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Impact of Exotic Carps in the Polyculture with Indigenous Carps: Competition for Food

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Abstract: The fingerlings of indigenous carps such as catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) with exotic carps such as silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*) and mirror carp (*Cyprinus carpio*) were cultured together in a fish pond at Bangladesh Agricultural University, Mymensingh, in order to determine the food electivity, dietary overlap and food competition among indigenous major carps and exotic carps. Phytoplankton (Chlorophyceae, Cyanophyceae), zooplankton (rotifers) were the dominant groups in the cultured pond. Chlorophyceae was dominant in the diet of rohu. Chlorophyceae and rotifers were the preferred food of catla. Mrigal preferred phytoplankton than zooplankton. Rohu showed positive electivity for zooplankton. Silver carp consumed large quantity of phytoplankton and also preferred rotifers. Chlorophyceae was the dominant food group in the diet of bighead. Mirror carp also preferred plant food organisms dominated by Chlorophyceae. Bighead had positive trends towards phytoplankton. Both mrigal and mirror carp had positive electivity towards phytoplankton. The higher level of dietary overlap occurred between rohu and silver carp followed by between rohu and bighead carp and between catla and silver carp. The lowest level of dietary overlaps occurred between rohu and mirror carp.

Key words: Indigenous carps, exotic carps, food electivity, dietary overlap, physicochemical parameters

INTRODUCTION

Fisheries play an important role in the economy of Bangladesh. It plays a vital role in the nutrition of the people by supplying protein, fat, vitamins and minerals. This sector contributes about 3.74 percent of GDP and about 3.00% of nation's foreign exchange earnings (DOF, 2011). Fish alone contributes 60% of animal protein to the diet of the people of Bangladesh. Fortunately our country is blessed with vast water resources such as rivers, canals, beels, ponds, estuaries and the vast coastal areas, from where we can produce enough fish to meet the protein requirement of our people. On the other hand through more fish production may our bright national economy could be ensured. But in spite of having all these water bodies, the fish production of our country is not up to the mark as compared to other countries in the region due to lack of proper knowledge about modern fish culture and management practices. The production of fish can be increased many folds by adopting scientific method of its culture and management.

Out of different fish culture techniques practiced throughout the world, polyculture of indigenous major carps has traditionally been practiced in the countries of South Asian Regions including Bangladesh from time unmemorable. Poly-culture or composite culture is the system in which fast growing compatible species having different feeding habits are stocked in proportions in the same pond (Jhingran, 1975). Poly-culture management techniques are based on the relationships between organisms at different levels of food chain and environment. It is fact that poly-culture may produce an expected result if the fish with different feeding habits are stocked in proper ratios and combinations (Horvath *et al*., 1984). Generally, three carp species such as rohu, catla and mrigal are cultured together in the farmers' pond in our country. Sometimes, calbaus (*Labeo calbasu*) is also used in the poly-culture. Recently, some Chinese carps

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have been introduced in the polyculture system in our country for their rapid growth and favorable food habits. These Chinese carps are silver carp, grass carp, bighead carp and mirror carp. Jhingran (1975) stated that polyculture of major carps with exotic carps had laid the foundation of silver revolution of India. He also observed that exotic carps have higher growth rates and attain marketable size much earlier than our endemic major carps. Due to fast growing, the exotic carps should be harvested at the earliest possible time and ensure multiple cropping for higher rates of production (Jhingran, 1991). So, the acceptance and popularity of these exotic carps are gradually increasing in our country.

Polyculture is possible through proper understanding of the various ecological factors which are responsible directly or indirectly for the production of biomass in a water body. Among the various ecological factors, food and feeding habits of fishes is a pre-requisite to understand the interspecies relationship for efficient management of any culture system. The knowledge of food competition between interspecies is helpful to select the species combination for the scientific fish culture. Food competition between silver carp and rohu was occurred but not serious. The feeding habits of surface feeder silver carp and column feeder rohu somewhat different and these two species are considered as quite compatible species and recommended as composite fish culture (Dey *et al*., 1979).

