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Taxonomical diversity of genus *Euglena* (Ehrenberg – 1838) in different wetlands of Bhagalpur District, Bihar, India

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Abstract
Wetlands are one of the most important ecosystem, which are highly productive and biologically diverse in nature. They act as a home for both aquatic and terrestrial living organism and support its food web. While studying the algal taxonomy of different wetlands of Bhagalpur district, Bihar during December 2020 to June 2022, the author come across various algal communities which are also a good biological indicators of water quality. Among all the members of Euglenoids studied i.e. *Euglena, Phacus, Lepocinclis, Strombomonas, Trachelomonas, Cyclidiopsis*, and *Colacium.* In this paper we will focus on Genus *Euglena*. The algal samples were collected seasonally from the wetlands located in the sixteen blocks of Bhagalpur district. The sampling was performed following standard methods. Based on the available investigative information a total of 18 taxa of *Euglena* were recorded from various wetlands. This baseline analysis will help to understand the taxonomy and morphology of freshwater Genus *Euglena* and will pave a way for upcoming researchers, conservationists, and scientists to improve the taxonomic system of the genus. The *Euglena* community in the present study includes the following taxa: *Euglena oxyuris, E. gracilis, E. limnophila, E. viridis, E. clavata, E. acus, E. gaumei, E. proxima, E. deses, E. rostrifera, E. sanguine, E. pisciformis, E. granulate, E. texta, E. mutabilis, E. anabaena, E. tuberculata* and *E. acus* var. *rigida*

Keywords: Euglenophytes, *Euglena*, freshwater

Introduction

Euglenophytes are the planktonic microorganism, unicellular flagellates, free living protista which are phototrophic that contributes to the primary productivity of an aquatic ecosystem. Euglenophytes is an important group in terms of its richness and abundance in shallow aquatic ecosystem with higher concentrations of organic materials (Singh and Dwivedi, 2009) [19]. Euglenophytes are mostly studied for their ecological importance as an indicators of organic pollution due to their nature of switching between photosynthesis and carbon utilization i.e. mixotrophic mode of nutrition. The genus *Euglena* (Ehrenberg, 1838) belongs to division Euglenophyta, order Euglenates and family Euglenaceae. The name *Euglena* comes from a Greek word meaning "eyeball organism'' (Brocklesby, 1851) [6]. The genus *Euglena* were among the first protists viewed under the microscope and characterized as unicellular eukaryotes. They are green colored, free swimming, spindle, cylindrical, ovate or band-form micro algae. They are motile due to presence of single whip like flagella or some time crawling due to non-motile palmella. Euglena grow luxuriantly in freshwater and marine environment which are rich in organic matter and shallow turbid in nature such as ponds, lakes, ditches, puddles river. Some of the species like *Euglena sanguinea* and *Euglena gracilis* can form "green or red blooms" in water bodies indicating its presence. Some of the species can grow well on moist soil.

In India, considerable works has been done about systematic survey and diversity of freshwater Euglenoids (Philipose 1982 [12], 1984 [14], 1988 [13], Ratha *et al.*2006 [16], Arulmurugan *et al.* 2010 [4], Satpati and Pal, 2017 [18] Roy and Pal, 2016) [17]. The present work is an attempt to explore the genus *Euglena* diversity and make a taxonomic account on it from the selected wetlands of Bhagalpur District, Bihar.

Study Area

Bhagalpur district is one of the thirty-eight districts of Bihar state, India. Bhagalpur is the oldest district of Bihar. Bhagalpur city is the administrative headquarters of this district. It is extended between the northern latitudes of 25° 03'40" and 25°30'00" and eastern longitudes of 86°30'00" and 87°29'45". It occupies an area of 2570 km^2. The river Ganga flows through it and the district is situated in the Ganga basin at 141 feet above the sea level. Bhagalpur Sadar, Kahalgaon, and Naugachhia are the three sub-divisions of the district with a total of sixteen community development blocks namely Pirpainti, Kahalgaon, Sanhoula, Sabour, Nathnagar, Jagdishpur, Sultanganj, Shahkund, Bihpur, Naugachhia, Gopalpur, Kharik, Narayanpur, Goradih, Ismailpur, and Rangra chowk. The wetlands in these sixteen community development blocks were surveyed for documenting the taxonomic diversity of the genus *Euglena.* The selected sampling sites from all the sixteen blocks have been shown in Fig.1.

