



Taxonomic diversity of genus *Lepocinclis*, *Strombomonas*, *Cyclidiopsis* and *Colacium* in different wetlands of Bhagalpur District, Bihar, India

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Abstract

The present paper is an attempt to explore the genera *Lepocinclis*, *Strombomonas*, *Cyclidiopsis* and *Colacium* and to make a taxonomical account on it, from different selected wetlands of Bhagalpur District, Bihar. The algal samples were collected seasonally from the wetlands located in the sixteen blocks of Bhagalpur district, Bihar. The study was conducted from December 2020 to June 2022, using the standard methods. This study revealed presence of 22 species of Euglenoids consisting of 4 genera namely *Strombomonas*, *Lepocinclis*, *Cyclidiopsis* and *Colacium* from wetlands of Bhagalpur district. Among all the species, presence of species like *Strombomonas gibberosa*, *Strombomonas acuminata*, *Lepocinclis ovum*, *Lepocinclis acus* and *Lepocinclis texta* were found often in wetlands of district. On the other hand species like *Strombomonas schauinslandii*, *Lepocinclis playfairiana*, *Cyclidiopsis acus* and *Colacium arbuscula* showed their presences as rare species in selected wetlands.

Keywords: Freshwater, taxonomy, *Colacium*, *Cyclidiopsis*, *Lepocinclis*, and *Strombomonas*

Introduction

The diversity of Euglenophyceae is determined by the level of its richness and their functional importance in the process they mediate. Euglenoids are unicellular flagellates numbering around 1500 in species count and are commonly found in freshwater especially when it is rich in organic material (Leander *et al.*, 2017) [21]. The genus *Strombomonas* (Deflandre, 1930) [9] is well known algae for a group of interesting and widely distributed euglenoid flagellate. They have been subject of controversy regarding the validity of its separation from genus *Trachelomonas*. In 1930 Deflandre subsequently elevated members of the *Trachelomonas* sub group “Saccatai” to generic level and renamed it *Strombomonas*. He combined 33 species and 28 taxonomical variations from the genus *Trachelomonas* to from this new genus. His work was based on morphological characteristics such as shape of lorica (metal – incrustated envelop), possession of a tail piece, lack of distinctive collar and regular ornamentation. Along with that he also put emphasis on ability of *Strombomonas* species to aggregate detritus particles on the lorica surface. The lorica is a protective envelope surrounding the protoplast, whose shape ornamentation and size acts as key diagnostic traits for species identification. According to Algal base there are 275 *Strombomonas* names (specific and intraspecific) only 96 of which are taxonomically accepted species name (Guiry, 2018) [15]. Genus *Lepocinclis* was first describe in the 19th century (Perty, 1849) [26] but its diagnostic description was updated in 21st century after molecular data was used to transfer five species from *Euglena* to *Lepocinclis*. They are forms with a rigid periplast that possess resting stage (Fritsch, 1935) [13]. It differ from *Euglena* in being completely rigid and from *Phacus* in being unflattened. The species of this genus is identified mainly by characters like numerous discoidal, parietal chloroplasts without pyrenoids. This planktonic organism is cosmopolitan but predominantly present or found in lakes, ponds and streams some species have been found in brackish water (Marin and

Melkonian, 2003) [4]. Conrad 1934 [7], 1935 was the first to produce a taxonomical and monographic study of 78 taxa. Currently there are over 114 species names (as well as 176 intraspecific names) listed under *Lepocinclis* in Algae base of which 85 are flagged as taxonomically accepted (<http://www.algaebase.org>) (Guiry and Guiry, 2021) [14]. *Colacium* is cosmopolitan genus of phytoplankton which complete its lifecycle in two phase, a motile phase and other sessile phase in which it is attached to aquatic invertebrates such as copepods, rotifers etc. It was firstly reposted by Ehrenberg, 1833 [11]. The genus *Colacium* is of wide spread occurrence with numerous species describe but species are rarely encountered (Johnson, 1934) [16]. The apparent rarity of species and the lack of any extensive work on the genus can be attributed to several factors. Firstly, the organism is easily confused with *Euglena*, particularly in the motile stage (Skuja, 1948) [36]. The distinguishing feature are the inner projecting pyrenoids and the attached of motile cells by their anterior apex to a substrate, whereby they become non-motile. According to (Starmach, 1983) [39] the genus contain 9 species to 25 species (Sliva, 2007) which are typically epibionts on freshwater arthropods. The most interesting observations on *Colacium* were reported by Rosowski and Kugrens (1973) [31]. *Colacium* attached to loricated Euglenoids has been reported so far by Skvortzov (1957) [37], Fott and Komárek (1960) [12], Kaštovský *et al.* (2009) [18] and Juráň (2010) [17]. Many research papers have been documented the abundant development of Euglenoids in countries with a warm and temperate zone such as (Poniewozik 2009, Duangjan and Wolowski, 2013) [10, 29].

