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Studies on the Diversity of Plankton in the Wetlands of Nameri National Park and its Adjacent Area, Assam, India

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ABSTRACT

The present investigation deals with the study on the diversity of phytoplankton and zooplankton community structure in twelve selected sampling sites of the wetlands of Nameri National Park and its adjacent area using various diversity indices. The survey was carried out from January 2018 to February 2020. A total of 36 genera of phytoplankton and 21 genera of zooplankton belonging to four families each were identified in this study, which include Chlorophyceae, Bacillariophyceae, Cyanophyceae, Desmidiaceae, Cladocera, Copepoda, Rotifera and Protozoa. Family Chlorophyceae was dominant among the other groups of phytoplankton and the family Cladocera and Rotifera were found to be the most dominant group in the zooplankton followed by Copepoda and Protozoa. Low community similarities, seasonal species richness variations and the cluster groupings affirmed heterogeneity of plankton species composition. The maximum diversity of phytoplankton was observed in pre-monsoon at S_3 and minimum in monsoon season at site S_6 and for zooplankton, diversity index (H´) was found to be the highest at S_6 during pre-monsoon and lowest at S_5 in monsoon period. Slight variations of the species diversity of plankton population among the four seasons across all the studied sites indicate good quality of the habitat Ecosystem.

Key words : *Phytoplankton, Zooplankton, Abundance, Wetlands, Diversity*

Introduction

Planktons are microscopic organisms essential for many fishes as food. Their ability to move around is very limited, following the water current (Yulianna, *et al*., 2012). The plankton population which occurs in an ecosystem is an indication of the physico-chemical characteristics of the water body (Pradhan *et al*., 2008). Plankton has its ecological function as a primary producer and the initial link in food networks, making it as a scale of fertility measurement ecosystem (Alamanda *et al*., 2012). The plankton community occurs in both lotic and lentic water ecosystems and can be classified into two groups: phytoplankton and zooplankton.

Phytoplanktons as primary producer play a pivotal role in fixation of solar energy and are the pioneer of aquatic food chain. They are the source of food for zooplankton, fishes and other aquatic organisms. The Zooplankton and fish production depend immensely on the phytoplankton (Boney 1975). In India, phytoplankton diversity in different freshwater water bodies along with their physico-chemical characteristics has been studied by many researchers. However, works of Ravikumar *et al*. (2006); Tiwari and Shukla (2007); and Senthilkumar

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and Das (2008) are worth mentioning.

Zooplanktons are microscopic animals that occupy a central position between the autotrophs and heterotrophs and form an important link in food web of the freshwater ecosystem. Zooplankton is of profound importance because they represent important and sometimes unique food source for fish and many aquatic vertebrates (Ochang *et al*., 2005). Ovie (2011) defined zooplankton as the free-floating, aquatic invertebrates, which are microscopic because of their usual small sizes that range from a few to several micrometres, rarely exceeding a millimetre. Zooplankton is greatly affected by any changes that occurs in the environmental conditions and is a good indicator of any changes in the water quality of the habitat ecosystem.

Literature studies revealed that, though numerous works on diversity of plankton are being reported from different parts of India but there is scarcity of report from the freshwater bodies of different parts of Northeast India. Therefore, the present study is an attempt to report the plankton diversity in the wetlands of Nameri National Park and its adjacent area.

Materials and Methods

Study area

The present study was carried out in Nameri National Park (27.01° N-92.79° E) and its adjacent area. Nameri National Park is situated in the foothills of the eastern Himalayas. Nameri National Park and its adjacent areas are unique for their topographical position as well as undulating terrain, hill streams, and river networks. The area is crisscrossed by the river Jia- Bharali. Altogether, twelve sampling sites have been selected throughout the study for plankton collection and analysis.

Sample collection

Water samples were collected at early morning on a monthly basis from the twelve selected sampling sites of the study area. Plankton samples were collected by filtering 100 l of water through plankton net made of bolting silk of 70 micron mesh size. All the samples were immediately fixed with 4% formalin solution. For identification, water samples were taken in a Sedgwick-Rafter counting chamber and observed under a light microscope under required magnification (10 X intially, followed 40 X) and the specimens were identified following the descriptive keys of Battish (1992); Turner and Da Silva (1992); Brooks (1959); Edmondson (1959); Michael and Sharma (1998); Sharma (1998); Sharma and Sharma (2008); Alekseev (2002); APHA (2005), and Munshi *et al*. (2010).

