Current World Environment Vol. **10**(1), 206-214 (2015)

Phytoplanktonic Diversity and Its Relation to Physico-chemical Parameters of Water at Dogarwada Ghat of River Narmada

JYOTI SHARMA[1], ALKA PARASHAR[1], PRATIBHA BAGRE and IMTIYAZ QAYOOM[2]*

[1]Department of Zoology, Sarojini Naidu Government P.G. Girls (Autonomous) College, Bhopal, 462026, India.
[2]Faculty of Fisheries, Sher e Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, J&K 190006, India.

(Received: December 08, 2014; Accepted: March 12, 2015)

http://dx.doi.org/10.12944/CWE.10.1.24

ABSTRACT

Present study was undertaken to assess the spatial and temporal distribution of phytoplanktons with respect to the changes in various physico-chemical parameters of Dongarwada ghat of river Narmada Madhya Pradesh. The study was carried for a year from March 2010 to February 2011. The results revealed presence of total 27 taxa of phytoplanktons belonging to 4 families were found in order of *Chlorophyceae* (47%) >*Cyanophyceae* (27%) >*Bacillariophyceae* (23%)>*Euglenophyceae* (3%).Diversity parameters Shannon index ranged from 1.092-0.37, Simpson index from 0.6622-0.6202, evenness diversity index from 0.9932 -0.7288and Margelef index between 0.5459-0.2951. Various physico-chemical parameters of water analyzed depicted a positive correlation with diversity and distribution of Phytoplankton.

Key words: River Narmada, Diversity, Phytoplankton, Water quality, Correlation.

INTRODUCTION

Plankton occupies the first link in the food chain and hence forms an important source of food for large aquatic animals. The primary producers are known to contribute significantly to the biological productivity of a water body besides mitigating the carbon cycle by photosynthesis and help to regulate temperature of the area of their prevalence. These are very sensitive to environment they live in and any alteration in the water system leads to the change in their communities in terms of tolerance, abundance, diversity and dominance in the habitat (Amarsinghe and Viverberg, 2002). Phytoplankton are possibly the most important group of organisms on earth generating most of the oxygen and also produce vegetative matter required at various links in a food chain. Wu (1984) has described a relation between aquatic organisms to the degree of pollution and introduced the concept of bio-indicators of pollution in their saprobic system. However, excessive growth and accumulation of phytoplankton as blooms lead to destruction of any water body resulting in dire consequences.

Over the last few decades, there has been much interest in the processes influencing the diversity, distribution and development of phytoplankton communities (Bhosale, *et al.*, 2010; Achary, *et al.*, 2010; Negi and Rajput, 2011) primarily in relation to physico-chemical factors (Akbay*et al.*, 1999 and Achary, *et al.*, 2010). Study of physico-chemical parameters is basic tool that contributes in making up of the ecosystems and determine the tropic dynamics of the water body. The change in water quality tends to change the living conditions especially in the number, diversity and distribution of the biota of the ecosystem (Sharma and Singh, 2013). Phytoplankton are the productive base of the food chain in freshwater ecosystems and healthy aquatic ecosystem is dependent on its physical, chemical and biological characteristics (Venkatesharaju *et al.*, 2010). Therefore, the present study was undertaken to assess the spatial diversity of phytoplankton community of river Narmada at Dongarwada and its correlation with the physiochemical parameters of the water body.

MATERIAL AND METHODS

Study area

Narmada originates from Amarkantak hill in shahdol district of Madhya Pradesh is known for crystal clear water. Biological production in any aquatic body gives a direct correlation with its physico-chemical status. Hoshangabad town earlier called Narmadapur falls within the geographical coordinates of +22^0 44'40'17" and +77^0 40'52.66" is famous for its beautiful ghats and is situated about 100 km away from capital city, Bhopal. Water samples were collected at Dongarwada site in Hoshangabad from March 2010 to February 2011. The investigation period was divided into four seasons i.e. summer, monsoon, post-monsoon and winters.

