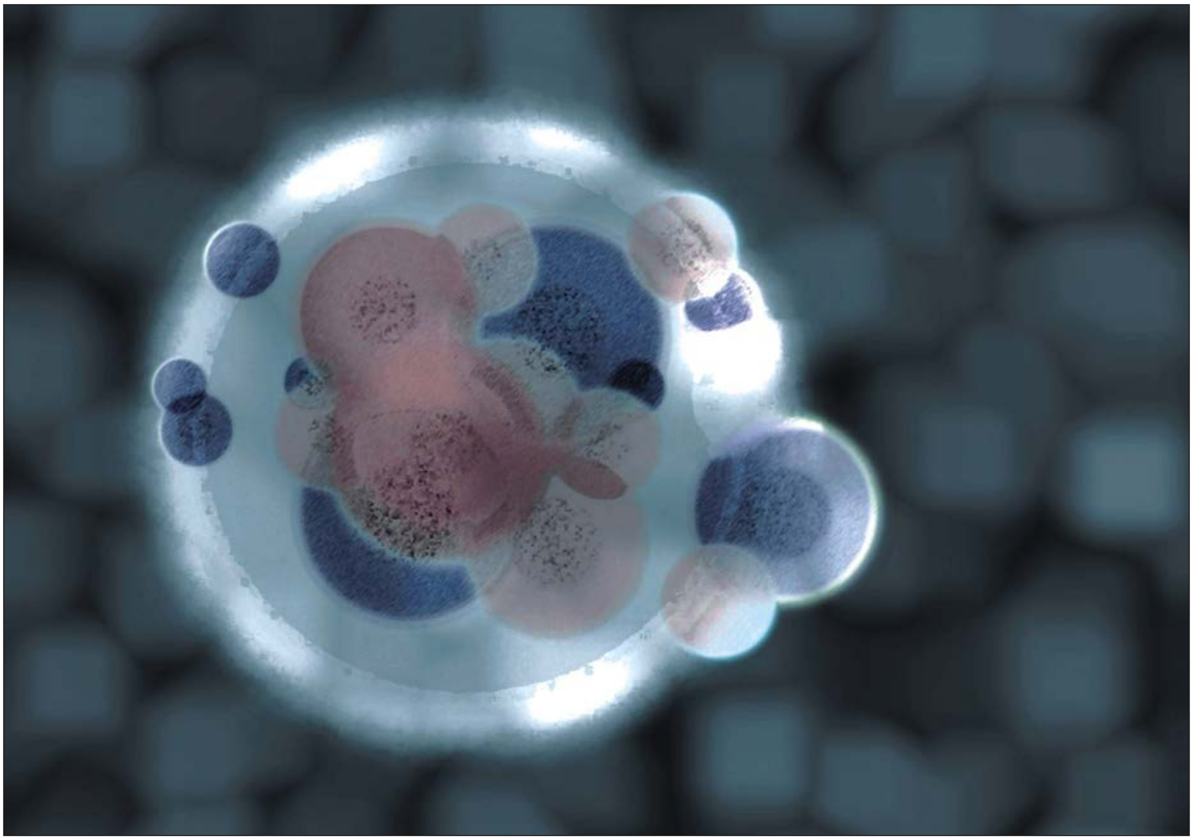

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Limnological Parameters Affecting Monthly Abundance of Chironomid Larvae in a Fish Pond and Their Role in the Diet of Catfish, *Clarias batrachus*

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Abstract: Six months-long experiment was carried out in a fish pond at Bangladesh Agricultural University (BAU), Mymensingh from September 2008-February 2009 to evaluate the limnological parameters affecting monthly abundance of Chironomid larvae and their role in the diet of catfish, *Clarias batrachus*. The water-quality and soil parameters were monitored and found to be within suitable range for freshwater aquaculture. The composition of the benthic macro-invertebrates at the bottom indicated that Chironomidae was most dominant group in this pond. The body-weight percentage of the organisms showed that Chironomids and Oligochaetes were major two groups. The quantitative and qualitative studies of Chironomid larvae indicated that there was monthly variation in the abundance of Chironomids where *Chironomus* was most dominant. The highest (3585.19 m^{-2}) and the lowest (548.15 m^{-2}) abundance of Chironomids in 3 samples were recorded in the month of January 2009 and October 2008, respectively. Gut content analysis suggested that Chironomids was dominant food item in the diet of *Clarias batrachus*. The maximum 768 and minimum 25 occurrences were recorded in the months of December and October 2008, respectively in 5 fishes sampled from the experimental pond. The electivity indices suggested a shifting to Chironomid larvae from negative selection to positive selection in different months.