Study Area

Bhagalpur district is located in the southern part of Bihar in the Ganga basin and extends between the northern latitudes of 25° 03'40" and 25°30'00" and eastern longitudes of 86°30'00" and 87°29'45". It has three sub-divisions consist of sixteen community development blocks namely Pirpainti, Kahalgaon, Sanhoula, Sabour, Nathnagar, Jagdishpur,

Sultanganj, Shahkund, Bihpur, Naugachhia, Gopalpur, Kharik, Narayanpur, Goradih, Ismailpur, and Rangra Chowk. From each blocks we have selected two sampling

sites. Their name and GPS coordinates are given below in table 1.

Table 1: Name of the sampling sites with their GPS coordinates

Name of the Blocks	Name of the Wetlands	GPS coordinates in DMS	GPS coordinates in DMS
1.Nathnagar	Kajrauli Pokhar (Govt.)	lat-N 25°8'51"	long-E 86°56'04"
	Digghi Pokhar (Govt./Private)	lat-N 25°13'22"	long-E 86°56'02"
2.Jagdishpur	Block Office Pond (Govt.)	lat-N 25°06'49"	long-E 86°59'06"
	Jamgaon Talab (Private)	lat-N 25°09'08"	long-E 86°58'28"
3.Pirpanti	Jichho Pokhar (Govt.)	lat-N 25°18'56.25"	long-E 87°25'53.94"
	Majhrohi Pokhar	lat-N 25°17'16.7"	long-E 87°26'08.6"
4.Kahalgaon	Bajrangbali Pond	lat-N 25°15'03.5"	long-E 87°15'18.2"
	Kua Nala	lat-N 25°15'9"	long-E 87°13'44"
5.Shahkund	Shahkund Market Pokhar (Govt.)	lat-N 25°09'57.37"	long-E 86°49'10.79"
	Purandaha Pokhar (Govt.)	lat-N 25°09'35.46"	long-E 86°48'22.62"
6.Sultanganj	Bhudhani Talab (Govt.)	lat- N 25°14'27.0"	long-E 86°43'39"
	Sultanganj Block Office Pond (Govt.)	lat-N 25°14'48.16"	long-E 86°14'59.37"
7. Sabour	Lalmatiya/Khankitta Pokhar (Govt.)	lat- N 25°14'17"	long E 87°03'12"
	Bhitti Birniya Pokhar (Govt.)	lat N 25°14'20"	long E 87°02'50"
8. Goradih	Kumrah Pokhar (Govt.)	lat N 25°08'51"	long E 87°03'14"
	Badari Pokhar (Govt.)	lat N 25°06'04"	long E 87°02'51"
9. Sanhoula	River Michhi	lat-N 25°04'58.5"	long-E 87°09'40.4"
	Dasrath Pokhar (Private)	lat-N 25°09'14.80"	long-E 87°09'57.63"
10. Gopalpur	Mahavir Pokhar (Private)	lat N 25°21'26"	long E 87°09'19"
	Saidpur Pokhar (Private)	lat N 25°20'55"	long E 87°09'52"
11. Ismailpur	Luxmipur Dhar	lat N 25°20'33"	long E 87°06'15"
	Dimha Jalkar	lat N 25°19'14"	long E 87°08'38"
12. Rangra Chowk	Parihara Kundi Dhar (Govt.)	lat N 25°23'54"	long E 87°10'10"
	Sitwal Pokhar	lat N 25°23'31"	long E 87°09'07"
13. Naugachhia	Tilljugiya Jalkar (Govt.)	lat N 25°23'30"	long E 87°05'53"
	Jagatpur Wetland	lat N 25°20'21"	long E 87°02'62"
14. Kharik	Govt. Pond	lat N 25°23'13"	long E 86°59'42"
	Dehri Talab (Govt.)	lat N 25°23'42"	long E 87°00'23"
15. Narayanpur	Birbanna Dhala (Private)	lat N 25°24'10"	long E 86°53'07"
	Private Pond	lat N 25°24'10"	long E 86°51'49"
16. Bihpur	Kalbaliya Dhar (Rly + Private)	lat N 25°20'41"	long E 86°57'22"
	Dayalpur Pokhar (Private)	lat N 25°23'18"	long E 86°58'24"