Physico-chemical analysis

Water samples were collected in the morning hours between 9 to 11 AM, in polythene bottle. The samples were immediately brought to laboratory for the estimation of various physico-chemical parameters. Water temperature, pH and turbidity were recorded on spot at the time of sample collection, by using thermometer, pocket digital pH meter and turbidity meter. The samples were stored in 4°C. Total hardness (TH) and alkalinity was analysed using standard procedures in the laboratory by using methods as prescribed by APHA (2002) and Trivedy and Goel (1986).

Biological analysis of phytoplanktons

Samples for plankton analysis were collected once in a month from for a period of one year from March 2010 to February 2011.The samples were collected following Welch (1952), Wetzel (1975) and Adoni (1985) as close to the water surface as possible. 100 l of water filtered through plankton net having mesh size of 60 microns and allowed to settle down for 24-48 hours. The samples were preserved in Lugol's Iodine solution and further concentrated to approximately 30 ml with 4% formalin. The phytoplankton were identified with the help of keys given by Prescott (1982), Agarkar (1975) and Desikachary (1959) .Counting of the individual plankton was done by "Lac Keys" dropping method (1935) using the formula:-

$$\text{Plankton units/l} = \frac{N \times C \times 100}{Y}$$

N= No. of plankton counted in 0.1 ml concentrate.
C= Total volume of concentrate in ml.
Y= Total volume of water filtered for sample in litres.

The data generated in present study was subjected to quantitative analysis of parameters using Microsoft past software version 3.0.2.

RESULTS AND DISCUSSION

Physico-chemical parameters

In present investigation, the mean temperature of the water body ranged from 26.183 ± 3.720. Water temperature is of enormous significance as it regulates various abiotic characteristics and biotic activities of an aquatic ecosystem (Ishaq *et al.*, 2013). The lowest water temperature was recorded in the month of February (20.1°C) and highest in May (31.2°C). pH marked a fluctuation from 7.3 in January to 8.9 in June with lower value of pH was observed during winters because of low temperature and photosynthetic activities. Change in pH concentrations have a definite impact on aquatic life by altering other aspects of water chemistry e.g. low pH levels can increase the solubility of certain heavy metals. This allows the metals to be more easily absorbed by aquatic organisms. The mean pH values ranged from 7.831 ± 0.490.

Turbidity concentration was highest in monsoon with 30.2 NTU in August and lowest 15.2 NTU in January. Turbidity was highest in monsoon and low in winters with mean values ranging from 19.617 ± 4.113. It is attributed to the addition of sand particles in river waters due to monsoon rains. Similar findings were also recorded by Tali *et al.*, 2012 who also observed fluctuations of turbidity in river Narmada at Maheshwar dam.

Alkalinity of water is its capacity to neutralize a strong acid and is characterized by presence of all hydroxyl ions capable of combining with hydrogen ions (Koshy and Nayar, 2000).Alkalinity ranged

Table 1: Monthly variation in phytoplankton density (Units/l) in river Narmada, Hoshangabad during March 2010 – February 2011

