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Heleoplankton productivity at lower trophic level in two types of aquaculture ponds, Guwahati, Assam

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Abstract
The study is conducted on the productivity of lower trophic status in two types of pond environment in an aquaculture system located in the Aquaculture campus of Gauhati University, Assam. One type of experimental pond (Pond A) is manually managed having fertilization effect of inorganic and organic fertilizers while the other is a naturally managed pen culture pond (Pond B) surrounded by dense reed swamps. The lower trophic system is constituted by planktonic productivity in the fertilized pond seen to be influenced by application of lime and other fertilizers in one hand and in the other hand the pen culture pond got influenced by leasing nutrient from the swamps. The seasonal variations of both phytoplankton and zooplankton densities are compared in both the pond types to determine their fluctuation trend and productivity state. The seasonal variations of phytoplankton productivity in the studied ponds are not well marked, despite the soil of Pond B is nitrogen limiting. However, zooplankton productivity of the two ponds shows significant variation. Phytoplankton exhibits bimodal pattern of seasonal growth in Pond A while tetramodal in Pond B. The study also reveals that Chlorophyceae is the most dominant group in terms of population density over the other phytoplanktonic group. The next dominant group of phytoplankton is Myxophyceae with blooms of *Microcystis aeruginosa* during late monsoon to early autumn in Pond A indicating inclination toward eutrophic condition. Stastical analysis reveals a bimodal pattern of plankton production with a significant negative correlation between phytoplankton and zooplankton for both the ponds. The study also reveals that productivity of phytoplankton is found to be more than that of zooplankton productivity.

Keywords: heleoplankton, phytoplankton, zooplankton, *Microsystis aeruginosa*, artificially managed pond, natural pen culture pond

1. Introduction
Productivity of an aquatic regime is the capacity to support aquatic living organisms. It depends on several attributes such as climatological parameters, physico-chemical factors and nutrient status to support autotrophs to trigger a flow of energy for sustenance of the different organism at various trophic levels. For an ecosystem to be studied appropriately in terms of productivity and nutrients, it is important to be acquainted with the biotic communities that are present at autotrophic level of an ecosystem. In aquatic ecosystem autotrophic level is occupied by phytoplankton and other hydrophytes. Depending on their ability to carry out photosynthetic activity, plankton is divided into two types (1) Phytoplankton (plant plankton) and (2) Zooplankton (animal plankton). Phytoplankton being the primary producer occupies the first position in an aquatic grazing food chain and the fate of the productivity largely depends on it. Moreover, phytoplankton acts as a primary food organism in the pond aquatic ecosystems.

2. Material and Methods
2.1 Study area: The present work has been conducted in two types of ponds – an artificially managed pond (Pond A) and a natural pen culture pond (Pond B) located at Gauhati University Campus, Guwahati, Assam, India ($26^{0}09^{/}26^{//}$ N and longitude of $91^{0}40^{/}21^{//}$ E). The Pond A is triangular in shape having 1.4 ha surface area. After dewatering the Pond A in 2006, 40 kg urea, 2500 kg organic manure (wet cowdung) and 50 kg lime were added. The Pond B is rectangular and nitrogen limiting pond, recovered from a part of reed swamp and maintained naturally without addition of any fertilizer. The reclaimed zone (with 0.5 ha area) of the pen culture pond is separated from the perennial swamp (unrecovered zone with surface area of 2.5 ha) by bamboo screens. The unrecovered zone of pen culture pond is dominated by

Phragmites karka. From the decomposed water of unrecovered zone, swamp nutrients are leaching to the recovered zone. In comparison to Pond B, fish productivity is more in the Pond A. Both the ponds show high mesotrophic to eutrophic condition of water.

2.2 Sampling: The present work is based on the studies carried out for a period of 2 years, commencing from Nov, 2007 to Oct, 2009. The heleoplankton density of the two ponds was calculated at UGC-SAP (DRS) Phase-II laboratory of the Zoology department of Gauhati University.

Plankton samples were collected separately from both the surface and bottom layers of Pond A and Pond B of the studied ponds by filtering 100 litres of water through a 55 µm mesh sized bolting silk net (plankton net). Before mixing the surface and bottom samples each sample were shaken carefully to maintain the homogeneity. Then 50 ml of surface and 50 ml of bottom samples were mixed to make 100 ml plankton sample. The samples were preserved in 4 % aqueous formaldehyde solution. Manual centrifugation was done gently and carefully to obtain the total volume of the each plankton sample.

