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A Study on the Diversity of the Zooplanktons with the Aid of Foldscope in Few Waterbodies of the Alipurduar district of West Bengal, India

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Abstract: ***The present investigation was carried out on 26 waterbodies situated at the 3 subdivisions of Alipurduar district from March to December, 2018 to assess the plankton diversity with the aid of foldscope. The device is significantly effective in the field study. Among the studied water bodies, 5 of them under the Alipurduar-I sub-division, 13 under Alipurduar-II, 1 under the Kumargran sub-division and other 7 under the Municipality area. Among them 14 becomes pond, 4 noyanjuli and 8 rivers spots. A total of 27 types of Zooplanktons and Protista were identified from different lentic and lotic wetlands. One larval form i.e. Nauplius larva have also been recorded during the course of study. Out of 27 species 14 belongs to phylum Crustacea, 8 Rotifera and 5 belong to the Kingdom Protista. Data were statistically analyzed for the species abundance (i.e. diversity, dominance and evenness indices) according to various waterbodies and species specific are presented in to article. Spot No. 23 showed the highest diversity indices then Spot-6 and Spot-24 after then Spot-2 as per diversity. Paroecium sp is the most abundant species, and then comes to Cyclops sp, Arcella sp and Mesocyclops sp regarding their abundance. Therefore pond water are recorded higher zooplankton diversity indices compare to river spots.***

Keywords: Foldscope, Zooplankton diversity, Alipurduar, Doors

1. Introduction

In search of diversity of Zooplankton populations in the lentic and lotic water bodies of Alipurduar district which is located at sub-Himalayan Doors region of West Bengal, India, the team of DBT sponsored R & D project conceived by the Botany department of Alipurduar college in collaboration with the department of Zoology, Tufanganj Mahavidyalaya has surveyed 26 water bodies within the Alipurduar district in its 1st phase and in this article the team documented their findings.

Dr. Manu Prakash and Jim Cybulski from Stanford University invented an Origami based folded paper microscope named as "Foldscope" whose cost is low compare to conventional microscope and also convenient to carry in the field for research work. Very few articles are available regarding the use of this type of microscope. Some of them are: as mentioned by Ephraim *et al*. (2015) in the diagnosis of *Schistoma haematobium* infection by this instrument. In an article Salazar *et al*. (2016), mentioned the use of Foldscope in diagnosis of cervical cancer, Saeed and Jabbar (2017) mentioned the "Smart Diagnosis" by using same instrument to identify parasite, Moravapalle *et al*. (2017) describe the complete blood count by using smartphone and foldoscope, in an article Joshi *et al*. (2018) mentioned the effectiveness of Foldscope in interpretation of the Maize starch powder, Das *et al*. (2019) compare the diversity of Phytoplankton by using the Foldoscope.

Therefore we designed to use this smart Foldoscope and compared the result with the conventional system of study i.e. by compound microscope (Olimpus : *Ch 20i*) to study the zooplankton diversity in various lentic and lotic water bodies in Alipurduar district of West Bengal. In the review part of the study regarding the Zooplankton studied in the Doors region of West Bengal, few authors have documented their findings on the diversity and density such as Dutta (2011), Mondal *et al*. (2012), Das *et al*. (2012), Mondal *et al*. (2013), Das *et al*. (2013), Pal *et al*. (2015a), Patra *et al*. (2015), Pal *et al*. (2015b) and Sarkar *et al*. (2016) etc. All investigators have studied the water samples microscopically and none by the Foldoscope system except the article by Das *et al*. (2019) regarding the diversity of Phytoplankton only. Therefore this paper is the first one regarding the study of zooplankton diversity by using Foldoscope at Doors region of Alipurduar district of West Bengal.

In our first phase of study, we have collected water samples along with the GPS readings and administrative parameters and have recorded the types of water bodies from 26 sites of Alipurduar district of West Bengal. Spots are designated as S1 to S26, and details of the spots along with administrative parameters are presented in Table-1 and the spots location are placed in Google earth map in pictorial form which is presented in Plate-1.

