T1 which was followed by T2 (2553 kg/acre/90 days) and treatment 3 (2448 kg/acre/90 days) respectively.

Keywords: Stocking ratios, carps, pangs, plankton population, pond

Introduction
The basic principle of fish polyculture, i.e. culture of different fish species with different feeding habits in the same pond, is the best utilization of natural foods of different strata and zones without any harm to each other but selection of different fish species plays an important role for any culture practices [1, 2]. Stocking density of different fish species in a polyculture system plays a vital role on overall production of fish. Higher density of a species may affect the growth of another species. Similarly lower density of a species may reduce the overall production. So, for the better utilization of different strata and zones of a pond three or more species with proper ration must be stocked. Ahmed [3] reported that in species selection for polyculture, primary importance was given to Indian major carps; rohu (*Labeo rohita*), catla (*Catla catla*), and mrigal (*Cirrhinus mrigala*). Sometimes calbasu (*Labeo calbasu*) has been included in the polyculture in the pond culture in Indian sub-continent including Bangladesh.

On the basis of national demand, monoculture of pangas was started because of its higher growth rate, but due to its high investment it is limited among some rich farmers. Poor farmers were far away from getting any benefit from pangas culture because of their limited resources for aquaculture. They have the only ability to feed the pangas population partially in their ponds. However, to get the better production it was started by many poor farmers, but they were not able to continue it for the lack of money and at the middle of the culture they bound to sell their small size fish in the market with low price, which causes great economic loss for them. Finding no other alternatives, finally they again get back into the traditional carps culture system, though it is less profitable. These results in decrease of fish production, which ultimately fail to fulfill the protein requirement of the nation.

Many farmers of our country are very poor and they cannot take a risk for pangas culture. On the other hand carp culture is giving them less profit. In order to minimize the farming risks,

carps and pangas polyculture is being practiced by the small farmers. In this system famers are providing feed only for pangas, which is added to carps polyculture with, low stocking density in comparison to monoculture. In this system waste of the feed can be used by the carps directly as food or it can be used to enhance the plankton population in a pond. Carps prefer plankton than artificial feeds. Plankton availability reduced the feed cost for the poor farmers in the carps and pangas polyculture system. The preferences of plankton population are varied by species to species. Plankton plays an important role to enhance the carps production.
Since carps and pangas polyculture is not a new thought in Bangladesh. Their culture is practicing under the level of poor farmers. There is no available information on different ration of carps and pangas in a polyculture system. But there is hardly any published information on the effect different ratio of carps and pangas on the palankton population of a pond system. So, the present study has a significant importance to know the effect of different ratio of carps and pangas on the plankton population of a pond system. Considering the above stated facts the aspects of present study was conducted the effect of different ratio of carp and pangas on the plankton population of a pond system.

Materials and Methods

Description of the study area and experimental design

The experiment was conducted in farmer's pond under semi-intensive rearing system in Shamgonj under Netrokona district for a period of 90 days from 1st June 2003 to 31st August 2003. A total of nine perennial ponds were divided under three treatments i.e. T1, T2 and T3 each having three replicates. In the experiment four species were used. In every treatment the total stocking density was same (100/decimal) with different ratio of carp and pangas. In case of carp only three Indian major carps were used viz rohu (*Labeo rohita*), catla (*Catla catla*), and mrigal (*Cirrhinus mrigala*). The ratios of rohu, catla, mrigal and pangas in the three treatments were at 35:17.5:17.5:30 (T1), 30:15:15:40 (T2) and 25:12.5:12.5:50 (T3), respectively.

Pond preparation

The area of each pond was 0.8 ha with an average water depth of 1.2 meter. All the ponds were more or less similar shape, size, basin conformation and bottom type. The ponds were flood free rain fed, free from aquatic vegetation and well exposed to sunlight. Each ponds have inlet and outlet to provide water and when needed. After selection, at first broken dikes and holes of all ponds were repaired. After that, all kinds of aquatic vegetation (floating, emergent, submerged and spreading) were removed manually and the branches of all trees on the ponds were trimmed off. The predatory and undesirable fishes were eradicated by netting repeatedly and cleaned by poisoning with rotenone at the rate of 5 ppm. Liming was done immediately after poisoning at the rate of 100.0 kg/acre. Three days after liming, all the ponds were manured with cow dung at the rate of 1160kg/acre. After 5 days of liming, urea and TSP were used in all of those ponds at the rate of 9.00 kg/acre and 6 kg/acre respectively.

