Investigation of Phytoplankton and Physico-chemical Parameters in Nursery, Growout and Broodstock Ponds

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Abstract

The study measures the relationship between physicochemical variables with the cell density of phytoplankton in different stages of pond – nursery ponds, grow out ponds and brood stock ponds. The study was conducted on nine fish ponds as three from each category of pond at Natore Government Fish Farm in Bangladesh, during the months of January to June in 2012. The observed physicochemical variables– water temperature, transparency, dissolved oxygen, pH, ammonia-nitrogen, total alkalinity and total hardness – were found within the standard ranges. Four groups of phytoplankton– Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae– were found among the ponds where Euglenophyceae was recorded highest number almost in all ponds over the study period. Total abundance of different groups of phytoplankton was recorded as mean ($\pm$ SD) cell density (cell/l) $62.77 \pm 2.16 \times 10^4$, $47.22 \pm 0.69 \times 10^4$, and $77.12 \pm 3.42 \times 10^4$ in nursery pond, grow out pond and brood stock pond, respectively. Overall phytoplankton was found better in brood stock pond than others. Total phytoplankton density has been exhibited significantly positive correlation with DO and inverse relation with water temperature, pH, ammonia-nitrogen and total alkalinity in case of nursery pond. In case of grow out pond, total phytoplankton density has been exhibited significantly positive correlation with temperature and transparency, and significantly negative correlation with others physicochemical characteristics. In case of brood stock pond, total phytoplankton density has no significant relationship with any physicochemical variables of water.

Keywords: Nursery ponds; Grow out ponds; Brood stock ponds; Phytoplankton; Bacillariophyceae; Chlorophyceae; Cyanophyceae; Euglenophyceae; Water temperature; transparency; Dissolved oxygen; pH; Ammonia-nitrogen; Total alkalinity; Total hardness; Bangladesh

Highlights:

1. measures the relationship between physicochemical variables with the cell density of phytoplankton in different stages of pond – nursery ponds, grow out ponds and brood stock ponds
2. Phytoplankton was found better in brood stock pond than other ponds
3. Physicochemical variables show different types of relationship with phytoplankton density based on pond type

1. Introduction

Water body is the habitat as well as the supplier of food for fish. Fish production of a water body is directly dependent on the quality and quantity of the food organisms available there. Live organisms of the water consist of three major groups of organisms namely plankton, nekton and benthos. Among these, plankton is very important for fish production. Phytoplankton is the basis of primary production of all types of water bodies and is used as food by fish directly or indirectly.

The aquatic organisms are directly or indirectly depend on phytoplankton population. The knowledge of planktonic biomass available in an ecosystem is of fundamental importance for fish culture. The value of phytoplankton in a water body forming the basic link of food chain of fishes is well recognized. Although phytoplankton is an essential component of an aquatic ecosystem it should be in an optimum range to ensure proper productivity. The qualitative and quantitative abundance of plankton and its relation to environmental condition has become a prerequisite for fish production. Therefore, a thorough knowledge of abundance of phytoplankton and its quality in time and space in relation to environmental condition has become a prerequisite for fish production. Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and productions on which the fish subsist are immensely influenced by the inherent water quality parameters of the habitat. So, the factors controlling aquatic fertility need to be understood in order to perform adequate management of the water bodies to enhance fish production.

Water quality determines the species optimal for culture under different environments (Dhawan and Karu, 2002). The overall productivity of a water body can easily be deduced from its primary productivity, which forms the backbone of the aquatic food chains (Ahmed and Singh, 1989). The plankton community is comprised of the primary producers or phytoplankton and zooplankton; the secondary producers (Battish, 1992). The phytoplankton population represents the biological wealth of a water body, constituting a vital link in the food chain. Both the qualitative and quantitative abundance of phytoplankton in a fish pond are of great importance for 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). Phytoplankton not only serves as food for aquatic animals, but also plays an important role in maintaining the biological balance and quality of water (Pandey et al., 1998). They have a short life span and responds quickly to environmental changes (Kawecka and Eloranta, 1994; Zębek, 2004).

The productivity of freshwater community that determines the fish growth is regulated by the dynamics of its physicochemical and biotic environment (Wetzel, 1983). The physicochemical and biological characteristics of water also play a big role in plankton productivity as well as the biology of the cultured organisms and final yields. The pH, dissolved oxygen, alkalinity and the dissolved nutrients are important for the phytoplankton production (Bais and Agarwal, 1990). Plankton diversity responds rapidly to changes in the aquatic environment particularly in relation to nutrients. Physicochemical attributes of a water body are principle determinants of fish growth rates and developments (Jhingran, 1991). Climate has a major influence on water quality and consequently, the biodiversity within the water bodies (Boyd and Tucker, 1988).

The microscopic plankton algae of the ponds are critical food for planktivorous fish species (carps) as well as the larvae of commercially important crustaceans and fin fishes. In most cases, the proliferation of planktonic algae is beneficial for aquaculture, fish production and wild fisheries operations. However, in some situations algal blooms can have a negative effect, causing severe economic losses to aquaculture, fisheries operations and having major environmental and human health impacts. So, the monitoring programmes of plankton are very important because they may provide information on possible new introductions and may serve as early warning systems to detect the onset of potentially hazardous blooms and may suggest predicative factors for blooms. Species diversity indices when correlated with

physical and chemical parameters provide one of the best ways to detect and evaluate the impact of pollution on aquatic communities (Maraglef, 1968).

Development and scientific fish culture is dependent on various information about limnological factors such as water quality, microorganism, plankton, benthos etc., where aquatic animals largely dependent on planktonic organism. Therefore, knowledge regarding plankton and their culture in the laboratory and use of cultured plankton are very important and can contribute significantly for the development of fisheries and fish production. Considering the importance of nutrient transformation and recycling process in the aquatic systems, the present study tries to understand the situation in Bangladesh. Instead of having a wide scope for fish farming in Bangladesh, the farming system is not so developed scientifically. Therefore, the findings of the study will help to improve the productivity of fish culture in Bangladesh.

2. Materials and Methods

Study Sites

The study ponds were situated at the Government fish seed production farm, Natore sadar Upazila under Natore district in Bangladesh (figure 1). The district of Natore situated between latitude 24°45' north and longitude 88°59'.

Figure 1: Geographical location of the study area –Natore Sadar Upazila, Bangladesh

Sample selection

The study was conducted for a period of six months from January to June, 2012 to measure the present status of physicochemical characteristics and plankton population. The water quality characteristics and plankton population were collected from nine ponds –3 nursery ponds (T_1), 3 grow out ponds (T_2), and 3 brood stock ponds (T_3). Area of the ponds was between 30 decimal to 60 decimal. Each pond has inlet for watering but no outlet. The ponds were dependable on rainfall and deep tube well water. The depths of different brood stock ponds were ranged from 1.5 to 2 meter.