Dewan *et al*. (1991) reported that dietary overlap was observed between catla-rohu and between silver carp-bighead carp were found in Bangladesh ponds. He also reported that greatest overlap was occurred between catla-silver carp and catla-bighead carp in the ponds of Bangladesh. It was also found that bighead carp is a filter feeding fish and feeds on free floating swimming organisms throughout its life (Henderson, 1978). On the other hand (Cremer and Smitherman, 1980) reported that bighead carp consumed large quantities of zooplankton and detritus in addition to phytoplankton. To reviewed the food and feeding habits of fishes it was found that the gut contents of Mrigal were composed of Cyanophyceae, Chlorophyceae, Bacillariophyceae, rotifers, cladocerans and debris (Chandra and Haq, 1986). Our knowledge regarding food competition between endemic carps and Chinese carps under natural condition is very poor and insufficient. Extensive work have been done on the food and feeding habits of various fishes but few studies have so far been reported on food electivity, dietary overlap and food competition between endemic major carps and Chinese carps. But it is very important to study the food electivity, dietary overlap and food competition among the endemic major carps and Chinese carps.

Therefore, the present study is undertaken to find out the electivity, dietary overlap and food competition between exotic carps i.e. silver carp (*Hypophthalmichthys molitrix*, bighead carp (*Aristichthys nobilis*), mirror carp (*Cyprinus carpio*) and endemic carps i.e., rohu (*Labeo rohita*), catla (*Catla catla*) and *mrigal (Cirrhinus mrigala*).

MATERIALS AND METHODS

Study area and duration: The experiment was conducted in a rain fed artificial pond situated at the experimental pond area of the Department of Aquaculture, Bangladesh Agricultural University (BAU), Mymensingh for a period of nine months from April 2009 to December 2009. The size of the pond was 0.06 hectare with an average depth of 1.5 m.

Pond preparation: The pond was prepared by removing the bottom mud and raising the height of embankments. After that, lime was applied at the rate of 250 kg ha^{-1}. Before being used lime was diluted with water and then broadcasted over the bottom of the pond. After 15 days of lime application pond was filled up with water with a depth of 1.5 m. After that, 4,500 kg ha^{-1} cow dung, 125 kg ha^{-1} urea and 62.5 kg ha^{-1} Triple Super Phosphate (TSP) were applied in an initial dose. After diluted of urea and TSP were broadcasted throughout the pond and cow dung was applied the pond corners.

Stocking the pond: After seven days of fertilization, ponds were stocked with the fingerlings of six carp species of both indigenous and exotic origin, namely rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*) and mirror carp (*Cyprinus carpio*). These fishes were stocked at the rate of 10,000 (No. ha^{-1}) with 100 rohu, 100 catla, 100 mrigal, 100 silver carp, 100 bighead carp and 50 mirror carp. In stocking time the number, length (cm) and weight (g) of each species were recorded. All fingerlings were collected from the specific hatcheries. Transportation of fingerlings was done very carefully as much as possible in order to minimize the mortality. Before stocking the fingerlings were acclimatized for three hours.

Application of fertilizers: The pond was fertilized fortnightly throughout the experimental period with cow dung, urea and TSP at the rate of 4,500, 62.5 and 31.25 kg ha^{-1}, respectively. Cow dung was always applied at the pond corners but the urea and TSP were spread throughout the pond after diluted.

Collection and preservation of planktonic samples: Ten liter samples of water were collected from different areas and depth of the pond fortnightly and filtered through a fine mesh phytoplankton net. Filtered sample was taken into a plastic vial and carefully make up to a standard volume with distilled water. With a series of settling and re-suspension procedures, plankton were concentrated into 50 mL and preserved using 5% formalin in small plastic bottles for subsequent studies.

Identification and enumeration: Using a Sedgwick-Rafter cell and a binocular microscope (Olympus model-BH-2, with phase contrast facilities), 1 mL sub-sample was examined from each 50 mL preserved sample. All organisms, present in 10 cells other 5-R cell chosen at random were counted and identified up to genus level. Identification of plankton was made with the help of Pennak (1953) and Ward and Whipple (1959). Then, plankton population as cell/1 was determined. The percentage composition of each genus and family was then calculated from the raw data.

Collection of fish sample: Fishes were collected by using a cast net. Fortnightly, sampling of fish was done throughout the experimental period. Sample of five fish from each species except mirror carp was collected at each sampling date. Only three mirror carp was sampled due to its small stocking number. All fishes were killed immediately by a blow on the head. Fishes were then preserved in a jar containing buffered 10% formalin to prevent further digestion of food item in the stomachs of the fish. Then, the jars with fish were taken back to the laboratory for further analysis.