Statistical analysis

The relative abundance (R.A.) i.e. percentage of catch of fish across different sites of individual species was calculated by the following formula:
RA = Number of samples of particular species x 100/Total number of sample

The plankton density (Org/L) was calculated following the method of Das (2013) by using the formula:

Organism/Litre (Org/L) = 1000 x N/n

Where,

n = Volume of sample water taken (in ml)

N = Number of plankton observed in sample water

L = Total water filtered in litres

The diversity indices were calculated as per standard method
(Shannon-Wiener Diversity Index, 1963): Formula: $H' = \Sigma\, pi \log (pi)$

Where H ' = The Shannon-Weiner Diversity Index and pi = the relative abundance of each group of organisms.

Pielou's evenness index (J') (Pielou, 1966): Formula: e = H / In S,

Where,

e =Evenness Index

H = Shannon – Wiener diversity index

S = total number of species in the sample.

Similarity of the species in all sampling station was calculated using

Jacquard's index: Formula: Sj = j / (x + y – j)

Where, Sj is the similarity between any two zones X and Y, j the number of species common to both the zones X and Y, x the total number of species in zone X and y the total number of species in zone Y.

The statistical analysis for all the experiments in the present study were estimated using, MS Excel, PAST software version 3.

Results and Discussion

In the present study, the phytoplankton community constituted about 63.15% and the zooplankton community constituted about 36.84% of the total plankton collected throughout the study period in all the sampling sites. Dabgar (2012) opined that abundance of phytoplankton is more compared to zooplankton in a water body as the latter is dependent on the former for food. This might be a possible reason for more phytoplankton abundance and density compared to zooplankton in the present study. Basistha (2006) in his study on the Manas river system also recorded the same trend of less zooplankton abundance and density compared to that of phytoplankton. Phytoplankton community is generally dominated by the members of Bacillariophyceae perhaps because of their capability in utilizing the nutrients (Oritz and Cambra, 2007). However, in the present study of the total 36 genera of phytoplankton identified. Chlorophyceae was found to be the most dominant group; followed by Bacillariophyceae, Desmidiaceae and Cyanophyceae. The family Chlorophyceae consists of 15 genera viz. *Closterium* sp., *Chaetophora* sp., *Oedogonium* sp., *Closteriopsis* sp., *Microthamnion* sp., *Chaetomorpha* sp., *Docidium* sp., *Pandorina* sp., *Cladophora* sp., *Rhizoclonium* sp., *Spirogyra*sp., *Gonatozygon* sp., *Hydrodictyon* sp., *Eudorina* and *Microspora* sp. However, 9 genera viz. *Pinnularia* sp., *Navicula* sp., *Frustulia* sp., *Gyrosigma* sp., *Diatoma*sp., *Achnanthes* sp., *Tabellaria* sp., *Synedra* sp and *Fragilaria* sp. belonged to the group Bacillariophyceae. The group Desmidiaceae and Cyaenophyceae forms the third dominant group with 6 genera each viz. *Micrasterias* sp., *Desmidium* sp., *Cosmarium* sp., *Spirotaeni* sp., *Mesotaenium* sp., *Docidium* sp., *Spirulina* sp., *Anaebaena* sp., *Rivularia* sp., *Microcytis* sp. *Oscillatoria* sp. and *Nostoc* sp. Bhivgade *et al*. (2010), also observed Chlorophyceae as a dominant species than other zooplanktons in Nagzari tank, Beed. Similar observation was made by Das (2013) from Pagladia River. Moreover, Chlorophyceae is one of the important indicators of water quality (Jena *et al*., 2008). However, during the survey period fluctuations were observed in the qualitative and quantitative composition of the phytoplankton in the different study sites over the seasons. This might be due to several environmental factors, which keep varying in different seasons and regions (Hossain *et al*., 2012).