Fingerling stocking

The experimental carp fry of same size group having average length and weight of 3.8 cm and 3.0 g respectively were collected from farmers having confirmed that the source of fry was BFRI (Bangladesh Fisheries Research Institute), freshwater station, Mymensingh. The carp fry were transferred within polythene bag supplied with O_2. The fry of pangas was taken from the same farmer but the source was not the BFRI. The average length and weight of pangas fry were 6.3 cm and 6.69 g respectively. All the fry were acclimatized with experimental pond water in polythene bag and then stocked at 4.00 PM. The species composition is given in the Table 1.

Table 1: Stocking rate of fry in different treatments

Treatments	Species composition	Stocking ratio	Stocking rate/acre
T1	Rohu	35%	3500
	Catla	17.5%	1750
	Mrigal	17.5%	1750
	Pangas	30%	3000
T2	Rohu	30%	3000
	Catla	15%	1500
	Mrigal	15%	1500
	Pangas	40%	4000
T3	Rohu	25%	2500
	Catla	12.5%	1250
	Mrigal	12.5%	1250
	Pangas	50%	5000

Supplementary feeding

Throughout the experiment for the proper growth of fishes supplementary feed was given to pangas at the rate of 8 to 6% of their body weight.
The feeding was adjusted on the basis of monthly take fish weight. The feed was supplied in the dough form and feeding was done directly without any feeding trays. Half of the ration was supplied at 9.00 AM and remaining half was supplied at 4.00 PM. The composition of experimental feed was wheat bran 20%, rice bran 30%, mustard oil cake 20%, meat and bone meal 20%, wheat 9%, vitamin premix and mineral 1%.

Sampling

Sampling was done monthly in the morning at 9 Am to 10 AM. In each sampling ten fish of each species from each pond were caught by cast net. Among these ten only three from each species were chosen for gut content analysis and the remaining fishes were released in the respective ponds after recording the weight and length. The weight was taken by ordinary balance and length was taken by measuring scale. Chosen fishes from each of the species were killed immediately by heating at the head and then bally were open carefully with the help of a scissor and knife. Only the anterior portion of digestive tract of carps lying between the esophagus and the first major curve of the small intestine was taken instead of the entire gut. This was done because these fishes have not well-defined stomach, and digestion is less advanced in this portion of digestive tract and representative food items mostly identifiable. McComish[4], Mckeehnime and Fenner[5] and Dewan)[6] have also adopted similar methods in their study. In case of pangs, stomach was taken out. By this time sample was preserved in 10% buffered formalin for further study.
Water samples were collected from different depth of the pond for the qualitative and quantitative study of plankton. The collected water sample was preserved with 10% buffered formalin for 7 days to settle down the plankton at the bottom and then concentrated by draining out the upper portion of the sample through siphoning to 15 ml in plastic vials for

subsequent studies. Water temperature was recorded on spot with the help of an ordinary thermometer graduated in centigrade scale. Electronic pH meter was used to measure the pH of water. pH recorded by pH meter (Model-445, UK) on the spot in a same time.

Plankton counting and identification
For the quantitative study of plankton, a drop of the concentrated plankton sample was taken by a dropper and then on the Lund chamber [7], a simple counting chamber for nanoplankton. After pouring the sample, counting chamber was covered with a cover slip so as to eliminate the air bubbles and left to stand for a few minutes to allow the plankton to settle down. Then counting chamber was placed under an electric binocular microscope and the plankton was counted. The mean number of plankton was recorded and expressed numerically per liter of water of each pond. The qualitative analysis of plankton was done according to Ward and Whipple [8], Prescott [9] and Bellinger [10]).

Examination of the stomach content
The stomach of each fish was open with the help of a scissors, forceps and needles, and the contents of it were removed on a petridish to identify the different food items that were eaten the fish. For plankton study, gut contents were taken out and diluted in 15 ml distilled water. The plankton were identified as genera with the help Lund chamber [7], a simple counting chamber for nanoplankton. According to Numerical method [11]-the number of different genera of plankton were recorded. The whole and the part with head of zooplankton were considered as whole during counting.

Electivity index
Electivity index (E) was calculated by applying the formula [12] as:

$$E = \frac{P_g - P_w}{P_g + P_w}$$

Where
P_g is the relative content of any ingredient in the ration expressed as percentage of total ration, and P_w is the relative proportion of the same item in the pond water. The resultant values of E will range from +1 to -1. Positive values indicate selection of particular food items and negative values indicate avoidance.

Growth parameters
To evaluate the fish growth performance length gain (cm), weight gain (g), specific growth rate (SGR%/day), survival rate (%) and production/acre/90 days were measured after end of the experiment.
The following parameters were used to evaluate the growth of experimental fishes:

Length gain (cm) = Mean final length (cm) - Mean initial length (cm)

Weight gain (g) = Mean final weight (g) - Mean initial weight (g)

Specific Growth Rate

$$\textbf{SGR (\% per day)} = \frac{\text{ln final weight} - \text{ln initial weight}}{\text{Number of experimental days}} \times 100$$ [13]

$$\textbf{Survival rate (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

Fish harvesting
After 90 days of culture, all the fishes were harvested by netting repeatedly with seine net from each pond and then counted species wise. Then the final growth gained by each species was recorded by measuring weight (g) and length (cm) of individual fish.

