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Water quality and plankton composition in fed and unfed fish ponds in Rajshahi district, Bangladesh

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Abstract: The study was conducted to explore the plankton composition and abundance in fed (used artificial fish feed and fertilizers) and unfed fish pond (not used artificial feed and irregularly applied fertilizers) located in Rajshahi district, Bangladesh from September 2016 to February 2017. Samples were collected at fortnightly intervals during the entire study period using plankton net. All the water quality parameters were within the optimal ranges for plankton productivity. In fed pond, the phytoplankton population consisted 20 genera of which 7 belonged to Chlorophyceae (34.15%), 5 Cyanophyceae (28.03%), 4 of Bacillariophyceae (22.43%) and 4 of Euglenophyceae (15.38%). The highest cell density of phytoplankton was 444122 units/l in October 2016 and lowest number of phytoplankton was 235150 units/l in January 2017 in fed pond. Whereas in case of zooplankton it consisted of 11 genera of which 5 belonged to rotifer (29.14%), 2 copepod (30.18%) and 3 cladocera (25.90%) and crustacean larvae (14.78%). The maximum number of zooplankton was 6200 units/l in January 2017 and minimum number of zooplankton was 3430 units/l in October 2016. In unfed pond, the phytoplankton population consisted 14 genera of which 4 belonged to Chlorophyceae (33.41%), 4 Cyanophyceae (27.40%), 3 Bacillariophyceae (22.59%) and 3 Euglenophyceae (16.58%). The maximum number of phytoplankton was 280000 units/l in October 2016 and minimum number of phytoplankton was 154400 units/l in January 2017. Zooplankton population in unfed fish pond consisted 8 genera of which 3 belonged to rotifer (20.09%), 2 of copepod (36.77%) and 2 cladocera (22.54 %) and crustacean larvae (20.72%). In the unfed pond maximum number of zooplankton was 2880 units/l in January 2017 and minimum number of zooplankton was 1570 units/l in October 2016. It is concluded that the phytoplankton groups provide the main support for pond aquaculture compared to zooplankton classes. The present findings indicated that the fed pond showed better result than unfed pond regarding plankton abundance and species composition.

Key words: Water quality, plankton, fish pond

Introduction

Successful pond fishery development largely depends on the water quality, i.e., the physico-chemical and biological characteristics of water, which play vital roles in plankton productivity and the biology of the cultured organisms and final yields. Each species has optimal water quality when culture under different environments (Dhawan & Karu, 2002).The plankton community is comprised of the primary producers or phytoplankton's and zooplanktons as secondary producers (Battish, 1992). Both the qualitative and quantitative abundance of plankton in a fish pond are of great importance in managing the successful aquaculture operations, as they vary from location to location and pond to pond within the same location even within similar ecological conditions (Boyd, 1982). The phytoplankton population represents the biological wealth of a water body, constituting the vital link in the food chain. The variation and distribution pattern of phytoplankton in freshwater systems depend on the physicochemical features of the systems (Cetin & Sen, 2004). Phytoplankton species can be used as indicators of water quality for their dynamics response to changes in the surrounding environment. The variability of phytoplankton with the seasonal changes in aquatic environment is very much necessary for the maintenance of water quality and sustainable aquaculture. Taxonomic studies of plankton are also very effective in re-evaluation of the uses and stability of ponds. In particular, data on plankton of water bodies are commonly used in the preservation, improvement and control of water quality. Rajshahi is situated in

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north-western region of Bangladesh. There are thousands of small and larger ponds available in Rajshahi region where extensive fish culture is practiced depending on natural food i.e. phytoplankton and zooplankton. Many researchers worked on the percentage composition, seasonal variation and occurrence of freshwater planktons (Affan *et al*., 2005; Hossain *et al*., 2007; Sharmin *et al*., 2015), but little or no information is available on water quality and plankton abundance in fed and unfed fish ponds. The current research was designed to investigate the plankton composition and their abundance in earthen fed and unfed fish ponds in relation to water quality parameters in Rajshahi region, Bangladesh.

Materials and Methods

Sampling period and location

The study was carried out over a period of six months from September 2016 to February 2017. The first pond (fed pond) was located in Rajshahi University Campus (north side of Rokeya Hall) and second pond (unfed) was at Khorkhori bypass, Rajshahi. Samplings were done fortnightly during the entire study period.

