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A study on the abundance of zooplankton of a culture and a non-culture pond of the Rajshahi University campus

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Abstract: Zooplankton constitute important food item of many omnivorous and carnivorous fishes. The study was conducted with an aim to study the zooplankton production including physico-chemical parameters with an emphasis to the existing management practices taken by the operators. The study was carried out in a culture and a non-culture pond of Rajshahi University campus was carried out from September, 2004 to February, 2005. Monthly fluctuations of some physico-chemical parameters were noted. The ponds showed alkaline in nature with moderate bicarbonate alkalinity. Diurnal change of water temperature, free CO_2 and dissolved Oxygen were also studied. Four groups of zooplankton were identified, of which copepods (1260 units/l and 973.33 units/l in pond-1 and pond-2 respectively) were most dominant. A total of 9 genera of zooplankton were identified of which *Cyclops* (68.25% and 60.28% of total copepods) was most abundant in both ponds. Total zooplankton showed positive correlation with pH, carbonate alkalinity (CO_3) and bicarbonate alkalinity (HCO_3) in both ponds and DO, carbon dioxide (CO_2) in pond-1. Present findings indicated that the culture pond showed better result than that of the non-culture pond regarding zooplankton production.

Key words: Zooplankton, culture pond, non-culture pond, physico-chemical parameters.

Introduction

Plankton is the natural food of many species of fishes, especially zooplankton constitute important food item of many omnivorous and carnivorous fishes. The larvae of carps feed mostly on zooplankton (Dewan *et al*., 1977) because zooplankton provides the necessary amount of protein for the rapid growth and specially that of the gonad. According to Prasad & Singh (2003), the zooplankton forms the principal source of food for fish within the water body, zooplankton contributes about 82% of the food items of *Anabas testudineus* (Shafi & Mustafa,1976), 32% of *Notopterus notopterus* (Mustafa & Ahmed, 1979), 47.06% of *Catla catla* and 6.37% of *Labeo rohita* (Ali & Islam,1981), 24.19% of *Oreochromis nilotica* (Ismail *et al*., 1984), 38.5% of *Rohtee cotio* (Ali *et al*., 1984) and 30% of *Mystus vittatus* (Bhuiyan & Haque, 1984). Bhuiyan & Islam (1988) observed that the main food items of *Xenentodon cancila* was zooplankton. Zooplankton also plays a very important role in the food chain as they are in the second trophic level as primary consumer and also as contributors to the next trophic level. Both the qualitative and quantitative abundance of plankton in a fish pond are of great importance in managing the successful aquaculture operation, as they vary from location to location and pond to pond within the same location even within similar ecological conditions (Boyd, 1982). George (1966), Krishnamurty & Visvesvara (1966), Sreenivasan (1967) and Michael (1968) worked in detail on the ecology of zooplankton population from different waters of India. Some of the works which have been done in Bangladesh include those of Das & Bhuiyan (1974), Islam & Mendes (1976), Khan *et al*. (1978), Bhuiyan & Nesa (1998a and 1998b) and Bhuiyan *et al*. (1997). Islam *et al*. (2000) studied ecology and seasonal abundance of some zooplankton of a pond in Rajshahi. Naz (1992) studied the eutrophic and hypertrophic nature of fish ponds of Rajshahi university campus. Homyra & Naz (2005) studied limnology of an artificial lake of Rajshahi. Chowdhury & Mamun (2006) worked on physico-chemical conditions and plankton population of two fish ponds in Khulna. Many researchers worked on the percentage composition, seasonal variation and occurrence of freshwater zooplankton, but little or no information is available on the abundance of zooplankton in culture and non-culture pond in relation to water quality parameters.

Among the different systems, the semi-intensive aquaculture encourages the natural food production through fertilization. Thus, the understanding in natural food production in pond especially on the zooplankton production is considered very important for the development of fertilizer based rural aquaculture practice in Bangladesh. Both organic and inorganic fertilizers are used for zooplankton production in our country. Comparatively the organic fertilizer is easily available and low cost than that of the inorganic fertilizer. The purpose of the present investigation is to study the changes in the zooplankton production including the physico-chemical parameters with an emphasis to record the existing management practices operated by the pond owners in the two ponds.