Nursery pond is a pond which is prepared for rearing the spawn to fingerling stage, for a period of 50-60 days. In general, the size of nursery pond is small and depth of water is low (1-1.5 m). The Grow Out pond is used to produce table fishes from fingerlings. Whereas, a Brood Stock pond is used to rear mature male and female fishes in order to produce spawn. The size and depth of grow out and brood stock ponds are generally higher than that of nursery pond. Mean size ($\pm$ SD) of the ponds were- 0.178 ± 0.015 ha (nursery, T_1), 0.227 ± 0.021 ha (grow out, T_2) and 0.242 ± 0.031 ha (brood stock, T_3).

In nursery ponds fish seeds of 3-5 days were reared up to a size of 5-7 inches. Mixed carp species (Rohu, *Labeo rohita*; Catla, *Catla catla*; Mrigal, *Cirrhinus cirrhosus*; Silver carp, *Hypophthalmichthys molitrix*; Bighead carp, *Aristichthys nobilis*; Common carps, *Cyprinus carpio* and Bata, *Labeo bata*) were reared in all the ponds. Both fertilizers (cow dung, urea and triple super phosphate) and supplementary feeds (rice bran, mustard oil cake and commercial pellet feeds) were applied in grow out and brood stock ponds. Only mustard oil cake was applied in nursery ponds and fertilizers were used during preparation of nursery ponds.

Data Collection

Among the physicochemical characteristics, some important parameters such as temperature, dissolved oxygen, pH, transparency, alkalinity, hardness and ammonia nitrogen of water in the ponds were considered in the study. Six sampling sites in each pond were selected and data recorded on-the-spot. Samplings were restricted to strategic sites and 10 liters of water were collected from each selected site by a plastic bucket to measure the physicochemical characteristics. The samples were always collected from the subsurface with minimum disturbance of water. Data were taken monthly basis at 9.00-11.00 in the morning.

For the study of phytoplankton abundance, water samples were collected monthly from nine stations during the study period. In every case, twenty liters of water samples were filtered through plankton net of 25μ mesh size. Then the samples were concentrated to a volume of 20 ml and preserved in plastic vials with 5% formalin. For analysis, a sub-sample

of 1 ml was quickly drawn with a wide mouthed pipette and poured into a Sedgewick Rafter counting chamber of one ml capacity and organisms were counted as outlined by Boyd (1979).

Measurements of Variables

The researchers collect data by themselves and compute the data in different ways. The transparency of water was measured with the help of a secchi-disc which value was expressed in cm. Water temperature was recorded by a centigrade thermometer within the range of 0°C to 120°C. Dissolved oxygen (DO) of water was recorded by dissolved oxygen meter (YSI-85/10 FT), and the concentration of Dissolved oxygen was expressed in milligram per liter (mg/l) of water. pH of water was recorded by pH meter (YSI-60/10 FT). Total alkalinity was measured by bromophenol blue indicator and HI 3811-0 solution by titrimetric method (HI 3811 Alkalinity Test Kit), and the value was expressed in milligram per liter (mg/l) of water. Total hardness: Total hardness was measured by bromophenol blue indicator and HI 3811-0 solution by titrimetric method (HI 3811 Hardness Test Kit), and the value was expressed in milligram per liter (mg/l) of water. Ammonia-Nitrogen was determined by the help of water quality test kit (HACH, FF2, USA), which was expressed in milligram per liter (mg/l) of water.

There is no single method for this estimation of phytoplankton population per ml/L that can be considered the best under all circumstances and for all purposes. Various kinds of cells are used for phytoplankton counting, such as the haemocytometer, Sedgewick-Rafter etc. In this study, Sedgewick-Rafter counting chambers were used for the purpose. For the qualitative and quantitative study of plankton, 1ml of the concentrated plankton sample was taken by a dropper and then put on the S-R (Sedgewick-Rafter) counting cell. The S-R cell is a special type of slide having a counting chamber of 55 mm in length, 20 mm width and 1mm depth. The volume of chamber is 1ml. the counting chamber is equally divided into 1000 fields each having volume of 0.001 ml.

For analyzing the phytoplankton, the S-R counting cell was placed under a binocular microscope (NOVA 950) for phytoplankton identification. Phytoplankton was counted from 20 random fields out of total fields of the S-R counting cell. For each pond, mean abundance of phytoplankton were recorded and expressed numerically per liter of water according to Greenberg et al. (1987). The qualitative calculation of abundance of phytoplankton was done by using the following formula.

$$N = \frac{A \times 1000 \times C}{V \times F \times L} \quad (1)$$

Where,

N = No. of phytoplankton cells or units per liter of original sample;

A = Total no. of phytoplankton counted;

C = Volume of final concentrate of the sample in ml;

V = Volume of a field;

F = Number of fields counted: and

L = Volume of original water in liter

The mean number of phytoplankton was recorded and expressed numerically per liter of water (cells/l). The qualitative and quantitative analysis of phytoplankton was done up to

the genus level according to Prescott (1964), Pennak (1953), Greenberg *et al* (1987) and Bellinger (1992).

Data Validation and calibration

Data were validated by testing stoical significance of the mean value. Different treatments were further tested by using one way analysis of variance (ANOVA) F-test. To identify significant differences among means, Post Hoc (Tucky) test were conducted. Correlation coefficient was estimated by Pearson's Correlation coefficient method and also tested for statistical significance at 1%, 5%, and 10% level. This statistical analysis was performed with by using SPSS software.

3. Results and Discussion

Physicochemical Status

Water temperature plays a vital role in aquatic production through influencing physical, chemical and biological conditions of a water body. Optimum temperature helps to obtain maximum production. Jhingran (1991) quoted that the suitable temperature range for production of phytoplankton in tropical ponds were between 18.3 to 37.9°C. During the study period water temperature was found to vary from 15.4±0.1°C in January to 32.3±0.26°C in June. The mean (±SD) values of water temperature ranged from 15.4±0.1 to 32.17±0.15 in T₁, 15.5±0.0 to 32.3±0.26 in T₂, and 15.57±0.06 to 32.3±0.3°C in T₃, and the overall mean values (±SD) were 26.40±0.02°C in T₁, 26.51±0.11°C in T₂ and 26.50±0.09°C T₃. Similar results also reported by other studies, like Affan *et al.* (2001) recorded temperature 18.3°C to 35.1°C in fish ponds of BAU and BFRI; Hasan (2000) recorded water temperature 18.2°C to 34.2°C in Chalan Beel. The statistical test (Tuckey) shows that the temperature does not differ significantly among the ponds except for T₁ and T₃ in January which differs significantly at 5% level (Table 1).