The quantitative ($u.l^{-1}$) analysis of plankton was done by drawing 1 ml well mixed preserved samples using a wide mouthed graduated pipette and poured into a Sedgwick Rafter cell under a CZ-NFPK Stereoscopic microscope. The entire square cells were examined carefully. The phytoplanktons were recorded as unit cell per litre (However, the filament and colonies represented by Myxophyceae are considered as a unit), while the zooplanktons were recorded as individual number in per litre water following Welch (1948) [31].

3. Results

The observed seasonal variations of phytoplankton in the studied ponds are depicted in Figure-1. The differences of phytoplankton density between the two studied ponds are not well marked as the lowest value ranged between 201 and 213 $u.l^{-1}$ and the highest between 392 and 398 $u.l^{-1}$. However, little variation is observed between the two ponds in respect of the maximum and minimum ranges in zooplankton (Table 1-4). The maximum phytoplankton density is recorded in May, 2009 in Pond A and October, 2008 in Pond B. On the other hand the minimum values are recorded in June, 2008 in Pond A and in February, 2008 in Pond B. Zooplankton density is found to be the highest in June, 2009 and the lowest in September, 2008 during the study period in the Pond A. In Pond B, the highest value is recorded in November, 2008 and the lowest in October, 2009 (Figure-2).

The phytoplankton density fluctuates between 213 $u.l^{-1}$ and 392 $u.l^{-1}$ in Pond A with an average of 304.75±47.15 while 201 and 398 $u.l^{-1}$ in Pond B with an average of 294.38±60.32 $u.l^{-1}$.

The average zooplankton density of the studied ponds has been depicted in Figure-2. The average zooplankton density of the two ponds also shows a narrow range of variation in Pond A (38 to 155 in $n.l^{-1}$ with an average of 75.25±29.36) over Pond B (35 to 124 $n.l^{-1}$ with an average of 76.46±24.77).

