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STUDY ON MONTHLY VARIATIONS OF PLANKTON IN RELATION TO THE PHYSICO-CHEMICAL CONDITION OF RICE-FISH FIELDS IN *BORO* SEASON

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ABSTRACT

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A study was conducted at the rice-fish plots of Rajbari and Faridpur district to observe the monthly variations of plankton (qualitatively and quantitatively) in relation to the physico-chemical conditions in *boro* season. Water quality parameters and different genera of plankton belonging to different groups were recorded and identified during the study. A total of 23 genera of phytoplankton belonging to 4 major group *viz.*, Chlorophyceae (11), Euglenophyceae (2), Cyanophyceae (4) and Bacillariophyceae (6) and 7 genera of zooplankton belonging to 2 major groups *viz.*, Crustacea (3) and Rotifera (4) were identified. Some nauplius were found along with zooplankton. The recorded water quality parameters such as temperature, transparency, dissolved oxygen, pH, CO_2, bicarbonate and chlorophyll-*a* in the rice-fish plots were found to be in the suitable range for fish culture. A correlation coefficient was made between the different major groups of plankton and physico-chemical parameters of water to find out the roles of them. Both physico-chemical and biological conditions varied monthly and showed an inverse relationship between them. Cyanophyceae and Chlorophyceae were the most dominant food group for fish among phytoplankton population. Phytoplankton population was also found to be highly dominant over zooplankton population. Water temperature vs Cyanophyceae and Clorophyceae showed strong positive (r=0.75 and 0.73) correlations. Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Crustacea and Rotifera showed negative and weak relationship with water transparency, CO_2 and bicarbonate while, Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Crustacea and Rotifera showed positive correlations with water temperature, pH, dissolve oxygen and Chlorophyll-*a*.

Key words: *plankton, phytoplankton, zooplankton, physico-chemical parameter, correlation*

INTRODUCTION

Bangladesh is an agro-based developing country and is uniquely endowed with natural fisheries resources. There is enough scope for increasing fish production in our country. Fish production can be increased not only by utilizing the vast water resources such as ponds, rivers, canals, *beels*, *haors*, floodplains and estuaries etc. But it can be increased by following integrated aquaculture practice, which is commonly termed as rice-fish farming. Rice fields, being a kind of artificial swamp, are very productive for plankton production, which is very much important as primary productivity for fish production (Halwart 1994). There are about 2.83 million hectares of inundated rice fields in Bangladesh where water stands for about 4-6 months (DoF 2008) providing great scope for rice fish culture. A rice-fish field is just like a small open ecosystem. In the abiotic part, the environmental factors are water, temperature, light, air, nutrients and soil. As compared to fish ponds, a rice plot is a shallow water body. There is a great diurnal change of water temperature, within the range of 10^0C (Zheng *et al*. 1962; Ding 1978). The fertility of rice fields fluctuates. The soil contains high organic mater content. The dissolved oxygen level is, on the average, normal: 1.5-8.2 mgL^{-1} (Ding 1978). If rice-fish farming is practiced, the respiration of fish or living organism will produce a large amount of CO_2, which could be beneficial for rice and in the same time for phytoplankton. In the biotic part, aquatic vegetation, rice and phytoplankton are autotrophs, zooplankton and fish are heterotrophs. One has to know what their feeds are and how many trophic levels are involved in the feeding fish. Within the rice-fish eco-systems, the plants, plankton and animals complement and interact with each other. The organized food chains produced various materials (living and non-living, organic and inorganic, molecular and ionic) that interact with the other biological, chemicals and physical activities in the rice-fields. As a result, soil and water in the fields made fertile, the structure of the water and soil is improved, insect pest are diminished, diseases are controlled and weeds in the rice fields are reduced but the primary productivity i.e. plankton are increased (Ali 1992). Primary productivity is very much essential to know for fish culture practice on releasing fingerlings aiming sustainable increase of fish production. Considering the above facts, the present study has been undertaken "Study on monthly variations of some plankton in relation to the physico-chemical condition of rice–fish fields in *boro* season" with the following basic aims: To measure the suitability of water quality parameters for plankton production and to identify plankton population qualitatively and quantitatively in the rice-fish fields.