Production
At the end of the experiment most of fishes were caught by net and the rest by drying the pond. It was calculated as:
Production = No. of fish harvested × Mean final weight

Statistical analysis
The data obtained from three different treatments and the abundance of plankton was tabulated for statistical analysis. The growth performance data of the experiment was performed by one way analysis of variance by computer (SPSS package program).

Results
Among water quality parameters only temperature and pH were studied during the period of experiment which were presented in Table 2. The values of water temperature under different ponds were varied from 31.17 to 31.70 ºC throughout the experiment. The highest value was recorded in August in T1 and the lowest value was recorded in June in T2. The pH values of

Table 2: Monthly variation of temperature and pH in different treatments

Parameters	Treatments	June	July	August
Temperature (ºC)	T1	31.2±0.06	31.47±0.05	31.7±0.08
	T2	31.17±0.10	31.45±0.06	31.65±0.06
	T3	31.22±0.05	31.55±0.06	31.62±0.05
pH	T1	7.38±0.02	7.45±0.02	7.42±0.01
	T2	7.31±0.01	7.37±0.01	7.34±0.02
	T3	7.27±0.02	7.30±0.01	7.11±0.02

water were varied from 7.11 to 7.45. The highest pH value of water was recorded in July in T1 and the lowest value recorded in August in T3.

Plankton population
Plankton population in the water of the experimental pond was found to be consisting of 33 genera under 6 planktonic groups. The total planktonic organisms mainly composed of 4 groups of phytoplankton including Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and 2 groups of zooplankton including Cladocera and Rotifera. Total 27 genera of phytoplankton were recorded belonging to Bacillariophyceae (4), Chlorophyceae (14), Cyanophyceae (7)

and Euglenophyceae (2). Six genera of zooplankton were also identified under the groups of Cladocera (3) and Rotifera 93). The highest abundance (91.8 $\times 10^3$/L) of total phytoplankton was found in the month of August in T1 and the lowest abundance (56.7 $\times 10^3$/L) of phytoplankton was found in the month of June in T3. was found in the month of July in T2. On the other hand, the highest abundance (0.12 $\times 10^3$/L) of zooplankton was found in the month of July in T1 and the lowest abundance (0.05 $\times 10^3$/L) was found in the month of July in T3. Phytoplankton of Chlorophyceae group was the most dominant and Euglenophyceae group was the least abundant as observed during the study period. Zooplankton of Rotifera group was the most dominant in terms of both numbers and genera compared to Cladocera group among the treatments. Monthly variation of phytoplankton and zooplankton has been also shown in Table 3

Table 3: Monthly variation of plankton groups ($\times 10^3$/L) during the study period

Plankton groups	T1			T2			T3		
	June	July	August	June	July	August	June	July	August
Bacillariophyceae	9.45	6.75	8.10	6.75	4.05	13.50	10.80	14.85	8.10
Chlorophyceae	47.25	48.60	51.30	33.75	39.15	42.20	28.35	36.45	44.85
Cyanophyceae	20.25	24.30	28.35	17.55	21.60	14.85	16.20	6.75	10.80
Euglenophyceae	1.35	2.70	4.05	2.70	1.35	4.05	1.35	2.70	1.35
Total phytoplankton	78.30	82.35	91.80	60.75	66.15	74.60	56.70	60.75	64.80
Cladocera	0.03	0.05	0.05	0.03	0.05	0.03	0.03	0.02	0.03
Rotifera	0.05	0.07	0.05	0.03	0.05	0.05	0.05	0.03	0.03
Total zooplankton	0.08	0.12	0.10	0.07	0.10	0.08	0.08	0.05	0.07
Total plankton	78.38	82.47	91.90	60.82	66.25	74.68	56.78	60.80	64.87

Plankton population in the gut of fishes

Total 4 groups of phytoplankton consisting of 17 genera and 6 genera of zooplankton groups were identified in the gut content of fishes from different treatment during study period. The average plankton number per gut of fishes under different treatments during the study period has been presented in the Table 4 and 5. Among the various phytoplankton groups Chlorophyceae was the most dominant group. In case of zooplankton, Cladocera and Rotifera were identified in the gut content of fishes in different treatments during study period. Cladocera was the most dominant group in all treatments.