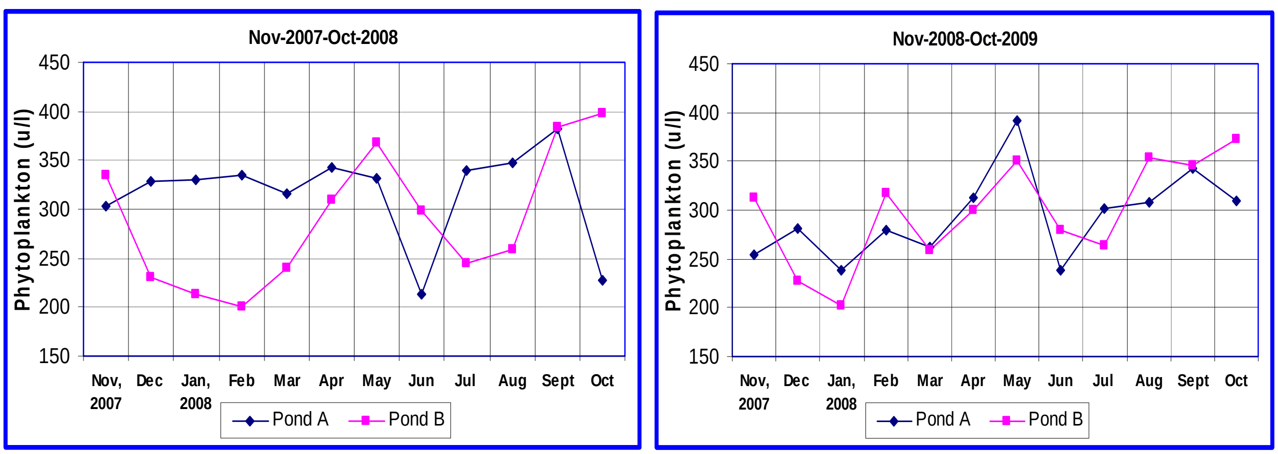

Fig 1: Monthly variation of Phytoplankton ($u.l^{-1}$) in Pond A and Pond B

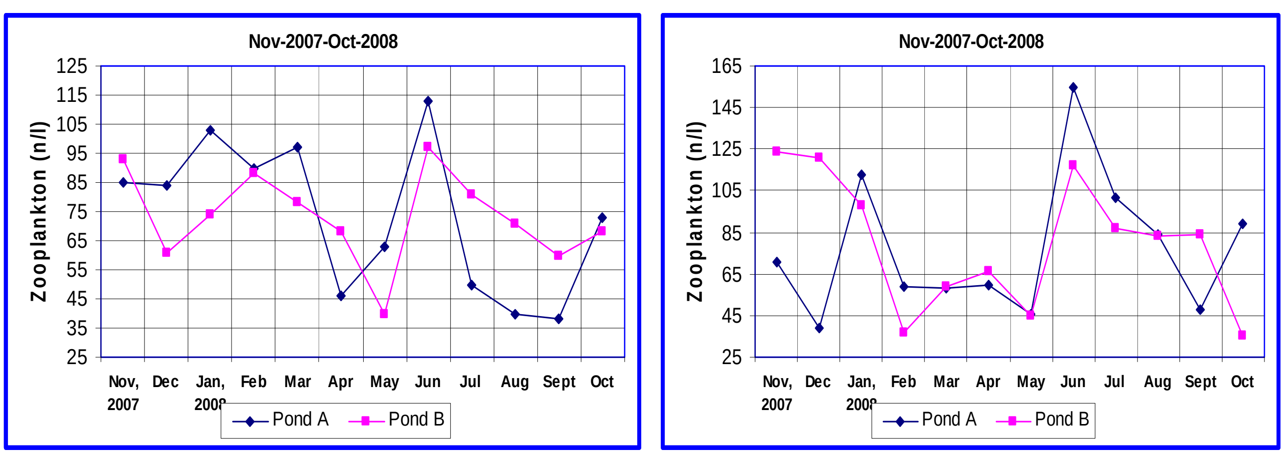

Fig 2: Monthly variation of Zooplankton ($n.l^{-1}$) in Pond A and Pond B

Chlorophyceae is the most dominant phytoplankton (58% in Pond A and 62% in Pond B) in the studied ponds showing its average density 163.33±35.37 $u.l^{-1}$ in Pond A and 171.63±47.35 $u.l^{-1}$ in Pond B. The Chlorophyceae is followed by Myxophyceae showing its average density 81.08±15.07 $u.l^{-1}$ and contribute to about 22% of the total phytoplankton density in Pond A and 61.33±13.72 $u.l^{-1}$ in Pond B to contribute about 19% of the total density. The least dominant phytoplankton in Pond A is Dynophyceae (3%) with an average of 9.17±3.92 $u.l^{-1}$ and in Pond B the Chrysophyceae (3%) with an average density of 16.38±6.32 $u.l^{-1}$. A Myxophycean bloom contributed by *Microcystis aeruginosa* is found to occur in Pond A during the monsoon period.

Rotifer is the most dominant zooplankton group in the studied ponds showing its average density 32.33±11.69 $n.l^{-1}$ in Pond A and 34.29±12.69 $n.l^{-1}$ in Pond B. Rotifers contribute about 46% and 45% of the total Zooplankton density in Pond A and Pond B respectively. Next to Rotifera, Copepoda constitute with its average 20.46±1.56 $n.l^{-1}$ (about 33%) in Pond A and 19.33±7.50 $n.l^{-1}$ (about 31%) in Pond B. The least dominant Zooplankton group is Cladocera, major bulk of which is represented by *Moina sp* as observed in both the ponds showing its average 9.75±4.38 $n.l^{-1}$ and 8.54±2.06 $n.l^{-1}$ respectively in Pond A and Pond B.

Table 1: Monthly incidence of the phytoplankton in terms of numerical density ($u.l^{-1}$) and zooplankton in terms of $n.l^{-1}$ recorded at Pond A (Nov 2007-Oct 2008) (For myxophyceae colony and filament is expressed as $u.l^{-1}$)

Phytoplankton	**Nov, 07**	**Dec**	**Jan, 08**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**
Myxophyceae	68	75	78	68	71	94	75	61	101	108	101	87
Chlorophyceae	177	181	176	198	189	180	184	108	177	184	221	103
Dinophyceae	8	8	7	12	9	11	8	4	9	7	6	4
Chrysophyceae	18	25	27	14	19	26	25	11	24	21	23	10
Bacillariophyceae	32	39	42	42	28	31	39	29	29	28	31	24
Total	303	328	330	334	316	342	331	213	340	348	382	228
Zooplankton	**Pond A**											
Protozoa	12	11	13	14	16	11	11	15	12	10	9	17
Rotifera	39	35	43	35	38	20	31	49	22	18	17	31
Copepoda	28	27	35	26	33	8	14	37	9	6	7	17
Cladocera	6	11	12	15	10	7	7	12	7	6	5	8
Total	85	84	103	90	97	46	63	113	50	40	38	73