MATERIALS AND METHODS

The experiment was carried out at medium low land of north south region in Rajbari and Faridpur district for a period of 4 months from February to May, 2007. Six rice-plots of an area ranged from 40-55 decimal were used for the study. All plots were stocked with fingerlings of Thai silver barb (*Barbodes gonionotus*) @ 15 nos dec^{-1}. The present study was made on the monthly variations and occurrence of some plankton in respect to physico-chemical parameters in rice-fish plots. Water and plankton samples were collected at weekly interval directly from three different spots in each plot at the time between 10.00-12.00 hrs of the day in order to calculate the mean value. During the study period, water temperature was measured by a Celsius thermometer, dissolved oxygen was measured by a digital dissolved oxygen meter (Yellow springs Instrument, Model 58, USA), pH was measured by a portable pH meter (Jenway model 3020) and transparency was measured with the help of Aquamate (Model WQA-1A-Japan). For determining the chlorophyll-a, water samples were collected and 100 ml sample was filtered through a high quality glass microfibre filter (Whatman GF/C, Whatman International, Maidstone, England) with the help of a vacuum pressure air pump. Then the filter paper were preserved in 10 ml acetone in a test tube and the paper ground by using a glass rod and kept in refrigerator for 24 hours. Later, chlorophyll-a. was determined using a spectrophotometer (Spectronic, Milton and Roy, Model 1001 plus) at 665 and 750 mm wave lengths (APHA 1989). CO_2 and bicarbonate were measured by titrimetric method (Welch 1984). Water samples were collected from different areas of the rice-fish plots and passed through a fine mesh (25µ) plankton net for collection of plankton sample. Filtered samples were taken into a measuring cylinder and carefully made up to a standard volume of 50 ml. Then the collected plankton samples were preserved in 5% buffered formalin in small plastic vials for subsequent studies. Microscopic identification was performed up to genera using keys from Rahman (1992), Prescott (1964); Needham and Needham (1972). From each 50 ml preserved sample, 1 ml sub- sample was examined using Sedge-Wick-Rafter counting cell (S-R Cell) under a binocular microscope (Olympus, Model B-2, with phase contrast facilities). Ten squares of the cell were chosen randomly and all planktonic organisms were studied qualitatively and quantitatively. Finally, the existing plankton was expressed as cells/l. Monthly quantitative fluctuation and percent composition of various groups were also determined. Statistical analysis was done by MS Excel to find out the co-efficient of correlation between different water quality parameters and major groups of plankton.

RESULTS

Monthly variations in the values of physico-chemical parameters in the water of rice-fish plots during study period are shown in Table 1.During the study period, water temperatures varied from 18^0C (February) to 35^0C (May) with a mean value of 29.37 ± 2.92^0C. The dissolved oxygen content ranged from 2.8 mgL^{-1} (February) to 7.3 mgL^{-1} (May) with a mean value of 4.95 ± 0.69 mgL^{-1}. The pH value observed to fluctuate between 5.8 (February) to 8.4 (May) with a mean value of 7.35 ± 0.21. The free CO_2 fluctuated from 0.3 mgL^{-1} (February) to 11.2 mgL^{-1} (May) with a mean value of 5.37 ± 0.6 mgL^{-1}. The bicarbonate alkalinity varied from 20.1 mgL^{-1} in March and 71 mgL^{-1} in May with a mean value of 43.84 ± 12.56 mgL^{-1}. The chlorophyll-a value was found to be ranged from 16.5 μgL^{-1} (February) to 50.5 μgL^{-1} (April) with a mean value was 31.97 ± 7.53 μgL^{-1}.