Table 4: Monthly variation of plankton groups ($\times 10^3$/L) during the study period

Treatments	Phytoplankton	June				July				Augsut			
		Rohu	Catla	Mrigal	Pangas	Rohu	Catla	Mrigal	Pangas	Rohu	Catla	Mrigal	Pangas
T1	Bacillariophyceae	12295	14754	4918	6148	23361	18443	13525	12295	19672	15984	14754	13525
	Chlorophyceae	23361	29508	14754	13525	41803	31967	25820	22131	27049	31967	25820	23361
	Cyanophyceae	7377	8607	3689	4918	17213	13525	14754	7377	18443	20902	17213	7377
	Euglenophyceae	1230	2459	1230	1230	2459	1230	1230	1230	2459	6148	3689	2459
Total		44262	55328	24590	25820	84836	65164	55328	43033	67623	75000	61476	46721
T2	Bacillariophyceae	8607	11066	6148	4918	25820	29508	15984	8607	24590	30738	18443	6148
	Chlorophyceae	13525	22131	12295	9836	43033	60246	33197	14754	46721	56557	40574	24590
	Cyanophyceae	7377	13525	4918	2459	13525	22131	11066	6148	14754	18443	12295	3689
	Euglenophyceae	1230	2459	1230	1230	3689	6148	2459	1230	3689	4918	2459	1230
Total		30738	49180	24590	18443	86066	118033	62705	30738	89754	110656	73771	35656
T3	Bacillariophyceae	6148	8607	7377	6148	19672	24590	15984	8607	23361	25820	19672	9836
	Chlorophyceae	14754	14754	13525	9836	33197	41803	18443	20902	38115	49180	31967	22131
	Cyanophyceae	8607	11066	4918	3689	14754	18443	9836	6148	11066	13525	9836	4918
	Euglenophyceae	1230	2459	1230	1230	2459	3689	2459	1230	2459	3689	2459	1230
Total		30738	36885	27049	20902	70082	88525	46721	36885	75000	92213	63935	38115

Table 5: Monthly variation of zooplankton groups in average number per gut of fishes during the study period in different treatments

Treatments	Zooplankton	June				July				Augsut			
		Rohu	Catla	Mrigal	Pangas	Rohu	Catla	Mrigal	Pangas	Rohu	Catla	Mrigal	Pangas
T1	Cladocera	3689	1230	3689	2459	2459	2459	2459	2459	1230	1230	2459	2459
	Rotifera	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230
Total		3690	3690	2460	2460	3690	2460	3690	2460	3690	3690	3690	3690
T2	Cladocera	3689	1230	3689	2459	2459	2459	2459	2459	1230	1230	2459	2459
	Rotifera	1230	1230	1230	2459	1230	1230	1230	1230	2459	2459	1230	1230
Total		4918	2459	4918	4918	3689	3689	3689	3689	3689	3689	3689	3689
T3	Cladocera	1230	2459	2459	1230	3689	1230	1230	0	1230	2459	0	1230
	Rotifera	1230	1230	1230	1230	1230	2459	1230	3689	1230	1230	2459	1230
Total		2459	3689	3689	2459	4918	3689	2459	3689	2459	3689	2459	2459

Electivity Indices

The values of electivity indices ranged from -1.0 to 1.0 in different treatments during the study period. Among the different food groups Bacillariophyceae, Euglenophyceae, Cladocera and Rotifera were preferred food of rohu, catla, mrigal and pangas in all treatments of carp pangas polyculture system, whereas the fishes showed negative selection from Chlorophyceae and Cyanophyceae in T1 and T2 respectively of carp and pangas polycultrue system (Table 6).

Table 6: Mean electivity of plankton groups during the study period in different treatments