Materials and Methods

The study ponds: Two perennial ponds are selected for the present study. The first pond (culture pond) is managed properly and leased out to a local fish farmer .The pond is rectangular in shape and has an area of 297decimel with an average depth of 8 feet, which varies throughout the year. The second pond (non-culture pond) is under the supervision of

Fisheries department. It has an area of 1 acre with an average depth of 3 feet and irregular in shape. It is not managed culturally.

Inputs applied to the culture pond: During prestocking management farmers manually clean aquatic weeds and use "Quickfume" and "Sumithion" at the rate of 2000 tablets/ha and 75050ml/ha respectively for removing predatory fish. Lime is applied at the rate of 375kg/ha during pond preparation. Cowdung, TSP and Urea were applied at the rate of 1125.70kg/ha, 281.43kg/ha and 187.62kg/ha respectively. In the culture pond the stocking density of Rohu(*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), Silver carp(*Hypophthalmicthys molitrix*), Bighead carp(*Aristichthys nobilis*), Grass carp(*Ctenopharyngodon idella*) and Sarpunti(*Puntius gonionotus*) was 855individual/ha, 427individual/ha, 513 individual/ha, 294 individual/ha, 187individual/ha, 168 individual/ha and 312individual/ha respectively. In the non culture pond four species namely- Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*) and Silvercarp (*Hypophthalmicthys molitrix*) were stocked. The stocking density was 15individual/ha, 100individual/ha, 150 individual/ha and 3250individual/ha respectively. During the growout management cowdung and TSP was applied at the rate of 200kg/ha/week and 5kg/ha/week in the culture pond. Among the supplementary feeds mustard oilcake and wheat flour was applied at the quantity of 3.37kg/ha/daily and 1.68kg/ha/daily.

Analysis of water quality: Analysis of water quality and plankton sampling was done fortnightly three times a day (morning 7am, noon 12pm, and evening 5pm), from 4 points of the pond at a depth of 20cm below the surface. A centigrade thermometer was used to measure water temperature. Transparency (cm) was measured with a secchi disc of 15.5cm diameter. pH was measured by a digital pH meter (model-98107, Made in Mauritius). DO was measured by Winkler's Titration method (APHA, 1989). CO_2, CO_3 and HCO_3 alkalinity was measured by titration method (Welch, 1948).

Plankton sampling and analysis: Ten liter water was collected from different points and depths of the pond and filtered through a 25µm mesh plankton net to sample the experimental plankton. The sample was preserved in Transeau's solution. Analysis was done on a Sedgwick-Rafter counting cell, under an Olympus light microscope, model CX21FS1.

Zooplankton were identified following keys given by Ward & Whipple (1959), Mellanby (1963), Needham & Needham (1972), Tonapi (1980) and Bhouyain & Asmat (1992). Analysis involved transfer of 1 ml sub sample from each of the samples to the Sedgewick-Rafter counter and counting of cells within 10 squares of the cells, chosen randomly. The cells counted were used for quantitative estimation of cell density using the following formula of Stirling (1985)-

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$

Where,

N= Number of plankton cells or units per liter of original water
A= Total number of plankton counted
C= Volume of final concentration of the samples in ml
V=Volume of a field in cubic mm
F= Number of fields counted
L= Volume of original water in liters

Statistical analysis was done using SPSS programme.

Results and Discussion

Physico-chemical aspects: Some selected physico-chemical parameters of water were studied in the culture and non-culture pond and their monthly mean values are shown in the Table1.

Water temperature: During the study period, water temperature ranged from a minimum of 18.51^{o}C (February, 2005) to a maximum of 31.10^{o}C (September, 2004) in pond-1, while minimum of 18.77^{o}C (February, 2005) to a maximum of 31.20^{o}C (September, 2005) in pond-2.

Transparency: Transparency was observed to be lowest (22.46cm) in January, 2005 and highest (41.37cm) in October, 2004 in pond-1.Similarly lowest value (42.35cm) was observed in January, 2005 and highest value (63.37cm) was observed in October, 2004 in pond-2.