Stomach contents analysis: The abdomen of the individual fish was cut open and the gut contents were taken out carefully and then put into a clean petri dish. Only the anterior portion of the digestive tract lying between the esophagus and the small intestine has been used for the present study. This has been done because the food items in this portion of the digestive tract are least digested and mostly identifiable. Similar method has also been followed by McKehni and Penner (1971), Dewan *et al.* (1977, 1991) in their works.

The stomach content of individual fish has removed into a clean petri dish with the help of a fine needle. Then, it was diluted with distilled water to 20 mL. One milliliter sub-sample from 20 mL sample was transferred by a pipette to a Sedgwick-Rafter cell. Using a binocular microscope, all organisms found in 10 of the thousand cells chosen at random, were identified and counted. All the organisms were identified up to genus level.

Electivity indices: The electivity indices were determined by applying Ivlev (1961) formula as follows:

$$E = \frac{ri-pi}{ri+pi}$$

where, ri is the relative content of any ingredient in the ration expressed as percentage of total ration and pi is the relative proportion of same item in the environment. The calculated value of E ranges from+1 to -1, where positive values indicate selection for certain food items, negative values indicate avoidance.

Dietary overlap: Dietary overlap were measured by using Schoener's index (Schoener, 1970):

$$a = 1\text{-}0.5\ (n = 1pxi\text{-}pyi1)$$

where, a is the overlap index, pxi is the proportion of food category in the diet of species x, pyi is the proportion food category in the diet of species y and n is the number of categories.

RESULTS

Plankton population: During the study period, the plankton population of the pond was determined and the results obtained so far have been shown in Table 1. During the experimental period, 22 genera of phytoplankton belonging to the Chlorophyceae (12), Bacillariophyceae (3), Euglenophyceae (2), Cyanophyceae (5) were recorded. Ten genera of zooplankton were identified and they were Hydrozoa (1), Rotifera (4), Protozoa (1) and Crustacea (4). Crustacean nauplii were also recorded in the pond water with other zooplankton. Total phytoplankton population ranged between 4.4×10^3 L^{-1} to 35.76×10^3 L^{-1}. Both phytoplankton and zooplankton population changed qualitatively and

Table 1: Monthly variations in the abundance of plankton population during August to December 2010

	Population ($\times10^3$ L^{-1})				
Plankton	August	September	October	November	December
Chlorophyceae	3.3	9.63	2.55	9.63	19.25
Bacillariophyceae	0.38	0.00	0.45	0.75	1.68
Euglenophyceae	0.48	1.13	0.6	3.88	3.78
Cyanophyceae	1.88	3.88	0.8	4.38	11.05
Total	6.04	14.64	4.4	18.64	35.76
Hydrozoa	0.40	6.25	0.30	0.50	1.25
Rotifera	1.50	4.88	1.05	2.63	4.98
Crustacea	0.40	0.25	0.10	0.00	0.63
Total	2.30	11.38	1.45	3.13	9.86

quantitatively during the experimental period. Maximum phytoplankton population was recorded in December and minimum of the same was recorded in October. Similarly, maximum zooplankton population was recorded in September and minimum was recorded in October. Among phytoplankton groups, Chlorophyceae was found to be the most dominant group in the pond. Cyanophyceae showed its dominance next to the Chlorophyceae. Euglenophyceae showed its dominance next to the Cyanophyceae. Bacillariophyceae was recorded as a less dominant group in the pond water (Table 1). Among the zooplankton, rotifers were recorded to the most dominant group while crustaceans were recorded as a less abundant group (Table 3). Among the different genera of phytoplankton *Chroococcus*, *Protococcus*, *Scenedesmus*, *Crucigenia*, *Oscillatoria* and *Ankistrodesmus* were found to be dominant. Whereas among different genera of zooplankton, *Asplanchna* was the most dominant genera was recorded. The mean percentage of plankton were also calculated where Chlorophyceae formed the highest percentage (41.76%), Cyanophyceae (20.09%) was the next to Chlorophyceae, Euglenophyceae (8.97%) was next to Cyanophyceae, Bacillariophyceae (4.09%) was the next to Euglenophyceae. Among zooplankton Hydrozoa was 7.21%, Rotifera was 15.82% and Crustacea was (2.04%). Total phytoplankton and zooplankton constituted 74.91 and 25.07%, respectively, in the pond water.