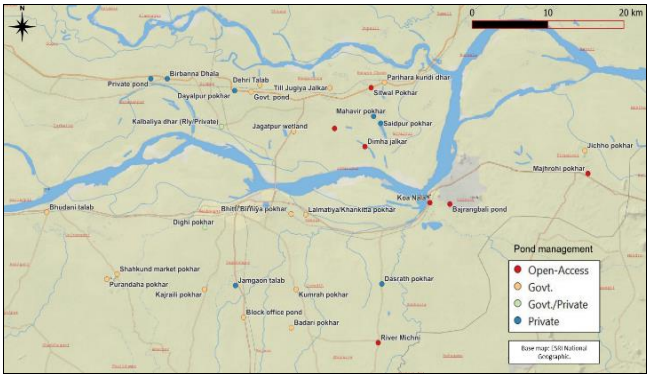


Fig 1: Different Sampling Sites of Bhagalpur District

Material and methods

The algal sample collection was done seasonally from December 2020 to June 2022 from different wetlands of the Bhagalpur district. A sampling bottle of 125 ml was used for collecting water through a phytoplankton net of 65µmesh size. 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 transported samples were analyzed following standard method (APHA, 2005). The algal taxa were observed under a light microscope with a high magnification of 45X. For taxonomic diversity studies camera lucida technique was adopted for writing diagram. For current publication of manuscript only photographic images have been used in (Plate – I & II). *Euglena* was identified up to species level using relevant literature and monographs on algal taxonomy (Prescott 1962 [15], Philipose 1982 [12], 1984 [14], Cramer, 1984 [7], Roy and Pal, 2016 [17], Satpati and Pal, 2017) [18].

Results

In the present study, 18 taxa of the genus *Euglena*, freshwater free-swimming Euglenophytes, was recorded and described. The following are the taxonomical comments on the recorded taxa of *Euglena.*

Taxonomy of Euglenophyta

Division - Euglenophyta
Class - Euglenophyceae
Order - Euglenales
Family - Euglenaceae
Genus – Euglena

Taxonomical identification of taxa *Euglena*

***Euglena oxyuris* Schmarda 1846 var. *minor* Prescott 1944 (Fig. A, Pl. I)**

Body elongated, green in color, flattened, cylindric, anterior end rounded, posterior end form short tail piece, chloroplast numerous, chloroplast numerous, disc like, paramylon two, large, flattened ring, one anterior and one posterior, length 114.7µm, apical width 7.4µm, middle width 18.5µm, tail length 14.8µm, pl. 85, fig. 18, G. W. Prescott, 1962 [15], page 393.

***Euglena gracilis* Klebs 1883 (Fig. B, Pl. I)**

Body fusiform, green in color, elongate, anterior rounded, posterior bluntly pointed, chloroplast many, disc shaped, length 37µm, width (anterior) 3.5µm, width (middle) 11.1µm, width (posterior) 7.4µm, fig. 19 a-b, page 385, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599, pl. 85, fig. 17, G. W. Prescott, 1962 [15], page 393.

***Euglena limnophila* Lemmermann 1898 (Fig. C, Pl. I)**

Body spindle shaped, green in color, truncate anterior end, slightly curved tail at posterior end, chloroplast small numerous, paramylum two, rod shaped, length 77.7µm, width (anterior) 7.4µm, width (middle) 18.5µm, tail length 11.1µm, fig. 4 a-c, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599.

***Euglena viridis* Ehrenberg 1830 [8] (Fig. D, Pl. I)**

Body fusiform, color green, anterior end rounded, posterior end conical, narrow cylindrical tail, widest in the middle length of cell, chloroplast numerous, length 55.5µm, width (anterior) 3.7µm, width (middle) 18.5µm, tail length 18.5µm, fig 23 b, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599, Phytomorphology, fig. 2b, 66 (3&4), 2016, pp-113-121.

***Euglena clavata* Skuja 1948 (Fig. E, Pl. I)**

Cell dark green in color, ovoid, spindle shaped, fusiform, anterior elliptical, posterior tapered into tail, chloroplast numerous, small, rounded, paramylum ovoid, length 37µm, width 25.9µm, tail length 11.1µm, plate 1, fig. 7, Algae, Volume 21(1),: 61-73, 2006,

***Euglena acus* Ehrenberg 1830 [8] (Fig. F, Pl. I)**

Body long, color green, elongate, cylindrical, anterior end narrow, truncate, slight constriction, posterior end sharply pointed tail, chloroplast numerous, disc like, paramylon many, length 133.2µm, width 7.4µm, tail length 14.8µm, pl 85, fig. 28, G. W. Prescott, 1962 [15], page 390, fig. 1 c, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599.