Key words: Catfish, limnological parameters, abundance, chironomid larvae, electivity indices

INTRODUCTION

Bangladesh is endowed with rich and extensive fisheries resources. Fish and fisheries have been a part and parcel of life and culture of the people of Bangladesh from time immemorial. Bengali people were popularly referred to as "Macché-Bhaté Bangali" (Fish and rice make the Bengali). Fisheries sector contribute 4.43% to Gross Domestic Products (GDP) and 22.21% to agricultural GDP. Fish supplement to about 60% of our daily animal protein intake (DOF, 2011). About 1.4 million people are engaged in fisheries sector for their full time employment and 12 million on part time basis for deriving their livelihood support (DOF, 2002).

Bangladesh is enriched with enormous inland water bodies including 371, 309 ha of ponds and ditches, producing 1.2 million metric tons fish (DOF, 2011). In a resource constrained country such as Bangladesh, where more than 75% of households spend 90% of income on basic needs (BBS, 1995) and many cannot afford to provide even rudimentary supplementary feeds for their fish ponds (O'Riordon, 1992).

Selection of species is also an important factor of consideration for successful fish culture, because all fish species are not suitable for intensive aquaculture in the fish ponds. Catfish is an important group of fishes and its popularity is increasing day by day showing a promising future for commercial culture (Brua, 1989). *Clarias batrachus* (Linn.), locally known as magur is an important catfish in the South-east and South-Asian countries for aquaculture, it is a delicious and widely accepted fish. However, this fish is rarely cultured in farmers level in Bangladesh, although it can thrive in any type of freshwater habitat and can survive well in

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extremely oxygen depleted conditions (Barua *et al*., 1986). One of the main setbacks of its culture is the non-availability of stockable fry on demand. However, some pioneer works on its breeding technology were done by Rahmatullah *et al.* (1993) and Mollah *et al.* (1987). Considerable amount of work has been done which included the larvae rearing aspects of this species. To mention a few are those of Mollah and Nurullah (1988). However, no detailed study has been conducted on the abundance of Chironomid larvae and its role in the diet of *C. batrachus* in a fish pond.

Chironomidae is one kind of benthic organisms found in large quantities in the mud. These are one of the most common and essential organisms in an aquatic medium. The bottom fauna forms a very important element in the food chain and a source of potential food for *Clarias batrachus*. Thus, the capacity of fish production of an aquatic environment is often evaluated on the basis of the kinds and abundance of Chironomid larvae. The Chironomidae is considered to be one of the most important group of fish food and is most widely distributed and frequently the most abundant group of insects in freshwater environments (Pinder, 1989). Larval Chironomidae have been reported to be important secondary producers in the benthic environment of lakes (Charles *et al*., 1974) and to be an important element of invertebrate communities of shallow lakes (Mason, 1977; Lindegaard and Jonasson, 1979). Despite the enormous literatures on various aspects of the ecology of Chironomidae (Fittkau *et al*., 1976; Hoffrichter and Reiss, 1981), there is a dearth of information on the biology and ecology of Chironomid populations in fish pond environments. The principal reason for such deficiencies is probably due to the difficulty in identification of the various stages coupled with a large number of species frequently encountered within even a small waterbody (Pinder, 1989). Considering the importance of this unexplored area, the study was undertaken in pond, subjected to yearly drying up at the end of one fish culture cycle.

Considering the above facts, it was felt necessary to conduct a research work on the abundance of Chironomid larvae and its role in the diet of *Clarias batrachus*.

MATERIALS AND METHODS

Study area: The experiment was carried out in one organic pond situated at the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh for a period of six months from September 2008-February 2009. The experimental pond is rectangular shaped having surface area of 100 square meters with an average depth of 1 meter. The pond was well exposed to sunlight and free from aquatic vegetation. The dikes of the pond were well constructed and had no inlet or outlet. There was a facility to supply water from a deep tube-well using a flexible plastic pipe whenever needed. Plastic nets were used to prevent the fish from escaping.