Treatments	Plankton groups	Rohu			Catla			Mrigal			Pangas		
		P_w	P_g	E	P_w	P_g	E	P_w	P_g	E	P_w	P_g	E
T1	Bacillariophyceae	9.7	26.7	0.5	9.7	24.0	0.4	9.7	21.3	0.4	9.7	25.3	0.4
	Chlorophyceae	58.3	44.7	-0.1	58.3	46.0	-0.1	58.3	46.3	-0.1	58.3	47.7	-0.1
	Cyanophyceae	28.7	20.0	-0.2	28.7	20.7	-0.2	28.7	21.7	-0.2	28.7	16.0	-0.3
	Euglenophyceae	3.1	3.0	0.0	3.1	4.7	0.2	3.1	4.3	0.2	3.1	4.0	0.2
	Cladocera	0.1	3.7	1.0	0.1	3.0	1.0	0.1	4.3	1.0	0.1	4.0	1.0
	Rotifera	0.1	2.0	1.0	0.1	2.0	0.9	0.1	3.0	1.0	0.1	3.0	1.0
T2	Bacillariophyceae	11.8	26.3	0.5	11.8	24.0	0.4	11.8	23.0	0.3	11.8	20.7	0.3
	Chlorophyceae	57.5	45.3	0.0	57.5	47.0	-0.1	57.5	48.0	-0.1	57.5	49.3	-0.1
	Cyanophyceae	27.1	17.3	-0.1	27.1	20.0	-0.2	27.1	16.7	-0.2	27.1	12.7	-0.4
	Euglenophyceae	4.0	3.7	0.0	4.0	4.7	0.1	4.0	3.7	0.0	4.0	4.0	0.0
	Cladocera	0.1	4.7	1.0	0.1	1.7	0.9	0.1	6.7	1.0	0.1	8.3	1.0
	Rotifera	0.1	2.3	1.0	0.1	1.7	0.9	0.1	2.7	0.9	0.1	6.0	1.0
T3	Bacillariophyceae	18.6	25.0	0.1	18.6	25.0	0.2	18.6	29.0	0.2	18.6	23.7	0.1
	Chlorophyceae	59.5	45.7	-0.2	59.5	44.0	-0.1	59.5	43.3	-0.2	59.5	49.7	-0.1
	Cyanophyceae	18.8	20.0	0.1	18.8	20.3	0.1	18.8	17.0	0.0	18.8	14.3	-0.1
	Euglenophyceae	3.0	3.3	0.1	3.0	4.7	0.2	3.0	4.3	0.2	3.0	2.7	0.1
	Cladocera	0.0	3.7	1.0	0.0	3.3	1.0	0.0	3.7	0.3	0.0	2.7	0.3
	Rotifera	0.1	2.7	1.0	0.1	2.3	0.9	0.1	3.7	1.0	0.1	6.7	1.0

Growth performance and production of fishes

The mean initial weight (g), final weight (g), specific growth rate (SGR, % per day), survival rate and the total production of fishes (kg/acre/ 90 days) during the study period were recorded and presented in Table 7. There was no significant difference in initial weight of experimental fish species under different treatments. Rohu, catla and mrigal showed significantly higher ($p < 0.05$) final growth, weight gain and specific growth rate (% per day) in T1 than T2 and T3. On the other hand, pangas showed significantly higher ($p < 0.05$) final growth, weight gain and specific growth rate in T3 than T1 and T2. The survival rate was not differed significantly ($p > 0.05$) among the treatments but the highest survival rate was found in T1 and lowest in T3.

Table 7: Growth, survival, feed utilization and production of fish in different treatments during the study period

Parameters	T1	T2	T3
Initial weight (g)			
Rohu	3.14 ± 0.24^{a}	3.20 ± 0.29^{a}	3.10 ± 0.22^{a}
Catla	4.20 ± 0.08^{a}	4.16 ± 0.11^{a}	4.10 ± 0.10^{a}
Mrigal	3.60 ± 0.18^{a}	3.45 ± 0.13^{a}	3.50 ± 0.21^{a}
Pangas	6.73 ± 0.12^{a}	6.65 ± 0.17^{a}	6.71 ± 0.09^{a}
Final weight (g)			
Rohu	250.28 ± 4.52^{a}	203.20 ± 5.39^{b}	200.37 ± 6.82^{c}
Catla	324.19 ± 5.26^{a}	310.77 ± 7.31^{b}	271.59 ± 3.48^{c}
Mrigal	290.70 ± 5.96^{a}	250.72 ± 3.82^{b}	226.53 ± 3.20^{c}
Pangas	218.19 ± 3.81^{c}	323.23 ± 7.12^{b}	340.10 ± 8.21^{a}
Weight gain (g)			
Rohu	247.14 ± 3.14^{a}	200.00 ± 5.12^{bc}	197.27 ± 5.82^{c}
Catla	319.99 ± 4.54^{a}	306.61 ± 7.15^{b}	267.49 ± 3.12^{c}
Mrigal	287.10 ± 4.58^{a}	247.27 ± 3.42^{b}	223.03 ± 3.48^{c}
Pangas	211.48 ± 3.49^{c}	316.58 ± 6.98^{b}	333.37 ± 7.95^{a}
SGR (% per day)			
Rohu	4.86 ± 0.21^{a}	4.64 ± 0.13^{b}	4.59 ± 0.09^{b}
Catla	4.83 ± 0.17^{a}	4.68 ± 0.11^{a}	4.56 ± 0.12^{a}
Mrigal	4.81 ± 0.13^{a}	4.75 ± 0.12^{a}	4.53 ± 0.08^{b}
Pangas	3.87 ± 0.15^{b}	4.32 ± 0.10^{a}	4.36 ± 0.10^{a}
Survival rate (%)			
Rohu	92.41 ± 0.92^{a}	91.82 ± 0.89^{a}	91.31 ± 0.96^{a}
Catla	92.42 ± 0.65^{a}	92.00 ± 0.52^{a}	91.92 ± 0.61^{a}
Mrigal	90.72 ± 0.71^{a}	90.12 ± 0.57^{a}	89.95 ± 0.62^{a}
Pangas	87.87 ± 0.88^{c}	88.71 ± 0.82^{b}	89.12 ± 0.79^{a}
Species wise production (kg/acre/90 days)			
Rohu	774.05 ± 9.75^{a}	540.51 ± 18.08^{b}	445.26 ± 18.89^{c}
Catla	510.13 ± 21.90^{a}	413.28 ± 13.19^{b}	297.57 ± 4.15^{c}
Mrigal	447.63 ± 10.43^{a}	330.47 ± 6.56^{b}	250.70 ± 1.51^{c}
Pangas	895.67 ± 25.87^{c}	1269.51 ± 40.39^{b}	1453.88 ± 9.72^{a}
Total Production (kg/acre/90 days)	2627.48 ± 56.81^{a}	2553.77 ± 71.99^{b}	2448.41 ± 18.89^{c}