Monthly variation in the abundance of plankton ($\times 10^3$cells L^{-1}) in the water of rice-fish plots are shown in Table 2 and Fig 2a, 2b & 2c.The measured total phytoplankton populations were divided into 4 major groups such as Chlorophyceae, Euglenophyceae, Cyanophyceae and Bacillariophyceae. During the study a total number of 23 genera of phytoplankton were recorded. Out of the 23 genera, 11 genera were belonged to Chlorophyceae, 2 to Euglenophyceae, 4 to Cyanophyceae and 6 to Bacillariophyceae. The recorded zooplankton populations were grouped into 2 *viz.*, Crustacea and Rotifera. A total 7 genera of zooplankton were recorded in the pond. Out of the 7 genera, 3 were belonged to Crustacea and 4 to Rotifera. Nauplius (immature stage of Diaptomus and Cyclops) was also recorded along with zooplankton. Among the phytoplankton populations Cyanophyceae (21.6×10^3 cellsL^{-1}) followed by the Chlorophyceae (19.46×10^3 cellsL^{-1}), Bacillariophyceae (6.4×10^3 cellsL^{-1}) and Euglenophyceae (2.17×10^3 cellsL^{-1}) were found to be the dominant food groups among phytoplankton. Among zooplankton, Crustacea was found to be the dominant group (1.78×10^3 L^{-1}) than Rotifera (1.34×10^3 L^{-1}).The phytoplankton and zooplankton population showed monthly variations in their abundance in the rice fields. The maximum abundance of phytoplankton was recorded on March and minimum on May whereas, the maximum number of zooplankton was recorded on May and the lowest on February. However, a more or less inverse relationship between phytoplankton and zooplankton was recorded .On average, the total phytoplankton and zooplankton population were 49.09×10^3 cellsL^{-1} and 3.12×10^3 L^{-1}, respectively. The highest density of Cyanophyceae and Chlorophyceae were found 28.08×10^3 L^{-1} and 27.30×10^3 L^{-1} in March and Crustacea was found (2.58×10^3 L^{-1}) in May. A distinct fluctuation of both phytoplankton and zooplankton were observed in different months. The monthly variations in density of different groups of plankton are shown in figures 1a, 1b and 1c. A correlation coefficient was made between the different major groups of plankton and physico-chemical parameters of water which are given in Table 1.

Table 1. Monthly variation in the values of physico-chemical parameters in the rice-fish plots during study period

Parameter	Months				Mean value
	February	March	April	May	
Temerature (^{0}C)	19.6	23.9	29.8	33.1	26.60
Transparency (cm)	33	33	35	33.5	33.63
Dissolved oxygen (mg L^{-1})	3.9	5.1	5.6	6	5.15
pH	7.2	7.5	7.4	7.2	7.33
CO_2 (mgL^{-1})	2.3	4.3	5.9	8.3	5.20
Bicarbonate (mgL^{-1})	25	20.1	59.3	71	43.84
Chlorophyll-*a* (μgL^{-1})	16.5	23.6	50.5	37.3	31.97

Table 2. Monthly variation in the abundance of plankton ($\times10^{3}$cells L^{-1}) in the water of rice-fish plots

Parameter	Months				Mean abundance
	February	March	April	May	
A. Phytoplankton					
Chlorophyceae	19.77	27.3	21.84	8.94	19.46
Euglenophyceae	1.65	3.37	2.64	1	2.17
Cyanophyceae	22.55	28.08	21.06	12.55	21.06
Bacillariophyceae	6.41	8.41	7.53	3.24	6.4
Total	50.38	69.16	53.07	25.73	49.09
B. Zooplankton					
Crustaceae	1.01	1.64	1.88	2.58	1.78
Rotifera	1	1.25	1.43	1.67	1.34
Total	2.07	3.55	3.83	4.34	3.12
Total plankton	53.87	70.71	56.9	27.74	51.72