Management system of the selected ponds

The first experimental pond (fed pond) was rectangular in shape and has an area of 45 decimal with an average depth of 2.5 feet, which varies throughout the year. Fed pond was managed properly and was stocked with exotic and indigenous fish species. The pond was well protected from the entrance of surface runoff water and lime was applied before start of culture. The ponds were limed at the rate of 247 kg/ha. One week after liming, the ponds were filled with water from adjacent deep tube-well. Then the ponds were fertilized with urea and TSP at the rate of 38 and 20 kg/ha respectively. Commercial-pellet was applied with 5% of body weight for first three months and 3% of body weight for last three months. Different types of artificial fish feed was also applied in this pond.

The second pond (unfed pond) was irregular in shape and has an area of 56 decimal with an average depth of 3.0 feet. The unfed pond was not managed properly and artificial fish feed was not applied. Lime and fertilizers were not used regularly in this pond. Both ponds were free from any shading and adequate sunlight was present throughout the day.

Analysis of water quality

Water samples were collected in dark bottles fortnightly between 10:00 and 11:00 AM, for analysis of various physico-chemical parameters. Water temperature and transparency were measured with a Celsius thermometer and a black and white standard colour coded Secchi disc of 30 cm diameter. Water pH was measured using an electronic pH meter (Jenwary 3020) and dissolved oxygen (DO) was measured directly with a DO meter (Lutron DO-5509). Ammonia-nitrogen and total alkalinity were measured using HACH kit (model FF-2, No. 2430-01; Loveland, CO, USA). Nitrate-nitrogen and phosphate-phosphorus concentrations were measured using the HACH Kit (DR/2010, a direct-reading spectrophotometer) with high range chemicals (Nitra Ver. 5 Nitrate Reagent Powder Pillows for 25 ml sample for Nitrate-nitrogen and Phos. Ver. 3 Phosphate Reagent Powder Pillows for 25 ml sample for phosphate-phosphorus analysis).

Plankton sampling and analyses

Sampling of pond water for plankton analyses was done on ten litre water samples from different areas and depths of the selected ponds, filtered through 25 µm mesh plankton net. Preservation of the samples before analyses was done by addition of 5% buffered formalin in small plastic bottles. Analysis of water was done on a Sedgewick-Rafter counting cell, under a compound

binocular microscope (Model no. SWIFT M 4000-D). Analysis involved transfer of 1 ml sub-samples from each of the samples to the Sedgewick- Rafter counter and counting of cells within 10 squares of the cells, chosen randomly. The cell counts were used for computing the cell density using the Stirling (1985) formula where the plankton density is estimated by the following formula:

$$N = (A \times 1000 \times C)/(V \times F \times L)$$

Where,

N = No. of plankton cells or units per litre of original water.
A = Total No. of plankton counted.
C = Volume of final concentrate of the samples in ml.
V = Volume of a field in cubic mm.
F = No. of fields counted.
L = Volume of original water in liters.

The plankton were then identified up to genus level and enumerated using the following references: (APHA, 1992; Bellinger, 1992; Ward and Whipple, 1954; Needham and Needham, 1962).

Results and Discussion

Physico-chemical variables

Some selected physico-chemical variables of water were studied from fed and unfed ponds and their monthly mean values are shown in the Table 1.The data shows that values of all the parameters were nearly similar in both the ponds.

Water temperature (^{0}C): During the study period, water temperature ranged from a maximum of 31.52±0.58 ^{0}C (September, 2016) to a minimum of 19.50±0.50 ^{0}C (January, 2017) in fed pond, while maximum of 31.10±0.56 ^{0}C (September, 2016) to a minimum of 19.00±0. 0.29 ^{0}C (January, 2017) in unfed pond. The observed temperatures are within the optimal ranges (18.3-37.8 ^{0}C) for production of plankton as recommended for tropical ponds (Jhingran, 1991; Begum *et al*., 2003). Islam *et al.* (1974) and Patra & Azadi (1987) recorded highest water temperature during summer and lowest in winter months recorded from the Burigonga and Halda Rivers.

