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IMPACT OF NUTRIENTS ON DISTRIBUTION OF *MICRASTERIAS SP*. IN HOOGHLY PROVINCE, WEST BENGAL, INDIA

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Abstract

In the present paper morpho-taxonomic descriptions along with the illustrations of three infraspecific taxa of genus *Micrasterias* C. Ag. ex Ralfs, analysis of ecological parameters and correlation coefficients between nine limnological parameters as well as the relative abundances of the genus had been described. These three taxa are *Micrasterias pinnatifida* var. *pinnatifida* fa. *pinnatifida* (Kütz.) Ralfs, *Micrasterias tropica* Nordstedt var. *crassa West & West* and *Micrasterias foliacea* var. *foliacea* Bailey ex Ralfs belonging to the order Zygnematales under the class Chlorophyceae. All these taxa were distributed in ponds (inland water bodies) in Hooghly district, West Bengal, India. The results of analysis of physico-chemical parameters of the ponds water revealed that lower temperature and nutrient status in respect of nitrate-nitrogen (NO_3-N): phosphate (PO_4^{3-}): potassium (K); higher dissolved oxygen (DO) values and, slight alkaline water prompted their occurrences, growth and diversity. The above said infraspecific taxa are new taxonomic reports from West Bengal, India. The taxonomic study explored the present biodiversity of this genus while the ecological study showed a clear picture of ecological conditions and water quality of the studied water bodies.

Key Words: Taxonomy, Ecology, *Micrasterias*, West Bengal, India

Introduction

Recently, demands of water bodies are rising up for human welfare and seasonal changes or variations have a great impact on water chemistry that affects ultimately the plant life (Bajpai *et al*., 2013). Algae are most common plant group that occur naturally in diverse water bodies and play significant role in functioning the aquatic ecosystems and, recycling of nutrients like nitrate, phosphate and potassium. The algal diversity and occurrence in aquatic bodies vary considerably based upon the changes of physico-chemical features (Halder, 2015a). Among the different classes of algae, Chlorophyceae is one of the most leading and dominant groups in water bodies. The members belonging to the family Desmidiaceae are collectively known as "desmids". Desmids are beautiful, planktonic, mostly unicellular phycoflora of the class Chlorophyceae and they are primary producers and some desmids are pollution indicators of water bodies (Das, 2007). They occur in diverse types of fresh water aquatic ecosystems throughout the world. The richness of some desmids populations in water bodies is an indicator of good water quality (Nagrathna and Hosmani, 2002). The plant body of unicellular desmid consists of two semicells or halves which are adjoined at the isthmus region. The species of *Micrasterias* C. Ag. ex Ralfs exhibit a higher level of structural complexity and semicells are typically divided into several lobes and lobules as a result of highly complex cells organization (Neustupa *et al*., 2009, 2010).

It was Wallich (1860), a British worker, who probably first studied the members of Desmidiaceae from coal field area in Ranijang, West Bengal, India. Next Dickie (1882), Turner (1892) and Brühl and Biswas (1926) worked on the taxonomy of this genus before the independence of India. Latter, Agarkar (1969), Bharati and Pai (1972), Kamat (1975), Agarkar and Agarkar (1977), Pandey and Pandey (1980), Gurudeva *et al*., (1983), Prasad and Misra (1985), Hegde (1986), Habib (1993,1997), Mukherjee and Srivastava (1993), Tarar *et al*., (1998), Misra *et al*., (2001), Gupta (2002), Kumar and Chaudhary (2009), Deca *et al*., (2011), Yasmin *et al*., (2011) contributed too much on the taxonomy of *Micrasterias* C. Ag. ex Ralfs from this country. So, from the survey of literatures, it was found that a little work had been carried out from West Bengal, India on taxonomy of this genus.

Ecological study of algae in inland water bodies had been carried out by Singh (1960), Zafar (1967), Munawar (1974), Dwivedi and Pandey (2002) and Hosmani (2014). Based on the analysis of water, an attempt has been made to assess the impact of water chemistry on the periodicity of *Micrasteria*s C. Ag. ex Ralfs.