Figures in the same row with same superscripts are not significantly different ($p > 0.05$)

After 90 days of culture, rohu, catla and mrigal showed highest production in T1 than T2 and T3 except pangas. The production of pangas recorded significantly higher ($p < 0.05$) in T3 than T1 and T2 But total productions of fishes were recorded in T1 (2627.48±56.810 kg/acre) followed by T2 (2553.77±71.985 kg/acre) and T3 (2448.41±18.884 kg/acre). The result indicated that highest production was found when there were highest carps combination was stocked.

Discussion

Water quality parameters

Water quality parameters are very important factors in aquaculture as they control the ultimate production of fishes. Water quality parameters such as temperature and pH were recorded in the present study showed very little variation among the treatments. Water temperature is one of the most important factors which influence the growth, reproduction and other biological activities of fish. The range of temperature was varied from 31.17°C to 31.70°C in each treatment of present study, which is suitable and more or less similar to that reported by Rahman *et al.* [14]. Dewan *et al.* [15] and Ali *et al.* [16]. In the present study the range of pH in different treatments varied from 7.11 to 7.45 that was near neutral to slightly alkaline this is suitable for fish culture. The findings of the present study are more or less similar to the findings of Lakshminarayana *et al.* [17], Mumtazuddin *et al.* [18] and Dewa *et al.* [15].

Plankton population in pond water

Plankton is the basic food items of all aquatic animals including fish. So, higher plankton number in pond water normally indicates higher productivity of the pond. The average number of plankton recorded in the present study, ranged from 60.82 × 10^3/L to 89.73 × 10^3/L among different treatments which is more or less similar to the findings of Mumtazuddin and Khaleque [19]. Wahab *et al.* [20] Kohinoor *et al* [21] found phytoplankton numbers of 20,000 to 2, 00,000 units/L and 29,67,000 units/L respectively. These findings also support the result of phytoplankton number obtained in the present study. The average number of zooplankton recorded in the present study ranged from 0.07 × 10^3/L to 0.10 × 10^3/L which was not related to the findings of Saha *et al.* [22], Wahab *et al.* [20] and Kohinoor *et al.* [21]. This might be due to the higher grazing pressure on zooplankton population in the present study.

Plankton in the gut content of fishes

In the present study, 20 genera of phytoplankton are belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and 6 genera of zooplankton belonging to Cladocera and Rotifer, debris and other food particles were identified in the gut content of rohu, catla, mrigal and pangas. Wahab *et al.* [23] found that the fish *Labeo rohita* showed positive response to Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, Cladocera and Rotifer. This finding is very closely related to the present study. The present study is also more or less similar to the findings of Wahab *et al.* [23] and Rahmatullah *et al.* [24]. Among the different froups of phytoplankton and zooplankton, Chlorophyceae and Cyanophyceae were the most dominant in the gut contents of fishes. Fishes showed slightly negative selection to Chlorophyceae and positive selection to Cladocera. This might be due to the high abundance of Chlorophyceae in the environment which has been ingested by the fish always with other plankton and ultimately dominant in the gut content.

Electivity Indices

In the present study rohu, catla, mrigal and pangas have showed positive selection to Bacillariophyceae, Euglenophyceae, Cladocera and Rotifer and no or slightly negative (-0.1) selection to Chlorophyceae and Cyanophyceae in all treatments. It is indicate that Bacillariophyceae, Euglenophyceae, Cladocera and Rotifer are preferable food items for rohu, catla, mrigal and pangas than Chlorophyceae and Cyanophyceae. These findings are more or less similar to Dewan *et al.* [15] and Sarker [25]. The present investigation also suggested that rohu, catla, mrigal and pangas are not strictly selective in their feeding habits. This finding is agreed by Dewan *et al.* [15].