Transparency (cm): Transparency of water was observed to be highest (33.28±0.81 cm) in September, 2016 and lowest (25.58±0.94 cm) in February, 2017 in fed pond; whereas the highest value of transparency (35.50±0.52 cm) was observed in October, 2016 and lowest value (30.09±0.49 cm) was observed in February, 2017 in unfed pond. Transparency value was comparatively low in fed pond than unfed pond; it may be due to higher cell density of plankton in fed pond. Similar observation was also made by Reid & Wood (1976) where they reported that the transparency of water may be affected by plankton density. However, Hossain *et al.* (2007) recorded maximum transparency in October and minimum in February which was more or less similar to the findings of the present study.

pH: pH of the fed pond fluctuated between 7.60±0.05 (January. 2017) to 7.20±0.07 (November, 2016); and in unfed pond between7.30±0.23 (February, 2017) to 6.92±0.23 (November, 2016). Fluctuation in pH between a near neutral to alkaline range has also been recorded in fish culture pond by Hossain *et al.* (2007). Such type of result was also reported by Islam *et al.* (2000) who reported average pH value of 7.77 from the pond of Taposhi Rabeya Hall, Rajshahi University.

Dissolved oxygen (mg/l): The dissolved oxygen (DO) content of water varied between 6.0±0.52 (February, 2017) to 4.8±0.14 mg/l (September, 2016) in fed pond and 5.20±0.23 (February, 2017) to 3.5±0.23 mg/l (September, 2016) in unfed pond. Dissolved oxygen was lowest in September in both ponds, this could be attributed due to high temperature in September with low density of

Table 1. Monthly mean±SD values of different physico-chemical parameters of water of fed and unfed ponds during study period

	Temperature (°C)		Transparency(cm)		pH		DO (mg/l)		Alkalinity (mg/l)		NH_3(mg/l)		NO_3-N(mg/l)		PO_4-P(mg/l)	
	Fed pond	Unfed pond	Fed Pond	Unfed pond	Fed pond	Unfed pond	Fed pond	Unfed pond	Fed Pond	Unfed pond	Fed pond	Unfed pond	Fed pond	Unfed pond	Fed pond	Unfed pond
Sep'16	31.52±0.58	31.10±0.56	33.28±0.81	34.10±1.41	7.5±0.20	7.5±0. 33	4.8±0.14	3.5±0.23	112.18±2.02	110±2.03	0.04±0.01	0.03±0.02	1.40±0.05	1.00±0.10	0.47±0.06	0.30±0.06
Oct'16	30.00± 0.72	28.50±0.50	29.48±0.86	35.50±0.52	7.40±0.23	7.34±0.05	5.0±0.14	3.9±0.10	119.23±2.65	111.5±1.37	0.08±0.01	0.04±0.01	1.50±0.04	1.10±0.06	0.63±0.06	0.40±0.10
Nov'16	25.00±0.30	24.50±29	29.65±0.88	32.59±0.47	7.20±0.07	6.92±0.23	5.2±0.23	4.5±0.07	124.95±2.41	116.19±0.97	0.12±0.03	0.06±0.01	1.66±0.07	1.20±0.01	1.00±0.10	0.53±0.12
Dec'16	22.50±0.29	22.00±0.50	28.04±3.11	32.43±1.09	7.34±0.14	7.15±0.35	5.6±0.14	5.0±0.14	125.60±1.65	117.886±2.51	0.16±0.02	0.09±0.01	1.96±0.10	1.25±0.04	1.14±0.06	0.75±0.05
Jan'17	19.50±0.50	19.00±0.29	26.81±1.06	30.73±0.49	7.60±0.05	7.10±1.02	5.9±0.31	5.10±0.19	130.80±1.50	120.66±0.51	0.20±0.01	0.11±0.01	2.20±0.03	1.45±0.01	1.32±0.03	0.90±0.12
Feb'17	24.10±0.74	24.00±0.54	25.58±0.94	30.09±0.49	7.49±0.03	7.3±2.23	6.0±0.52	5.20±0.23	134.43±1.32	122.57±2.09	0.22±0.02	0.15±0.02	2.50±0.05	1.70±0.02	1.40±0.11	0.98±0.08

phytoplankton in both ponds. The highest DO was found at February 2017 in both ponds when temperature was relatively low. This data is supported by the findings of George (1966) from the Indrasagar Tank of India. Sharmeen & Hussain (2008) recorded highest dissolved oxygen during winter and lowest in summer in earthen fish ponds.