Materials and Methods

Algal samples were collected in plastic and glass containers from two ponds located at Balagarh (23.10°N/88.46°E) and Dumurdaha (23.03°N/88.43°E) of Hooghly district (20°30'32″-23°1'20″N/ 87°30'20″-80°30'15″E) in West Bengal, India. The pond which situated at Balagarh was site 1 and at Dumurdaha was site 2. Detailed taxonomic study was made by examining the algal specimens under Olympus microscope (Model-CH20i) for descriptions of these species. The samples were preserved in 4% formalin solution. Identifications of the taxa accomplished with the help of authentic literatures (Prescott *et al*., 1977; Oliveira *et al*., 2009; Menezes *et al*., 2013; Ribeiro *et al*., 2015). The limnological parameters of water were analyzed as described earlier (Halder and Sinha, 2015; Halder, 2015b). The statistical analyses were done using the statistical package for social sciences (SPSS v. 13, Inc., USA) and correlation coefficients among variables were calculated using Pearson correlation coefficient (r) test. A level of $p<0.05$ was considered as significant.

Results and Discussion

The systematic position of the genus *Micrasteria*s C. Ag. ex Ralfs had been given according to Smith classification (1950). Morpho-taxonomic descriptions with author citations and illustrations of three infraspecific taxa of the genus had been provided below:

Key to the taxa

1. Cells filamentous; rectangular--------------------------------- *Micrasterias foliacea* var. *foliacea*
1. Cells not so and solitary--- (2)
2. Both polar & lateral lobes bifid at extremities with two distinct curved spines-- *M. pinnatifida* var. *pinnatifida*
2. Both lobes not so--*Micrasterias tropica* var. *crassa*

Class: Chlorophyceae; Order: Zygnematales

Family: Desmidiaceae; Genus: *Micrasterias* C. Ag. ex Ralfs

1. *Micrasterias pinnatifida* var. *pinnatifida* fa. *pinnatifida* (Kütz.) Ralfs in Brit. Desm.77, pl.10, fig.3, 1848; Oliveira, Moura & Bicudo in Revista Brasil. Bot. 32(2): 230, fig. 16, 2009; Menezes et al. in Iheringia, Sér. Bot., Porto Alegre 68(1): 14, fig.32, 2013; Ribeiro et al. in Sitientibus Série Ciências Biológicas 7, figs. 12-13, 2015. **(Fig. 1A)**

Euastrum pinnatifidum Kütz, 1845

Description: Cells small, slightly broader than longer , deeply constricted, sinus opened from interior part; lateral lobes single, undivided, conical, horizontally extended and constricted just before the bifid extremity; polar lobes horizontally spreading, its apex flat or very slightly convex or retuse; polar extension smaller than the lateral lobes, bifid at the extremities; sub-polar incision is deep and semicircular within; cells are fusi-form with acuminate poles in vertical view whereas in lateral view they are pyramidal and constricted below the rounded apices; cell wall generally smooth or may be punctate; chloroplast with curved lamellae having few pyrenoids; cell length 64.0-70.0 µm, breadth 62.0-66.5 µm, apex 40.0-42.0 µm and isthmus 11.0-12.0 µm.

Habitat: In association with phytoplanktons in pond water at Balagarh (site 1), Hooghly, West Bengal.

Collection No: NH 801; **Dated:** 03.12.2011

Ecological Significance: It acts as a primary producer in pond.

Conservation status: The conservation status of this species is least concern in this locality.

2.*Micrasterias tropica* Nordstedt var. *crassa* West & West in J. Bot. 35: 87, pl. 366, fig. 3, 1897; Krieger, Die Desmidiaceen Europasmit Berücksichtigung der aussereuropäischen Arten. Rabenhorst`s Kryptogamen Flora von Deutschland, Österreich und der Schweiz 13: 56, pl. 112, figs. 3-6, 1937; Prescott, Croasdale & Vinyard, A synopsis of North American Desmids Part II: Desmidiaceae: Placodermae sect. 2:193, pl. 140, figs. 3, 4, 1977. **(Fig. 1B)**