***p*H:** The pond water showed alkaline condition. The pH was noted to be between 8.7 (February, 2005) to 9.5 (January, 2005) in pond-1 and 8.1 (October, 2004) to 9.4 (January, 2005) in pond-2.

Dissolved Oxygen (DO): The dissolved oxygen content of water varied between 3.4mg/l (September, 2004) to 7.7mg/l (January, 2005) in pond-1 and 1.6mg/l (September, 2004) to 2.55mg/l (December, 2004) in pond-2.

Free Carbon dioxide (CO_2): Free carbon dioxide was recorded from 2.75mg/l (September, 2004) to 7.5mg/l (October, 2004) in pond-1, while 3.7mg/l (December, 2004) to 17.22mg/l (October, 2004) in pond-2.

Carbonate alkalinity (CO_3^-): Carbonate alkalinity varied between 0.96mg/l (September, 2004) to 4.5 mg/l (January, 2005) in pond-1. Similarly, in pond-2 carbonate alkalinity varied between 1.0mg/l (September, 2004) to 3.5mg/l (January, 2005).

Bicarbonate alkalinity (HCO_3^-): Bicarbonate alkalinity fluctuated from 85.16mg/l (February, 2005) to 110.0mgl (January, 2005) in pond-1, whereas 55.75mg/l (September, 2004) to 98.45mg/l (January, 2005) in pond-2.

Table 1. Monthly variation of water quality parameters of pond-1 and pond-2 (September, 2004 to February, 2005).

Months	Temperature (°C)		Transparency (cm)		pH		DO (mg/l)		CO_2 (mg/l)		CO^-_3 (mg/l)		HCO_3^- (mg/l)	
	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2
Sep'04	31.10	31.20	33.61	51.25	8.8	8.6	3.4	1.60	2.75	4.20	0.96	1.00	86.75	55.75
Oct'04	28.50	28.32	41.37	63.37	8.9	8.1	4.8	1.80	7.50	17.22	3.10	1.50	94.14	61.25
Nov'04	25.32	25.55	28.25	49.15	9.1	8.7	5.2	2.15	3.30	4.80	2.50	2.25	96.19	75.31
Dec'04	24.67	24.25	26.55	47.22	9.4	9.2	5.5	2.55	4.16	3.70	2.67	2.00	105.00	83.37
Jan'05	19.16	19.23	22.46	42.35	9.5	9.4	7.7	1.81	4.75	7.95	4.50	3.50	110.00	98.45
Feb'05	18.51	18.77	25.31	46.13	8.7	8.3	7.0	2.30	4.37	6.23	3.70	2.50	85.16	79.15
Mean ± SD	24.54 ±4.99	24.55 ±4.92	29.59 ±6.86	49.91 ±7.24	9.07 ±0.33	8.72 ±0.50	5.60 ±1.55	2.04 ±0.36	4.47 ±1.65	7.35 ±5.08	2.91 ±1.20	2.13 ±0.86	96.21 ±9.83	75.55 ±15.46

Zooplankton: The recorded zooplanktonic organisms were rotifers, copepods, cladocerans and crustacean larvae. There was marked difference in the density of total zooplankton in the two ponds. In pond-1, minimum number of zooplankton was 3320units/l in September and maximum 6000units/l in January whereas, in pond-2 minimum number of zooplankton was recorded 1820 units/l in October and November and maximum was recorded 2960 units/l in January (Table-2, Table-3 and Fig 1).

Table 2. Monthly distribution of zooplankton (units/l) in pond-1.