Table 1: Descriptive Statistics of Physicochemical Variables

Parameters	Pond Type	Jan	Feb	Mar	Apr	May	Jun	Jan-Jun
Water Temperature (°C)	T1	15.4±0.1 ^{c^}	22.47±0.15	27.17±0.15	30.13±0.15	31.07±0.12	32.17±0.15	26.4±0.02
	T2	15.5±0	22.3±0.1	27.3±0.26	30.37±0.15	31.27±0.23	32.3±0.26	26.51±0.11
	T3	15.57±0.06 ^{a^}	22.37±0.15	27.27±0.25	30.27±0.21	31.23±0.25	32.3±0.3	26.5±0.09
Transparency (cm)	T1	23.33±1.53	23±3.61	19.33±4.04	18.67±2.08	18.33±2.08	17±2.65	19.94±0.98
	T2	21±4.36	21.67±0.58	19.67±2.52	19±1	19±1	18.67±7.37	19.83±2.64
	T3	24±2.65	23.67±1.53	22.33±3.06	19.33±2.52	20.33±2.52	18±1	21.28±0.78
Dissolved oxygen (mg/l)	T1	7.8±0.5	6.2±1.41	5.93±1.23	5.17±0.65	3.93±0.47	3.57±0.8	5.43±0.39
	T2	7.03±0.23	6.53±0.95	4.9±0.2	5.17±0.96	3.77±0.83	4.03±0.25	5.24±0.38
	T3	7.17±0.76	6.2±0.36	4.8±1.06	4.7±0.62	4.13±0.76	3.53±0.7	5.09±0.23
pH	T1	7±0.1	7.5±0.2	7.83±0.5	7.83±0.25	6.77±0.67 ^{b^ c^}	8.32±0.75	7.54±0.27
	T2	7.33±0.15	7.37±0.32	7.97±0.22	7.6±0.36	7.83±0.21 ^{a^}	7.73±0.06	7.64±0.11
	T3	7.27±0.25	7.63±0.49	7.77±0.36	6.64±0.95	8.15±0.22 ^{a^}	8.17±0.76	7.61±0.29
Ammonia-Nitrogen (mg/l)	T1	0.03±0 ^{c^}	0.04±0 ^{c^}	0.05±0.01 ^{c^}	0.04±0.01 ^{c^}	0.05±0 ^{c^}	0.05±0.01 ^{c*}	0.04±0.01 ^{c*}
	T2	0.03±0.01 ^{c^}	0.03±0.01 ^{c^}	0.03±0.01 ^{c^}	0.03±0 ^{c*}	0.03±0 ^{c*}	0.03±0.01 ^{c*}	0.03±0 ^{c*}
	T3	0.12±0.07 ^{a~ b^}	0.1±0.02 ^{a* b*}	0.21±0.08 ^{a* b*}	0.16±0.06 ^{a* b*}	0.17±0.07 ^{a* b*}	0.15±0.05 ^{a* b*}	0.15±0.02 ^{a* b*}

Total Alkalinity (mg/l)	T1	190.7±44.3	178±39 ^{c^}	208±42.6 ^{c^}	212.7±32.3 ^{c~}	248±28.1	209.3±27 ^{b^}	207.78±7.45 ^{b~ c^}
	T2	199.7±29.8	237±29.1	237±15.7	237.7±49.2	246±67.1	279±15.9 ^{a^ c^}	239.39±20.14 ^{a~}
	T3	210±15.5	256.7±29.2 ^{a^}	276.3±16.1 ^{a^}	290±21 ^{a~}	305.3±19.9	169.7±17 ^{b^}	251.33±5.09 ^{a^}
Total Hardness (mg/l)	T1	264.7±25	225.7±38.3	254±11	247.7±36.7	225.7±60.3	232±15.6	241.61±17.99
	T2	261.7±49.2	242±17.8	242.3±51.3	246.7±24	276±34.4	265.3±30.7	255.67±13.43
	T3	207.3±45.4	241±38.3	234.7±30.9	267.7±20.1	233±41.3	277.3±45.3	243.5±9.83

*, ^, ~ denotes significant at the 1%, 5%, and 10% level, respectively; T₁, T₂, T₃ represents grow out ponds, nursery ponds, and brood stock ponds, respectively; ^a denotes mean data differs significantly with T₁, ^b denotes mean data differs significantly with T₂, ^c denotes mean data differs significantly with T₃

Boyd (1982) recommended a transparency between 15 to 40 cm as appropriate for fish culture. During the period of the study the lowest amount of transparency was vary from 17±2.65 cm in June, 2012 to 24±2.65 cm in January. The mean (±SD) values of water transparency ranged from 17±2.65 to 23.33±1.53 cm in T₁, 18.67±7.37 to 21.67±0.58 cm in T₂ and 18±1.0 to 24±2.65 cm in T₃, and the overall mean values (±SD) were 19.94±0.98 cm in T₁, 19.83±2.64 cm in T₂ and 21.28±0.78 cm in T₃. Similar results also reported by other studies, like Hasan (2000) recorded water transparency 12 to 29 cm in Chalan Beel; Kohinoor (2000) recorded water transparency 12 to 50 cm. The statistical test (Tuckey) shows that the transparency of water does not differ significantly among the ponds (Table 1).

The mean (±SD) values of DO ranged from 3.57±0.8 to 7.8±0.5 (mg/l) in T₁, 3.77±0.83 to 7.03±0.23 (mg/l) in T₂ and 3.53± 0.7 to 7.17± 0.76 (mg/l) in T₃, and the overall mean values (±SD) were 5.43±0.39 (mg/l) in T₁, 5.24±0.38 (mg/l) in T₂ and 5.09±0.23 (mg/l) in T₃. During the period of the study the lowest amount of DO varied from 3.53±0.7 mg/l in June to 7.8±0.5 mg/l in January. Similar results also reported by other studies, like Mumtazuddin et al. (1982) found DO value of 5 to 10 mg/l in the selected ponds at the Aquaculture Experiment Station, Mymensingh in Bangladesh; Dewan et al. (1991) studied a Bangladesh Agricultural University (BAU) pond and found DO 2.2-8.8 mg/l; Wahab et al. (1995) found DO value of 2.2-7.1 mg/l; Kohinoor (2000) recorded DO value of 2-7.5 mg/l. The statistical test (Tuckey) shows that the DO value does not differ significantly among the ponds (Table 1).