Total Alkalinity (mg/l): Total alkalinity of fed pond ranged from 134.43±1.32 (February, 2017) to 112.18±2.02 mg/l (September, 2016), while in unfed pond from 122.57±2.09 (February, 2017) to 110±2.03 mg/l (September, 2016). Chowdhury *et al.* (2007) also recorded total alkalinity of water from 48.50 to 133.0 mg/l in Borobila beel, Rangpur which is more or less similar with the present study.

Ammonia (mg/l): The NH_3 of the fed pond fluctuated between 0.22±0.02 (February, 2017) to 0.04±0.01 mg/l (September, 2016) and 0.15±0.02 (February, 2017) to 0.03±0.02 mg/l (September, 2016) in unfed pond. Total ammonia values recorded by Azim *et al.* (1995) was 0.1 mg/l in fish ponds that is relatively low than the present finding.

Nitrate- Nitrogen (NO_3-N mg/l): In fed pond, NO_3-N concentration varied from 2.50±0.05 to 1.40±0.05 mg/l with higher concentration in February, 2017 and lower in September, 2016 while in case of unfed pond, higher concentration of NO_3-N was recorded (1.70±0.02 mg/l) in February, 2017 and lower (1.00±0.10 mg/l) in September. Berg (2002) recorded that the mean value of nitrate-nitrogen varied from 1.57-2.12 mg/l respectively in rice-fish culture system, Mymensingh, Bangladesh that is slightly higher than the present study.

Phosphate-Phosphorus (PO_4-P mg/l): PO_4-P was observed to be highest (1.40±0.11 mg/l) in February, 2017 and lowest (0.47±0.06 mg/l) in September, 2016 in fed pond, while the highest value (0.98±0.08 mg/l) was observed in February, 2017 and lowest value (0.30±0.06 mg/l) was observed in September, 2016 in unfed pond. Chowdhury *et al.* (2007) also recorded the fluctuation of PO_4-P concentration from 0.08 to 0.88 mg/l in Borobila beel,with the maximum in April and minimum in October that is more or less similar with the present findings.

Qualitative status of phytoplankton population in fed and unfed ponds

During the study period, the recorded phytoplankton was classified as four classes namely Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. The identified number of 20 genera in fed pond was twenty and that in unfed pond was 14. Among the identified genera, 7 belonged to Chlorophyceae, 5 to Cyanophyceae, 4 to Bacillariophyceae and 4 to Euglenophyceae in fed pond whereas 4 genera belonged to Chlorophyceae, 4 to Cyanophyceae, 3 to Bacillariophyceae and 3 to Euglenophyceae in unfed pond (Table 2). Phytoplankton diversity in freshwater ponds was identified by many researchers, such as Verma & Shukla (1970) recorded 30 genera of phytoplankton from Kamala Nehru Tank, Muzaffarnagar, India. Hossain *et al.* (2007) found 17 genera of phytoplankton from earthen fish ponds within the Rajshahi region, Bangladesh.

Table 2. Generic status of plankton with their different groups recorded from fed and unfed ponds during study period

	Phytoplankton		Zooplankton	
	Fed pond	**Unfed pond**	**Fed pond**	**Unfed pond**
Family	**Chlorophyceae**	**Chlorophyceae**	**Rotifera**	**Rotifera**
Genus	*Spirogyra* *Chlorella* *Ulothrix* *Closterium* *Oedogonium* *Pediastrum* *Scenedesmus*	*Spirogyra* *Chlorella* *Closterium* *Coelastrum*	*Brachionus* *Keratella* *Filinia* *Polyarthra* *Asplancha*	*Brachionus* *Keratella* *Polyarthra*
Family	**Cyanophyceae**	**Cyanophyceae**	**Copepoda**	**Copepoda**
Genus	*Anabaena* *Microcystis* *Oscillatoria* *Rivulatoria* *Merismopedia*	*Anabaena* *Microcystis* *Oscillatoria* *Rivulatoria*	*Cyclops* *Diaptomus*	*Cyclops* *Diaptomus*
Family	**Bacillariophyceae**	**Bacillariophyceae**	**Cladocera**	**Cladocera**
Genus	*Navicula* *Nitzschia* *Cyclotella* *Tabellaria*	*Navicula* *Nitzschia* *Cyclotella*	*Moina* *Daphnia* *Diaphanosoma*	*Moina* *Daphnia* *Diaphanosoma*
Family	**Euglenophyceae**	**Euglenophyceae**	**Crustacean larvae**	**Crustacean larvae**
Genus	*Euglena* *Phacus* *Trachelomonas* *Strombomonus*	*Euglena* *Phacus* *Trachelomonas*	Nauplius larvae	Nauplius larvae