Zooplankton constitutes important food item of many omnivorous and carnivorous fish (Shrifun, 2007). Zooplanktons serve as important aquatic organisms, occurred abundantly in all types of aquatic habitats and has vital role in energy transfer of aquatic ecosystems (Altaff, 2004). During study period, a total of 21 genera of zooplankton were recorded from all the sampling sites of the study area. The family Cladocera and Rotifera with 6 genera each were observed to be the most dominant group which includes *Moina* sp., *Alona* sp., *Daphnia* sp., *Bosmina* sp., *Leydigia* sp., *Macrothrix* sp., *Brachionus* sp., *Filina* sp., *Monostyla* sp., *Keratella* sp., *Noteus* sp. and *Lepadella* sp. respectively. Similar finding were made by Jindal *et al*. (2010) in Hill stream Nogli at Rampur Bhusnar, District, Shimla. Rotifers appear to be more sensitive indicators of changes in water quality (Majumder *et al*., 2015). Cladocerans are also reported to be the indicators of eutrophic nature of water bodies (Sharma, 1998). Green *et al*. (2005) in their study reported Cladocerans abundance with five diversified species. Copepoda and Protozoa also consist of 4 genera each (*Diaptomus* sp., *Nauplius* sp., *Mesocyclops* sp., *Cyclops* sp., *Paramoecium* sp., *Volvox*., *Ceratium* sp. and *Chlamydomonous* sp.) respectively (Table 1). Similarly, four species of Copepods were observed by Suresh *et al*. (2009) from Tungabhadra River.

In the present study, *Cosmarium* had the highest relative abundance (25.93%) among all the phytoplanktons and the lowest was *Cladophora* with relative abundance 2.14% as shown in Table 1. The *Copepoda* had the highest abundance among the zooplanktons with 44.77% relative abundance and *Peridimium* had the least relative abundance (1.87%) during the study period (Table 1). Relative abundance (%) of both phytoplankton and zooplankton groups at twelve sampling sites of the study site is shown in Fig. 1.

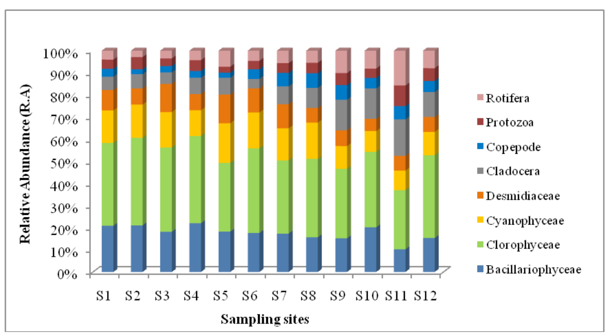

Fig. 1. Relative abundance (%) of plankton groups at twelve sampling sites of the study area

Species diversity of the plankton population varied slightly among the four seasons in all seven sampling sites of the study area. The overall Shannon-

Table 1. Site wise diversity and relative abundance (R.A.) of plankton genera collected from the wetlands of Nameri National Park and its adjacent area.