Material and Methods

The phytoplankton samples were collected seasonally from December 2020 to June 2022 from different wetlands of the Bhagalpur district. Samples were collected with the help of plankton net of 65µmesh size and the filtered contents was then transferred to 125 ml container. The filtrate was immediately preserved in 4% formaldehyde and was transported to the Environmental Biology Research Laboratory of University Department of Botany, T. M. Bhagalpur University. The taxonomical study has been undertaken on a calibrated compound microscope with 45X objective and slides were preserved by fresh materials and mounting was done by glycerin. The line drawing of algal taxa were made with the help of prism type camera lucida technique using pencil under appropriate magnification. For current publication of manuscript only photographic images have been used from (Plate: I - II). The identification of both the taxa was done with the help of pertinent literature and monographs on algal taxonomy (Prescott 1962, Philipose 1984 [28], Smith 1950, Alves-da-Silva and Hahn 2001, Wehr and Sheath 2003, Roy and Pal 2016, Satpati and Pal, 2017) [1, 30, 32, 34, 38, 42].

Results

In present work a total of 22 species within 4 genera of class Euglenophyceae (i.e. *Lepocinclis*, *Strombomonas*, *Cyclidiopsis* and *Colacium*) were identified, recorded and

taxonomically described during the study period of two years from selected wetlands of Bhagalpur district, Bihar. List of taxa with taxonomical comments

Division – Euglenophyta

Class – Euglenophyceae

Order - Euglenales

Family – Euglenaceae

***Strombomonas borystheniensis* (Y.V. Roll), Deflandre, 1930** [9]

Lorica ovoid, broad, neck oblique, light brown in color, length 22.2µm, width 18.5µm, fig. 50 h, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.) Vol. 98, No. 5, October 1988 [27], pp 317-398.

***Strombomonas ensifera* (Daday) Deflandre, 1930** [9]

Lorica large, rhomboid in middle, narrow towards front end, long neck, oblique towards hind, long pointed tail, length 55.5µm, width (middle) 37µm, anterior length 11.1µm, tail length 18µm, fig. 64 a, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas gibberosa* (Playfair) Deflandre, 1930** [9]

Lorica rhomboid, sides slightly concave, median broad, neck oblique, tail straight, pointed, fig. 62 b, M. T.

Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas verrucosa* (Daday) Deflandre 1930 [9] Var. *zmiewika* (Swirenko) Deflandre, 1930 [9]**

Lorica ellipsoid, top shaped, middle broad, front end narrow pointed, lorica granulated, brown in color, length 37µm, width 22.2µm, tail length 11.1µm, fig. 50 l, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas tortuosa* M. T. Philipose, 1992**

Lorica rhomboid, irregular, winged in front view, middle broad, oblique cut neck, straight tail, dark brown in color, length 81.4µm, width 37µm, neck length and width 7.4µm, tail length 37µm, fig. 70 a-c, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas lanceolata* (Playfair) Deflandre, 1930 [9]**

Lorica broad, elliptical, slightly oblique collar, anterior ending short, posterior conical, very small caudal process, yellow green in color, length 18.5µm, width 14.8µm; Acta bot. bars. 18 (3): 555-572, 2004, fig. 12 (d), Turk J. Fish & Aquatic Sci. 22 (8), TRJFAS 19319, 2022.

***Strombomonas eurystoma* (Stein) T. G. Popova fam. *incurve* (Buzeuko) Popova, 1966**

Lorica broad, ovate, narrow at anterior end, neck very short, posterior end wide, brown in color, length 44.4µm, width 27.7µm, fig. 2, Eur. J. Phycol. 42 (4):409- 431, 2007.