Table-2. Monthly incidence of the phytoplankton in terms of numerical density ($u.l^{-1}$) and zooplankton in terms of $n.l^{-1}$ recorded at Pond B (Nov 2007-Oct 2008) (For myxophyceae colony and filament is expressed as $u.l^{-1}$)

Phytoplankton	**Nov, 07**	**Dec**	**Jan, 08**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**
Myxophyceae	62	44	52	33	43	67	69	62	74	53	82	74
Chlorophyceae	211	136	102	108	152	196	220	180	100	141	222	245
Dinophyceae	16	9	13	18	12	11	24	9	23	18	23	22
Chrysophyceae	10	12	12	14	8	13	16	12	17	14	14	13
Bacillariophyceae	36	30	34	28	25	22	39	35	31	33	43	44
Total	335	231	213	201	240	309	368	298	245	259	384	398
Zooplankton	**Pond B**											
Protozoa	13	10	17	16	15	13	5	15	18	19	10	14
Rotifera	42	28	28	33	29	31	18	44	31	26	29	32
Copepoda	29	15	18	32	22	15	12	27	23	19	14	14
Cladocera	9	8	11	7	12	9	5	11	9	7	7	8
Total	93	61	74	88	78	68	40	97	81	71	60	68

Table-3: Monthly incidence of the phytoplankton in terms of numerical density ($u.l^{-1}$) and zooplankton in terms of $n.l^{-1}$ recorded at Pond A (Nov 2008-Oct 2009) (For myxophyceae colony and filament is expressed as $u.l^{-1}$)

Phytoplankton	**Nov, 08**	**Dec**	**Jan, 09**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**
Myxophyceae	71	64	62	67	72	70	80	78	90	97	101	107
Chlorophyceae	128	152	103	151	130	188	226	119	150	147	201	147
Dinophyceae	13	13	14	7	12	10	22	4	8	9	7	8
Chrysophyceae	18	19	23	15	21	19	27	14	21	24	11	18
Bacillariophyceae	24	33	37	39	27	26	37	23	33	31	22	29
Total	254	281	239	279	262	313	392	238	302	308	342	309
Zooplankton	**Pond A**											
Protozoa	16	10	18	8	9	14	8	23	14	11	9	14
Rotifera	30	17	51	30	27	24	21	63	41	38	23	33
Copepoda	17	6	31	11	12	14	11	44	35	26	10	27
Cladocera	8	6	13	10	10	8	6	25	12	9	6	15
Total	71	39	113	59	58	60	46	155	102	84	48	89

Table 4: Monthly incidence of the phytoplankton in terms of numerical density (u.l^{-1}) and zooplankton in terms of n.l^{-1} recorded at Pond B (Nov 2008-Oct 2009) (For myxophyceae colony and filament is expressed as u.l^{-1})

Phytoplankton	Nov, 08	Dec	Jan, 09	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Myxophyceae	61	53	33	71	63	61	73	77	51	62	78	74
Chlorophyceae	211	121	112	175	131	195	225	122	165	238	189	222
Dinophyceae	9	12	15	23	18	9	11	29	10	12	28	19
Chrysophyceae	12	12	14	16	14	14	20	23	19	18	19	22
Bacillariophyceae	19	30	28	33	33	21	22	29	18	23	32	35
Total	312	228	202	318	259	300	351	280	263	353	346	372
Zooplankton	**Pond B**											
Protozoa	26	23	13	8	15	13	6	21	16	16	15	6
Rotifera	54	61	47	17	24	28	21	59	44	40	42	15
Copepoda	32	29	29	6	13	17	12	27	17	16	17	9
Cladocera	12	8	9	6	7	8	6	10	10	11	10	5
Total	124	121	98	37	59	66	45	117	87	83	84	35

4. Discussion

Heleoplankton productivity of aquaculture pond constitutes a food chain linkage with the trophic state of the system through the seasonal incidence and energy flow. All other living forms at higher trophic levels directly or indirectly depend on phytoplankton for energy supply and therefore, performing vital functions (James and Adejare, 2010) [20].

The present investigation reveals that seasonal variations of phytoplankton productivity in the studied ponds are not well marked, despite the soil of Pond B is nitrogen limiting. Hecky and Kilham, 1988 [19]. opined that marine and estuarine phytoplankton tends to be nitrogen limited while freshwater phytoplankton tends to be phosphorus limited. This may be the reason why heleophytoplankton productivity of the two ponds is more or less similar. It is noteworthy that the autochthonous input of nitrogen of leaching water from decomposed *Phragmites karka* of non-recovered zone of Pond B and high grazing pressure of fishes in Pond A may cause low density variation of phytoplankton productivity. However, zooplankton productivity of the two ponds shows significant variation.