Pelagic Zooplanktons from different survey spots were collected by dragging 50 mesh size plankton net below 8"-10" from the surface with a 150 ml conical flask tied in its lower end by a cotton thread (modified Khan, 2003). A total of 50 liter of water samples was concentrated into 150ml for the study by calculating the cylinder volume of the dragged

area (m^2/h). Each sample was preserved in Borosil conical flask and 4% formalin was added drop wise to cease the movement of the plankton for preservation with a few drops of Glyceraldehydes (Pal *et al*, 2015). For the study of the collected specimens, a few of them were stained by 90% aqueous eosin (where it were required) and with the aid of binocular microscope (Olimpus : *Ch 20i*). Zooplanktons were identified by consulting various literatures like Edmondson (1959), (www.cfbkey/html) etc. Diversity indices were calculated using software PAST (Hammer *et al*. 2001). Photographs were taken by using Redmi-4 smartphone during the study by Foldoscope or by using "Amscope" at the time study by microscope adjusted in eye-piece connected with a desktop.

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation. Then select the "Equation" markup style. Press the tab key and write the equation number in parentheses.

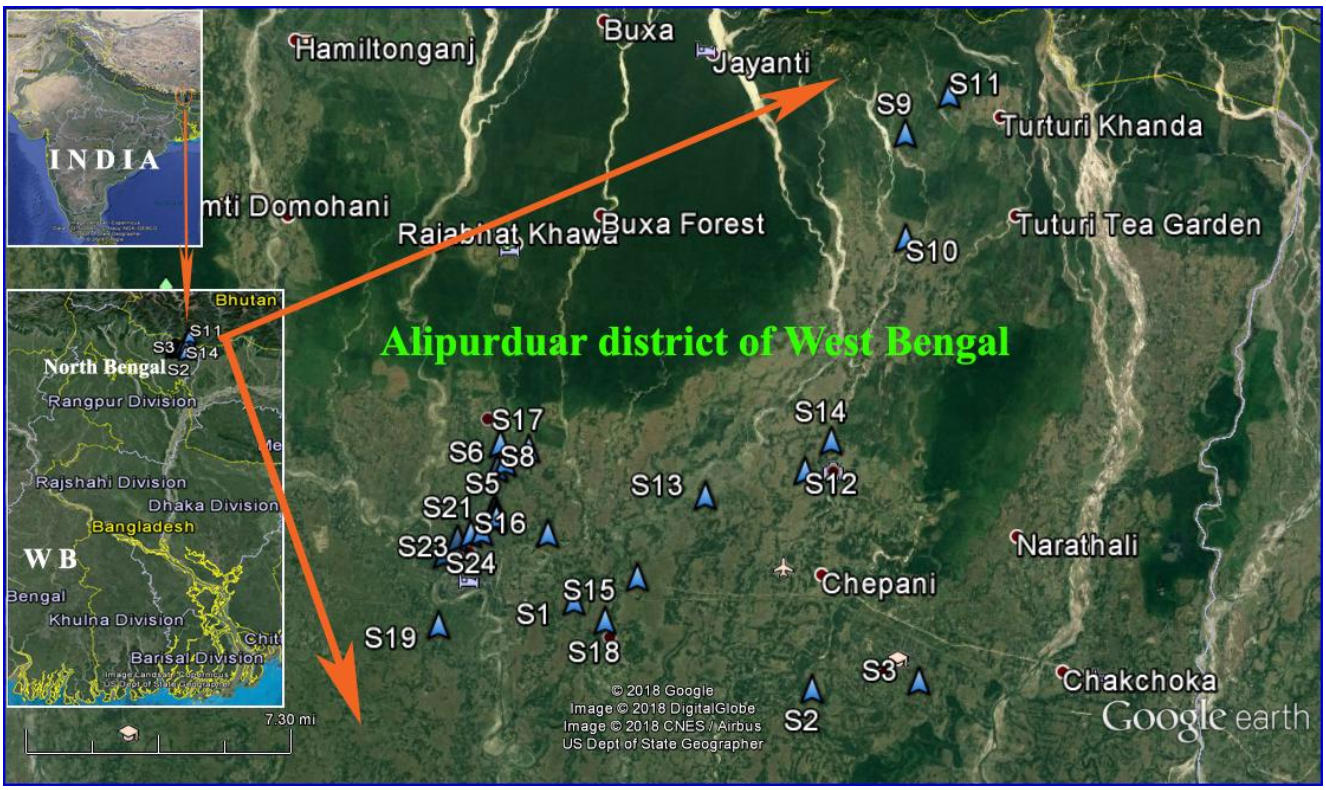

Plate 1: Location of the 26 survey spots in Alipurduar district of West Bengal (Courtesy: Google earth surfed on November 15, 2018 at 8.00 pm)

Table 1: Administrative Parameters of the Surveyed Spots at Alipurduar district of West Bengal

Spot No.	Name of the spot	Village / Mouza / Municipality	Sub-division	GPS readings	Type of water body