Preparation of pond: At first pond dikes were repaired, weeds and other unwanted animals were removed from the experimental pond. Then lime ($CaCO_3$) was applied at the rate of 100 kg ha^{-1}. Three days after liming, the pond was fertilized with cow dung at a rate of 500 kg ha^{-1}. After five days of fertilization, the fishes were stocked.

Stocking of Fish and Post Stocking Management: *Clarias batrachus* at the average size of ±23.39 cm were collected from commercial fish trader and were stocked in the pond. The stocking density 1 fish m^{-2} was maintained for better growth of fish. To ensure better survival and production of fishes following management measures were taken:

- **Feeding:** Catfish is mainly dependent on natural food organisms. Therefore, no inorganic fertilizer was used. Fishes were fed with supplementary diet containing 30% protein. The following ingredients were used to make the supplementary feed (Table 1). The supplementary feed was applied daily at the rate of 1% of body weight. Beside this diet, rice bran was also used at the rate of 100 g per day. The feed was supplied regularly at a given hour

Sampling procedure: The Water, soil, Chironomid larvae and fish samples were studied during the experimental period. The sampling procedures of these samples are described below:

Water sample: The water samples were collected monthly. The water quality parameters like temperature (°C), transparency (cm), pH, dissolved oxygen (ppm), alkalinity (ppm) and total suspended solids (ppm) were recorded. Water samples were collected and transported in black glass bottles to the ‘Water Quality and Pond

Table 1: Supplementary food ingredients used in pond

Ingredient	Inclusion in diet (%)
Fish meal	33.60
Mustard oil cake (MOC)	15.08
Wheat bran	15.00
Rice bran	29.42
Ata	5.00
Vitamin premix	1.00
Salt	1.00
Total	100.00

Dynamics Laboratory' for chemical analysis. Sampling was started at about 10 am and continued up to about 11 am. The procedure and methods for analysis of physical and chemical factors are stated below:

- **Temperature:** Water temperature was recorded by a Celsius thermometer (1 div. = 0.1°C)
- **Transparency:** Transparency of pond water was measured by a Secchi disc of 30 cm in diameter
- **Dissolved oxygen (DO):** To determine dissolved oxygen, water samples were collected in black glass bottles with care to avoid any air bubble and immediately brought to the laboratory and measured titrimetrically using Winkler's solution (Stirling, 1985)
- **Hydrogen ion concentration (pH):** Water samples were collected in plastic bottle and immediately brought to the Laboratory, pH was measured using a pH meter (Corning-445)
- **Total alkalinity:** Water samples were collected in plastic bottle and immediately brought into the Laboratory and alkalinity was measured titrimetrically following APHA (1992)
- **Total suspended solids (TSS) measurement:** One hundred milliliter water was passed through a pre-washed and pre-washed glassfibre filter paper (Whatman GF/C). The filter paper was then dried at 105°C for 12 h, cooled and weighed again. The difference in weight was divided by volume of water sample, which gave the mg L^{-1} solids. The filter paper with the dry solids obtained from final weighing as above was ashed in a muffle furnace at 500°C for 12 h, allowed top cool in a desiccator and reweighed. The decrease in weight gave the content of particulate organic matter in the corresponding volume of water sample (Stirling, 1985)

Soil sample: Soil samples were collected from 3 locations (both sides and middle) of the pond bottom monthly and carried to the Laboratory using three different plastic bags. The samples were dried in the air, ground and sieved by 0.03 mm mesh size sieve and kept in three different plastic pots. The pots were marked with dates and locations for future analysis:

- **Soil pH:** pH of the pond soil mud was determined from a mixture of pond soil mud and distilled water in a 1:2.5 (w/v) ratio and stirred at intervals. After 1 h the pH of the freshly stirred suspension was measured with a digital pH meter (Smith *et al.*, 1981)
- **Organic matter content:** The organic carbon estimation helps to know the amount of organic matter present in soil. In this method, the soil is digested with chromic and sulphuric acids, making use of the heat of dilution of the sulphuric acid. This is done by oxidizing the organic carbon with potassium dichromate in presence of concentrated sulphuric acid. The amount of organic matters (organic carbon) present in soil was calculated by Walkley-Black method