pH is an important factor in the aquatic environment. It is called the index of water body. The pH value was fluctuated due to fluctuation of water level. The optimum pH range for production of plankton is from 6.5 to 9.0 (Jhingran, 1991 and Rahman et al., 1982). The pH value of water during the study period was found to vary from 6.64±0.95 in April to 8.32±0.75 in June. The mean (±SD) value of pH ranged from 6.77±0.67 to 8.32±0.75 in T₁, 7.33±0.15 to 7.97±0.22 in T₂ and 6.64±0.95 to 8.17±0.67 in T₃, and the overall mean values (±SD) were 7.54±0.27 in T₁, 7.64±0.11 in T₂ and 7.61±0.29 in T₃. Similar results also reported by other studies, like Hossain et al. (1997) and Kohinoor (2000). The statistical test (Tuckey) shows that the temperature does not differ significantly among the ponds except for T₁ with T₂ and T₃ in May, which differs significantly at 5% level (Table 1).

According to BAFRU (1990), ammonia should be less than 0.025 mg/l in culture pond. According to Nathan and Hugh (1977) the acceptable limit of ammonia-nitrogen is 0-0.4 mg/l. During the study, the maximum value of ammonia nitrogen was found 0.21±0.08 mg/l in March. The mean (±SD) values of ammonia nitrogen ranged from 0.03±0.0 to 0.05±0.01 (mg/l) in T₁, 0.03±0.01 to 0.03±0.0 (mg/l) in T₂ and 0.1±0.02 to 0.21±0.08 (mg/l) in T₃, and the overall mean values (±SD) were 0.04±0.01 (mg/l) in T₁, 0.03±0.0 (mg/l) in T₂ and 0.15±0.02 (mg/l) in T₃. Similar results also reported by Amin and Salauddin (2008).The

statistical test (Tuckey) shows that the ammonia nitrogen of T₃ differs significantly with T₁ and T₂ for overall the study period (Table 1).

Total alkalinity has little direct effect on fishes but indirectly the wellbeing of fish may be affected by total alkalinity, because water of low values of alkalinity are generally biologically less productive than those with high values. According to Alkunhi (1957) total alkalinity more than 100 ppm should be present in highly productive water bodies. According to Nathan and Hugh (1977) the acceptable limit of total alkalinity as CaCO₃ is 20 mg/l to less than 400 mg/l. During the study period total alkalinity was ranged 169.7±17.0 to 305.3±19.9 mg/l. The mean (±SD) values of total alkalinity ranged from 178±39 to 248±28.1 (mg/l) in T₁, 199.7±29.8 to 279±15.9 (mg/l) in T₂ and 169.7±17 to 305.3±19.9 (mg/l) in T₃, and the overall mean values (±SD) were 207.78±7.45 (mg/l) in T₁, 239.39±20.14 (mg/l) in T₂ and 251.33±5.09 (mg/l) in T₃. Similar findings also reported by Alam and Kabir (2003) but low alkalinity was reported by Islam (2007) (10.68±5.69 mg/l) and Nargis and Pramanik (2008) (9.8-12.5 mg/l). The statistical test (Tuckey) shows that total alkalinity of T₁ and T₃ differs significantly in February to April, and T₂ differs significantly with T₁ and T₃ only in June (Table 1).

According to Nathan and Hugh (1977) the desirable range of total hardness is 50-150 mg/l and acceptable limit of total hardness is above 10 mg/l less than 400 mg/l as CaCO₃. In the period of the study total hardness was found 207.3±45.4 mg/l to 277.3±45.3 mg/l. The mean (±SD) values of total hardness ranged from 225.7±60.3 to 264.7±25 (mg/l) in T₁, 242±17.8 to 276±34.4 (mg/l) in T₂ and 207.3±45.4 to 277.3±45.3 (mg/l) in T₃, and the overall mean values (±SD) were 241.61±17.99 (mg/l) in T₁, 255.67±13.43 (mg/l) in T₂ and 243.50±9.83 (mg/l) in T₃. The present results are much higher than that of the findings of Islam and Bhuiyan (2007), Nargis and Pramanik (2008) and Shamsad et al. (2010) who recorded 126.15±10.48 mg/l, 59.1-79.1 mg/l and 16.76-42.28 mg/l total hardness respectively in their study. The statistical test (Tuckey) shows that the total hardness value does not differ significantly among the ponds (Table 1).

Phytoplankton Status

During the present study, 23 genera of phytoplankton belonging to Bacillariophyceae (4), Chlorophyceae (11), Cyanophyceae (6) and Euglenophyceae (2) were recorded which agreed with the findings of Wahab et al. (1994) who observed the phytoplankton population consisted of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae in the ponds of BAU campus. Hossain et al. (1998) recorded the phytoplankton of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. Ahmed et al. (1993) recorded 27 genera of phytoplankton composed of Bacillariophyceae (4), Chlorophyceae (15), Cyanophyceae (6) and Euglenophyceae (2). Kohinoor et al. (1998) recorded 31 genera of phytoplankton belonging to Bacillariophyceae (4), Chlorophyceae (15), Cyanophyceae (8) and Euglenophyceae (3) in the research ponds of BAU campus Mymensingh. The statistical test (Tuckey) shows that the four group of phytoplankton value differs significantly among different ponds ecosystems (Table 2).

Table 2: Descriptive Statistics of Phytoplankton

Phytoplankton groups	Pond Type	Jan	Feb	Mar	Apr	May	Jun	Jan-Jun
Bacillariophyceae	T1	58.33±16.07 ^{b* c*}	28.33±5.77 ^{b*}	15±5 ^{b* c*}	8.33±2.89 ^{b*}	6.67±2.89 ^{c*}	11.67±7.64	21.39±4.93 ^{b*}