Growth performance and production of fishes

During the study period of 90 days it has been observed that in case of pangas, the maximum final weight gain (333.37±7.95 g) was recorded in T3. In T1 the growth of pangas was also lower. This might be due to the species combination and ratio of carp and pangas. Hossain *et al.* [26] showed the similar results of lower growth when stocked fish at more than 100/dec.

Carps grew well in T1 and then followed by T2 and T3, respectively. This might be due to the combination effect which stimulate the metabolic rate of carps and reduce the competition among the species. In all treatments catla attained the highest growth than mrigal and rohu. The result of final weight gain of catla in the present study was higher than the result reported by Bhandari [27]. This might be due to the low stocking density of catla that reduces the competition of its own biological niche. As a result feeding rate was increased. The growth rate of mrigal was higher that of rohu. It might be due to the effect of available benthos on the organic matter of pond bottom for mrigal. Jhingran [28] also quoted that the bottom feeder fish like mrigal prefer decayed form of organic matter.

The specific growth rate of pangas in different treatments ranged between 3.87 to 4.36%. the significantly ($p<0.05$) higher SGR value was recorded in T3 (4.36±0.10) than T1 (3.87±0.15). But there was no significant variation was found between T2 (4.32±0.10) and T3 (4.36±0.10). SGR value of rohu were significantly ($p<0.05$) higher in T1 (4.86±0.21) than T2 (4.64±0.13) and T3 (4.59±0.09). But there was no significant difference between T2 and T3. In case catla there was no significant difference in SGR value among the treatments. The SGR value of mrigal was significantly lower ($p>0.05$) in T3 (4.53±0.08) than T1 (4.81±0.13) and T2 (4.75±0.12). But there was no difference between T1 and T2. SGR values obtained in the present study are similar to that obtained by Hossain *et al.* [26] and Salimullah [29]. The survival rate of carp species in different treatments was fairly high. This might be due to application of both fertilization and supplementary feed. There was no significant variation of survival rate (%) of different carp species among the treatments. But the highest survival rate of carps was found in T1 and lowest in T3. On the other hand, the significantly higher ($p<0.05$) survival rate (%) of pangas was found in T3 (389.12±0.79) than T1 (87.87±0.88) and T2 (88.71±0.82). Similar types of survival rates were observed by Mostaque [30], who recorded the survival rates of 86 to 95% in a polyculture system in BAU ponds.

In the present study, carps species showed significantly higher

($p<0.05$) production in T1 than T2 and T2. But pangas showed significantly higher ($p<0.05$) production in T3 than T1 and T2. So, the result indicated that the total production of fishes varied in different treatments in the experiment. Treatment 1 showed highest production (2627.48±56.81 kg/acre/90 days) than that of T2 and T3. Kanak [31] found the gross production of 2623kg/ha over the period of six months. This might be due to the reason of his poor feeding rate (3% of total body weight daily) of pangas.

Conclusion

Carps and pangas polyculture is not new thought in Bangladesh. Their culture is being practicing in the farmers level. However, there is no sufficient published information on different ratios of carps and pangas polyculture. The present study has a significant importance to know the effect of different ratio of carps and pangas on the plankton population of a pond system. So, it can be concluded that stocking density of 100/decimal of rohu, catla, mrigal and pangas at the rations of 35:17.5:17.5:30 is the most suitable combination for optimum production when cultured with carps and pangas on the plankton population of a pond system.