Quantitative analysis of phytoplankton population in fed and unfed ponds

There were marked differences in the total species and density of phytoplankton among the fed and unfed fish ponds. In fed pond, the highest number of total phytoplankton was recorded 444122 units/l in October 2016 and lowest was 235150 units/l in January 2017, while in unfed pond, maximum number of phytoplankton was recorded 280000 units/l in October 2016 and minimum was 154400 units/l in January 2017 (Tables 3 and 4). Singh (1960) recorded primary peak of phytoplankton in the month of September- October which is similar to the finding of the present study. According to Ayaz & Ashwani (2015), the highest peak abundance in phytoplankton was recorded during summer and lowest during winter months. In the present study, number of species and total density of phytoplankton was comparatively high in fed pond than that of unfed pond. The higher cell abundance of phytoplankton in fed pond may be due to higher concentration of nutrients in this pond (regularly used of artificial feeds and fertilizers) which agreed with the finding of Affan *et al*. (2005) who stated that phytoplankton population in nutrient rich water is more diverse than those in nutrient deficient water. Sedwick *et al*. (2002) correlated variation with the nutrients as well as other micro-elements as nutrient had a positive effect on the growth rate of phytoplankton. According to Boyd (2004), although phytoplankton is present in water bodies, their supply as food supplement can be increased through external supply from cultures or by development of prevailing algae through fertilization.

Table 3. Monthly abundance and percentage composition of phytoplankton population (units/l) of fed pond during study periods

Family/Genus	Sep	Oct	Nov	Dec	Jan	Feb	Average	% of total phytoplankton
Chlorophyceae								
Spirogyra	27590	27761	20000	17000	12200	22000	21091.83	5.96
Ulothrix	25000	24850	18500	15800	11500	21500	19525	5.51
Closterium	22500	22000	17500	14500	11000	20000	17916.67	5.1
Chlorella	21800	23600	16900	14950	9000	18000	17375	4.91
Pediastrum	19500	21000	15500	12000	8500	16800	15550	4.39
Oedogonium	23900	24761	15000	11000	7000	12500	15693.5	4.43
Scenedesmus	21500	22100	12000	10500	5750	11000	13808.33	3.84
Total	**161790**	**166072**	**115400**	**95750**	**64950**	**121800**	**120960.3**	**34.15**
Cyanophyceae								
Microcystis	28500	29000	22500	18500	12500	25500	22750	6.42
Anabaena	26350	27500	21000	17500	11500	22500	21058.33	5.95
Oscillatoria	25500	26900	20500	15000	11000	19500	19733.33	5.54
Rivulatoria	22300	25000	19000	14500	10100	18800	18283.33	5.2
Merismopedia	21500	24950	18750	12050	9800	17500	17425	4.92
Total	**124150**	**133350**	**101750**	**77550**	**54900**	**103800**	**99250**	**28.03**
Bacillariophyceae								
Nitzschia	23800	25500	16500	17500	11000	25500	19966.67	5.63
Navicula	25800	28500	21000	19050	12500	27500	22391.67	6.32
Cyclotella	23550	26800	16500	15000	9000	24500	19225	5.43
Tabellaria	23000	25900	15900	12000	7800	22500	17850	5.03
Total	**96150**	**106700**	**69900**	**63550**	**40300**	**100000**	**79433.33**	**22.43**
Euglenophyceae								
Euglena	8300	11700	15500	22500	24000	20500	17083.33	4.82
Phacus	8500	10000	11000	20000	23100	18000	15100	4.26
Trachelomonas	7000	9300	10500	15500	15300	16500	12350	3.48
Strombomonus	6500	7000	8000	13000	12600	12700	9966.67	2.82
Total	**30300**	**38000**	**45000**	**71000**	**75000**	**67700**	**54500**	**15.38**
Total phytoplankton	**412390**	**444122**	**332050**	**307850**	**235150**	**393300**	**354143.6**	**100**