	T2	25±8.66 ^{a^}	10±5 ^{a^}	3.33±2.89 ^{a^}	20±5 ^{a^ c^*}	5±5 ^{c^}	6.67±2.89 ^{c~}	11.67±2.11 ^{a^ c^}
	T3	28.33±7.64 ^{a~}	15±5	6.67±2.89 ^{a~}	8.33±5.77 ^{b^*}	13.33±5.77 ^{a~ b^}	13.33±7.64 ^{b~}	14.17±1.78 ^{b^}
Chlorophyceae	T1	8.33±2.89 ^{c~}	23.33±10.41 ^{b~}	8.33±2.89 ^{b^}	5±0 ^{c~}	6.67±2.89 ^{c^}	15±5 ^{c^}	11.11±3.52 ^{c^}
	T2	6.67±2.89 ^{c~}	8.33±2.89 ^{a~}	30±13.23 ^{a^ c^}	8.33±2.89	8.33±5.77 ^{c~}	11.67±5.77 ^{c^}	12.22±4.01 ^{c^}
	T3	18.33±7.64 ^{a~ b~}	10±5	10±5 ^{b^}	25±15 ^{a~}	21.67±7.64 ^{a^ b~}	68.33±20.82 ^{a^ b^}	25.56±6.37 ^{a^ b^}
Cyanophyceae	T1	21.67±2.89 ^{c^}	28.33±10.41 ^{c^}	10±5 ^{b^}	6.67±2.89 ^{c^}	8.33±5.77	21.67±2.89 ^{b^ c^}	16.11±2.94
	T2	6.67±2.89 ^{c^}	18.33±10.41	66.67±20.21 ^{a^ c^}	10±5 ^{c~}	11.67±7.64	6.67±2.89 ^{a^}	20±6.57 ^{c^}
	T3	5±0 ^{a^ b^}	6.67±2.89 ^{a^}	18.33±5.77 ^{b^}	28.33±14.43 ^{a^ b~}	6.67±2.89	5±5 ^{a^}	11.67±4.97 ^{b^}
Euglenophyceae	T1	5±0 ^{c^}	21.67±2.89 ^{b^ c^}	13.33±7.64	28.33±18.93	18.33±5.77	8.33±2.89 ^{b~}	15.83±6.7
	T2	8.33±2.89 ^{c^}	10±5 ^{a^}	15±8.66	5±0 ^{c~}	21.67±16.07 ^{c^}	25±13.23 ^{a~ c~}	14.17±6.19 ^{c~}
	T3	21.67±2.89 ^{a^ b^}	11.67±2.89 ^{a^}	6.67±2.89	35±10 ^{b~}	65±20 ^{b^}	6.67±2.89 ^{b~}	24.44±7.01 ^{b~}
Total Phytoplankton	T1	93.33±16.07 ^{b^}	101.67±18.93 ^{b^ c^}	46.67±16.07 ^{b^}	48.33±18.93	40±5 ^{c^}	56.67±7.64 ^{c^}	64.44±5.97
	T2	46.67±2.89 ^{a^ c^}	46.67±20.82 ^{a^}	115±25.98 ^{a^ c^}	43.33±2.89	46.67±30.55 ^{c^}	50±15 ^{c^}	58.06±11.65 ^{c~}
	T3	80±8.66 ^{b^}	50±13.23 ^{a^}	41.67±5.77 ^{b^}	93.33±38.19	111.67±24.66 ^{a^ b^}	101.67±14.43 ^{a^ b^}	79.72±12.02 ^{b~}

*, ^, ~ denotes significant at the 1%, 5%, and 10% level, respectively; T1, T2, T3 represents grow out ponds, nursery ponds, and brood stock ponds, respectively; ^a denotes mean data differs significantly with T₁, ^b denotes mean data differs significantly with T₂, ^c denotes mean data differs significantly with T₃

In this study, Bacillariophyceae was dominated by four genera namely *Cyclotella*, *Navicula*, *Tabellaria* and *Amphora*. The minimum amount of Bacillariophyceae was found 3.33±2.89×10⁴cells/l in March and maximum 58.33±16.07×10⁴cells/l in January. The mean (±SD) cell density (cell/l) of Bacillariophyceae varied from 8.33±2.89×10⁴ to 58.33±16.07×10⁴ in T₁, 3.33±1.67×10⁴ to 25±5.00×10⁴ in T₂, and 6.67±2.89×10⁴ to 28.33±7.64×10⁴ in T₃, and the overall mean (±SD) cell density (cell/l) were 21.39±4.93×10⁴ in T₁, 11.67±2.11×10⁴ in T₂, and 14.17±1.78×10⁴ in T₃. Other studies also reported similar findings, such as according to Affan et al. (2005) maximum abundance of Bacillariophyceae is 8.67×10⁴ cells/l in January and according to Chowdhury *et al.* (2007) the minimum abundance of Bacillariophyceae is 5×10⁴ cells/l in March. Variations in the cell density of Bacillariophyceae among the three types of pond during the whole experimental period are shown in figure 2.

Figure 2: Mean cell density of Bacillariophyceae among three types of ponds

Chlorophyceae was dominated by eleven genera namely *Chlorella*, *Pediastrum*, *Scenedesmus*, *Spirogyra*, *Coelastrum*, *Ankistrodesmus*, *Tetraedron*, *Closterium*, *Selenastrum*, *Volvox* and *Ulothrix*. Chlorophyceae was found minimum $5.0 \pm 0.0 \times 10^4$ cells/l in April and maximum was $68.33 \pm 20.82 \times 10^4$ cells/l in June. The mean ($\pm$ SD) cell density (cell/l) of Chlorophyceae varied from $5.0 \pm 0.0 \times 10^4$ to $23.33 \pm 10.41 \times 10^4$ in T₁, $6.67 \pm 2.89 \times 10^4$ to $30.0 \pm 13.23 \times 10^4$ in T₂, and $10.0 \pm 5.0 \times 10^4$ to $68.33 \pm 20.82 \times 10^4$ in T₃, and the overall mean ($\pm$ SD) cell density (cell/l) were $11.11 \pm 3.52 \times 10^4$ in T₁, $12.22 \pm 4.01 \times 10^4$ in T₂, and $25.56 \pm 6.37 \times 10^4$ in T₃. Other studies also reported similar types of value, such as Affan et al. (2005) reported maximum abundance of Chlorophyceae is 10.5×10^5 cells/l in June and according to Chowdhury et al. (2007) the minimum abundance of Chlorophyceae is 8.3×10^4 cells/l in April. Variations in the cell density of Chlorophyceae among the three types of pond during the whole experimental period are shown in figure 3.

Figure 3: Mean cell density of Chlorophyceae among three types of ponds

Cyanophyceae was dominated by six genera namely *Microcystis*, *Anabaena*, *Gomphoshaeria*, *Agmenellum*, *Oscillatoria* and *Nostoc*. In the present study Cyanophyceae was the highest $66.67 \pm 20.21 \times 10^4$ cells/l in March and the lowest $5.0 \pm 5.0 \times 10^4$ cells/l in June. The mean ($\pm$ SD) cell density (cell/l) varied from $6.67 \pm 2.89 \times 10^4$ to $28.33 \pm 10.41 \times 10^4$ in T₁, $6.67 \pm 2.89 \times 10^4$ to $66.67 \pm 20.21 \times 10^4$ in T₂, and $5.0 \pm 5.0 \times 10^4$ to $28.33 \pm 14.43 \times 10^4$ in T₃, and the overall mean ($\pm$ SD) cell density (cell/l) were $16.11 \pm 2.94 \times 10^4$ in T₁, $20.0 \pm 6.57 \times 10^4$ in T₂, and $11.67 \pm 4.97 \times 10^4$ in T₃. Other studies reported more value after using different treatments, such as Rahman (1999) reported mean abundance of Cyanophyceae 85.6 ± 59.4 , 133.8 ± 108.9 , 95.3 ± 72.1 and 101.7 ± 92.8 in four different treatments. Variations in the cell density of Cyanophyceae among the three types of pond during the whole experimental period are shown in figure 4.