S1	Chandijhar, Salbari	Chaporer Par-I	Alipurduar-II	26°28'06.71"N & 89°34'36.76"E	Pond
S2	Baklapar, Purba Chikliguri	Parokata	Alipurduar-II	26°26'39.48"N & 89°41'11.17"E	Pond
S3	Lalpool wetland	Parokata	Alipurduar-II	26°27'01.62"N & 89°42'51.93"E	River
S4	Alipurduar College Pond	Ward-3, Alipurduar	Alipurduar-I	26°30'04.58"N & 89°32'14.21"E	Pond
S5	Alipurduar College field	Ward-3, Alipurduar	Alipurduar-I	26°30'00.20"N & 89°32'12.78"E	Noyanjuli
S6	Ram Thakur Pond	Vivekananda-I	Alipurduar-I	26°31'13.13"N & 89°32'22.43"E	Pond
S7	Alipurduar Junction	Vivekananda-I	Alipurduar-I	26°31'03.41"N & 89°32'10.49"E	Pond
S8	Railway Hospital pond	Vivekananda-I	Alipurduar-I	26°31'39.13"N & 89°32'11.04"E	Pond
S9	Turturi River	Kohinoor	Alipurduar-II	26°40'01.28"N & 89°42'57.33"E	River
S10	Turturi pond	Kohinoor	Alipurduar-II	26°37'34.60"N & 89°42'17.73"E	River
S11	Moter Jhora, Hatipota	Manabari	Kumargram	26°41'03.19"N & 89°42'59.72"E	River
S12	Samuktola	Samuktola	Alipurduar-II	26°31'48.88"N & 89°40'21.56"E	Noyanjuli
S13	Jashodanga	Tatpara-I	Alipurduar-II	26°30'58.05"N & 89°37'46.79"E	Pond
S14	Mahakalguri	Tatpara-I	Alipurduar-II	26°32'36.35"N & 89°40'57.62"E	Noyanjuli
S15	Pond beside River Gadadhar	Tatpara-II	Alipurduar-II	26°28'51.11"N & 89°36'13.17"E	Pond
S16	Gadadhar River	Tatpara-II	Alipurduar-II	26°29'38.72"N & 89°33'42.91"E	River
S17	Nonoi at Chechakhata	Vivekananda-II	Alipurduar-II	26°31'36.51"N & 89°32'57.45"E	River
S18	Chilkiguri Pond beside Rishi Road	Tatpara-II	Alipurduar-II	26°27'43.99"N & 89°35'29.62"E	Pond
S19	Kholta pond	Chaporer Par-I	Alipurduar-II	26°27'11.00"N & 89°31'05.36"E	Pond
S20	College Para pond	Ward-3, Alipurduar	Alipurduar Municipality	26°29'58.11"N & 89°32'16.98"E	Pond