***Strombomonas fluviatilis* (Lemmermann) Deflandre, 1930 [9]**

Lorica ellipsoid, spindle shaped, narrow neck, hind end short tail, collar cylindrical, light brown in color, length 25.9µm, width 11.1µm, neck length and width 3.7µm, tail 1.8µm, fig. 58 a, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas schauinslandii* (Lemmermann) Deflandre, 1930 [9]**

Lorica cuneiform, sides rounded cylindrical neck, smooth margin, straight tail, light yellow brown in color, length 29.6µm, width 11.1µm, neck length 5.5µm, neck width 3.7µm, tail length 14.8µm, fig. 61 b, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas rotunda* (Playfair) Deflandre, 1930 [9]**

Lorica ellipsoid, body broad, neck straight, slightly curved, tail long, short flagellum, dark brown in color, length 24µm, width 12.9µm, neck length 7.4µm, tail length 5.5µm, fig. 59, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 98. No. 5, October 1988 [27]. Pp. 317-394.

***Strombomonas treubii* (Wolowski) Deflandre Arch., 1930 [9]**

Lorica elliptical, median region large, rounded polar sight, oblique collar, posterior pole conical, brown reddish in color, length 62.9µm, width 18.5µm, collar length 7.4µm, tail length 11.1µm, fig. 48-49, Acta bot. bars., 18(3): 555-572, 2004.

***Strombomonas acuminata* (Schmarda) Deflandre Var. *deflandriana* Conrad, 1952**

Lorica elliptical, anterior cylindrical collar, posterior narrow, tail straight, yellow brown in color, length 48.1µm, width 22.2µm, collar length and width 3.7µm, tail length 7.4µm, Acta bot. bars.18 (3): 555-572, 2004.

***Lepocinclis glabra* Drezepolski, 1925**

Cell ellipsoidal, middle broad, anterior shortened, posterior sharp end, tail straight, yellow-green in color, length 48.1µm, anterior and posterior width 14.8µm, middle width 29.6µm, tail length 11.1µm, pl. 2a, Biological Applied Environment Research, Vol. 5(1):114-129, 2021.

***Lepocinclis playfairiana* (Deflandre) Deflandre, 1932**

Cell fusiform, slight depression on one side at anterior, forming beat at tip, posterior long tail, slightly bent at one side, yellow-green in color, length 55.5µm, width 11.1µm, width (caudal), tail length 18.5µm, pl 6(i), Biological Applied Environment Research, Vol. 5(1):114-129, 2021; fig. 9a, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.) Vol. 93, No. 5, October 1984 [28], pp 503-562.

***Lepocinclis fusiformis* (Carter) Lemmermann, Emend, Conrad, 1935 [8]**

Cell broad, fusiform, blackish-green in color, anterior end blunt, posterior end slightly pointed, two large oval rings one in each side, length 33.3µm, width 22.2µm, fig. 7a-b, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.) Vol. 93, No. 5, October 1984 [28], pp 503-562.

***Lepocinclis steinii* Lemmermann Emend, Conrad, 1935 [8]**

Cell fusiform, anterior end beak like, posterior short conical straight tail, deep brown in color, chromatophores numerous, small, rounded, length 29.6µm, width 11.1µm, tail length 3.7µm, fig. 2a, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.) Vol. 93, No. 5, October 1984 [28], pp 503-562.

***Lepocinclis ovum* (Ehrenberg) Lemmermann, 1901**

Cell ovoid, dark green in color, broad, anterior and posterior end rounded, posterior blunt projection, chloroplast numerous, length 25.9µm, width 14.8µm, fig. 4 a, M. T. Philipose, Proc. Indian Acad. Sci. (Plant Sci.) Vol. 93, No. 5, October 1984 [28], pp 503-562; fig. 2 J, *Phykos* 47(1): 105-122, 2017; fig. 6-7, Bangladesh J. Plant Taxon 28(1): 11-12, 2021, L C Saha, J. Econ. Tax. Bot. Vol.7 No.3, 1985 [33].

***Lepocinclis acus* (O. F. Muller) Marin & Melkonian, 2003 [4]**

Cell long, green in color, elongated, pointed posterior end, truncate anterior end, chloroplast numerous, paramylon bodies two, rod shaped, length 71µm, width 8µm, *Protist*, Volume 154, page 99-145, 2003, fig. 6, 30, *Algologie*, 31(3): 305- 319, 2010, fig. 3 a, Turk J. Bot. 37: 1176-1187, 2013.

***Lepocinclis texta* (Dujardin) Lemmermann, Emend, Conrad, 1935 [8]**

Cell ovoid, dark green in color, anterior end rounded, posterior end narrow, chloroplast numerous, caudal short, length 50µm, width 31.5µm, fig. 1(K), *Phykos*, 47(1): 105-122, 2017; fig.7a, b; Bangladesh J. Plant Taxon, 15(2): 107-114, 2008.