Name of group & species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mean ± SD
Chlorophyceae													
Eudorina Sp.	15	19	9	19	24	29	0	21	1	4	0	2	11.917 ± 10.457
Closeridium Sp.	31	0	10	30	51	0	30	0	0	10	0	0	13.500 ± 17.516
Chlorella Sp.	4	7	13	21	61	19	10	11	13	0	0	0	13.250 ± 16.625
Crucigenia Sp.	14	14	15	41	13	21	33	8	7	0	0	0	13.833 ± 12.841
Scenedesmus Sp.	21	9	20	32	0	24	29	0	0	0	12	15	13.500 ± 11.851
Pediastrum duplex	36	12	16	0	25	0	36	31	21	12	1	4	16.167 ± 13.630
Microspora Sp.	23	32	0	47	20	40	43	44	19	0	20	5	24.417 ± 17.000
Oedogonium Sp.	21	0	48	33	35	32	5	11	27	21	1	22	21.333 ± 14.841
Spirogyra Sp.	19	55	29	22	26	17	0	21	10	0	23	27	20.750 ± 14.486
Zygnema Sp.	6	23	40	11	18	0	41	32	0	22	18	27	19.833 ± 13.921
Closterium Sp.	7	41	33	21	7	31	0	27	11	30	19	3	21.667 ± 12.922
Ulothrix Sp.	8	34	47	14	19	8	0	0	30	21	18	34	19.417 ± 14.607
Volvox Sp.	29	31	32	33	22	11	30	23	34	22	6	39	26.000 ± 9.695
Total	234	277	312	324	321	232	257	229	173	142	118	208	235.583 ± 67.721
Bacillariophyceae													
Asterionella sp.	12	8	11	45	71	22	11	0	36	20	5	0	20.083 ± 21.065
Lyngbya Sp.	0	21	31	56	49	0	0	0	37	11	7	0	17.667 ± 20.742
Fragilaria Sp.	32	12	44	27	37	34	31	44	41	0	0	0	25.167 ± 17.414
Melosira Sp.	56	41	56	41	22	66	45	32	0	0	0	2	30.083 ± 24.619
Microcystis SP.	43	32	71	21	23	19	1	29	26	1	9	9	23.667 ± 19.551
Total	143	114	213	190	202	141	88	105	140	32	21	11	116.667 ± 68.901
Cyanophyceae													
Anacytis Sp.	23	32	34	23	41	7	4	0	37	0	0	1	16.833 ± 16.386
Oscillatoria Sp.	45	31	47	34	33	0	33	31	29	0	0	3	23.833 ± 17.898
Spirulina Sp.	21	30	16	29	39	0	27	12	22	0	0	2	16.500 ± 13.661
Anabaena Sp.	1	55	28	27	41	22	21	14	0	12	0	5	18.833 ± 17.198
Nostoc Sp.	0	31	22	38	0	23	22	16	20	2	0	8	15.167 ± 13.023
Cyclotella Sp.	33	10	26	21	32	45	23	25	21	13	14	19	23.500 ± 9.765
Cymbella Sp.	14	21	28	28	15	29	24	0	1	17	2	0	14.917 ± 11.564
Diatoma Sp.	1	0	31	34	0	3	5	2	3	18	5	1	8.583 ± 12.176
Total	138	210	232	234	201	129	159	100	133	62	21	39	138.167 ± 72.902
Euglenophyceae													
Euglena	16	20	33	17	13	9	13	18	14	14	0	2	14.083 ± 8.490

between 69 –210 mg/l with maximum value in July (210 mg/l) and minimum in December (69 mg/l).Alkalinity was highest in monsoon and low in winters but no regular trend was observed with mean values of 136.667 ± 55.849. This might be due to the photosynthetic activities of the algae.Tali *et al.* (2012) observed the value of alkalinity varied from 80 mg/l to 240 mg/l from April to September in river Narmada. Total hardness varied from 79 – 196 mg/l highest peak being observed in the month of May (196 mg/l) and lowest in July (79 mg/l). Total hardness was highest during summer months and lower in monsoon that can be attributed to higher temperature level which includes concentration of salts by excessive evaporation. The mean value of total hardness was recorded 125.750 ± 44.785 (Fig. 1) showing variation in water parameters of river Narmada at Hoshangabad, Madhya Pradesh.

Phytoplankton

Plankton population largely depends on the physico-chemical characteristic of a water body. Phytoplankton showed variations in their abundance during different months of the year. In river Narmada four groups of phytoplankton Chlorophyceae, Bacillariohyceae, Cyanophyceae, Euglenophyceae were recorded throughout the year. Seasonally maximum number of phytoplankton was observed during summer and lowest in winters with mean significant values of 235.583 ± 67.721, 116.667 ±