Groups	Sep'04	Oct'04	Nov'04	Dec'04	Jan'05	Feb'05	Average	% among total zooplankton
Rotifera								
Brachionus	280	1040	240	480	1240	1200	746.67	18.06
Asplanchna	-	240	-	280	240	-	253.33	3.06
Keratella	480	-	-	-	420	240	380	4.59
Filinia	-	360	-	-	-	-	360	1.45
Total	760	1640	240	760	1900	1440	1123.33	27.16
Copepoda								
Diaptomus	480	600	240	240	480	360	400	9.67
Cyclops	1240	780	540	1200	720	680	860	20.80
Total	1720	1380	780	1440	1200	1040	1260	30.47
Cladocera								
Daphnia	-	360	720	420	1440	720	732	14.75
Moina	240	240	840	-	240	-	390	6.29
Diaphanosoma	-	240	240	240	420	360	300	6.05
Total	240	840	1800	660	2100	1080	1120	27.09
Crustacean larvae	600	500	520	720	800	650	631.67	15.28
Total zooplankton	3320	4360	3340	3580	6000	4210	4135	100

Copepoda

Copepods were first dominant in both ponds and constituted 30.47% and 43.39% of total zooplankton in pond-1 and pond-2 respectively (Table 2 and Table 3). In pond-1, highest number of the copepods (1720 units/l) was observed in September, 2004 and lowest (780 units/l) in November, 2004 (Table 2). In pond-2, highest (1320 units/l) was observed in September, 2004 and lowest (600 units/l) in November, 2004 (Table 3). *Diaptomus* and *Cyclops* were the identified genera. *Cyclops* was most dominant (68.25% and 60.28% of total copepods) in both ponds (Fig 2).

Rotifera

Rotifers were second dominant. They contributed to 27.16% and 19.17% of total zooplankton population in pond-1 and pond-2 respectively (Table 2 and Table 3). Highest number of rotifers (1900 units/l) were observed in January, 2005 and lowest (240 units/l) in November, 2004 in pond-1 (Table 2). Similarly, in pond-2 highest values (720 units/l) was observed in January, 2005 and lowest (240 units/l) in October and November, 2004 (Table 3). *Brachionus*, *Asplanchna*, *Keratella* and *Filina* were the identified genera. *Brachionus* was most dominant (66.47% and 60.47% of total rotifers) in both ponds (Fig. 3).

Table 3. Monthly distribution of zooplankton (units/l) in pond-2.

Groups	Sep'04	Oct'04	Nov'04	Dec'04	Jan'05	Feb'05	Average	% among total zooplankton
Rotifera								
Brachionus	240	240	-	360	480	240	312	11.59
Asplanchna	-	-	-	-	240	300	270	4.01
Keratella	240	-	240	-	-	-	240	3.57
Filinia	-	-	-	-	-	-	-	-
Total	480	240	240	360	720	540	430	19.17
Copepoda								
Diaptomus	360	640	240	240	600	240	386.67	17.24
Cyclops	960	520	360	480	480	720	586.67	26.15
Total	1320	1160	600	720	1080	960	973.33	43.39
Cladocera								
Daphnia	-	-	-	480	240	480	400	8.92
Moina	-	-	240	-	240	-	240	3.57
Diaphanosoma	240	-	240	-	200	-	226.67	5.05
Total	240	-	480	480	680	480	472	17.54
Crustacean larvae	300	420	500	560	480	420	446.67	19.91
Total zooplankton	2340	1820	1820	2120	2960	2400	2243.33	100

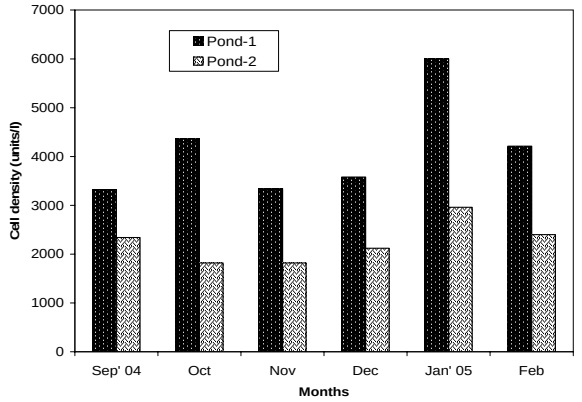

Fig. 1. Monthly variation of zooplankton population of pond-1 and pond-2

Cladocera

The cladocerans constituted the third dominant (27.09% and 17.54% of total zooplankton in pond-1 and pond-2 respectively) group (Table 2 and Table 3). Cladoceran number fluctuated between 240units/l to 2100 units/l in pond-1. Highest was observed in January, 2005 and lowest in September, 2004 (Table 2). In pond-2, highest value (680units/l) was observed in January, 2005 and lowest (240 units/l) in September, 2004 (Table 3). *Daphnia*, *Moina* and *Diaphanosoma* were the identified species. *Daphnia* was most dominant (54.46% and 50.85% of total cladocerans) in both ponds (Fig 4).