S21	College Para Noyanjuli	Ward-3, Alipurduar	Alipurduar Municipality	26°29'53.05"N & 89°32'18.13"E	Noyanjuli
S22	Madhyapara Pond	Ward-3, Alipurduar	Alipurduar Municipality	26°29'50.99"N & 89°32'13.66"E	Pond
S23	Powerhouse Pond	Ward-4, Alipurduar	Alipurduar Municipality	26°29'26.07"N & 89°31'40.21"E	Pond
S24	Govinda Hish School Pond	Ward-4, Alipurduar	Alipurduar Municipality	26°29'30.70"N & 89°31'57.44"E	Pond
S25	Dima River at Itkhola	Ward-7, Alipurduar	Alipurduar Municipality	26°29'16.51"N & 89°31'20.10"E	River
S26	Kaljani River at New town	Ward-11, Alipurduar	Alipurduar Municipality	26°28'52.38"N & 89°31'01.88"E	River

2. Results and Discussion

So far we have studied the 26 water bodies, 5 of them under the Alipurduar-I, 13 under Alipurduar-II, 1 under the Kumargran sub-division and 7 under the Municipality area. According to the types of water bodies 14 becomes pond, 4 noyanjuli and 8 rivers spots were covered under this phase (all administrative parameters and GPS readings are presented in Table-1).

A total of Twenty seven types of Zooplanktons and Protista were identified from different lentic and lotic wetland. One crustacean larva namely Nauplius larva have also been recorded during the the study. Out of 27 species 14 belongs to phylum Crustacea (5 Cladocera, 8 Copepodans, 1 Ostracoda), 8 Rotifera (6 belongs to order Ploima, 1 each belongs to order Flosculariacea and Bdelloidea) and 5 belong to Kingdom Protista. All data including the abundance (i.e. diversity indices, dominance and evennse) in various water bodies are presented in the Table-2 and Plate-2.

Table 2: Checklist of recorded Zooplanktons and Protista along with the density and diversity indices from 26 survey spots of Alipurduar district of West Bengal, India

Planktons / Protista	*Recorded in no. of Spots*	*Total No. of sp. recorded in 1 ml sample*	*Dominance_D*	*Shannon_H*	*Simpson_1-D*	*Evenness_e^H/S*
Kindom: Animalia; Phylum: CRUSTACEA						
Nauplii_larvae	15	41.72	0.1294	2.251	0.8706	0.6333
Order: Copepoda						
Neodiaptomous sp	4	8.85	0.433	0.9441	0.567	0.6426
Heliodiaptomous sp	7	28.48	0.2355	1.616	0.7645	0.7191
Leptodiaptomous sp	2	5.05	0.8059	0.3442	0.1941	0.7055
Diaptomous sp	12	47.19	0.1475	2.117	0.8525	0.6922
Cyclops sp	20	98.4	0.08296	2.678	0.917	0.7275
Mesocyclops sp	19	64.7	0.0889	2.608	0.9111	0.714
Tropocyclops sp	13	13.85	0.1303	2.251	0.8697	0.7306
Diaphanosoma sp	11	25.38	0.2049	1.908	0.7951	0.6127
Order: Cladocera						
Chydorus sp	3	7.46	0.3613	1.054	0.6387	0.9565
Daphnia sp	7	5.39	0.1789	1.812	0.8211	0.8746
Moina sp	6	6.51	0.5078	1.076	0.4922	0.4886
Alona sp	6	10.23	0.2337	1.592	0.7663	0.8189
Bosmina sp	8	22.44	0.2224	1.672	0.7776	0.6655
Order: Ostracoda						
Hemicypris sp	4	4.4	0.3479	1.213	0.6521	0.8412
Phulum: ROTIFERA; Class:Monogonta; Order: Ploima						
Brachionus sp	11	179.21	0.4097	1.151	0.5903	0.2873
Keratella sp	10	18.37	0.2107	1.801	0.7893	0.6055
Lecane sp	3	5.9	0.7317	0.5203	0.2683	0.5608
Euchlanis sp	10	106.76	0.8547	0.4237	0.1453	0.1528
Asplanchna sp	3	3.81	0.4467	0.889	0.5533	0.8109
Lepadella sp	2	8.67	0.8139	0.3334	0.1861	0.6978
Order: Flosculariacea						
Chonochilus sp	3	20.93	0.5228	0.7524	0.4772	0.7074
Class:Bdelloidea						
Bdelloidea sp	3	2.77	0.4873	0.8848	0.5127	0.8075
Kingdom: PROTISTA						
Paramoecium sp	22	117.06	0.1128	2.577	0.8872	0.5978
Euglena sp	5	10.39	0.3341	1.266	0.6659	0.7093
Phacus sp	3	2.86	0.5547	0.7809	0.4453	0.7278
Arcella sp	20	152.51	0.1826	2.13	0.8174	0.4206
Centropyxis sp	7	7.48	0.1871	1.776	0.8129	0.8438