Table 2: Seasonal numeric data of phytoplanktons in Narmada river at Hoshangabad

Summer				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Taxa_S	3	3	3	3
Individuals	823	470	580	69
Simpson _ 1-D	0.6622	0.6432	0.6523	0.6335
Shannon _ H	1.092	1.064	1.076	1.051
Eveness _ e H/S	0.9932	0.9663	0.9776	0.9531
Margalef	0.2979	0.3251	0.3143	0.4724
Monsoon				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Taxa_S	3	3	3	3
Individuals	877	533	564	39
Simpson _ 1-D	0.6596	0.6593	0.6485	0.6456
Shannon _ H	1.088	1.087	1.07	1.067
Eveness _ e H/S	0.989	0.9886	0.9719	0.9684
Margalef	0.2951	0.3185	0.3157	0.5459
Post- Monsoon				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Taxa_S	3	3	3	3
Individuals	659	333	392	55
Simpson _ 1-D	0.6582	0.654	0.6553	0.6202
Shannon _ H	1.086	1.08	1.081	1.033
Eveness _ e H/S	0.9871	0.9815	0.9828	0.9364
Margalef	0.3081	0.3443	0.3349	0.4991
Winters				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Taxa_S	3	3	3	3
Individuals	468	122	64	16
Simpson _ 1-D	0.6468	0.6099	0.6128	0.2188
Shannon _ H	1.07	1.01	1.01	0.37
Eveness _ e H/S	0.9715	0.9165	0.9197	0.7288
Margalef	0.3253	0.4163	0.4809	0.3607

68.901, 138.167 ± 72.902 and 14.083 ± 8.490 for Chlorphyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae respectively. This variation may be due to progressively increasing water temperature and nutrients in water that are responsible for high amount of phytoplanktons growth during the summer season. Tyor and Deepti, 2012 also reported that phytoplankton grow and multiply best during summer months when the temperature is high and having longer photoperiod.

The temporal succession of phytoplankton groups were noticed as Chlorophyceae>Cyanophyceae>Bacillariophyceae>Euglenophyceae.27 species were identified of which Chlorophyceae were found most dominating having 2,827(47 %) taxa followed by Bacillariophyceae with 1400 (23 %) taxa, Cyanophyceae having 1658 (27 %) taxa and Euglenophyceae with 169 (3 %). (Fig. 2) shows percentage compositions of phytoplankton in river Narmada. The result indicated that phytoplankton was more during summers and low in winters and rainy seasons but no regular trend was observed. Our findings are in agreement to Dhimdhime *et al.*, 2012; Suresh *et al.*, 2013 and Chergui *et al.,* 2013 who observed the highest phytoplankton concentration during summer months. The dominant group in each family are listed in (Table 1) and (Fig. 3) showing monthly variation in phytoplankton in river Narmada. Sharma *et al.*, 2011 concluded the same results seasonal fluctuation in abundance of phytoplankton in river Narmada.Jafari and Alavi, 2010 observed similar result from Talar River Iran and concluded that phytoplankton appears and disappears without regularity.Murugesan and Sivasubramanian, 2008 observed enhanced growth of Chlorophytes

Table 3: Co-relation matrix of physico-chemical parameters and phytoplanktons of river Narmada at Hoshangabad from March 2010- February 2012.

Summer				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Watertemperature	0.62126	0.38861	0.10039	0.060204
pH	0.74058	0.4141	0.9031	0.74251
Turbidity	0.44252	0.11603	0.60503	0.44444
Alkalinity	0.65481	0.32833	0.81732	0.65673
Total Hardness	0.4195	0.093015	0.58201	0.42142
Monsoon				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Water temperature	0.57426	0.13685	0.15686	0.21652
pH	0.6332	0.077916	0.2158	0.27546
Turbidity	0.34304	0.36807	0.74358	0.014699
Alkalinity	0.77272	0.51616	0.80988	0.86954
Total Hardness	0.71112	0.98907	0.29372	0.35338
Post- Monsoon				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Watertemperature	0.46942	0.004537	0.83124	0.88713
pH	0.80704	0.81158	0.02420	0.80086
Turbidity	0.42347	0.03781	0.87359	0.92948
Alkalinity	0.1869	0.18236	0.98185	0.92597
Total Hardness	0.30355	0.004537	0.83124	0.88713
Winters				
Variable	Chlorophyceae	Baciliriophyceae	Cyanophyceae	Euglenophyceae
Water temperature	0.75927	0.24265	0.36177	0.15751
pH	0.28858	0.8052	0.59038	0.79464
Turbidity	0.71855	0.76483	0.16041	0.36467
Alkalinity	0.4148	0.10182	0.70624	0.50198
Total Hardness	0.42769	0.94431	0.45127	0.65553