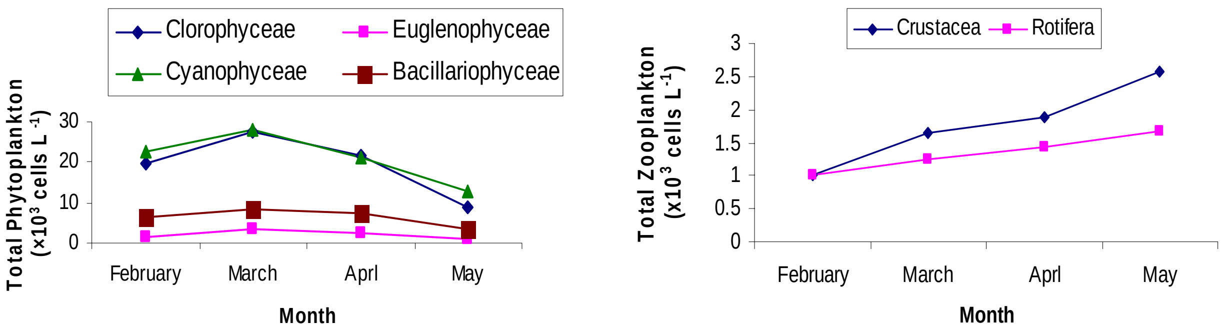

Fig. 2a, 2b Monthly fluctuation in the abundance of phytoplankton and zooplankton in rice-fish plots

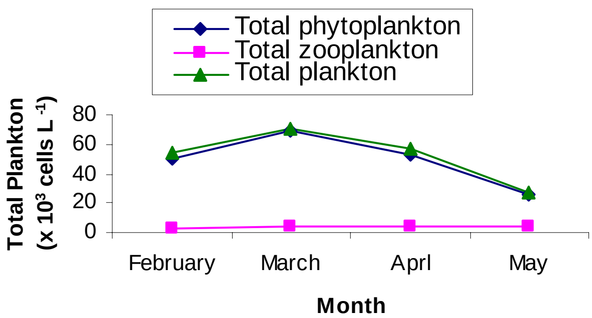

Fig. 2c Monthly fluctuation in the abundance of total plankton in rice-fish plots

Table 3. The coefficient of correlation between physico-chemical parameters of water and different dominant major groups of plankton

Relationship	Co-efficient of correlation	Relationship	Co-efficient of correlation
Water temperature vs Cyanophyceae	0.75**	Water temperature vs Bacillariophyceae	0.27
Water transparency vs Cyanophyceae	-0.33	Water transparency vs Bacillariphyceae	0.21
pH vs Cyanophyceae	0.19	pH vs Bacillariophyceae	0.15
DO vs Cyanophyceae	0.32	DO vs Bacillariophyceae	0.19
Chlorophyll-a vs Cyanophyceae	0.49	Chlorophyll-*a* vs Bacillariophyceae	0.41
CO_2 vs Cyanophyceae	-0.13	CO_2 vs Bacillariophyceae	-0.21
Bicarbonate vs Cyanophyceae	-0.12	Bicarbonate vs Bacillariophyceae	-0.23
Water temperature vs Chlorophyceae	0.73**	Water temperature vs Crustacea	0.08
Water transparency vs Chlorophyceae	-0.25	Water transparency vs Crustacea	-0.23
pH vs Chlorophyceae	0.16	pH vs Crustacea	0.06
DO vs Chlorophyceae	0.29	DO vs Crustacea	0.08
Chlorophyll-a vs Chlorophyceae	0.52	Chlorrophyll-*a* vs Crustacea	0.16
CO_2 vs Chlorophyceae	-0.15	CO_2 vs Crustacea	-0.05
Bicarbonate vs Chlorophyceae	-0.10	Bicarbonate vs Crustaceae	-0.04
Water temp. vs Euglenophyceae	0.22	Water temperature vs Rotifera	0.05
Water transparency vs Euglenophyceae	-0.09	Water transparency vs Rotifera	-0.24
pH vs Euglenophyceae	0.11	pH vs Rotifera	0.04
DO vs Euglenophyceae	0.26	DO vs Rotifera	0.07
Chlorophyll-*a* vs Euglenophyceae	0.34	Chlorophyll-*a* vs Rotifera	0.13
CO_2 vs Euglenophyceae	-0.28	CO_2 vs Rotifera	-0.07
Bicarbonate vs Euglenophyceae	-0.27	Bicarbonate vs Rotifera	0.03