Collection of chironomid larvae from pond bottom: Composition of the bottom mud was recorded with visual identification and subsequent quantification was accomplished in accordance with the weight of the types of benthos. Bottom mud was collected from three different locations in the experimental pond (middle and two corner) using an Ekman Grab. Chironomid larvae were collected by using a standard brass sieve (mesh size 0.92 mm). Each sample was washed on the sieve with water in order to washout the soil content from the sieve. Chironomid larvae remaining within the sieve were collected with care and poured into small vials containing 5% formalin. These were carried to the laboratory for detailed quantitative and qualitative analysis:

- **Microscopic slide preparation and examination:** Chironomid larvae were mounted in polyvinyl lactophenol, each individual was mounted on a separate slide. The head capsule was separated from the body with the help of a needle. The body and head capsule of each individual was placed on the same slide under separate cover slips. Care was taken to remove excess water from the body by touching with tissue paper before placing on a slide because water along with ethanol makes the mounting difficult. Then, the specimens were ready for identification

Sampling of fish: Fishes were sampled monthly by using a cast net and 5 fishes were taken for gut content analysis:

- **Gut content analysis:** The gut contents of the collected fish samples were examined in this experiment. The composition of food was recorded and the components were quantified according to the body weight of food items present. The abdomen of the individual fish was cut by the help of scissors and gut content were taken out carefully and guts were collected and stocked in vials containing 5% formalin until the gut contents were examined. During analysis the guts were taken out from the vials and kept on petri dish. Then each gut was pieced and a small portion was washed with distilled water. Then, the washed water was sampled on a glass slide and observed under microscope. Thus, the qualitative and quantitative study of the Chironomid larvae was done

- **Electivity Index:** In order to gain an idea of the proportion of organisms in the diet relative to the proportion measured in the benthos, an index of selective feeding or electivity was calculated using the formula given by Ivlev (1961) as cited by Brown and Oldham (1984):

$$E = \frac{Pg-Pm}{Pg+Pm}$$

Where:

E = Electivity index value
Pg = Relative content of Chironomid larvae in the gut, expressed as percentage of total ration
Pm = Relative proportion of the same organism present in the bottom mud

The numerical assessment of gut contents and collected benthic faunal data provided the required information for measuring electivity index in this study.

Positive electivity or selection for an organism is expressed by values from 0+1 and negative electivity by values from −1-0.

Enumeration of benthos: Bottom mud samples were taken with the help of an "Ekman dredge" which covered an area of 225 cm^2. The Chironomid larvae were enumerated for the study of abundance in the investigated area. The specimens were counted species wise, recorded and converted to their abundance (m^{-2}).

The abundance was expressed as density (individuals m^{-2}) by following formula:

$$n = \frac{o}{a \times s} \times 10000$$

Where:

n = Number of individuals in one square meter
o = Number of individuals totally/actually counted
a = Area of samples in square centimeter
s = Number of samples taken at one sampling spot

Statistical analysis: The data obtained from monthly abundance of Chironomid fauna from the studied pond was tabulated for statistical analysis. Analysis of variance was done with the help of computer package SPSS version 10.0. The mean values were compared by Duncan's New Multiple Range Test at 5% level of significance.

RESULTS

Physicochemical chemical factors: Various physicochemical chemical factors (water quality and soil parameters) such as water temperature, transparency (Secchi disk), water pH, dissolved oxygen, alkalinity, Total Suspended Solids (TSS), soil pH and organic matter percent were studied during the period of experiment. They are presented in the Table 2, 3:

- **Water temperature:** The recorded temperature of water in the experimental pond over the period from September 2008-February 2009 was found to vary from 19-31°C. The average value±SD of the water temperature was 24.67°C±4.84
- **Transparency:** The transparency value (Secchi disc) was found to range from 12.5-22 cm. The average±SD of transparency was 18.033±4.306 cm
- **Water pH:** The range of pH values in the experimental pond was found to vary between 7.08 and 8.27. The highest pH value 8.27 was recorded in January 2009 and the lowest was observed in September 2008
- **Dissolved oxygen:** Dissolved oxygen content of water in the experimental pond was found to vary from 4.8-8.6 ppm. The average value of DO content was 6.35±1.252 ppm. The highest DO content was observed in February 2009 and the lowest in December 2008
- **Alkalinity:** Alkalinity was found to fluctuate during the study period in the experimental pond. Alkalinity of water was found to be in the range from