***Lepocinclis teres* (Schmitz) France fam. *parvula* Conrad, 1935^[8]**

Cell ovoid, anterior broad, rounded, posterior narrow, caudal short dark green in color, length 37µm, width 25.9µm, pl. 1, fig. 9a, b; Bangladesh J. Plant Taxon, 15(2): 107-114, 2008.

***Cyclidiopsis acus* Korschikow, 1917**

Cell cylindrical, anterior pole squared with apical opening, tapered conical posterior pole, pyramid 7-9, rod-shaped emergent flagellum, cell length 230µm width 7.5µm, tail

15µm, tail width 1.8µm, fig. 2 &3, Acta Botanica Brasilia 23 (4): 1076-1083, 2009.

Order – Colaciales

Family – Coaliaciaceae

***Colacium arbuscula* Stein, 1878**

Cell elliptic, joined by a branched gelatinous stalk to form plume like, chloroplast many ovoid cells, dark brown in color, Cell diameter 9.25µm, length 11.1µm, fig. 22, Pl. 89, G. W. Prescott, 1962^[30], pp 977, NeBIO, fig.1 (24), Vol. 2, No. 4, December, 2011, 36-40.

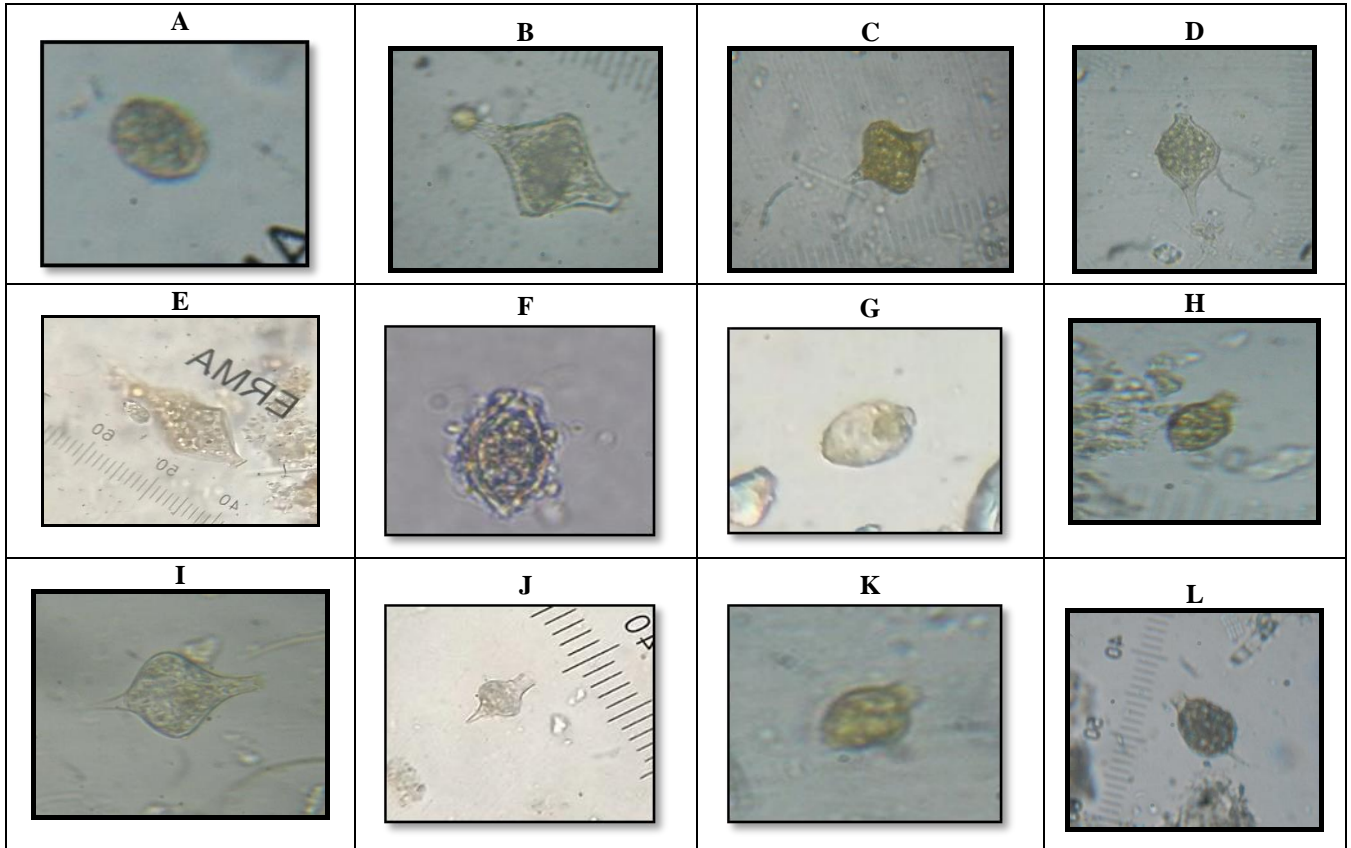
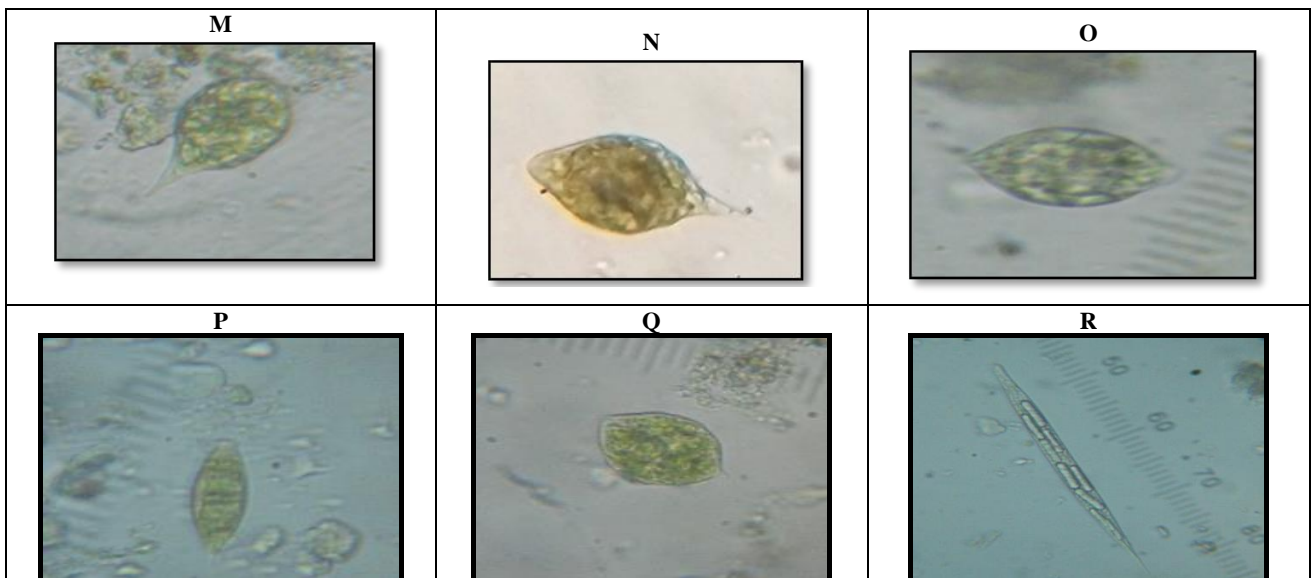


Fig 1: (A) *Strombomonas borysthensiensis*, (B) *Strombomonas ensifera*, (C) *Strombomonas gibberosa*, (D) *Strombomonas verrucosa* var. *zmiewika*, (E) *Strombomonas tortusa*, (F) *Strombomonas lanceolata*, (G) *Strombomonas eurystoma*, (H) *Strombomonas fluviatilis*, (I) *Strombomonas schauinslandii*, (J) *Strombomonas rotunda* (K) *Strombomonas treubii* (L) *Strombomonas acuminata* var. *deflandriana* (Scale 45µm)