References

1. Jhingran VG. Aquaplosion Lecture, Summer Int. Intensive Freshwater Fish Culture, Cuttack, Organized by centre, Inland Fish Res. Inst., Barrackpore (ICAR). 1975, 12.
2. Halver JE. Special Methods in Pen Fish Husbandry. Akademiai Nyomda, Budapest, 1984, 146.
3. Ahmed M. Status and Potential of Aquaculture in Small Water Bodies (Ponds and Ditches) in Bangladesh. ICLARM Technical Report. 1992; 37:15-28.
4. McComish TS. Food habits of big mouth and small mouth buffalo in Lewis and Clark Lake and Missouri River. Transactions of the American Fisheries Society. 1967; 96(1):70-74.
5. McKechnie R, Fenner RB. Food habits of white sturgeons, *Acipenser transmontanus* in San Pablo and Suisan Bays California. Clif. Fish and Game. 1971; 57(3):109-212.
6. Dewan S. Investigation into the ecology of fishes of a Mymensingh Lake. Ph.D Thesis, Bangladesh Agricultural University, Mymensingh, 1973, 337.
7. Lund JWG. A simple counting chamber for nanoplankton. Limnol. Oceanogr. 1959; 4:57-65
8. Ward HB, Whipple GC. Freshwater and Biology. John Willey and Sons Inc., New York, 1959, 1248.
9. Prescott GW. Algae of the western great lakes area. Wm. C. Brown co., Inc. Dubuque, Iowa, 1962, 946.
10. Bellinger EG. A key to common algae: Freshwater, estuarine and some coastal species. The institution of water and environmental management, London U.K., 1992, 138.
11. Hynes HBN. The food of fresh water sticklebacks, *Gasterosteus aculetus* and *Pygosteus pungititus* with a review of methods used in studies of the foods of fishes. Journal of Animal Ecology. 1950; 19:36-58
12. Ivlev VS. Experimental ecology of the feeding of fish. Yale University Press. New Haven, Connecticut, 1961.
13. Brown ME. Experimental studies on growth. In: The physiology of Fishes. Brown ME (Ed.). Academic press. New York. 1957; 1:361-400.
14. Rahman MS, Chowdhury MY, Haque AKM, Haque MS. Limnological studies of four ponds. Bangladesh Journal of Fisheries. 1982; 2-5(1, 2):25-35.
15. Dewan S, Wahab MA, Beveridge MCM, Rahman HM, Sarker BK. Food selection, electivity and dietary overlap among planktivorous Chinese and Indian Major Carps fry and fingerlings grown in extensively managed, reinfed ponds in Bangladesh. Agriculture and Fisheries Management. 1991; 22:277-294
16. Ali S, Rahman AKA, Patwary AR, Islam KHR. Studies on the diurnal variation of physico-chemical factors and zooplankton in a fresh water pond. Bangladesh Journal of Fisheries. 1982; 2-5(1, 2):15-23
17. Lakshminarayana JSS. Studies on the phytoplankton of the river Ganges varansi, India. Part I and II. Hydrobiology, 1965; 25(1, 2):119-137:138-164.
18. Mumtazuddin M, Rahman MS, Mostafa G. Limnological studies of four selected ponds at the aquaculture experiment station, Mymensingh. Bangladesh Journal of Fisheries, 1982; 2-5:83-90.
19. Mumtazuddin M, Khaleque MA. Observation on the growth potential of carp hatchlings in relation to fertilization and supplemental feeding. Bangladesh Journal Zoology. 1987; 15(1):71-77
20. Wahab MA, Ahmed ZF, Salam MA, Rahmatullah SM. Effect of introduction of common carp, *Cyprinus carpio* (L) of the pond ecology and growth of fish in polyculture. Aquaculture Research. 1995; 26:619-628.
21. Kohonoor AHM, Islam ML, Wahab MASH Thilsted. Effect of mola (*Amblypharyngodon mola* Ham.) on the growth and production of carps in polyculture. Bangladesh Journal Fisheries. 1998; 2(2):119-126.
22. Saha GN, Segal KL, Mitra E, Nandy AC. Studies on the seasonal and diurnal variation in physic-chemical and biological parameters of freshwater pond. Journal of Inland Fisheries Society, India. 1998; 3:79-102.
23. Wahab MA, Haque MM, Haider ANMA, Kohinoor AHM, Islam ML. Food composition of Thai sarpunti, *Puntius gonionotus* (Bleeker) with major carps in polyculture conditions. Bangladesh J Agricultural Sciences. 1998; 25(2):139-147.
24. Rahmatullah SM, Nurunnabi, Salim MA. Studies on the food and feeding habits and elective indices of young freshwater cyprinid mola (*Amblypharyngodon mola*). Bangladesh Journal Agricultural Sciences. 1997; 24(2):81-86.
25. Sarker BK. An evaluation of the electivity and dietary overlap between planktivorous rohu (*Labeo rohita*) and catla (*Catla catla*). MS Thesis, Department of Fisheries Biology and Limnology, Bangladesh Agricultural University, Mymensingh, 1992, 30-34.
26. Hossain MA, Ahmed M, Islam MN. Mixed culture of fishes in seasonal ponds through fertilization and feeding. Bangladesh Journal of Fisheries Research. 1997; 1(2):9-18.
27. Bhandari RK. Optimization of supplementary feeding rate for the composite carp culture in Bangladesh. MS Thesis. Department of Fisheries Aquaculture, Bangladesh Agricultural University, Mymensingh. 1998, 67.
28. Jhingran VG. Fish and Fisheries of India. Third edition, Hindustan Publishing Corporation, India, 1991, 727.
29. Salimullah MA. comparative study on the growth of fishes under polyculture system with supplementary and

fertilization. MS Thesis. Bangladesh Agricultural University, Mymesningh, 1997, 72.
30. Mostaque A. Studies on the mixed culture of fishes in seasonal ponds through fertilization and feeding. MS Thesis. Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. 1995, 79
31. Kanak MK. Performance on exotic fishes in polyculture with Indian major carps under three different species combinations. MS Thesis. Department of Aquaculture and Management, Bangladesh Agricultural University, Mymensingh, 1997, 74.