Table 2: Comparative status of water quality parameters of the BAU research ponds

Temperature (°C)	Secchi disc (cm)	Dissolved oxygen (mg L^{-1})	pH	PO_4-P (mg L^{-1})	NO_3-N (mg L^{-1})	NH_3-N (mg L^{-1})	Alkalinity/ hardness (mg L^{-1})	Chlorophyll-a (μg L^{-1})	References
26-32.44	91.5-127.0	1.19-7.74	7.19-7.44	0.055-0.174	0.091-0.799	-	71-87	-	Mollah and Haque (1978)
32.2-34.0	54-90	2.2-8.8	6.6-8.8	0.1-0.75	0.1-3.25	0.5-0.62	20-80	12-30	Dewan *et al.* (1991)
27.2-32.4	26-50	2.2-7.1	6.0	0.09-5.2	Up to 2.9	0.0-0.43	45-108	-	Wahab *et al.* (1995)
26	36.2	6.5	7.1	0.8	0.5	0.1	50.5	-	Azim *et al.* (1995)
29.9-30.2	39-46	4.4-4.9	-	2.1-2.8	0.4-0.57	0.05-0.07	87-94	-	Mazid *et al.* (1997)
27.72±0.01	32.50±2.40	4.20±0.12	7.18	0.292±0.03	1.23±0.10	0.14±0.02	104.80±8.12	-	Kohinoor *et al.* (1998)

Table 3: Water-quality and soil parameters of experimental pond during September 2008-February 2009

Month	Water temp. (°C)	Secchi disc (cm)	Water pH	DO (ppm)	Alkalinity (ppm)	TSS (ppm)	Soil pH	Organic matter (%)
September	31	12.5	7.08	6.0	124	55	6.55	2.18
October	29	21.5	7.32	6.6	110	48	7.18	1.98
November	26	18.5	7.99	6.0	202	37	6.94	1.86
December	19	21.0	7.71	4.8	284	40	7.05	2.06
January	20	22.0	8.27	6.1	280	87	7.05	2.06
February	23	13.0	7.71	8.6	212	164	7.12	1.96
Mean±SD	24.67±4.844	18.033±4.306	7.76	6.35±1.252	202±74.103	710.833±48.586	6.982±0.231	2.0161±0.383

Table 4: Monthly observation of different types of chironomid larvae in bottom mud from 3 locations in the experimental pond during September 2008-February 2009

	Type of chironomid larvae							
Month	A	B	C	D	E	F	G	Total
September	5^{c}	1^{c}	22^{a}	8^{c}	4^{c}	0^{b}	0^{b}	40
October	0^{b}	0^{b}	24^{a}	0^{b}	2^{b}	0^{b}	11^{a}	37
November	0^{c}	0^{c}	87^{a}	0^{c}	0^{c}	2^{c}	37^{b}	126
December	0^{b}	0^{b}	158^{a}	0^{b}	0^{b}	43^{b}	10^{b}	211
January	0^{c}	0^{c}	158^{a}	0^{c}	0^{c}	64^{b}	20^{c}	242
February	0^{c}	0^{c}	97^{a}	0^{c}	0^{b}	47^{b}	37^{b}	181

Table 5: Abundance of different types of Chironomid larvae in different months from 3 locations in bottom mud of the experimental pond during September 2008-February 2009

	Type of chironomid larvae							
Month	A	B	C	D	E	F	G	Total
September	74.07	14.81	325.93	118.52	59.26	0.00	0.00	592.59
October	0.00	0.00	355.56	0.00	29.63	0.00	162.96	548.15
November	0.00	0.00	1288.89	0.00	0.00	29.63	548.15	1866.67
December	0.00	0.00	2340.74	0.00	0.00	637.04	148.15	3125.94
January	0.00	0.00	2340.74	0.00	0.00	948.15	296.30	3585.19
February	0.00	0.00	1437.04	0.00	0.00	696.30	548.15	2681.48

110-284 ppm. The average±SD was obtained as 202±74.103 ppm. The maximum and minimum alkalinity was observed in December and in October 2008, respectively