Table 2: Relative contribution of food organism in the diets of endemic carp catla (*Catla catla*)

	Conc. (%)				
Food items	August	September	October	November	December
Chlorophyceae	34.73	33.82	30.12	33.02	11.49
Bacillariophyceae	0.00	1.61	8.21	8.69	5.49
Euglenophyceae	12.15	14.08	2.46	7.39	13.88
Cyanophyceae	19.08	21.52	29.88	29.77	46.50
Rhodophyceae	0.00	2.63	1.34	0.00	0.00
Hydrozoa	6.46	3.42	2.51	1.36	0.00
Rotifera	25.42	15.17	19.34	15.83	18.16
Crustacea	2.16	3.07	0.67	1.94	0.00
Protozoa	0.00	4.67	5.46	2.00	0.00

Table 3: Relative contribution of food organism in the diets of endemic carp rohu (*Labeo rohita*) and (*Cirrhinus mrigala*)

	Conc. (%)				
Food items	August	September	October	November	December
Chlorophyceae	30.07	42.29	41.60	38.04	27.11
Bacillariophyceae	34.41	4.05	0.63	0.24	13.42
Euglenophyceae	8.31	4.87	4.98	8.06	10.72
Cyanophyceae	8.61	21.08	17.17	16.93	34.55
Rhodophyceae	0.00	0.00	0.00	0.00	0.00
Hydrozoa	1.48	1.12	1.85	2.44	0.00
Rotifera	10.53	26.48	22.61	30.74	8.02
Crustacea	1.68	0.00	6.91	0.00	6.19
Protozoa	4.90	0.00	4.25	3.56	0.00

Gut content analysis: Monthly relative contributions of food organism in different carps are presented in Table 2-6. During the study period, 34 genera of phytoplankton belonging to the Chlorophyceae (19), Cyanophyceae (7), Bacillariophyceae (7), Euglenophyceae (2), Rhodophyceae (1), were recorded in gut content of carps. On the other hand 13 genera of zooplankton were identified and they were included Hydrozoa (1), Rotifera (6), Crustacea (5) and Protozoa (1). Crustacean nauplii were also recorded with them. Out of 34 genera Catla consumed 26 genera of phytoplankton and it also consumed 9 genera of zooplankton out of 13 genera. Rohu consumed 21 genera of phytoplankton and 10 genera of zooplankton with nauplii as well. Mrigal consumed 21 genera of phytoplankton and 7 genera of zooplankton including nauplii. Silver carp consumed 24 genera of phytoplankton and 6 genera of zooplankton.

Table 4: Relative contribution of food organism in the diets of exotic carp silver carp (*Hypophthalmichthys molitrix*)

	Conc. (%)				
Food items	August	September	October	November	December
Chlorophyceae	30.24	38.63	42.83	39.38	42.24
Bacillariophyceae	27.23	3.92	3.64	7.07	0.00
Euglenophyceae	5.72	12.87	12.76	14.14	17.63
Cyanophyceae	9.29	8.88	13.19	11.68	23.96
Rhodophyceae	0.00	0.00	0.00	0.00	0.00
Hydrozoa	0.83	2.54	2.70	8.79	0.70
Rotifera	25.24	26.78	21.14	15.90	15.46
Crustacea	0.00	0.00	0.00	0.00	0.00
Protozoa	1.44	6.36	3.75	3.04	0.00

Table 5: Relative contribution of food organism in the diets of exotic carp bighead carp (*Aristichthys nobilis*)

	Conc. (%)				
Food items	August	September	October	November	December
Chlorophyceae	49.55	24.62	40.11	52.78	39.40
Bacillariophyceae	0.00	18.29	9.72	7.06	7.56
Euglenophyceae	7.39	6.90	9.10	14.27	9.17
Cyanophyceae	23.96	23.48	13.44	9.28	25.01
Rhodophyceae	0.00	0.00	0.00	0.00	0.00
Hydrozoa	7.13	7.66	6.21	3.46	0.00
Rotifera	11.87	16.80	15.20	10.39	28.06
Crustacea	0.00	1.25	0.07	1.36	0.00
Protozoa	0.00	0.00	5.53	1.40	4.82