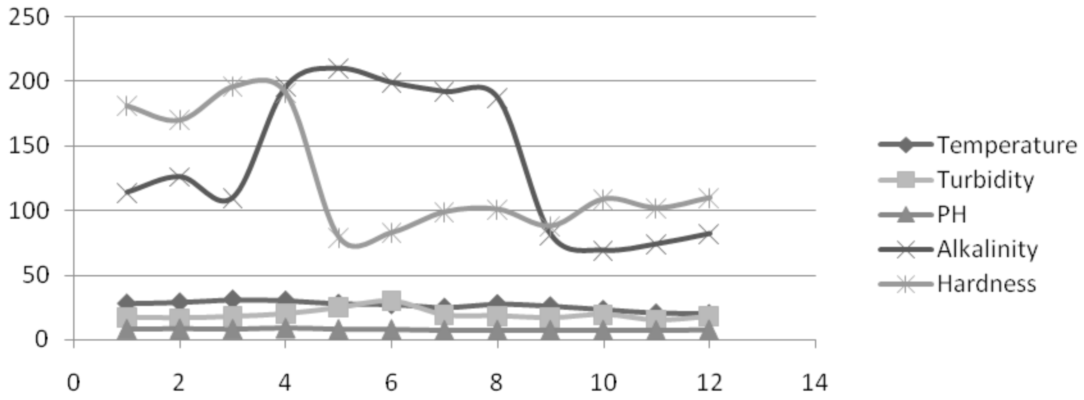

Fig. 1: Showing monthly variation in water-parameters of river Narmada at Hoshangabad (March 2010-February 2011)

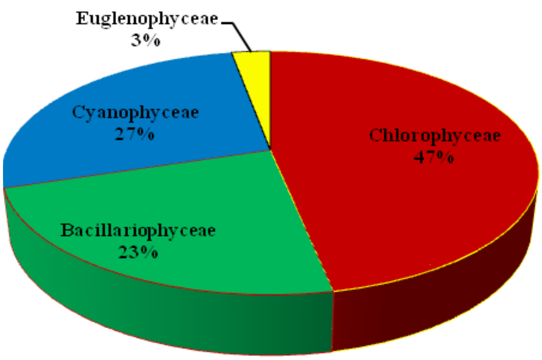

Fig. 2: Percentage of phytoplanktons during March 2010-February 2011

during summer months. Rise in temperature during summers increase the rate of decomposition and also due to evaporation water becomes nutrient rich resulting in higher concentration of phytoplankton while low density during monsoon season can be attributed to heavy floods.

Biotic Indices

Quantifying biodiversity is one of the most complicated aspects of biodiversity (Gaston and Spicer, 1998). The goal of using multiple indices is an attempt to describe the diversity of an ecosystem as accurately as possible. These indices attempt to define biodiversity in many different ways though most indices use a combination of number of species and the degree of difference between those species (Gaston and Spicer, 1998).