- **Total suspended solids (TSS):** The range of TSS values observed in the experimental pond was found to be between 37-164 ppm. The average value±SD of TSS was 71.833±48.586 ppm. The highest TSS value was recorded in February 2009 and the lowest TSS value was observed in November 2008
- **Soil pH:** The range of soil pH values in the experimental pond was found to be between 6.55 and 7.18. The highest soil pH value was recorded in October 2008. The lowest pH value was observed in September 2008
- **Organic matter:** The range of organic matter observed in the experimental pond during the study period was found to be between 1.86 and 2.18%. The average value±SD was 2.0161±0.383%. The highest value was recorded in September 2008. The lowest value was observed in November 2008

Abundance of Chironomid larvae in bottom mud: The occurrence of Chironomid larvae varied monthly from 37 (October 2008) to 242 (January 2009) in bottom mud of the experimental pond in the monthly samples taken in the study period. The species *Chironomus* was most dominant and was significantly higher at 5% level of significance (Table 4).

Chironomid population: Quantitative and qualitative studies of Chironomid larvae were made in every month both from the bottom mud of the experimental pond and from the gut of the sampled fishes. A summary of the data on the population abundance of the Chironomid larvae recorded during the experimental period is provided in Table 5.

The monthly abundance of Chironomid larvae in the bottom mud of the experimental pond during the study period was found to be between 548.15-3585.19 individuals m^{-2}. The second highest abundance was 3125.93 individuals m^{-2}. The maximum abundance of Chironomid larvae was found in the month of January 2003. The second highest abundance was recorded in the month of December 2008. The minimum abundance was recorded in the month of October 2008.

Gut content analysis of chironomid larvae: Monthly recorded No. of Chironomid larvae in the gut of 5 sampled fishes during the study period was found to vary between 25 and 768 in number. The second highest occurrence was 410 larvae. The most Chironomids were found in the

Table 6: Monthly observation of gut-content of chironomid larvae in the experimental pond during October 2008-February 2009

Month	No. of samples observed	Buccal cavity	Pharynx	Esophagus	Stomach	Intestine	Total	Average
October	5	0	3	0	13	9	25	5.0
November	5	0	7	0	33	370	410	82.0
December	5	0	6	0	52	710	768	153.6
January	5	0	0	0	21	254	275	55.0
February	5	0	0	0	19	18	37	7.4

Table 7: Composition (%) of benthic organisms present in the bottom mud of the experimental pond during September 2008-February 2009

Month	Chironomidae	Oligochaeta	Mosquito and other insects	Mollusk
October	23	26	13	38
November	32	25	10	33
December	25	33	11	31
January	35	30	9	26
February	29	31	12	28

Table 8: The composition (%) of diet as revealed by the stomach content analysis of the sampled fishes from the experimental pond during September 2008-February 2009

Month	Chironomidae	Oligochaeta	Mosquito and other insects	Organic matter and debris
October	15	5	50	30
November	25	22	35	18
December	65	27	6	2
January	76	19	5	0
February	59	25	16	0

Table 9: Monthly variation observed in the electivity for chironomid larvae during October 2008-February 2009

Month	Proportion in gut (%)	Proportion in mud (%)	Electivity Index (E)
October	15	23	-0.210530
November	25	32	-0.122810
December	65	25	0.444444
January	76	35	0.369369
February	59	29	0.340909

intestine of the sampled fishes. The maximum occurrence of Chironomid larvae was found in the month of December 2008. The second highest occurrence was recorded in the month of November 2008. The minimum occurrence was recorded in the month of October 2008. (Table 6-8).

Electivity index: Electivity indices were calculated for every month and it varied from −0.12 to +0.44. The high electivity was observed in December 2008 and the lowest value was calculated for the month of November 2008. For the first two months, the fishes showed negative selection in feeding the Chironomid larvae. For the last three months the fishes showed greater preferences to the Chironomids (Table 9).

DISCUSSION

Abundance of Chironomid larvae depends on physicochemical factors of the environment. In this study the measured factors were found to lie within the acceptable ranges. Water temperature is one of the most important factors for aquatic organisms because it influences other physical and/or chemical factors. Also, activities of fish are controlled by temperature. If temperature of water rises one degree, the metabolic rate of fish increases by 10%. Water temperature was low in December and high in September. Water temperature ranged from 19-31°C during the investigation period from September 2008-February 2009. The average temperature was 24.67±4.844°C. Mollah and Haque (1978) reported that water temperature ranged from 26.0-32.44°C in the ponds at BAU campus, Mymensingh. Azim *et al.* (1995) observed water temperature ranged from 27.5-30.5°C in earthen ponds of the Fisheries Faculty Field Laboratory, BAU Mymensingh. Boyd (1982) also reported that the range of water temperature of 26.06-31.97°C is suitable for fish culture. Taking the winter season into the account, we can consider that the range of water temperature was within the acceptable range of fish culture. So, the results of this study are more or less similar to the above authors.