Comparison of phytoplankton group between two ponds

Chlorophyceae: Chlorophyceae was the most dominant group among phytoplanktons in both ponds and constituted 34.15% and 33.41% of total phytoplankton (Tables 3 and 4). The average mean cell density of chlorophyceae were 120960.33 units/l in fed pond and 80233.33 units/l in unfed pond. *Spirogyra, Scenedesmus, Chlorella, Closterium, Ulothrix, Padiastrum, Oedogonium* were found in fed pond and *Spirogyra, Chlorella, Coelastrum, Closterium* in unfed pond (Table 2). Among Chlorophyceae, *Spirogyra* was the most dominant genera in both ponds. Hossain *et al.* (2007) also found that Chlorophyceae was first dominant (34.48%) group among phytoplankton in earthen fish ponds.

Table 4. Monthly abundance and percentage composition of phytoplankton population (units/l) in unfed pond during study period

Family/Genus	Sep	Oct	Nov	Dec	Jan	Feb	Average	% of total phytoplankton
Chlorophyceae								
Coelastrum	22100	25400	21000	18000	12800	23100	20400	8.49
Spirogyra	25500	28500	22200	24000	12500	25500	23033.33	9.59
Closterium	24000	23900	21000	12000	10000	23200	19016.67	7.92
Chlorella	23900	22850	20900	11550	8100	16500	17300	7.41
Total	**95500**	**100650**	**88000**	**65550**	**43400**	**88300**	**80233.33**	**33.41**
Cyanophyceae								
Microcystis	26800	24200	24200	19900	11100	25000	21866.67	9.11
Anabaena	22900	21900	21000	12500	7200	22100	17933.33	7.47
Oscillatoria	18950	19800	18000	10000	6900	15000	14775	6.15
Rivulatoria	10550	17050	15900	8500	4500	11000	11250	4.66
Total	**78200**	**82950**	**76900**	**52900**	**29700**	**74100**	**65791.67**	**27.40**
Bacillariophyceae								
Syndra	23300	22500	20500	16200	9000	19000	18416.67	7.67
Navicula	25500	25000	22000	18050	11500	24500	21091.67	8.78
Cyclotella	18000	21500	15500	12000	6000	15500	14750	6.14
Total	**66800**	**69000**	**58000**	**46250**	**26500**	**59000**	**54258.33**	**22.59**
Euglenophyceae								
Euglena	5500	11400	18500	22500	25000	18600	16916.67	7.04
Phacus	4500	8900	15500	17500	17500	16000	13316.67	5.61
Trachelomonas	3000	7100	10550	10050	12300	12500	9250	3.92
Total	**15000**	**27400**	**44550**	**50050**	**54800**	**47100**	**39816.67**	**16.58**
Total phytoplankton	**255500**	**280000**	**267450**	**214750**	**154400**	**268500**	**240100**	**100**

Cyanophyceae: Cyanophyceae was second dominant group among phytoplankton in both studied ponds. It contributed to 28.03% and 27.40% of total phytoplankton in fed and unfed pond respectively (Tables 3 and 4). The average mean cell density of cyanophyceae were 99250 units/l in fed pond and 65791.67 units/l in unfed pond. *Anabaena, Microcystis, Oscillatoria, Rivulatoria, Merismopedia* were the identified genera in fed pond and only *Merismopedia* genera was absent in unfed pond. Among these genera *Microcystis* was the most dominant genera in both ponds. Cyanophyceae was second dominant group of phytoplankton which is supported by to Ayaz & Ashwani (2015) who found Chlorophyceae and Cyanobacteria were the main dominating components of phytoplankton community in Bhoj Wetland where Cyanobacteria constituted 24.49% of total phytoplankton.

Bacillariophyceae: Bacillariophyceae was third dominant group of phytoplankton in both fed and unfed fish ponds. It contributed to 22.43% and 22.59% of total phytoplankton in fed and unfed pond respectively (Tables 3 and 4). The average mean cell density of cyanophyceae were 79433.33 units/l in fed pond and 54258.33 units/l in unfed pond. In case of fed pond, *Navicula, Nitzschia, Cyclotella, Tabellaria* and *Pinnuiaria* were the identified genera whereas *Syndra*, *Navicula, Nitzschia* and *Cyclotella* were found in unfed

pond. Among these genera *Navicula* was the most dominant genera in both ponds which is supported by Nair *et al.* (2015) who found *Navicula* was the most dominant genera among Bacillariophycea in ponds in Kerala. Bacillariophyceae was third dominant group of phytoplankton in fish ponds of Noakhali reported by Sharmin *et al.* (2015).