Crustacean larvae

Crustacean larvae constituted 15.28% and 19.91% of total zooplankton population in pond-1 and pond-2 respectively (Table 2 and Table 3). Highest (800 units/l) was observed in January, 2005 in pond-1 while 560 units/l in December, 2004 in pond-2. Lowest (500 units/l) was observed in October, 2004 in pond-1 and 300 units/l in September, 2004 in pond-2 (Table 2 and Table 3).

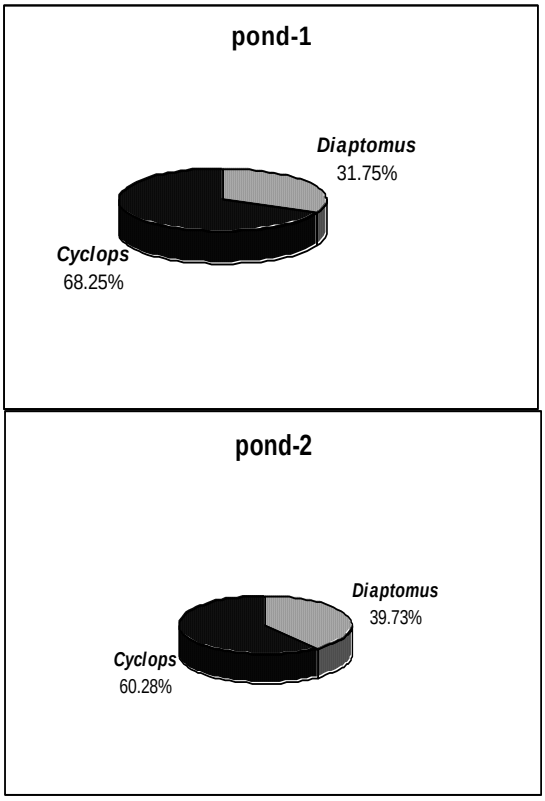

Fig 2. Relative abundance of copepods in pond-1 and pond-2.

Fig 3. Relative abundance of rotifers in pond-1 and pond-2.

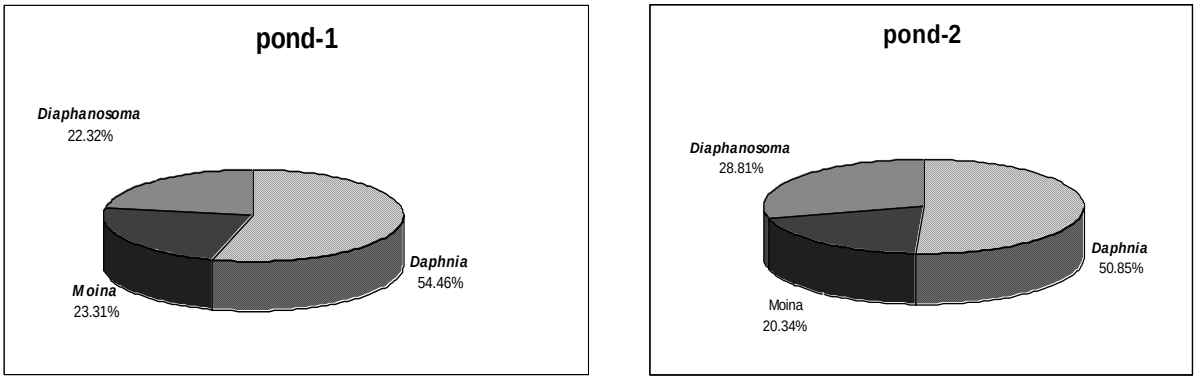

Fig 4. Relative abundance of cladocerans in pond-1 and pond-2.