Figure 4: Mean cell density of Cyanophyceae among three types of ponds

Euglenophyceae was dominated by two genera namely *Euglena*, *Phacus*. In the present study maximum abundance ($65 \pm 20 \times 10^4$ cells/l) of Euglenophyceae in May and minimum abundance ($5.0 \pm 0.0 \times 10^4$ cells/l) in January and April. The mean ($\pm$ SD) cell density (cell/l) of Euglenophyceae was varied from $5.0 \pm 0.0 \times 10^4$ to $25 \pm 13.23 \times 10^4$ in T₁, $5.0 \pm 0.0 \times 10^4$ to $25 \pm 13.23 \times 10^4$ in T₂, and $6.67 \pm 2.89 \times 10^4$ to $65 \pm 20 \times 10^4$ in T₃, and the overall mean ($\pm$ SD) cell density (cell/l) were $15.83 \pm 6.7 \times 10^4$ in T₁, $14.17 \pm 6.19 \times 10^4$ in T₂, and $24.44 \pm 7.01 \times 10^4$ in T₃. Other studies also reported similar types of findings, such as Chowdhury *et al.* (2007) reported that maximum abundance (13.33×10^5 cells/l) of Euglenophyceae in November and minimum abundance (13.3×10^4 cells/l) in January. Variations in the cell density of Euglenophyceae among the three types of pond during the whole experimental period are shown in figure 5.

Figure 5: Mean cell density of Euglenophyceae among three types of ponds

The mean ($\pm$ SD) cell density (cell/l) of total Phytoplankton (Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae) during the study period were found higher at T₃ than those of T₁ and T₂. Total cell density of different groups of phytoplankton

was $64.44 \pm 5.97 \times 10^4$ in T₁, $58.06 \pm 11.65 \times 10^4$ in T₂, and $79.72 \pm 12.02 \times 10^4$ in T₃. Other studies also reported similar types of findings, such as Hossain et al. (2007) found total number of phytoplankton was $72.0 \pm 6.6 \times 10^4$ cells/l, $27.43 \pm 2.35 \times 10^4$ cells/l and $61.50 \pm 6.42 \times 10^4$ cells/l with treated poultry manure, cow manure and urea and triple super phosphate respectively. Variations in the cell density of different groups of phytoplankton among the three types of pond during the whole experimental period are shown in figure 5.

Figure 6: Mean cell density of different groups of phytoplankton among three types of ponds

Relationships among the components of phytoplankton

It is also very important to check the interrelationships among the different types of phytoplankton, because growth of one types of phytoplankton may help to growth of another type of phytoplankton or reduction of another types of phytoplankton. Bacillariophyceae and Euglenophyceae shows significant negative correlation for T₂ (Table 3). Similarly, Cyanophyceae and Chlorophyceae shows significant positive relationship for T₁ and T₂. Only Chlorophyceae shows negative correlation sign with Bacillariophyceae for all types of ponds, but none is statistically significant. It is also statistically found that among all types of phytoplanktons, Bacillariophyceae and Cyanophyceae dominating significantly in T₁, and Cyanophyceae and Chlorophyceae both are dominating significantly in T₂.

Table 3: Correlation among the components of phytoplankton

Phytoplankton groups	Pond Types	Chlorophyceae	Cyanophyceae	Euglenophyceae	Total Phytoplankton
Bacillariophyceae	T1	0.16	0.58	-0.55	0.81~
	T2	-0.56	-0.51	-0.74~	-0.50
	T3	-0.03	-0.64	0.00	0.13
	All	-0.36	-0.29	-0.42	0.65
Chlorophyceae	T1		0.86^	-0.03	0.66
	T2		0.96*	0.18	0.99*
	T3		-0.24	-0.17	0.60
	All		-0.08	-0.32	0.19
Cyanophyceae	T1			-0.39	0.87^
	T2			0.01	0.98*
	T3			0.05	-0.14

	All	-0.46	-0.13
	T1		-0.44
	T2		-0.41
Euglenophyceae	T3		0.65
	All		0.44

*, ^, ~ denotes significant at the 1%, 5%, and 10% level, respectively; T1, T2, T3 represents grow out ponds, nursery ponds, and brood stock ponds, respectively

Relationships among physicochemical variables

The interrelationships among the different types of water quality parameters were also analyzed (Table 4). Water temperature and transparency show significant negative correlation for all the treatments *i.e.* T₁, T₂ and T₃. Similarly, dissolved oxygen (DO) and water temperature also show significant negative relationship for all the treatments (T₁-T₃). Water temperature and total alkalinity show significant positive relationship in T₂. Significant positive relationship is also observed in all the treatments among water transparency and dissolved oxygen. Significant negative relationship is observed in T₃ among water transparency and total hardness. Significant negative relationship is found in T₂ and T₁ among DO and pH, and DO and ammonia-nitrogen respectively. Highly positive relationship is observed in T₂ among ammonia-nitrogen and total alkalinity (Table 4).

Table 4: Correlation among physicochemical variables

Water quality variables	Pond Type	Transparency (cm)	Dissolved oxygen (mg/l)	pH	Ammonia-Nitrogen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)
Water Temperature (°C)	T ₁	-.943*	-.944*	0.448	0.79	0.68	-0.55
	T ₂	-.871*	-.931*	0.74~	0.744~	.852^	0.217
	T ₃	-.832^	-.981*	0.316	0.414	0.222	0.778~
	All	-.927*	-.967*	0.649	0.665	0.712	0.588
Transparency (cm)	T ₁		.896^	-0.47	0.673	-0.724~	0.32
	T ₂		.897^	-0.73~	0.467	-.649	-0.442
	T ₃		.898^	-0.165	-0.37	0.108	-.846^
	T ₁ -T ₃		.932*	-0.61	-0.64	-0.52	-.829^
Dissolved oxygen (mg/l)	T ₁			-0.34	-.812^	-0.687	0.698
	T ₂			-.839^	-.68	-0.79~	-0.468
	T ₃			-0.755	-0.594	-0.079	-0.742~
	All			-.72	-.66	-.647	-.594
pH	T ₁				-0.063	-0.262	-0.033
	T ₂				0.29	0.53	0.147
	T ₃				.18	-0.235	0.010
	All				.55	.151	.38
Ammonia-Nitrogen (mg/l)	T ₁					.686	-0.73~
	T ₂					.906^	.35
	T ₃					0.388	0.113
	All					.68	.29
Total Alkalinity (mg/l)	T ₁						-.28
	T ₂						0.202
	T ₃						-0.172
	All						.028