Description: Cells are of medium size, brownish; lateral lobes slightly broader at the bases than longer, horizontally expanded and tapered with small stout marginal spines toward the extremities; intramarginal teeth are in double rows at the poles of semicells; polar lobes broader, relatively shorter and stouter; sinus opening widely from a sharp-angled interior portion; apex flat or depressed between the long, spreading processes; spines stouter or paired at the depressed apex and above the isthmus; semicells in vertical view fusi-form with a blunt-angled median inflation; marginal and inter-marginal spines present; cell length 103.0-113.0 μm, breadth with processes and spines 87.0-95.0 μm; without processes and spines towards base 20.5-24.6 μm and isthmus 18.5 μm.

Habitat: Pond water at Dumurdaha (site 2), Hooghly, West Bengal, India.

Collection No: NH803; **Dated:** 05.12.2011

Ecological Significance: The alga plays a significant role as primary producer in water body.

Conservation status: Due to having data deficits, presently there is no conservation measure of this species from this locality.

3.*Micrasterias foliacea* var. *foliacea* Bailey ex Ralfs in Brit. Desm. 210: pl. 35, fig.3, 1848; Prescott, Croasdale & Vinyard, A Synopsis of North American Desmids Part II: Desmidiaceae: Placodermae Sect. 2:158, pl. 139, figs. 3-8, 1977. **(Fig. 1C)**

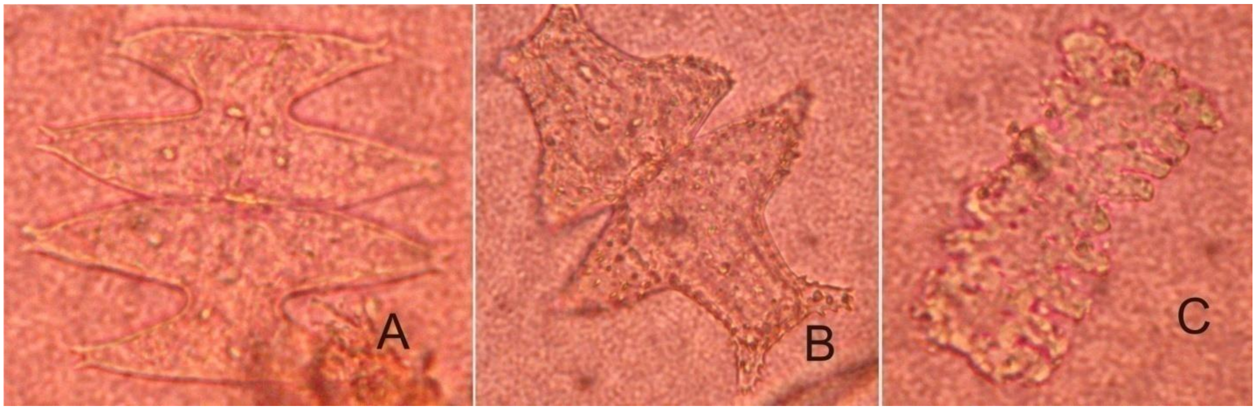
Description: Cells moderate size, without intra-marginal spines; cells rectangular, longer than broad; sinus sub-linear; lateral lobes divided to the second and third orders, dissimilar, the lower lobule horizontal and upper diverging; polar lobe distinctive, basal part narrow with erect parallel sides, upper three-quarters of the lobe expanded; with a very broad, deep sub rectangular excavation in the middle of the apex, angles stout, ending in two widely divergent teeth; apex depressed, unequal in size; semi cells in vertical view narrowly fusi-form and the central part obliquely rhomboidal,; cell length 85.0-95.0 μm, breadth 54.0-60.0 μm and isthmus 8.0-12.0 μm.

Habitat: Pond water, in association with phytoplanktons at Balagarh (site 1), Hooghly, West Bengal.

Collection No: NH 801; **Dated:** 03.12.2011

Ecological Significance: The species act as primary producer in pond water.

Conservation status: The conservation status of the species is least concern in this locality.