Water transparency expresses the level of productivity of a water body. The productivity level is related to the Chironomid abundance. The transparency value was found to range from 12.5-22 cm. The average transparency value was 18.033±4.306 cm during the investigation period, September 2008-February 2009. Reid (1964) reported that the transparency of a water body affected by several factors as concentration of phytoplankton, suspended organic matter, latitude, season and the angle of intensity of entering light. In the present study, the water transparency value indicated that the pond is productive. Wahab *et al.* (1994) reported that the transparency of productive water bodies should be 40 cm or less. Kohinoor *et al.* (1998) measured the mean values of transparency 32.50±2.40 cm in six research ponds of Faculty of Fisheries at BAU, Mymensingh. Boyd (1982) suggested that a transparency value between 15-40 cm is good for fish culture.

The pH of waterbody 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 this study, the highest value of pH (8.27) was recorded in January 2009 and lowest pH value (7.08) was observed in September 2008. The water pH of the experimental pond showed no greater fluctuations. The pH values in different months were more or less closed to each other and remained alkaline during the investigation period. According to Swingle (1967), pH 6.5-9.0 is suitable for pond fish culture and pH more than 9.5 in unsuitable because free CO_2 is not available in this situation. Hossain *et al.* (1997) found pH 6.7-8.3, while Kohinoor *et al.* (1998) recorded pH 7.2-7.3 in the research ponds of BAU campus, Mymensingh. From the above discussion, it can be stated that the range of pH values was within the suitable range for fish culture.

Dissolved oxygen is one of the most important factors in natural water as a regulator of metabolic process of plants and animals. Low oxygen content of water has great influence on the abundance and diversity of benthic macroinvertebrate. Dissolved oxygen content of water in the experimental pond in the study period was found to be within 4.8-8.6 ppm. The average value of dissolved oxygen content of water was 6.35±1.252 ppm. Wahab *et al.* (1995) recorded a low dissolved oxygen content ranging from 2.0-7.0 ppm during their experiment in the ponds of BAU campus, Mymensingh. Sukop (1976) concluded that the quantity of benthos may be influenced by the factors like water temperature and dissolved oxygen. Martien and Benke (1977) reported that the dissolved oxygen content of water should be higher than 1 ppm to maintain positive benthos production. So, the dissolved oxygen content of this study was in acceptable range for suitable fish culture as well as optimum benthos production.

Total alkalinity is an important factor controlling the productivity of a water body. Very low total alkalinity (<20 ppm) and very high total alkalinity in which pH will be more than 9 are not favorable for primary production (Boyd, 1982). In this study alkalinity of water was found to be in the range from 110-284. The highest value of total alkalinity was observed in December 2002 and lowest, in October 2002. Wahab *et al.* (1995) reported that total alkalinity of pond water in Mymensingh area usually ranged from 45-108 ppm. In another study, Azim *et al.* (1995) recorded total alkalinity as 50.5 ppm. On the basis of the above, we may conclude that the alkalinity levels were suitable for fish culture.

Total Suspended Solids (TSS) has got a relationship with the primary productivity. If the amount of TSS is high the water body will be more turbid. In this experiment, the recorded TSS ranges (37-164 ppm) were suitable for fish culture. TSS was high in the month of February 2009 and low in the month of November 2008. Rich information about TSS is lacking.

The variation of soil pH from soil to soil is due to the physical, chemical and biological characteristics of the soil. In the present study, mean value of soil pH in the experimental pond was 6.982±0.231. The highest pH value (7.18) was recorded in October 2008 and the lowest pH value (6.55) was recorded in September 2008. pH values of BAU soil is within the range of 6.8-7.2. Considerable pH range is 6.5-7.5 when most nutrients are available in pond water. From the above discussion, it can be concluded that the soil pH was within the acceptable range for a productive waterbody.