Table 6: Relative contribution of food organism in the diets of exotic carp mirror carp (*Cyprinus carpio*)

	Conc. (%)				
Food items	August	September	October	November	December
Chlorophyceae	22.02	9.91	11.27	15.69	21.56
Bacillariophyceae	36.47	37.44	43.75	40.63	34.77
Euglenophyceae	1.03	0.00	5.57	2.24	5.38
Cyanophyceae	25.61	42.37	35.84	35.28	34.20
Rhodophyceae	0.00	0.00	0.00	0.00	0.00
Hydrozoa	0.00	1.33	0.00	1.59	0.00
Rotifera	13.56	8.96	3.56	4.57	4.09
Crustacea	0.00	0.00	0.00	0.00	0.00
Protozoa	1.31	0.00	0.00	0.00	4.82

Bighead consumed 21 genera of phytoplankton and 6 genera of zooplankton and some nauplii. Mirror carp consumed 18 genera of phytoplankton, 5 genera of zooplankton. The gut contents of silver carp and mirror carp contained fewer crustaceans. Maximum number of phytoplankton (1627.4×10^3) and zooplankton (610.8×10^3) was consumed by silver carp and minimum number of phytoplankton (93×10^3) was consumed by rohu.

Electivity indices: In the present study, the Electivity (E) values of different food items were found to range from +1 to -1. The E values were calculated from the percentage of plankton in water and in the stomach contents both in endemic and exotic carps. Few consistent trends are apparent, other than a marked avoidance of Chlorophyceae and Hydrozoa in all the fishes. Catla showed neutral response to both phytoplankton and zooplankton. Among phytoplankton Bacillariophyceae, Euglenophyceae, Cyanophyceae and Rhodophyceae were the preferred food items of catla. It shows marked avoidance for Chlorophyceae. Among zooplankton, Rotifera and Protozoa were found to be the most preferred food items. It showed marked avoidance for hydrozoans and crustaceans. However, among the different genera of phytoplankton, *Spirogyra*, *Oocystis*, *Meridion*, *Gomphosphaeria* and *Merismopedia* were found to be the most preferred food items of the fish. Among the different genera of zooplankton, *Polyarthra*, *Daphnia* and *Arcella* were found to be the most preferred food items of this fish.

Rohu showed positive electivity for zooplankton. Among phytoplankton, this fish preferred *Spirogyra*, *Oocystis*, *Chlorella and Cocconeis* were the most preferred genera of phytoplankton consumed by this fish. Among the zooplankton, rohu showed avoidance of Hydrozoa. *Brachionus*, *Notholca*, *Daphnia* and *Arcella* were the most preferred genera of zooplankton consumed by this fish.

Mrigal showed negative response for zooplankton and positive for phytoplankton. However, among the different genera of phytoplankton, *Micrasterias*, *Staurastrum*, *Meridian*, *Phacus*, *Lamnea* and *Gleotrichia* were found to be the most preferred food of mrigal. From the above results this fish can be regarded as phytoplankton feeder rather than a zooplankton or benthic animal feeder.

Silver carp showed negative response for Chlorophyceae and Cyanophyceae. It also showed slightly negative electivity for phytoplankton. Among the different genera of phytoplankton, *Mesotaenium*, *Pediastrum*, *Actinastrum*, *Oedogonium*, *Oocystis*, *Cocconeis*, *Gomphosphaeria* and *Merismopedia* were found to be the most favorable food items for silver carp. Among zooplankton it showed avoidance for hydrozoans and crustaceans. *Asplanchna* and *Arcella* were favorable zooplankton consumed by this fish. This fish showed positive electivity for zooplankton.

Bighead carp showed negative response for zooplankton but positive for phytoplankton. Among the phytoplankton Bacillariophyceae and Euglenophyceae were the preferred food items of this fish. *Oocystis* and Diatoms were the preferred food items of this fish. Among zooplankton, *Notholca*, *Arcella* and *Bosnia* were the most favorable food. His fish showed neutral electivity for Chlorophyceae.

Mirror carp showed little response for phytoplankton and positive for zooplankton. Among phytoplankton, it showed positive response for Bacillariophyceae and Cyanophyceae. It also showed negative response for Chlorophyceae and Euglenophyceae. Among all plankton, *Oocystis*, *Cocconeis*, *Navicula*, *Tabellaria*, *Notholca* and *Arcella* were the preferred genera which were consumed by mirror carp.