Table 4. Relationship between zooplankton density and physico-chemical parameters.

Correlation coefficient	Pond-1	Pond-2
Zooplankton vs temperature	-0.6177198	-0.5732289
Zooplankton vs transparency	-0.3306065	-0.7029658
Zooplankton vs pH	0.45243241	0.57514802
Zooplankton vs DO	0.76444975	-0.2266082
Zooplankton vs CO_2	0.441145	-0.2477736
Zooplankton vs CO_3^-	0.84008218*	0.6281064
Zooplankton vs HCO_3^-	0.54722222	0.6103975

* indicates significant at 5% level

In the present study maximum water temperature was observed in September and minimum February in both ponds. Islam *et al.* (1974) and Patra & Azadi (1987) recorded highest water temperature during summer and lowest in winter months.

Transparency was lowest in January during highest density of zooplankton. Reid & Wood (1979) reported that the transparency of water depends on several factors such as silting, plankton density, suspended organic matter, latitude, season and the angle and intensity of incident light.

The pH value of pond water showed alkaline in nature. Such type of result was also reported by Islam *et al.* (2000) who reported average pH value of 7.77 from the pond of Taposhi Rabea Hall, Rajshahi University.

Dissolved Oxygen was lowest in September in both ponds. This could be attributed due to high temperature in September whereas, highest density was observed in January in pond-1 and December in pond-2 when temperature was low as supported by George (1966) in Indrasagar Tank in India.

Free CO_2 was highest in October in both ponds and lowest was observed in September in pond-1 whereas in December in pond-2. The high free CO_2 content during summer was possibly due to high temperature and heavy rainfall. Patra & Azadi (1987) also reported the same observation.

Carbonate alkalinity was minimum in September and maximum in January in both ponds. According to Islam *et al.* (2000) the high value of carbonate alkalinity were observed in spring whereas the lower values were observed in summer.

Bicarbonate alkalinity was lowest in February in pond-1 and in September in pond-2 whereas highest values were observed in January in both ponds. Islam *et al.* (2000) recorded low bicarbonate alkalinity in summer and high bicarbonate alkalinity in winter. This result was also supported by George (1966) in Indrasagar Tank in India.

From the observation, it is obvious that zooplankton showed their peak in January (a winter month). Bhuiyan & Nessa (1998a,b) and Islam *et al.* (2000) recorded highest density of zooplankton in January (442213units/L and1350units/L respectively). The peak of zooplankton in winter may be due to the favorable conditions of the physico-chemical parameters and the availability of nutrients in the pond.

Mainly four groups of zooplankton Copepoda, Rotifera, Cladocera and crustacean larvae were identified in the present study. Similar findings were found with Shankaran & Varghese (1981) and Hossain *et al.* (1999). Comparatively higher concentration of zooplankton was found with pond-1 (culture pond) than that of pond-2 (non-culture pond). This might be due to the effect of fertilizer and subsequent water quality changes in the ponds. These results were more or less agreed with Nayar (1965), Knud-Hansen *et al.* (1994) and Edwards *et al*. (1994). Copepods were dominant in September in both ponds, rotifers and cladocerans in January and crustacean larvae in January in pond-1 while in December in pond-2. Das & Srivastava (1956) divided their entire investigation year into various dominant periods eg. September, October and November constituted the copepodan period, December and January were characterized by cladocerans and April, May and June were characterized by crustacean larvae.

In pond-1, zooplankton showed positive correlationship with pH, DO, CO_2, CO_3^- and HCO_3^- (Table-4). In pond-2, positive correlationship between zooplankton density and pH, CO_3^- and HCO_3^- concentration was observed (Table-4). Zooplankton showed negative correlationship with water temperature, transparency in both ponds and DO, CO_2 in pond-2 (Table-4). According to Miah *et al*. (1981) and Alam *et al*. (1987) zooplankton showed positive correlation with CO_3^- and HCO_3^- alkalinity. Patra and Azadi (1987) reported that inverse relationship existed between zooplankton and water temperature.

It can be concluded that the present findings indicated that the culture pond showed better result than that of the non-culture pond regarding zooplankton production.

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