*** Significant at 5% level*

DISCUSSION

The water quality parameters are very important for monthly variation in density of dominants food group of plankton population. Water temperature is synergistic with the air temperature. The water temperature is influenced by the air temperature, hours of sunshine, rainfall, depth of water and overall weather condition. The lowest temperature in February and the highest temperature in May were found in Rice-fish plots which agree to the finding s of Ghosh (1992) and Whitton *et al*. (1988). Surface and bottom water temperature were more or less same throughout the study period which might be due to the continuous flow of water, low water depth and free movement of air and fish. Water temperature showed a direct positive relationship with plankton abundance, which is also reported by Chowdhury and Sultana (1998) and Mathias (1991). Oxygen is the most important factor for both aquatic and terrestrial environment as oxygen regulates the most of the vital process of plants and animals (Rahman 1992). Dissolved oxygen (DO) content in rice-fish plots was in expected level throughout the study period. The highest values of DO were recorded in May and the lowest in February. Similar findings were recorded by Faruque (1996), Ghosh (1992) and Uddin (1998). The observed higher concentration of dissolved oxygen in rice-fish plots might be due to low water temperature, low rainfall and low pH. Due to low temperature and low rain fall, the decomposition of organic matter was less producing less amount of free CO_2 by using lower amount of DO. The low DO content during spring and summer was possibly due to high temperature and heavy rainfall which enhanced the oxidation of organic matter by the consumption of DO producing higher amount of free CO_2. The observed average DO content ranged from 5-7mg/l which were within the acceptable ranges for pond aquaculture (Boyd 1998). pH is considered as an important factor in fish culture. An acidic pH of water reduces the growth rate, metabolic rate and other physiological activities of fishes (Swingle 1967). In the present study, water pH in different rice-fish plots varied from 6.65-7.85 indicates that the pH values of selected rice fields were found to be slightly alkaline and good productive condition. Ghosh (1992) reported that the pH values of water in rice fields ranging between 7.1-8.0 are within productive range. Almost similar range of pH values were recorded by Whitton *et al*. 1988 in deep water rice fields in Bangladesh. The recorded mean pH value in the present study was almost same to the findings of Rahman (1990). Chlorophyll-*a* concentration of water is a good index of planktonic biomass. The measured chlorophyll-*a* valued were ranged from 16.5 to 50.5 µg L^{-1} in the water of rice-fish plots. The highest concentration of chlorophyll-*a* was recorded in the month of April and the lowest in February. In Malaysia, Ali (1992) observed 45.2 μgL^{-1} chlorophyll-*a* concentration in rice-fish fields whereas, Ali and Ahmed (1988) mentioned that the chlorophyll-a concentration in the rice fields did not rise above 24 μgL^{-1}. Nath (1996) also recorded more or less similar chlorophyll-a concentration (20.5- 24.8 μgL^{-1}) in water of rice fields. The recorded higher concentration of chlorophyll-*a* at the month of April in rice-fish plots during the present study might be due to higher concentration of phytoplankton population and lower concentration in February might be associated by the grazing of fish on phytoplankton. This finding coincides with the finding of Uddin (1998). More or less a gradual increase in chlorophyll-*a* concentration towards the end of the experiment might be attributed by the shading effect of leaves of rice plants as they grew large which hindered mostly the growth of zooplankton as well as plankton population. Halwart (1994) found that transparency of water was caused by silting, microscopic organisms, suspended organic matter, latitude, season, and angle and intensity of incident light in the water. Nath (1996) also reported that the transparency and plankton affect the transparency of waters. In general, the productivity, growth, reproduction, metabolic rate and other biological, physiological activities of plant and animals depend on physico-chemical parameters of water. The productivity of a rice-fish plot has a direct bearing upon the welfare of fish life and the role of plankton in the tropic cycle has been well recognized. During the present study a distinct fluctuation of both phytoplankton and zooplanktons in different months was observed. Similar observations were noted by Chowdhury and sultana (1998) and Mathias (1991) in various habitats. It is evident from the observation that a variation with the months existed in the plankton standing crop. In the present study, the measured total phytoplankton population were divided into 4 major groups *viz.*, Clorophyceae, Euglenophyceae, Cyanophyceae, Bacillariophyceae and zooplankton populations into 2 groups *viz.*, Crustacea and Rotifera. A total 23 genera of phytoplankton and 7 genera of zooplankton were recorded during the study. Dewan (1992) identified 27 genera phytoplankton belonging to Chlorophyceae, Euglenophyceae, Cyanophyceae, Bacillariophyceae, Rhodophyceae and 9 genera of zooplankton belonging to Hydrozoa, Crustacea and Rotifera. Zhang (1986) reported 25 genera phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Euglenophyceae, Cyanophyceae and 5 genera of zooplankton belonging to Crustacea and Rotifera. The total number of genera of phytoplankton and zooplankton recorded by them are more or less similar to the finding of the present study. Mollah and Haque (1978) also reported almost similar number of genera of plankton in their study whereas Cagauan (1991) recorded 33 genera of phytoplankton and 14 genera of zooplankton in their study. Among the 4 groups of phytoplankton Cyanophyceae was the most dominant group and Bacillariophyceae was the less dominant food groups during the period of study. Both phytoplankton and zooplankton population showed monthly variations. Mollah and Haque (1978), and Dewan (1992) also observed similar seasonal variation in abundance of both phytoplankton and zooplankton population. The average total number of phytoplankton recorded in per litre of water during the period of study was 49.09×10^3 cellsL^{-1} and zooplankton was 3.12×10^3 cellsL^{-1}. The recorded plankton population was more or less similar of that the plankton population observed by Dewan (1992), Ali and Ahmed (1988). Between the phytoplankton and zooplankton the phytoplankton population was found to be highly dominant than that of zooplankton population during the present study. *Monostyla* spp. and *Rhabditis* spp. of nematodes were identified and they were less in abundance. Only *Nais* spp. of oligochetes was identified and found very rare. Nauplius and may-flies were found as crustacean and insect larvae. Nematodes and oligochaetes were found very rare. Similar observations were also reported Ali *et al*. (1985).