Out of recorded 5 Protista, 2 belongs to phylum Euglenozoa (autotrophs), 2 belongs to Amoebozoa (mostly eutrophic & diatom in nature) and one belong to phylum Ciliophora (either mixotrophs or heterotrophs) (Table-2). These Protista have a great role in balancing the equilibrium in the ecosystem by consuming bacteria or by their saprophytic habit (Levine, *et al.*, 1980).

According to Fig.-1, Spot No. 23 (Powerhouse pond under Alipurduar Municipality) showed the highest diversity

indices then comes Spot-6 (Alipurduar College pond under the municipality) and Spot-24 (Govinda High School under Alipurduar Municipality), after then Spot-2 as per diversity, it is also a pond situated at Chikliguri of Alipurduar-II sub-division. Therefore ponds water i.e. lentic system are recorded higher zooplankton diversity indices compare to river spots (lotic).

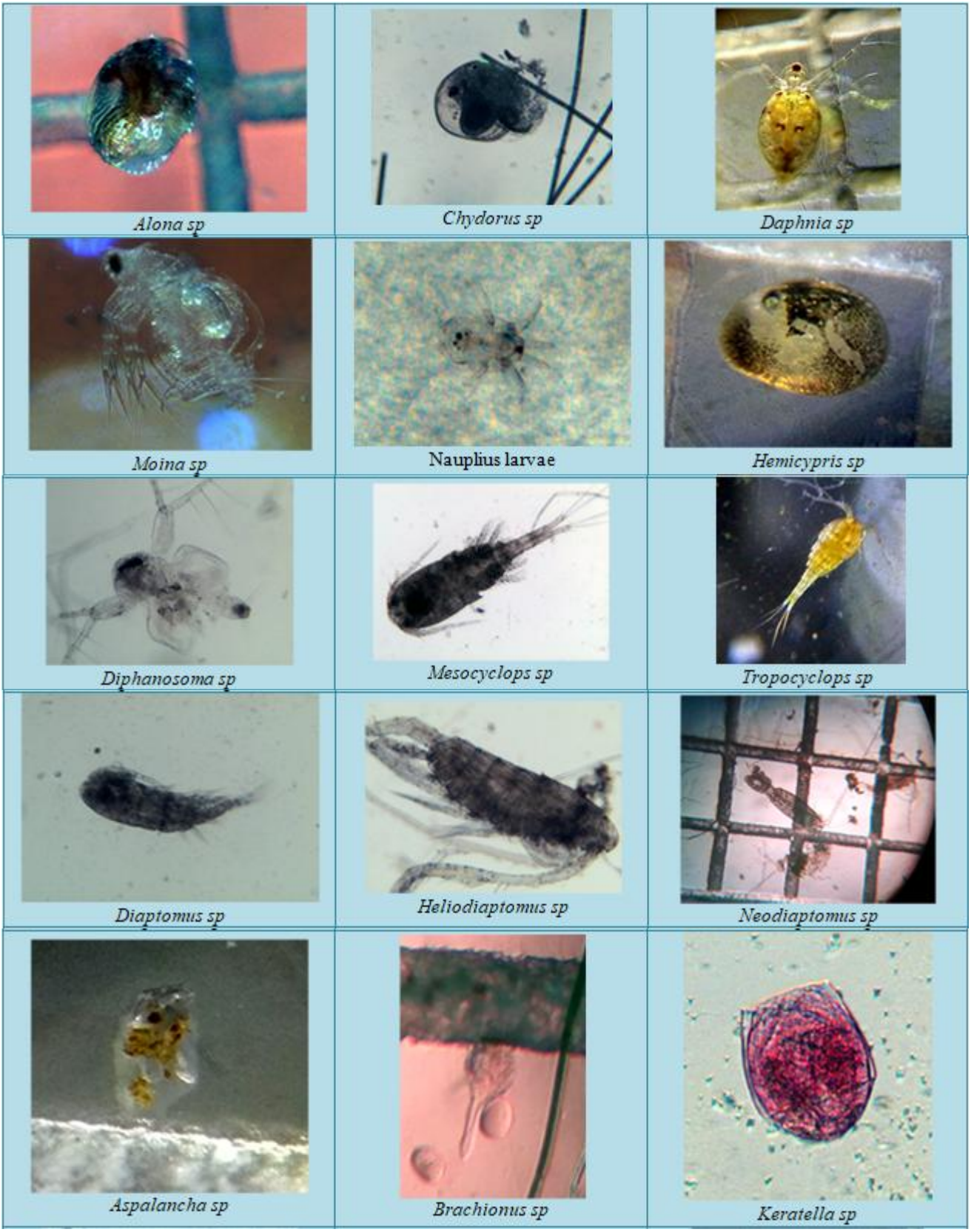

Plate 2: Photographs of the recorded Zooplankton and Protista from various water bodies of Alipurduar district of West Bengal, India

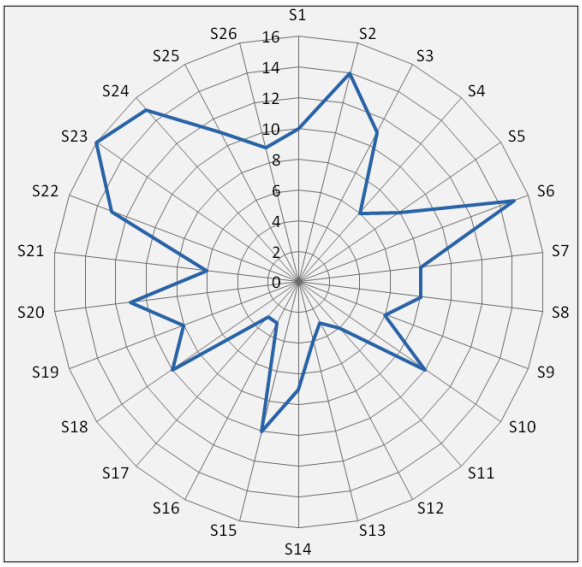

Figure 1: Graphical presentation of diversity frequency of the spot specific planktons recorded from 26 water bodies of Alipurduar district of West Bengal, India