Dietary overlap indices: Through using the Schoener's index dietary overlap were calculated from mean data. The dietary overlap for different food groups of phytoplankton varied from 0.85 to 1.00. The highest dietary overlaps were recorded between catla and bighead carp for Bacillariophyceae and between rohu and bighead carp for Cyanophyceae. The lowest value (0.85) was recorded between rohu and mirror carp for Bacillariophyceae.

Dietary overlap for different food groups of zooplankton ranged between 0.00 and 1.00. The highest value (1.00) was recorded for Hydrozoa and Protozoa between catla and silver carp. Similar records were recorded for Protozoa between catla and bighead; rohu and silver; rohu and bighead and for Hydrozoa between rohu and mrigal; mrigal and bighead. The highest overlap (1.00) was also recorded for crustacean between mrigal and bighead.

The Schoener's index for total phytoplankton ranged from 0.67 to 0.92. The highest value (0.92) was recorded between rohu and silver and the lowest value (0.67) was recorded between rohu and mirror carp. The Schoener's index for total zooplankton ranged from 0.92 to 0.99. The highest value (0.99) was recorded between catla and silver carp and the lowest value (0.92) was recorded between catla and mirror carp. The overall index ranged from 0.62 to 0.99. The highest value was recorded between rohu and silver carp and the lowest value was recorded between catla and mirror carp. These results indicate the mirror carp do not compete with indigenous major carps. It also

indicates that silver carp compete heavily with catla and rohu. Bighead competes with all three species of indigenous major carps, rohu, catla and mrigal.

DISCUSSION

Environmental parameters exert and immense influence on the maintenance of a healthy aquatic environment and production of sufficient fish food.

The environmental parameters such as physic-chemical factors like water temperature, dissolved oxygen, p^H and transparency measured over the entire period of study and were found to be more or less within the acceptable ranges for fish culture. A number of authors previously carried out investigation regarding the limnological aspects of pond waters Dewan (1973), Mumtazuddin *et al*. (1982) and the findings of the present study were more or less similar.

A wide variety of phytoplankton and zooplankton in terms of number and genera were recorded. Phytoplankton population composed of Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae and Rhodophyceae and the zooplankton groups consisting of Hydrozoa, Crustacea, Rotifera and Protozoa. Plankton population in number and genera were similar to those listed in the earlier studies carried out by several researchers in the fish pond in the same region. In a lake of Mymensingh, Dewan (1973) listed phytoplankton genera belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae. Mumtazuddin *et al*. (1982), studied phytoplankton in the ponds of Mymensingh region and found 33 genera of phytoplankton belonging to Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Euglenophyceae and Myxophyceae. They also found that the zooplankton comprised of 14 genera belonging to Crustacea and Rotifera. In an identical study Dewan *et al*. (1991) identified 21 genera of phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae and 9 genera of zooplankton Hydrozoa, Crustacea and Rotifera. In the present study, similar groups of phytoplankton such as Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae, Rhodophyceae and of zooplankton viz., Hydrozoa, Protozoa and Rotifera were recorded both in the gut of fishes and in water of the experimental pond. However, Rhodophyceae and Protozoa were not recorded in the pond water, although it was recorded in the guts of the fishes.

Gut content showed a wide variety of food organisms present in the diet of all fish species. It is most interesting to note that Chlorophyceae dominated as a single group of food item in terms of genera and number. Among zooplankton, rotifers, dominated in the diet of all fish species.

Rohu consumed 21 genera of phytoplankton and 10 genera of zooplankton including nauplii. Among different groups of plankton Chlorophyceae was the dominate food group. Chlorophyceae, Bacillariophyceae, Euglenophyceae, Hydrozoa, Crustacea, Rotifera and Protozoa were the food groups of the fish. Among different groups of zooplankton, Rotifera and Protozoa were the dominant food groups of the fish. Mookerjee (1944, 1945) noted different unicellular algae, rotifers and crustaceans in the diet of rohu.

Catla consumed 26 genera of phytoplankton and 9 genera of zooplankton. Chlorophyceae was dominant in its food item. Among the zooplankton, rotifers were the most preferred food. It also consumed Cyanophyceae, Bacillariophyceae, Euglenophyceae, Rhodophyceae, Crustacea, Hydrozoa and Rotifera. George (1963) recorded that catla consumed large quantities of crustacaeans and rotifers and which were found to be completely digested. Natarajan and Jhingran (1961) recorded crustacea, algae, plants, rotifers, insects, decayed organic matters, protozoa and mollusks were the food items of catla.