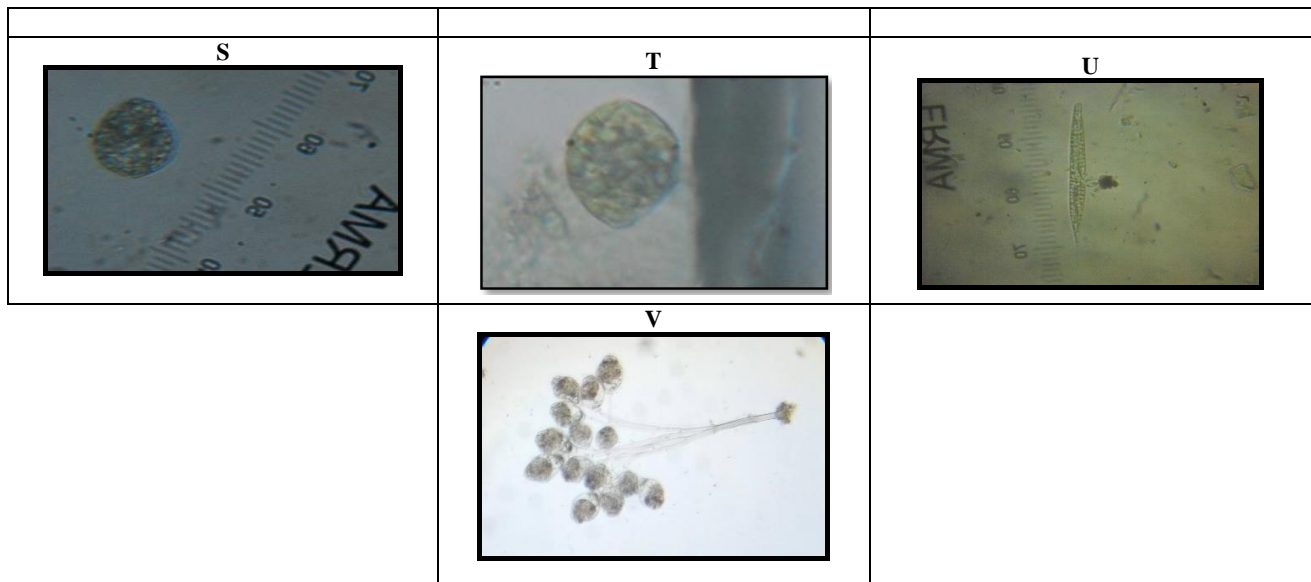


Fig 2: (M) *Lepocinclis glabra*, (N) *Lepocinclis playfairiana*, (O) *Lepocinclis fusiformis*, (P) *Lepocinclis steinii*, (Q) *Lepocinclis ovum*, (R) *Lepocinclis acus*, (S) *Lepocinclis texta*, (T) *Lepocinclis teres f. parvula*, (U) *Cyclidiopsis acus* (V) *Colacium arbuscula* (Scale 45µm)

Discussion

This study revealed presence of 22 species of Euglenoids consisting of 4 genera namely *Strombomonas*, *Lepocinclis*, *Cyclidiopsis* and *Colacium* from wetlands of Bhagalpur district. Among all the species, presence of species like *Strombomonas gibberosa*, *Strombomonas acuminata*, *Lepocinclis ovum*, *Lepocinclis acus* and *Lepocinclis texta* were found often in wetlands of district. On the other hand species like *Strombomonas schauinslandii*, *Lepocinclis playfairiana*, *Cyclidiopsis acus* and *Colacium arbuscula* showed their presences as rare species in selected wetlands. According to Palmer (1969) [25] we can also state that presence of species like *Lepocinclis ovum* and *Lepocinclis texta* may be responsible for organic pollution in the wetlands since both the species are the most pollution tolerant species of algae. In this study there were several other species that were suspected to be members of class Euglenophyceae but could not be determined due to lack of taxonomical information needed to determine the species name, further research needs to be done for more accurate results.

Conclusion

This study was to explore the species diversity of class Euglenophyceae in some of the wetlands of Bhagalpur district. During this study a total of seven genera of class Euglenophyceae were reported from whole district out of them four genera namely *Strombomonas*, *Lepocinclis*, *Cyclidiopsis* and *Colacium* have been deal in this paper. From the results it may be concluded that the environmental condition and water quality of wetlands of the district are favorable for the growth of different genera of class Euglenophyceae.

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Author's Contribution

Shadia Rahman (1st author) and Braj Nandan Kumar (2nd author) contributed in laboratory analysis, taxonomic identification of species and collected the data. 1st and 2nd

author contributed in the preparation and writing of the manuscript. Sunil Kumar Choudhary (3rd author) reviewed and revised the draft and approved the submission of the manuscript.

Conflict of interest: The authors declare that there is no conflict of interest regarding publication of this manuscript.

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