20µm

Figs. A-C

Figure 1: A, *Micrasterias pinnatifida* var. *Pinnatifida* fa. *pinnatifida* (Kütz.) B, *Micrasterias tropica* Nordstedt var. *crassa* West & West C, *Micrasterias foliacea* var. *foliacea* Bailey ex Ralfs

During the taxonomic investigation, it was found that they preferred to grow in stagnant water bodies like pods. The analysis of nine limnological parameters including minimum, maximum, mean, standard deviation (SD), standard error (SE) and variance values of six months data (July, 2011-December, 2011) in ponds at Balagarh (site 1) and Dumurdaha (site 2) were shown in tables 1 and 2. Monsoon was prevailed from July-October and the subsequent period November-December constituted winter in West Bengal, India. During the period of study, *Micrasterias* C. Ag. ex Ralfs occurred at the end of rainy season (September-October) and persisted still winter (November-December), when the temperature was lower. In winter, their relative abundances were greater. Zafar (1967) also noticed similar phenomenon while he working on ecology and periodicity of Chlorococcales in Hyderabad, India. Water temperature is one of the most important ecological factors for occurrence and periodicity of algal flora (Rao, 1955). In the present study, temperature was gradually decreased from July to December, 2011 due to changes of climatic conditions or seasons whereas, pH was increased from August to December, 2011 in site 2 probably due to increase of algal biomass in that site. In both the sites, pH values were comparatively lower in the months of July and August, 2011 that might be due to heavy rainfall and dilutions of water. Dissolved oxygen (DO) plays a significant role in the distribution of algae. Quite higher DO values were recorded from 2nd site. The values of DO varied from 6.2 mg l^{-1} to 7.2 mg l^{-1} (mean 6.7 mg l^{-1}) and 7.4 mg l^{-1} to 8.4 mg l^{-1} with an average 7.9 mg l^{-1} in sites 1and 2 respectively. Gonzalves and Joshi (1946) while studying the seasonal succession of freshwater algae in a tank at Bandra, Maharashtra opined that higher level of dissolved oxygen was favourable for growth of algae including Chlorococcales. In this investigation, similar pulse was found. Biological oxygen demand (BOD) values were found in normal ranges in the two sites but the fluctuations of chemical oxygen demand (COD) values were observed in both the water bodies while studying limnological parameters. COD values were ranged from 100.0 mg l^{-}

[1] to 150.0 mg l^{-1} in site 1 and 90.0 mg l^{-1} to 130.0 mg l^{-1} in site 2. The study also revealed that nutrient loads were lower in both the sites. The mean value of nitrate-nitrogen (NO_3-N) was slight lower (0.20 mg l^{-1}) in site 1 than site 2 (0.29 mg l^{-1}) while mean values of phosphates (PO_4^{3-}) were more or less alike (0.29 mg l^{-1} and 0.30 mg l^{-1}in sites 1 and 2). Potassium (K) was ranged from 17.0 mg l^{-1} to 18.0 mg $l^{-1}$and 16.0 mg l^{-1} to 17.0 mg l^{-1}in former and later sites. Total dissolved solids (TDS) also play a minor role in the occurrence of algae. Here, minimum and maximum values of TDS were found 132.0 mg l^{-1} to 148.0 mg l^{-1} with an average 138.6 mg l^{-1} in site 1 while, 122.0 mg l^{-1} to 158.0 mg l^{-1} with a mean value of 145.3 mg l^{-1} in site 2, respectively. Higher values of NO_3-N, PO_4^{3-}, K and TDS were noticed in monsoon as compared to winter in both the sites. It might be due to accumulation of agricultural, sewage and domestic run-off through rain water. The enrichment of those factors probably helped the growth and periodicity of those algal taxa.