Euglenophyceae: Euglenophyceae was least dominant group of phytoplankton in respect of both abundance and number of species in both ponds. It contributed to 15.38% and 16.58% of total phytoplankton in fed and unfed pond respectively (Tables 3 and 4). The average mean cell density of Euglenophyceae were 54500 units/l in fed pond and 39816.67 units/l in unfed pond. *Euglena, Phacus, Trachelomonas* and *Strombomonus* were the identified genera in fed pond. Except *Strombomonus* all genus of euglenophyceae were present in unfed pond. *Euglena* was the most dominated in both studied ponds. According to Hossain *et al.* (2007) Euglenophyceae was least abundant among phytoplankton an earthen fish pond in Bangladesh.

Qualitative and quantitative status of zooplankton population in fed and unfed ponds

In the present study, the zooplankton populations of fed and unfed ponds were composed of four major groups: Rotifera, Copepoda, Cladocera and Crustacean larvae which is similar to the findings of Shankaran & Varghese (1981) and Hossain *et al.* (1999). The identified group consisting of 11 genera in fed pond and 9 genera in unfed pond.

Table 5. Monthly abundance and percentage composition of zooplankton population (units/l) in fed pond during study period

Family/Genus	Sep	Oct	Nov	Dec	Jan	Feb	Average	% of total zooplankton
Rotifera								
Brachionus	300	280	520	1080	1260	1160	766.67	17.63
Keratella	500	250	-	-	260	-	336.67	3.03
Filinia	-	-	360	-	-	-	360	4.01
Polyarthra	-	-	500	-	260	-	380	3.03
Asplancha	-	-	250	260	250	-	253.33	1.44
Total	**800**	**530**	**1630**	**1341**	**2030**	**1160**	**1248.5**	**29.14**
Copepoda								
Diaptomus	500	250	610	260	460	380	410	9.42
Cyclops	1260	550	800	1240	750	700	883.33	20.76
Total	**1760**	**800**	**1410**	**1500**	**1210**	**1080**	**1293.33**	**30.18**
Cladocera								
Moina	260	850	250	-	240	-	400	9.19
Daphnia	-	720	380	410	1450	720	736	12.70
Diaphanosoma	-	-	240	300	460	380	345	4.01
Total	**260**	**1570**	**870**	**710**	**2150**	**1100**	**1110**	**25.90**
Crustacean larvae								
Nauplius larvae	620	530	400	720	810	720	633.33	14.78
Total zooplankton	**3440**	**3430**	**4410**	**4271**	**6200**	**4040**	**4285.16**	**100**

Among the identified genera, 5 genera belonged to Rotifera, 2 to Copepoda, 3 to Cladocera and one genera was belonged to Crustacean larvae in fed pond whereas 3 genera belonged to Rotifera, 2 to Copepoda, 3 to Cladocera and one genera was belonged to Crustacean larvae in unfed pond (Table 2). Hossain *et al.* (2007) found zooplankton population consisted of 10 genera during plankton study in earthen ponds, Rajshahi. There was marked difference in the density of total zooplankton between fed and unfed fish ponds. In the fed pond maximum total number of zooplankton was recorded 6200 units/l in January 2017 and minimum number of zooplankton was 3430 units/l in October 2016 whereas in the unfed pond maximum number of zooplankton was 2880 units/l in January 2017 and minimum number of zooplankton was 1570 units/l in October 2016 (Tables 5 and 6). In the present study, higher abundance of zooplankton was found in winter months in both fed and unfed ponds which agreed with the finding of Sharmeen and Hussain (2008) and Islam *et al.* (2000) who found high cell abundance of zooplankton in winter months. Comparatively higher cell density and diversity of zooplankton was found in fed pond than that of unfed pond. The higher cell abundance of zooplankton in fed pond might be due to the effect of fertilizer, used of comercial feeds, subsequent water quality and phytoplankton density. These results were more or less agreed with Knud-Hansen *et al.* (1994), Edwards *et al.* (1994) and Sharmin & Hussain (2008).