*, ^, ~ denotes significant at the 1%, 5%, and 10% level, respectively; T₁, T₂, T₃ represents grow out ponds, nursery ponds, and brood stock ponds, respectively

Relationships between phytoplankton and physicochemical variables

The statistical output shows, Bacillariophyceae is significantly negatively correlated with water temperature of T₁, T₃, and pH of T₂, but positively correlated with water transparency and dissolved oxygen of T₁ (Table 5). Chlorophyceae shows significant negative correlation with water transparency of T₃ and total Alkalinity of T₁. Euglenophyceae shows significant negative correlation with dissolved oxygen of T₂ but positive relationship with Total Alkalinity of T₂. Cyanophyceae has no statistically significant relationship with any physicochemical variables of any pond.

The combined value of all four types of phytoplankton shows positive correlation with water transparency of T₁, but negative correlation with Water Temperature and Total Alkalinity of T₁. The combined data for all three types of pond shows significant negative correlation between Bacillariophyceae and water temperature, Bacillariophyceae and ammonia-nitrogen, Bacillariophyceae and total alkalinity, Chlorophyceae and pH, Euglenophyceae and total alkalinity, but significant positive correlation between Bacillariophyceae and water transparency, Bacillariophyceae and dissolved oxygen.

Table 5: Correlation between phytoplankton and physicochemical variables

Water quality variables	Pond Type	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Euglenophyceae	Total Phytoplankton
Water Temperature (°C)	T1	-0.97*	-0.18	-0.54	0.39	-0.83^
	T2	-0.61	0.19	0.05	0.57	0.07
	T3	-0.79~	0.51	0.32	0.27	0.46
	All	-0.92*	0.49	-0.03	0.51	-0.60
Transparency (cm)	T1	0.85^	0.37	0.58	-0.13	0.89^
	T2	0.34	-0.17	0.03	-0.54	-0.07
	T3	0.51	-0.79~	-0.25	-0.21	-0.69
	All	0.72~	-0.59	0.18	-0.41	0.39
Dissolved oxygen (mg/l)	T1	0.87^	0.05	0.33	-0.23	0.70
	T2	0.69	-0.25	-0.08	-0.77~	-0.15
	T3	0.71	-0.61	-0.20	-0.20	-0.48
	All	0.86^	-0.58	0.14	-0.51	0.40
pH	T1	-0.39	0.24	0.09	0.03	-0.19
	T2	-0.75~	0.71	0.59	0.60	0.65
	T3	-0.06	0.35	-0.69	-0.01	0.11
	All	-0.68	0.84^	0.29	-0.16	0.04
Ammonia-Nitrogen (mg/l)	T1	-0.82	0.03	-0.36	0.24	-0.65
	T2	-0.61	-0.21	-0.31	0.70	-0.32
	T3	-0.63	0.00	0.47	0.17	0.03
	All	-0.73~	0.15	0.44	0.32	-0.26
Total Alkalinity (mg/l)	T1	-0.65	-0.64~	-0.76	0.16	-0.86^
	T2	-0.68	0.13	-0.05	0.74~	-0.01
	T3	-0.49	-0.69	0.54	0.62	-0.09
	All	-0.78~	-0.23	0.08	0.83^	-0.73~
Total Hardness (mg/l)	T1	0.57	-0.53	-0.18	-0.38	0.10
	T2	-0.07	-0.43	-0.54	0.63	-0.43
	T3	-0.63	0.69	0.35	-0.17	0.32

All	-0.27	0.64	-0.32	0.06	-0.11
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*, ^, ~ denotes significant at the 1%, 5%, and 10% level, respectively; T1, T2, T3 represents grow out ponds, nursery ponds, and brood stock ponds, respectively

In the study, Chlorophyceae dominated the phytoplankton groups, followed by Bacillariophyceae. This is attributed to high temperature and others favourable water quality attributes and high levels of total alkalinity. Similar findings were also reported by Seenayya (1971). Konopka and Brock (1978) determined temperature for photosynthesis and natural populations of blue green algae (Cyanophyceae) from Lake Mendota in Wisconsin, USA. They recorded that the dominant phytoplankton blue green algae in summer months, the optimum temperature for photosynthesis was usually between 20°C and 30°C, whereas the average environmental temperatures during the study period were 26.40±2.62°C in T₁, 26.50±2.64°C in T₂ and 26.57±2.64°C T₃. So water temperature in all the treatments was suitable for phytoplankton growth.

Pechar (1995) reported that grazing pressure of zooplankton and low light condition was suitable for mass development of the small species of Cyanophyceae. He also stated that high pH was not necessary to achieve cyanobacterial dominance. These findings are more or less similar with the present study.

Bacillariophyceae was most abundant at a low temperature with the least concentration of nutrients in the winter (December to January). It may be due to least rainfall causing not much run-off, calm weather and less mixing with nutrients rich bottom water. There was a less amount of fish feed as the feeding intensity of fish decreased with decreasing temperature. A similar suggestion was expressed by Havens (1991). These results agree with the finding of Talbot and Bate (1987) who concluded that blooms of surf diatom species, including *Asterionella* sp. and *Aulacodiscus* sp. appear to be unrelated to nutrient availability.

Euglenophyceae was most abundant in high temperature, low transparency and pH. According to Affan *et al.*, (2005), moderate temperature and clear sunlight may reasons for the dominance of euglenophytes. Phang and Ong (1988) reported that Euglenoides were dominant at elevated temperature. In addition Wild *et al.*, (1995) reported that *Euglena* assemblages were widely distributed at elevated temperature. These findings are closely related with the present study.