Table 1: Physico-chemical characteristics (Mean±SE) of pond water from July to December in 2011 during collections of *Micrasterias* desmid at Balagarh (site-1)

Water parameters (site 1)	Months (in year, 2011)											
	July	Aug.	Sept.	Oct.	Nov.	Decm.	Min	Max	Mean	SD	SE	Var.
Temp. (°C)	30.5±0.1	29.0±0.9	28.0±0.1	26.0±0.2	24.0±0.2	18.5±0.2	18.5	30.5	26.0	4.32	1.76	18.70
pH	7.3±0.04	7.2±0.05	7.5±0.05	7.6±0.05	7.5±0.05	7.6±0.05	7.2	7.6	7.45	0.16	0.06	0.02
DO (mgl^{-1})	7.2±0.1	7.0±0.1	6.4±0.1	6.2±0.1	6.6±0.1	6.8±0.1	6.2	7.2	6.7	0.37	0.15	0.14
BOD (mgl^{-1})	3.5±0.1	3.8±0.08	4.2±0.09	4.4±0.08	3.8±0.08	3.6±0.08	3.5	4.4	3.88	0.34	0.14	0.12
COD (mgl^{-1})	100±5.7	120±5.5	140±5.7	150±5.5	120±5.5	110±5.7	100	150	123.33	18.61	7.60	346.66
NO_3-N (mgl^{-1})	0.25±0.08	0.27±0.1	0.20±0.1	0.17±0.08	0.15±0.1	0.17±0.08	0.15	0.27	0.20	0.04	0.019	0.002
PO_4^{3-} (mgl^{-1})	0.30±0.1	0.32±0.08	0.31±0.1	0.3±0.1	0.28±0.1	0.27±0.1	0.27	0.32	0.29	0.018	0.0076	.00
K (mgl^{-1})	18.0±0.1	17.8±0.1	17.4±0.08	17.0±0.08	17.4±0.08	17.2±0.08	17.0	18.0	17.46	0.37	0.15	0.13
TDS (mgl^{-1})	148±1.1	144±1.2	132±1.5	136±1.6	138±1.8	134±1.8	132	148	138.66	6.15	2.51	37.86

Table 2: Physico-chemical characteristics of pond water from July to December in 2011 during collections of *Micrasterias* desmid (Mean±SE) at dumurdaha (site-2)

Water parameters (site 2)	Months (in year, 2011)											
	July	Aug.	Sept.	Oct.	Nov.	Decm.	Min	Max	Mean	SD	SE	Var.
Temp. (°C)	31.5±0.1	31.0±0.2	30.0±0.08	29.0±0.08	25.5±0.07	19.0±0.07	19	31.5	27.66	4.75	1.93	22.56
pH	7.2±0.04	7.1±0.05	7.4±0.04	7.5±0.05	7.6±0.05	7.7±0.05	7.1	7.7	7.41	0.23	0.09	0.05
DO (mgl^{-1})	8.4±0.1	8.2±0.1	7.4±0.1	7.6±0.1	7.8±0.1	8.0±0.1	7.4	8.4	7.9	0.37	0.15	0.14
BOD (mgl^{-1})	3.4±0.1	3.6±0.08	4.2±0.09	4.0±0.1	3.8±0.1	3.6±0.1	3.4	4.2	3.76	0.29	0.12	0.08
COD (mgl^{-1})	90±5.5	100±5.5	130±5.7	120±5.5	110±5.5	100±5.7	90	130	108.33	14.71	6.00	216.66
NO_3-N (mgl^{-1})	0.36±0.08	0.34±0.1	0.32±0.1	0.27±0.08	0.25±0.05	0.22±0.07	0.22	0.36	0.29	0.05	0.02	0.003
PO_4^{3-} (mgl^{-1})	0.33±0.1	0.32±0.08	0.31±0.1	0.3±0.1	0.28±0.09	0.26±0.1	0.26	0.33	0.30	0.02	0.01	0.001
K (mgl^{-1})	17.0±0.1	16.8±0.1	16.4±0.08	16.0±0.08	16.4±0.05	16.2±0.06	16.0	17.0	16.46	0.37	0.15	0.13
TDS (mgl^{-1})	158±1.1	156±1.1	152±1.0	148±1.2	136±1.5	122±1.6	122.0	158.0	145.33	13.83	5.64	191.46

The correlation coefficients between physico-chemical parameters were calculated and given in tables 3 and 4. The examinations of these values showed some variations among the variables. It was noted that some of these values were positively and negatively correlated at 5% level of significance. Most importantly, water temperature and pH as well as DO and COD were found significantly negatively correlated whereas NO_3-N and PO_4^{3-} values exhibited significant positive correlations in both the sites. Sharma *et al*., (2013) also observed negative correlation between DO and COD while working on statistical analysis of hydro-chemical parameters of surface and underground water of Rajgarh, Alwar in Rajasthan. Therefore, the present analysis of correlation coefficients among the various water parameters showed variability in respect to significance and non-significance levels whereas, ecological study revealed that nutrients factor and other chemical factors supported the production and growth of the above said algal species in those water bodies.