Sl. No	Type of Plankton	Sampling sites												R.A
		S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	
	PHYTOPLANKTON													
A.	Bacillariophyceae													
1	Achanthes	*	*	*	*		*	*	*	*	*	*	*	10.40
2	Diatoma	*	*	*	*		*	*	*	*	*	*		14.85
3	Fragilaria	*		*			*				*	*	*	10.51
4	Frustulia	*	*	*	*	*			*	*		*		10.81
5	Gyrosigma	*	*	*	*	*	*	*	*	*		*		13.23
6	Navicula	*	*	*	*	*			*	*				9.90
7	Pinnularia	*	*	*	*	*			*	*				12.83
8	Synedra	*		*	*		*	*			*	*	*	5.66
9	Tabellaria	*		*	*		*	*	*	*	*	*	*	11.82
B.	Chlorophyceae													
10	Chaetomorpha	*	*	*	*		*	*	*	*		*	*	8.55
11	Cheaetophora	*	*	*		*				*		*		7.43
12	Cladophora	*		*	*						*			**2.14**
13	Closteriopsis	*	*	*		*	*			*		*		7.13
14	Closterium	*	*	*		*				*		*		5.86
15	Dosidium	*	*	*	*		*	*	*	*		*	*	8.35
16	Eudorina	*		*	*		*	*	*	*	*	*	*	6.42
17	Gonatozygon	*	*	*	*		*	*	*	*	*	*	*	9.83
18	Hydrodictyon	*	*	*	*		*	*	*	*	*	*	*	9.78
19	Microspora	*		*	*		*	*	*		*	*	*	10.13
20	Microthamnion	*	*	*		*	*	*	*	*		*		7.38
21	Oedogonium	*	*	*		*				*		*		5.96
22	Pandorina	*		*	*		*				*			5.14
23	Rhizoclonium	*		*	*			*	*		*			2.55
24	Spirogyra	*		*	*						*			3.36
C.	Cyaenophyceae													
25	Anabaena	*	*	*	*	*	*	*	*	*	*			22.52
26	Microcytis	*	*	*	*		*	*	*	*	*	*	*	22.66
27	Nostoc			*								*	*	5.70
28	Oscillatoria		*	*								*	*	5.70
29	Rivularia	*	*	*	*	*	*	*	*	*	*	*	*	19.13
30	Spirulina	*	*	*	*	*	*	*	*	*				24.29
D.	Desmidiaceae													
31	Cosmarium	*	*	*	*	*	*	*	*	*	*	*	*	**25.93**
32	Desmidium	*	*	*	*					*	*	*	*	19.09
33	Docidium			*		*	*		*					5.19
34	Mesotaenium			*		*	*	*		*	*	*		11.41
35	Micrasterias	*	*	*	*					*	*	*	*	16.80
36	Spirotaenia	*	*	*	*	*	*	*	*	*	*	*	*	21.58
	ZOOPLANKTON													
A.	Cladocera													
1	Alona	*		*	*	*	*	*	*	*	*	*	*	24.70
2	Bosmina		*	*	*			*		*	*		*	13.75
3	Daphnia	*	*	*	*	*	*	*	*	*	*	*	*	29.08
4	Leydigia		*								*		*	4.98
5	Macrothrix		*	*	*	*	*		*	*		*	*	10.96
6	Moina	*				*				*	*	*	*	16.53
B.	Copepoda													

Table 1. *Continued ...*

Sl. No	Type of Plankton	Sampling sites												R.A
		S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	
		PHYTOPLANKTON												
7	Cyclops	*	*	*	*		*	*	*	*	*			20.92
8	Diaptomus	*	*		*	*			*	*	*	*	*	32.22
9	Mesocyclops									*				2.09
10	Nauplii	*	*	*	*	*	*	*	*	*	*	*	*	**44.77**
C.	Protozoa													
11	Ceratium	*	*	*	*		*		*	*	*	*		27.34
12	Chlamydomonus		*					*		*		*	*	10.86
13	Paramoecium	*	*	*	*	*	*	*	*	*		*		34.46
14	Peridimium			*								*		**1.87**
15	Volvox	*	*	*	*	*	*	*	*	*	*	*	*	25.47
D.	Rotifera													
16	Brachionus	*		*		*	*		*	*		*		7.78
17	Filinia	*		*	*	*	*	*	*	*	*	*	*	28.61
18	Keratella	*			*		*	*	*			*	*	12.22
19	Lepadella	*	*	*	*	*		*	*	*	*	*		13.06
20	Monostyle	*	*	*	*	*	*	*		*	*	*	*	28.06
21	Noteus		*						*	*	*	*	*	10.28

Note: * indicates the presence of plankton

Weiner diversity index (H´) for phytoplankton population was observed maximum in pre-monsoon (3.515) at S_3 and minimum (2.221) in monsoon season at S_6. The richness for phytoplankton was recorded highest during pre monsoon with 36 genera at S_3 and lowest in monsoon (11 genera) at S_6. However, evenness index (J´) indicated phytoplankton population to be moderately even and ranged between 0.785 and 0.941 at S_{11} (monsoon) and S_6 (pre monsoon) respectively. It was observed that maximum evenness index and population density of phytoplankton coincided with high diversity during the pre monsoon period and minimum in the winter season. The population density of phytoplankton was found to be highest in pre monsoon period (365Org/L) at S_3 and lowest in monsoon (27 Org/L) at S_{12} (Table 2).