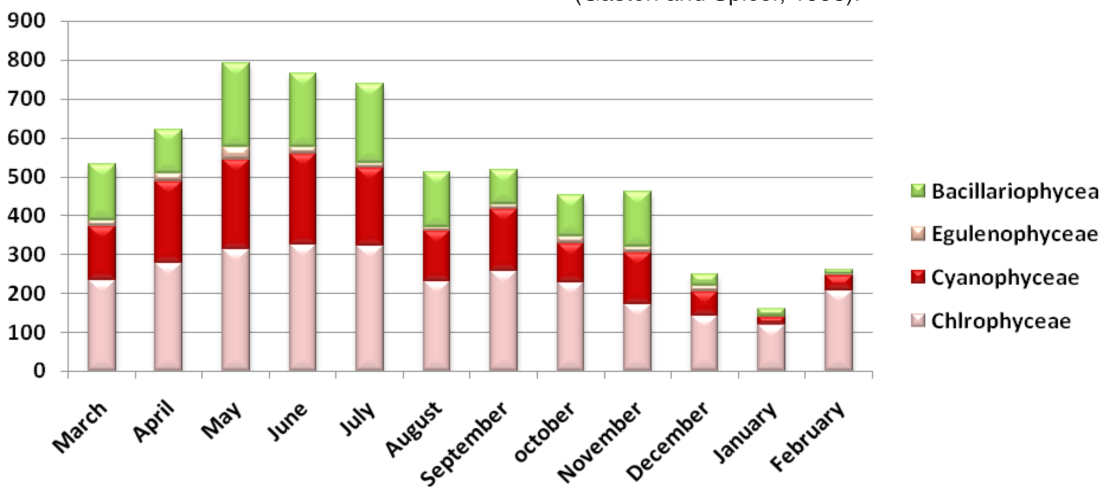

Fig. 3: Monthly variation in phytoplanktons in river Narmada

In the present study, four diversity indices were applied including Shannon index, Simpson index, Margalef index and Evenness index. (Table 2) showing season wise numeric data of phytoplankton in river Narmada. Simpson's diversity is one of a number of diversity indices, used to measure diversity. It takes into account the number of species present as well as the relative abundance of each species. In present study, Simpson index varied from 0.6622 for Chlorophyceae and 0.6202 for Euglenophyceae. Value of Simpson was highest in summer season. Shannon index ranged from 1.092 in summer for Chlorophyceae to 0.37 for Euglenophyceae in winters.

Species evenness refers to how close in numbers each species in an environment. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically. The value of evenness diversity index was between 0.9932 for Chlorophyceae in summer to 0.7288 for Euglenophyceae in winters. In present study for Margelef index highest values was present for Euglenophyceae (0.5459) in monsoon and lowest values for Chlorophyceae (0.2951) in monsoon respectively. It indicates that highest diversity was found for Chlorophyceae as compared to others.

The various diversity index used in present study gives species diversity of area studied. Diversity indices used in study provide important information about rarity and commonness of species in the area studied. The Shannon index gives information on statistic index, which means it assumes that all species are represented in a sample and that they are randomly sampled whereas Simpson index is a dominance index that are used mainly to quantify the biodiversity of habitat and gives more weight to common or dominant species. Margalef index is used to estimate the number of species to calculate diversity. The ability to quantify diversity in this way is an important tool to understand diversity of studied area.

The relationships between phytoplankton and physico-chemical parameters

Abiotic factors exert a considerable influence on phytoplankton abundance and diversity (Das *et al.,* 1996).

The study of correlation between water parameters and phytoplankton is useful in gaining basic knowledge of trophic status of a water body. In present study,the correlation between the phytoplankton and the physico-chemical variables in the surface water at the station was explored. The factors correlating with the composition of phytoplankton were water temperature, pH, turbidity, alkalinity and total hardness. Our result showed that there exist a positive correlation between phytoplankton and different water parameters thus indicating that the density of phyto-plankton is dependent on different abiotic factors either directly or indirectly. (Table 3) showing co-relation matrix of physico-chemical parameters and phytoplanktons of river Narmada at Hoshangabad from March 2010 to February 2012.

There are many detailed descriptions of phytoplankton succession being correlated with changes in environmental parameters particularly temperature, light, nutrients availability and mortality factors such as grazing and parasitism (Roelke and Buyukates, 2002).

According to Cabecadas and Brogueira, 1987 the growth and photosynthesis of algae are influenced by the pH and alkalinity of water. Pandey *et al*., 1995 observed a positive correlation between pH, dissolved oxygen, bicarbonate, phosphate and transparency. They reported a positive correlation between pH, dissolved oxygen, transparency and Chlorophyceae. Bhat and Pandit, 2005 found a close relationship between physico-chemical characters of water with growth and abundance of phytoplanktons. Senapati *et al.,* 2001 also observed positive correlation between certain water parameters and phytoplankton from a semi-lentic water body at Burdwan West Bengal. Sharma and Singh, 2013 observed positive correlation of phytoplankton with water parameters. Suresh *et al.,* 2013 studied a co-relation between physico-chemical parameters with phytoplankton and observed significant results.The diversity index used in present study for phytoplankton analysis would be an important step towards study of stress on biological data due to water parameters of the selected area of study.

ACKNOWLEDGMENTS

The authors are thankful to M.P. Council of Science and Technology, Nehru Nagar, Bhopal for providing necessary funding to carry out the work. We also extend our gratitude to the Department of Zoology, Sarojini Naidu Government Girls P.G. (Auto.) College, Bhopal for providing all the necessary facilities for conducting this research work.

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