Phytoplankton exhibits bimodal pattern of seasonal growth in Pond A for both year of investigation with one peak recorded in summer (April for the first year and May for the second year of study period) and the other in early autumn (September for both year of investigation period). The early autumn peak is the result of blooms of *Microcystis aeruginosa* of Myxophyceae. In Pond B, four peaks are prominent (tetramodal), i.e. in November, May, September and October in the first year and November, May, August and October in the second year is observed. Zooplankton exhibits four peaks in Pond A during January, March, June and October in the first year and three peaks during January, June and October in the second year of investigation period. In Pond B, three peaks are observed in November, February and June in the first year and two peaks in November and June in the second year. The peaks may be attributed to the interaction of different physico-chemical parameters (Deka and Goswami, 2011 [10]. Deka and Goswami, 2012) [11]. of the water body (Krishna Rao, 1985 [22]. (Davis, 1955) [8].

The study also reveals that Chlorophyceae is the most dominant group in terms of population density over the other Phytoplanktonic group namely Myxophyceae, Bacillariophyceae Dinophyceae and Chrysophyceae (Table-1 to 4). the dominance of Chlorophyceae among the phytoplankton has also been reported by Lahon, 1983; Goswami, 1985; Yadava, 1987; Dutta *et al.*, 1990; Chutia *et al.*, 1991; Hazarika and Dutta, 1994; Agarwala, 1996; Goswami, 2008; Pathak, 2009. [23, 15, 32, 13, 4, 18, 2, 16, 26]. The next dominant group of phytoplankton is Myxophyceae which is more in Pond A (with blooms of *Microcystis aeruginosa* during late monsoon to early autumn) in comparison to Pond B (Table-1 to 4), indicating inclination toward eutrophic condition. Pathak, 2009 has also opined that higher myxophycian results in inclination towards eutrophic condition of pond water. Statistical analysis in the present study reveals a bimodal pattern of plankton production with a significant inverse correlation between phytoplankton and zooplankton for both the ponds ($r= - 0.555$; $p= 0.005$ in Pond A and $r= - 0.409$; $p= 0.047$ in Pond B). This result corroborates with the findings of Das and Srivastava (1956, a and b, and 1959) [5, 6, 7].

The present study also reveals that productivity of phytoplankton is found to be more than that of zooplankton productivity. A similar observation was also reported by Goswami (1985) [15]. Agarwala (1996) [2]. from North Eastern region.

On the basis of total density during the study period, different groups of phytoplankton community structure can be represented as *Chlorophyceae* > *Myxophyceae* > *Bacillariophyceae*> *Chrysophyceae*> *Dinophyceae* in Pond A and *Chlorophyceae* > *Myxophyceae* > *Bacillariophyceae*> *Dinophyceae* > *Chrysophyceae* in Pond B. In Pond A, *Chlorophyceae* exhibits major peaks in February and September in the first year (Table-1) and May and September in the second year (Table-3) while in Pond B May and October in the first year (Table-2) and May and August in the second year (Table-4).

The predominance of Rotifera group is a common feature of Indian freshwaters (George, 1961; Michael, 1968; Sharma, 1996) [14, 25, 28]. Which is discernable in the present study. During the study period, the zooplankton community structure follow a similar trend which can be represented as Rotifera> Copepoda> Protozoa> Cladocera. The study also reveals that the ponds are with high zooplankton density which is an indicator of productivity as they convert plant food to animal food (Korstad, 1983) [21].

Better productivity of plankton which is more or less similar in both the ponds is the result allochthonous input of nutrients from the fertilizers of Pond A and autochthonous inputs of swamp fed nutrients from the litter of dense macrophytes particularly from the non-recovered zone of Pond B. The enhance production of plankton by use of fertilizers is also described by earlier worker namely Alikunhi, (1956) [3]. Govind *et al.* (1978) [17]. Sharma *et al.* (1979) [29].

Although the soil of Pond B is nitrogen limiting (Deka, 2012) [9]. the density of plankton observed in the two ponds are similar. This may be attributed to higher predation pressure of planktivorous fishes in Pond A and autochthonous input of nutrients from dense macrophyte of both the zone of Pond B. The reduction of plankton community due to predation pressure of planktiphagus and omnivorous fishes has also been reported by earlier workers like Sarvala *et al.*, 1998; Domaizon and Devaux, 1999 [12]. Tatrai *et al.*, 2003 [30]. from different water bodies.

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