Soil organic matter may be defined as the organic fraction of soil. It is one of the four major components of soil. Organic matter influences physical, chemical and biological properties of soil. The average value of organic matter was 2.0161±0.383 during the study period. The highest value (2.18%) was in the month of September 2002 and the lowest value (1.86%) was in the month of November 2002. In a recent study, about nutrient status of 18 important agricultural soils, organic matter (%) was found to vary within 0.5-2.1. So, the result of this study indicates that the bottom mud of the experimental pond was productive.

A total of 837 Chironomid larvae were collected from the sampling stations in the pond during 6 months of study period (September 2008-February 2009). Monthly observed total no. of Chironomid larvae in the bottom mud of the experimental pond during the study period was found to be between 548.15 and 3585.19 individuals m^{-2}. The major type of Chironomidae recorded during the present study were *Chironomus* (type-c). Its abundance was 2340.75 individuals m^{-2} in the month of December 2008-January 2009. The species *Chironomus* was most dominant and was significantly higher at 5% level of significance. Chironomids ranked one of the dominant groups of benthic fauna recorded during the study period. Monthly variation of total Chironomids shows statistically significant difference ($p<0.05$). A distinct seasonal variation in the population of Chironomids was observed in this study. The observed lower number in February 2009 might be due to heavy grazing by *Clarias batrachus*, which agrees with the observation of Brown and Oldham (1984). The ecological conditions of the ponds were probably favorable for the growth of these organisms. The soft bottom mud of the tropical fish ponds has been found to exert a significant influence upon the occurrence of the bottom organisms especially the Chironomids.

There were qualitative and quantitative variations of the Chironomid larvae. Higher abundance in the pond seems to be due to better feeding, environmental conditions and probably breeding. Seasonal changes in the population abundance of Chironomidae were investigated by many workers (Mundie, 1957; Titmus, 1979; Brown and Oldham, 1984). A distinct seasonal variation in total Chironomidae was observed in this study. Olfsson (1992) had similar observation where he found the highest number of individuals in June in the pond and lowest number was recorded in August. The general trend of seasonal variation in abundance was caused by the temperature and water level together with pH and dissolved oxygen as additional factors. High temperature accelerated the rate of decomposition of organic materials resulting higher activity and production of the Chironomid larvae. The lower water level of the pond reduced the space in the pond bottom and thus, competition caused the benthos to concentrate at a greater density in the reduced area of bottom mud. The depth and temperature of water as controlling factors in determining abundance was demonstrated by other workers.

Food composition of sampled fishes in the experimental pond suggested that Chironomids comprised a major component of the diet of *Clarias*. The food comprised mainly of insects, polychaetes, oligochaetes and debris. This result is similar to that observed by Dewan (1973). The electivity indices showed negative selection (E = -0.12) to Chironomids at first and thereafter it shifted to the greater preferences (E = +0.44) over the time elapsed as the fish grew older in months. Ali and Begum (1979) observed positive selection for insects. The information on electivity of *Clarias* on Chironomids seems to be lacking as well. Since, Chironomids were found to dominate in the diet of *Clarias* as it grows, efforts should be made to enhance Chironomid production in the catfish ponds for better fish production.

CONCLUSION

The composition of the benthic macro-invertebrates in the bottom and indicated that Chironomidae was the dominant group. The body-weight percentage of the organisms showed that Chironomids and Oligochaetes were two major groups. The quantitative and qualitative studies of Chironomid larvae indicated that there was monthly variation in the abundance of Chironomids where *Chironomus* was most dominant. The highest abundance of Chironomids 3585.19 individuals m^{-2} in 3 samples was recorded in the month of January 2009. The lowest abundance 548.15 individuals m^{-2} in 3 samples was observed in the month of October 2008.

The gut content analysis showed that Chironomids was the dominant food item in fish diet as they grow up. Maximum Chironomids were found in the intestine. The maximum occurrence of Chironomid larvae, 768 in number, was recorded for 5 fish samples in the month of December 2008. The minimum occurrence, 25, was recorded in October 2008.

The electivity indices calculated for Chironomid larvae in each month showed that fish had negative selection for Chironomids for the first 2 months; a shift in the electivity to greater preferences to Chironomids was observed thereafter. It may be concluded that a greater abundance of Chironomid larvae may be required in the *Clarias* culture ponds for better fish production.

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