The results of quantitative analysis of zooplankton population in the present survey were found to be similar with those found in river Pagladia (Das, 2013). The dominance of Cladocera may be due to short generation time which allows their in situ reproduction, in spite of a short residence time of the water (Roger *et al*., 1997). However, population density of zooplankton was recorded highest in winter (91 Org/L) at S_9 and lowest in the monsoon period (8 Org/L) at S_4. Basu and Pick (1996) in their study pointed out that zooplankton biomass in rivers is much lower compared to lakes. The fact that zooplankton in rivers is scanty compared to phytoplankton was also pointed out by Yves *et al*. (1996). Possible reason for the high density of zooplankton at site S_9 may be due to the stagnant water body. The evenness index (J') indicated that the zooplankton population was evenly distributed in all the twelve sampling sites of the study area. On the other hand, the Shannon Weiner diversity index (H) indicated low to moderate zooplankton diversity in the study area. Highest diversity index (H) was found to be during pre monsoon period (3.075) at S_6 and lowest was recorded in monsoon (1.273) at S_5 (Table 3).

The similarity of occurrence of Plankton species composition between the sampling sites were analysed using the Jaccard index (J). The 'J' value for phytoplankton was found to be highest in S_3 (Sj=0.88), followed by S_9 (Sj=0.85) and the lowest similarity was found in S_7 and S_8 (Sj=0.25). However, the 'J' value for zooplankton was found to be highest in S_3 and S_8 (Sj=0.75), followed by S_3, S_4 and S_8 (0.73). The lowest similarity was found in S_{10} (Sj=0.42). A cluster analysis was made based on plankton abundance data across the seven sampling site which is shown in Figure 2 & 3. The cluster analysis showed the formation of three clads for phytoplankton species composition. It has been observed that there was a close similarity in species

Table 2. Seasonal variation in phytoplankton (Org/L) in the seven sampling sites of the wetlands of Nameri National Park and its adjacent area.

Sampling sites	Seasons	Density (Org/L) (Abundance)	Richness (S)	Species Diversity (H´)	Evenness (J´)
S1	Pre monsoon	216	25	3.102	0.889
	Monsoon	109	22	2.932	0.852
	Retreating monsoon	88	19	2.858	0.917
	Winter	138	23	3.024	0.894
	Seasons combined	**137***	**22**	**2.978**	**0.888**
S2	Pre monsoon	182	23	3.002	0.875
	Monsoon	84	19	2.826	0.888
	Retreating monsoon	84	18	2.689	0.817
	Winter	103	20	2.816	0.835
	Seasons combined	**113***	**20**	**2.833**	**0.854**
S3	Pre monsoon	365	36	3.515	0.933
	Monsoon	81	21	2.901	0.866
	Retreating monsoon	101	25	3.063	0.856
	Winter	127	31	3.233	0.817
	Seasons combined	**168***	**28**	**3.178**	**0.868**
S4	Pre monsoon	111	21	2.943	0.903
	Monsoon	38	15	2.582	0.881
	Retreating monsoon	53	19	2.707	0.788
	Winter	61	19	2.743	0.817
	Seasons combined	**65***	**18**	**2.743**	**0.847**
S5	Pre monsoon	83	16	2.665	0.897
	Monsoon	37	12	2.3	0.831
	Retreating monsoon	67	14	2.533	0.899
	Winter	55	15	2.515	0.824
	Seasons combined	**60***	**14**	**2.503**	**0.863**
S6	Pre monsoon	122	23	3.075	0.941
	Monsoon	31	11	2.221	0.838
	Retreating monsoon	59	15	2.519	0.827
	Winter	94	20	2.87	0.882
	Seasons combined	**76***	**17**	**2.671**	**0.872**
S7	Pre monsoon	78	19	2.843	0.903
	Monsoon	45	16	2.553	0.802
	Retreating monsoon	65	16	2.645	0.88
	Seasons combined	**62***	**17**	**2.680**	**0.862**
S8	**Pre monsoon**	78	18	2.782	0.897
	Monsoon	37	12	2.372	0.893
	Retreating monsoon	39	13	2.403	0.850
	Winter	49	19	2.776	0.844
	Seasons combined	**51***	**16**	**2.583**	**0.871**
S9	Pre monsoon	167	25	3.073	0.863
	Monsoon	67	18	2.654	0.789
	Retreating monsoon	87	21	2.826	0.803
	Winter	71	20	2.824	0.849
	Seasons combined	**98***	**21**	**2.844**	**0.824**
S10	Pre monsoon	94	22	2.868	0.800
	Monsoon	44	14	2.411	0.796
	Retreating monsoon	72	17	2.691	0.867
	Winter	82	20	2.8	0.822
	Seasons combined	**73***	**18**	**2.692**	**0.821**
S11	Pre monsoon	165	27	3.085	0.810
	Monsoon	52	17	2.591	0.785