Variables Influences on Ponds Ecosystem

The statistical output of correlation estimations (Table 3) show when temperature increases by 1%, the average number of Bacillariophyceae decreases by 0.92% which differs from 0.79% to 0.97% based on pond types. When transparency increases by 1%, the average number of Bacillariophyceae increases significantly by 0.72% which is 0.85% for T₁, and the Chlorophyceae decreases by 0.79% only for the case of pond T₃. When DO increases by 1%, the average number of Bacillariophyceae increases by 0.86% which is also significant for T₁ at 0.87%, but it leads to decrease of Euglenophyceae at 0.77% only for the T₂. A 1% increase of pH leads to 0.75% decrease of Bacillariophyceae for T₂ but 0.84% increase of average number of Chlorophyceae. A 1% increase of Ammonia-Nitrogen leads to 0.73% decrease of average number of Bacillariophyceae. Total Alkalinity shows significant negative relationship with average number of Bacillariophyceae in the propensity of 78%. It also shows significant negative relationship with Chlorophyceae for T₁ at the propensity of 64%.

It also shows significant relationship with average Euglenophyceae at the propensity of 83%, and for T₂ only at the propensity of 74%.

It is important to note that different types of pond were influenced by different types of phytoplankton and at different times. Growth of phytoplankton in the Nursery Ponds Ecosystem is more in the starting of the period, and it reduces over the time (figure 7). As the newly hatched seeds are dependent only on their yolk sac for a short period of time after hatching, grazing pressure on phytoplankton during this time remains almost zero which greatly enhance the production of phytoplankton. Moreover, fertilization also plays a key role in the production of phytoplankton. At that time, Bacillariophyceae was dominating over other types of phytoplankton. Growth of phytoplankton in the Grow Out Ponds Ecosystem is more in the middle of the period, and it constant over the time (figure 8). This may be due to regular application of fertilizers, both organic and inorganic. At that time, Cyanophyceae was dominating over other types of phytoplankton. Growth of phytoplankton in the Brood Stock Ponds Ecosystem is more in the middle of the period, and it remains constant over the time (figure 9). This may be due regular application of fertilizers into the ponds which greatly enhance the phytoplankton production of a water body. Moreover, supplementary feeds were applied to brood fishes which reduce feeding pressure on plankton community resulting in higher abundance of plankton. At that time, Chlorophyceae and Euglenophyceae were dominating over other types of phytoplankton.

Figure 7: Growth of phytoplankton in the Nursery Ponds Ecosystem

Figure 8: Growth of phytoplankton in the Grow Out Ponds Ecosystem

Figure 9: Growth of phytoplankton in the Brood Stock Ponds Ecosystem

6. Conclusions

The present experiment was conducted for a period of six months from January to June 2012 in nine ponds in the Natore Government fish farm, Natore. Nine ponds are considered in three types viz., three nursery ponds (0.178 ± 0.015 ha) as type one (T_1), three grow out ponds (0.227 ± 0.021 ha) as type two (T_2) and three brood stock ponds (0.242 ± 0.031 ha) as type three (T_3). Sampling included some water quality parameters and phytoplankton communities. Plankton samples were collected monthly. The water quality parameters such as, water temperature, transparency, dissolved oxygen, pH, ammonia- nitrogen, total alkalinity and total hardness were recorded monthly.

The water temperature ranged from $15.4 \pm 0.1^\circ\text{C}$ in January to $32.43 \pm 0.09^\circ\text{C}$ in June, water transparency ranged from 17 ± 1.52 (cm) in June to 24 ± 0.152 (cm) in January, dissolved oxygen ranged from 3.53 ± 0.41 (mg/l) in June to 7.8 ± 0.29 (mg/l) in January, pH ranged from 6.64 ± 0.55 in May to 8.17 ± 0.44 in June, ammonia-nitrogen ranged from 0.027 ± 0.004 (mg/l) in January to 0.21 ± 0.041 (mg/l) in March, total alkalinity ranged from 178 ± 22.50 (mg/l) in February to 305.33 ± 11.46 (mg/l) and total hardness ranged from 207.33 ± 26.20 (mg/l) in January to 277.33 ± 26.18 (mg/l) in June.

Four groups of phytoplankton such as Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae were encountered in the present experiment. Bacillariophyceae was dominant by four genera namely *Cycloiella*, *Navicula*, *Tabellaria* and *Amphora*. Chlorophyceae was dominant by eleven genera namely *Chlorella*, *Pediastrum*, *Scenedesmus*, *Spirogyra*, *Coelastrum*, *Ankistrodesmus*, *Tetraedron*, *Closterium*, *Selenastrum*, *Volvox* and *Ulothrix*. Cyanophyceae were dominant by six genera namely *Microcystis*, *Anabaena*, *Gomphoshaeria*, *Agmenellum*, *Oscillatoria* and *Nostoc*. Euglenophyceae represented two genera of which both were dominant namely *Euglena* and *Phacus*. The group of Euglenophyceae was the most dominant group of phytoplankton followed by Bacillariophyceae, Chlorophyceae and Cyanophyceae.

The maximum and minimum number of Bacillariophyceae was found $58.33 \pm 9.28 \times 10^4$ cell/l in January at T₁ and $3.33 \pm 1.67 \times 10^4$ cell/l in March at T₂. The highest and lowest number of Chlorophyceae was found $68.33 \pm 20.82 \times 10^4$ cell/l in June in T₃ and $5.0 \pm 0.0 \times 10^4$ cell/l in April at T₁. Cyanophyceae was found highest $66.67 \pm 20.21 \times 10^4$ cell/l in T₂ in March and lowest $5.0 \pm 5.0 \times 10^4$ cell/l in June in T₃. The highest and number of Euglenophyceae was found $65 \pm 20.0 \times 10^4$ cell/l in T₃ in May and $5.0 \pm 0.0 \times 10^4$ cell/l in T₁ and T₂ in January and April respectively. Total abundance of different groups of phytoplankton was $64.44 \pm 5.97 \times 10^4$ cell/l, $58.06 \pm 11.65 \times 10^4$ cell/l, and $79.72 \pm 12.02 \times 10^4$ cell/l in T₁, T₂ and T₃ respectively.

From the aforesaid findings, it was recorded that Euglenophyceae was found to be the most dominant group among the four groups of phytoplankton. The abundance of Euglenophyceae was 30.19% among the total percentage. Phytoplankton population in type T₃ that means in brood stock ponds was found higher than other types.

Total phytoplankton density exhibited positive relation with DO, water transparency and total hardness, and inverse relation with rest of the parameters in T₁. It showed insignificantly positive relation with temperature and pH and negative relation with rest of the physico-chemical parameters in T₂. In T₃ total phytoplankton density showed negative relation with transparency, DO and total alkalinity and positive relation with rest of the parameters.

Type T₃ (i.e. brood stock ponds) was found best for the more existence of phytoplankton than other types. Further successive research is needed to evaluate the water quality parameters to characterize with the variabilities of phytoplankton in nursery, grow out and brood stock ponds for a longer period.

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