Comparison of zooplankton group between two ponds

Copepoda: Copepods were the most dominant group of zooplankton in both fed and unfed ponds. The members of copepoda constituted 30.18% (fed pond) and 36.77% (unfed pond) of

Table 6. Monthly abundance and percentage composition of zooplankton population (units/l) in unfed pond during study period

Family/Genus	Sep	Oct	Nov	Dec	Jan	Feb	Average	% of total zooplankton
Rotifera								
Brachionus	230	-	240	380	500	240	318	15.09
Keratella	240	260	-	-	-	-	250	2.09
Polyarthra	-	-	240	-	200	-	220	3.04
Total	**470**	**480**	**480**	**380**	**700**	**240**	**421.67**	**20.09**
Copepoda								
Cyclops	960	340	500	480	460	750	581.67	27.60
Diaptomus	380	240	680	240	560	260	393.33	9.17
Total	**1340**	**580**	**1180**	**720**	**1020**	**1010**	**775**	**36.77**
Cladocera								
Moina	-	230	-	-	240	-	235	11.15
Daphnia	-	-	-	500	240	500	413.33	3.45
Diaphanosoma	240	-	-	240	180	-	220	8.01
Total	**240**	**230**	**-**	**740**	**660**	**500**	**474**	**22.54**
Crustacean larvae								
Nauplius larvae	280	500	400	540	500	400	436.67	20.72
Total zooplankton	**2330**	**1570**	**2060**	**2380**	**2880**	**2150**	**2107.34**	**100**

the total zooplankton represented by two genera. The highest abundance of copepods (1760 units/l) was recorded in the month of September 2016 and the lowest abundance of copepods (800 units/l) was found in October 2016 in fed pond whereas 1340 units/l was recorded in the month of September, 2016 and 580 units/l was in October, 2016 in unfed pond. *Cyclops* was the most dominant genera among copepods in both ponds (Tables 5 and 6). Sharmeen and Hussain (2008) recorded, Copepods was first dominant group of zooplankton in the culture and non-culture ponds.

Rotifera: Rotifera was second dominant group in fed pond whereas it was least dominant in unfed pond among zooplanktons. They contributed 29.14% and 20.09% of the total zooplankton population in the ponds accordingly. The highest abundance of rotifers (2030 units/l) was found in the month of January 2017 and the lowest abundance of rotifers (530 units/l) was recorded in October 2016 in fed pond, whereas 700 units/l in January 2017 and 240 units/l in February 2017 in unfed pond. *Brachionus, Asplanchna, Keratella, Filinia* and *polyarthra* were the identified genera in fed pond whereas *Brachionus, Keratella* and *polyarthra* were only present in unfed pond. *Brachionus* was the most dominant genera among total rotifers in both ponds (Tables 5 and 6). Hossain *et al.* (2007) found rotifera was second dominant group of zooplankton in earthen ponds, Rajshahi.

Cladocera: Cladocera was the third dominant in fed pond and second dominant in unfed pond among zooplankton. The cladocerans constituted 25.90% and 22.54% of the total zooplankton population in fed and unfed pond respectively. Cladocera cell density was highest (2150 units/l) in January 2017 and lowest (260 units/l) was in September 2016 in fed pond, whereas 740 units/l in December, 2016 and 230 units/l in October, 2016 in unfed pond (Tables 5 and 6). *Daphnia, Moina,* and *Diaphanosoma* were the identified species in both ponds. In the present study, *Daphnia* was the most dominant genera among cladocerans in both fed and unfed ponds which is similar with the findings of Sharmin & Hussain (2008).

Crustacean larvae: Crustacean larvae constituted 14.78% and 20.72% of total zooplankton population in the fed and unfed pond respectively. The highest (810 units/l) crustacean larvae was found in January, 2017 and lowest (400 units/l) was recorded in November, 2016 in fed pond, whereas 540 units/l in December, 2016 and 280 units/l in September 2016 in unfed pond. (Tables 5 and 6). Sharmeen and Hussain (2008) recorded, Crustacean larvae constituted 15.28% and 19.91% of total zooplankton in culture and non-culture pond, Rajshahi. They also found, Crustacean larvae were high in January and low in October month.

Conclusion: It can be concluded that the present findings indicated that the fed pond showed better result than that of unfed pond regarding plankton diversity, production and water quality, and fed ponds would give higher fish production than unfed ponds.

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