Table 2. *Continued ...*

Sampling sites	Seasons	Density (Org/l) (Abundance)	Richness (S)	Species Diversity (H´)	Evenness (J´)
	Retreating monsoon	83	20	2.768	0.796
	Winter	77	23	3.03	0.9
	Seasons combined	**94***	**22**	**2.868**	**0.822**
S12	Pre monsoon	86	18	2.707	0.832
	Monsoon	27	12	2.365	0.886
	Retreating monsoon	48	14	2.441	0.820
	Winter	59	16	2.584	0.827
	Seasons combined	**55***	**15**	**2.524**	**0.841**

Note: * = average value of phytoplankton density in four seasons

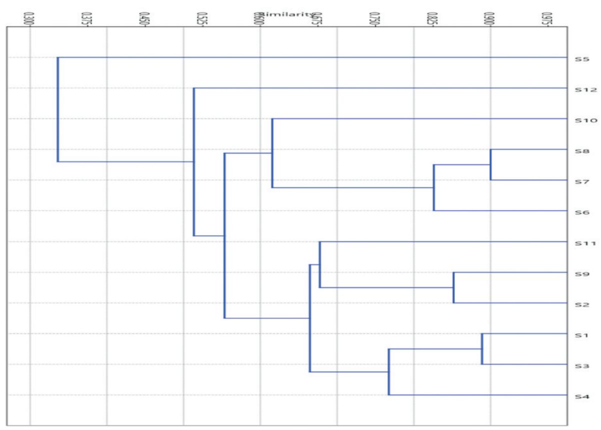

Fig. 2. Jaccard Cluster Analysis of phytoplankton using simple linkage method for seven sampling sites in the study area.

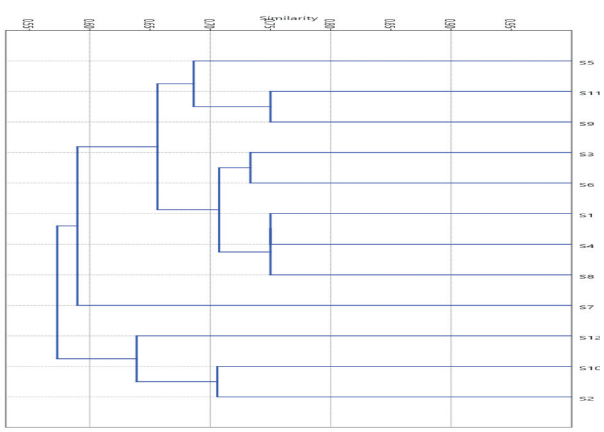

Fig. 3. Jaccard Cluster Analysis of zooplankton using simple linkage method for seven sampling sites in the study area.

composition between the sampling sites S_1 and S_3, sites S_2 and S_9 and between sampling sites S_7 and S_8. However, species composition of site S_4 was somewhat similar to site S_1 and S_3, S_{11} was similar to site S_2 and S_9 and species composition of S_6 and S_{10} was somewhat similar to sites S_7 and S_8. On the other hand, cluster analysis of zooplankton showed the formation of four clads. Close similarity in species composition between the sampling sites S_2 and S_{10}, S_1, S_4 and S_8, S_3 and S_6 and between sampling sites S_9 and S_{11} were observed during the survey period. Moreover, species composition of site S_{12} was somewhat similar to site S_2 and S_{10} and S_5 was somewhat similar to sites S_9 and S_{11}. Possible reason for this kind of similarity may be attributed to the resemblance in physical habitat between sampling sites.