Table 3: Simple correlation matrix (r) among different physico-chemical parameters of a pond at Balagarh (site1)

	Temp. (°C)	pH	DO (mgl^{-1})	BOD (mgl^{-1})	COD (mgl^{-1})	NO_3-N (mgl^{-1})	PO_4^{3-} (mgl^{-1})	K (mgl^{-1})	TDS (mgl^{-1})
Temp.(°C)	1								
pH	-0.790*	1							
DO (mgl^{-1})	0.039	0.665*	1						
BOD (mgl^{-1})	0.154	0.926*	0.926*	1					
COD (mgl^{-1})	-0.186	-0.937*	-0.944*	-0.945*	1				
NO_3-N (mgl^{-1})	0.176	0.946*	0.949*	0.958*	-0.970*	1			
PO_4^{3-} (mgl^{-1})	0.173	0.946*	0.949*	0.958*	-0.969*	0.967*	1		
K(mgl^{-1})	-0.194	-0.963*	-0.964*	-0.973*	0.957*	-0.980*	-0.980*	1	
TDS (mgl^{-1})	-0.174	-0.956*	-0.957*	-0.968*	0.957*	-0.974*	-0.974*	-0.854*	1

*=indicated correlation is significant at the 0.05 level

Table 4: Simple correlation matrix (r) among different physico-chemical parameters of a pond at Dumurdaha (site 2)

	Temp. (°C)	pH	DO (mgl^{-1})	BOD (mgl^{-1})	COD (mgl^{-1})	NO_3-N (mgl^{-1})	PO_4^{3-} (mgl^{-1})	K (mgl^{-1})	TDS (mgl^{-1})
Temp. (°C)	1								
pH	-0.848*	1							
DO (mgl^{-1})	-0.204	-0.723*	1						
BOD (mgl^{-1})	-0.041	0.929*	0.924*	1					
COD (mgl^{-1})	0.012	-.940*	-0.943*	-0.950*	1				
NO_3-N (mgl^{-1})	-0.019	0.946*	0.943*	0.959*	-0.973*	1			
PO_4^{3-} (mgl^{-1})	-0.022	0.946*	0.943*	0.959*	-0.973*	0.967*	1		
K(mgl^{-1})	0.001	-0.964*	-0.960*	-0.974*	0.959*	-0.980*	-0.980*	1	
TDS (mgl^{-1})	0.089	-0.951*	-0.947*	-0.961*	0.963*	-0.968*	-0.968*	-0.867*	1

*=indicated correlation is significant at the 0.05 level

Conclusion

All these three infraspecific taxa of the genus *Micrasterias* are first time records from West Bengal, India. The abundances and distributions of these species were depended on water parameters and the seasonal changes of climatic conditions. In the present work, ecological characteristics showed that they occurred in less polluted water and any alarming parameters of water quality deterioration that is responsible for decline of species diversity of algae was not found in both the studied sites. As a management strategy and to conserve those algal flora for sustainability, time to time remodifications of the water bodies could be done by adding required nutrients in waters (Jyotsna *et al*., 2014). In addition to that, periodic monitoring by the environment agencies as mentioned by Krokowski and Jamieson (2002) should be required to save these sites from eutrophic conditions. National conservation strategies might be strictly implemented to prevent the loss of those useful aquatic habitats and to save these natural sites of algal occurrences. Thus, these particular species need to conserve so that they do not get extinct in near future from their known habitats. Therefore, this investigation will be helpful for further research works regarding algal taxonomy and ecological study.

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