Mrigal consumed 21 genera of phytoplankton and 7 genera of zooplankton. Among the planktonic group, Chlorophyceae was the dominant group in the gut contents. It also consumed Cyanophyceae, Bacillariophyceae, Euglenophyceae, Rhodophyceae, Hydrozoa and Protozoa. Among crustacaean group, only nauplii were present in the diet of the fish. Among planktonic food items, it also preferred phytoplankton. George (1963) also showed that mrigal preferred plant matter including decaying vegetation.

Silver carp consumed 24 genera of phytoplankton and 6 genera of zooplankton. Among all the species of fish it consumed a large quantity of phytoplankton and dominated by Chlorophyceae. Among zooplankton, rotifers were the prominent food item and crustaceans were completely absent. It also consumed Bacillariophyceae, Euglenophyceae, Cyanophyceae, Hydrozoa and Protozoa. Silver carp widely reported as being phytoplanktivorous. The food of silver carp consists of mainly Cyanophyceae, organic detritus and Bacillariophyceae (Ghosh *et al*., 1973). The important food groups of silver carp were Bacillariophyceae, Cyanophyceae and debris (Cremer and Smitherman, 1980; Miah *et al*., 1984). The present finding is a true reflection of above mentioned authors.

Bighead consumed 21 genera of phytoplankton and 6 genera of zooplankton and some nauplii. Chlorophyceae comprised the dominant food items of this fish. Among

zooplankton, rotifers were the principal components. Diet of bighead consisted of Chlorophyceae, Bacillariophyceae, Euglenophyceae, Rotifera, Crustacea, Hydrozoa and Protozoa. Bighead selectively fed on *Fragilaria*, *Navicula*, *Cyclotella*, *Botryococcus*, *Crucigenia*, *Gonatozygon*, *Tetraodon*, *Trachelomonas* and *Gomphosphaeria* (Wahab *et al*., 1991) which is very similar to the present study.

Mirror carp consumed 18 genera of phytoplankton and 5 genera of zooplankton. Among phytoplankton, Chlorophyceae was the dominant food group. According to Opuszynski (1981), cladocerans copepods and chironomid larvae were the basic food items of common carp.

Electivity indices have provided a generalized idea on the food selection by the carp species. The findings from the present study showed that catla responded positively to Cyanophyceae, Bacillariophyceae, Euglenophyceae, Rhodophyceae, Rotifera and Protozoa. It showed an overall neutral response with slightly negative to Chlorophyceae, Hydrozoa and Crustacea. Rohu has a positive response to Bacillariophyceae, Hydrozoa, Rotifers, Crustacaeans and Protozoans. It showed an overall positive response to zooplankton as well. Mrigal respond positively to Bacillariophyceae, Cyanophyceae, Euglenophyceae, Rhodophyceae and Protozoa. It had an overall positive response to phytoplankton. Silver carp had positive elective values for Bacillariophyceae, Euglenophyceae, Rotifera and Protozoa. It showed a positive selection for *Crucigenia*, *Mesotaenium*, *Scenedesmus*, *Spirogyra*, *Tetraodon*, *Oedogonium* and *Oocystis* of Chlorophyceae. Its response to zooplankton was also positive.

Bighead showed a positive response to Bacillariophyceae, Euglenophyceae and Protozoa. It had selectively fed on Bacillariophyceae, Cyanophyceae and Protozoa. It had an overall positive trend towards phytoplankton.

Dietary overlap among fish species helps to explain community structure or to clarify competitive relationships. In the present study from the Schoener's index indicates that silver carp and bighead carp compete with rohu for food but mirror carp does not compete. Silver carp and bighead carp also compete with catla while mirror carp does not compete with catla. Silver carp heavily competes with catla and rohu for food and reduces their growth (Dewan *et al*., 1991; Wahab *et al*., 1991). According to Dewan *et al*. (1991), bighead carp also competes with catla. From the findings of the present study, it may be concluded that silver carp and bighead carp heavily compete with rohu and catla whereas mirror carp does not compete with any species of the indigenous carps.

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