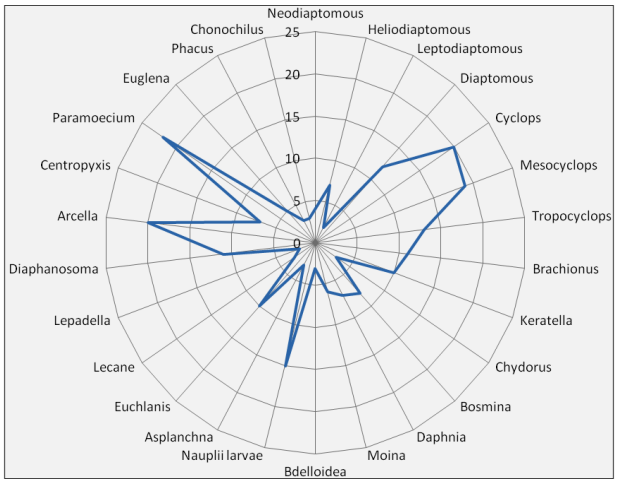

Figure 2: Graphical presentation of the density of the plankton species recorded from 26 water bodies of Alipurduar district of West Bengal, India

Among the recorded species *Paramoecium sp* are recorded from maximum number of spots (22 spots), its average density is 117.06/ml, Shannon diversity index is also high (2.577), next are *Cyclops sp* and *Arcella sp*, recorded from 20 spots, then *Mesocyclops sp* from 19 spots and their density is 98.4, 152.51 and 64.7 per ml respectively and Shannon diversity indices are 2.678, 2.13 and 2.608 respectively. *Tropocyclops sp* are recorded from 13 spots but the diversity index is very high (2.251) along with the *Dioptomus sp* (recorded from 12 spots & Shannon-H is 2.117), *Diphanosoma sp* (recorded from 11 spots & Shannon-H is 1.908). Then comes to *Daphnia sp* (recorded from only 7 spots & the diversity index is 1.812) and Rotifer *Keratella sp* (recorded from 10spots & diversity index is 1.801). *Centropyxis sp* is a diatom Protista recorded from 7 spots and Shannon diversity index is 1.776. One notable findings is *Alona sp* and *Bosmina sp* both belong to order Cladocera under Crustacea are recorded from 6 and 8 spots respectively and their diversity indices are moderate as 1.592 and 1.672 respectively (Fig.2). Spot specific diversity indices, dominance, evenness etc. are presented in Table-3.

Table 3: Diversity indices of the recorded planktons at 26 water bodies of Alipurduar district of West Bengal, India.

Spot No.:	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
No. of Taxa_S	12	15	12	7	9	15	9	9	6	11	4	3	4
Individuals	17.24	52.42	15.12	29.01	16.80	172.29	60.09	48.10	15.43	25.99	8.320	3.870	2.45
Dominance_D	0.224	0.164	0.203	0.190	0.235	0.349	0.351	0.403	0.324	0.155	0.359	0.391	0.550
Shannon_H	1.851	2.086	2.023	1.768	1.718	1.692	1.371	1.401	1.390	2.042	1.159	1.017	0.885
Simpson_1-D	0.777	0.836	0.797	0.810	0.765	0.651	0.649	0.597	0.676	0.846	0.641	0.609	0.451
Evenness_e^H/S	0.531	0.537	0.630	0.837	0.619	0.362	0.438	0.451	0.669	0.701	0.797	0.922	0.606
Spot No.:	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26

No. of Taxa_S	7	10	3	3	11	8	11	6	13	16	15	11	9
Individuals	7.880	14.33	4.230	4.230	75.70	13.49	40.34	11.83	83.57	61.71	156.51	74.28	11.54
Dominance_D	0.262	0.155	0.484	0.419	0.442	0.249	0.213	0.264	0.147	0.100	0.431	0.526	0.221
Shannon_H	1.581	2.032	0.883	0.942	1.335	1.658	1.860	1.490	2.192	2.450	1.428	1.148	1.728
Simpson_1-D	0.738	0.846	0.516	0.581	0.558	0.751	0.787	0.736	0.854	0.901	0.569	0.474	0.779
Evenness_e^H/S	0.694	0.763	0.806	0.855	0.345	0.656	0.584	0.739	0.689	0.725	0.278	0.287	0.625

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