The correlation coefficients between the different major groups of plankton and physico-chemical parameters of water were analyzed. Water temperature vs Cyanophyceae and Chlorophyceae showed strong positive (r = 0.75 and 0.73) correlations. Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Crustacea and Rotifera showed negative and weak relationship (r= -0.33, -0.13, -0.12, -0.25, -0.15, -0.10, -0.09, -0.28, -0.27, -0.21, -0.21, -0.23, -0.23, -0.05, -0.04, -0.24, -0.07 and -0.03, respectively) with water transparency, CO_2 and bicarbonate while, Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Crustacea and Rotifera showed positive correlations with water temperature, pH, dissolve oxygen and Chlorophyll-a. Ali *et al*. (1980) found similar result. All correlations between the different major groups of plankton and physico-chemical parameters of water were analyzed at 5% level of significance.

CONCLUSION

All parameters in the water of rice-fish fields were found to be increase more or less gradually towards the end of the experiment. This might be attributed on the summer season, free movement of air, and fish in the fields. The Physico-chemical parameters of rice-fish plots were in the suitable range. Plankton abundance is greatly related with water quality parameters. The abundance of plankton is regarded as an indicator of potential primary productivity. The results of the plankton population from the present study also indicate that these rice-fish plot is eutrophic in nature. Fish production may be increased in the rich fields through stocking with first growing short cycled carps fingerlings.

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