Conclusion

The present study on the diversity and abundance of phytoplankton and zooplankton in the wetlands of Nameri National Park and its adjacent area revealed the presence of few species of Rotifera, Copepoda, Cladocera and Protozoa which are very sensitive to any environmental change in the wetland. Moreover, present survey also revealed that the zooplankton in lotic wetlands were scanty compared to lentic wetlands. This study is a useful contribution to reveal the diversity of plankton in the present survey site. To conclude, plankton has the potential to act as bio-indicators of pollution status. Thus, keeping in view the importance of the study, steps should be taken for the maintenance and conservation of the freshwater wetland.

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Table 3. Seasonal variation in zooplankton (Org/l) in the seven sampling sites of the wetlands of Nameri National Park and its adjacent area.

Sampling sites	Seasons	Density (Org/l) (Abundance)	Richness (S)	Species Diversity (H´)	Evenness (J´)
Site S_1	Pre monsoon	41	11	2.27	0.88
	Monsoon	16	6	1.7	0.912
	Retreating monsoon	23	9	2.041	0.855
	Winter	33	11	2.046	0.859
	Seasons combined	**30***	**9**	**2.064**	**0.876**
Site S_2	Pre monsoon	26	8	1.928	0.859
	Monsoon	12	5	1.517	0.911
	Retreating monsoon	32	11	2.266	0.876
	Winter	23	7	2.786	0.852
	Seasons combined	**23***	**7**	**1.874**	**0.875**
Site S_3	Pre monsoon	41	12	2.37	0.891
	Monsoon	14	5	1.512	0.907
	Retreating monsoon	33	11	2.265	0.875
	Winter	31	9	2.104	0.910
	Seasons combined	**29***	**9**	**2.062**	**0.896**
Site S_4	Pre monsoon	12	6	1.705	0.916
	Monsoon	8	4	1.327	0.936
	Retreating monsoon	21	8	1.98	0.904
	Winter	23	8	2.04	0.963
	Seasons combined	**16***	**6**	**1.762**	**0.930**
Site S_5	Pre monsoon	14	6	1.631	0.851
	Monsoon	9	4	1.273	0.892
	Retreating monsoon	21	8	1.968	0.894
	Winter	16	7	1.904	0.867
	Seasons combined	**15***	**6**	**1.669**	**0.876**
Site S_6	Pre monsoon	13	6	3.075	0.886
	Monsoon	12	4	2.221	0.861
	Retreating monsoon	15	6	2.519	0.980
	Winter	23	8	2.87	0.894
	Seasons combined	**15***	**6**	**2.671**	**0.905**
Site S_7	Pre monsoon	13	6	1.738	0.947
	Monsoon	17	6	1.712	0.922
	Retreating monsoon	30	10	2.194	0.897
	Seasons combined	**20***	**7**	**1.881**	**0.922**
Site S_8	Pre monsoon	10	5	1.557	0.949
	Monsoon	10	6	1.696	0.908
	Retreating monsoon	26	10	2.162	0.868
	Winter	25	8	1.961	0.887
	Seasons combined	**17***	7	**1.844**	**0.903**
Site S_9	Pre monsoon	65	18	2.77	0.886
	Monsoon	19	8	1.986	0.911
	Retreating monsoon	52	14	2.453	0.83
	Winter	91	15	2.617	0.912
	Seasons combined	**56***	**13**	**2.456**	**0.884**
Site S_{10}	Pre monsoon	41	12	2.399	0.917
	Monsoon	13	5	1.565	0.956
	Retreating monsoon	39	12	2.366	0.888
	Winter	75	13	2.481	0.919
	Seasons combined	**42***	**10**	**2.202**	**0.920**
Site S_{11}	Pre monsoon	65	15	2.621	0.916
	Monsoon	29	9	2.062	0.873

Table 3. *Continued ...*

Sampling sites	Seasons	Density (Org/l) (Abundance)	Richness (S)	Species Diversity (H´)	Evenness (J´)
	Retreating monsoon	27	10	2.148	0.856
	Winter	78	11	2.351	0.954
	Seasons combined	**49***	**11**	**2.295**	**0.900**
Site S_{12}	Pre monsoon	23	9	2.103	0.91
	Monsoon	14	7	1.871	0.928
	Retreating monsoon	32	10	2.196	0.898
	Winter	56	10	2.189	0.892
	Seasons combined	**31***	**9**	**2.089**	**0.907**

Note: * = average value of zooplankton density in four seasons

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Conflict of interest

The authors have no conflict of interest.

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