***Euglena gaumei* P. Allorge & M. Lefevre 1933 (Fig. G, Pl. I)**

Cell spindle shaped, green in color, anterior and posterior end pointed, chloroplast numerous, length 55.5µm, width 11.1µm, fig. 3, Bangladesh J. plant Taxon 28(1): 11-15, 2021 (June), Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, page 571.

***Euglena proxima* Dangeard 1902 (Fig. H, Pl. I)**

Cell fusiform, color green, anterior broad, posterior narrow, blunt tip, chloroplast numerous, paramylon bodies numerous, small rod like structure on the cell, length 74µm, Width (apical) 14.8µm, width (middle) 29.6µm, pl 85, fig. 25, G. W. Prescott, 1962 [15], page 394.

***Euglena deses* Ehrenberg 1835 (Fig. I, Pl. I)**

Cell elongate, green in color, subcylindric, anterior end blunt, posterior short tail, chloroplast numerous, paramylon bodies many in the form of rod, length 62.9µm, width (apical and posterior) 7.4µm, width (middle) 9.2µm, pl 85, fig 20, G. W. Prescott 1962 [15], pl 1, fig. 8, Algae, Volume 21 (1):61-73, 2006, fig. 2f, Phytomorphology 66 (3&4), 2016, 113- 121,

***Euglena rostrifera* L. P. Johnson 1944 (Fig. J, Pl. II)**

Cell fusiform, green in color, chloroplast numerous, pellicle spirally striated, paramylon 2, rounded, anterior end narrow, posterior short tail, middle wide, length 74µm, width 14.8µm, tail length 14.8µm, fig. 1 E, Phykos 47 (1), 105-122, 2017.

***Euglena sanguinea* Ehrenberg 1838 (Fig. K, Pl. II)**

Cell ovoid, green in color, subcylindric, anterior end rounded, posterior end tapering to short blunt tail piece, chloroplast numerous, paramylon bodies several to many

ovoid grain, length 59.2µm, width 29.6µm, pl 86, pl 1,2; G. W. Prescott 1962 [15], fig. 22 (a-d), page 592, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599.

***Euglena pisciformis* Klebs 1883 (Fig. L, Pl. II)**
Body cylindrical, green in color, anterior end rounded, posterior end blunt pointed, chloroplast two, elongated, paramylon rod like, length 37µm, width 14.8µm, fig. 16 (a-c), page 582, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599.

***Euglena granulata* (Klebs) Schmitz 1884 (Fig. M, Pl. II)**
Body fusiform, color green, anterior end conical, bluntly rounded at apex, posterior end narrowed, chloroplast numerous, saucer shaped, length 70.3µm, width 14.8µm, tail length 11.1µm, fig. 17 c, page 582, Proc. Indian Acad. Sci. (Plant Sci.), Vol. 91 Number 6 December 1982, pp. 551-599.

***Euglena texta* (Dujardin) Hubner1886 (Fig. N, Pl. II)**
Cell ovoid, color green, anterior end slightly narrowed, posterior end broadly rounded, length 37µm, and width 29.6µm, fig. 5 a, Turk. J. Bot. (2013) 37: 1176-1187, Plate 1 a, Biological Applied Environment Research, Vol. 5 (1): 114-129, 2021, fig. 41; plate IV: 1-2, Konrad Wolowski, Fragm. Flor. Geobot. Suppl. 6:3-192, 1998.

***Euglena mutabilis* F. Schmitz, 1884 (Fig. O, Pl. II)**
Cell narrowly cylindrical, slender spindle shaped, anterior rounded, posterior tapered, chloroplast numerous, paramylum bodies ovoid, small rod like, length 118.4µm, width 11.1µm, pl 2, fig. 16, IJCRT, Vol.9 Issue 10 October 2021, pp.b521- b529

***Euglena anabaena* Mainx 1926 (Fig. P, Pl. II)**
Cell spindle shaped, anterior end rounded, posterior end narrowing to tail piece, chloroplast numerous, large, plate shaped with folded edges, paramylum small and few, length 48.1µm, width (middle) 18.5µm, Width (Apical) 7.4µm, pl 350, page 152, John *et al*.; The fresh water Algal flora of British Isles, 2002.

***Euglena tuberculata* Swirenko 1915 (Fig. Q, Pl. II)**
Body fusiform, anterior rounded, posterior conical, narrow, middle of the body wide, tail narrow and short, length 44.4µm, width (middle) 18.5µm, Width (anterior) 7.4µm. fig. 2 (g, j), Phytomorphology, 66 (3&4) 2016, 113-121.

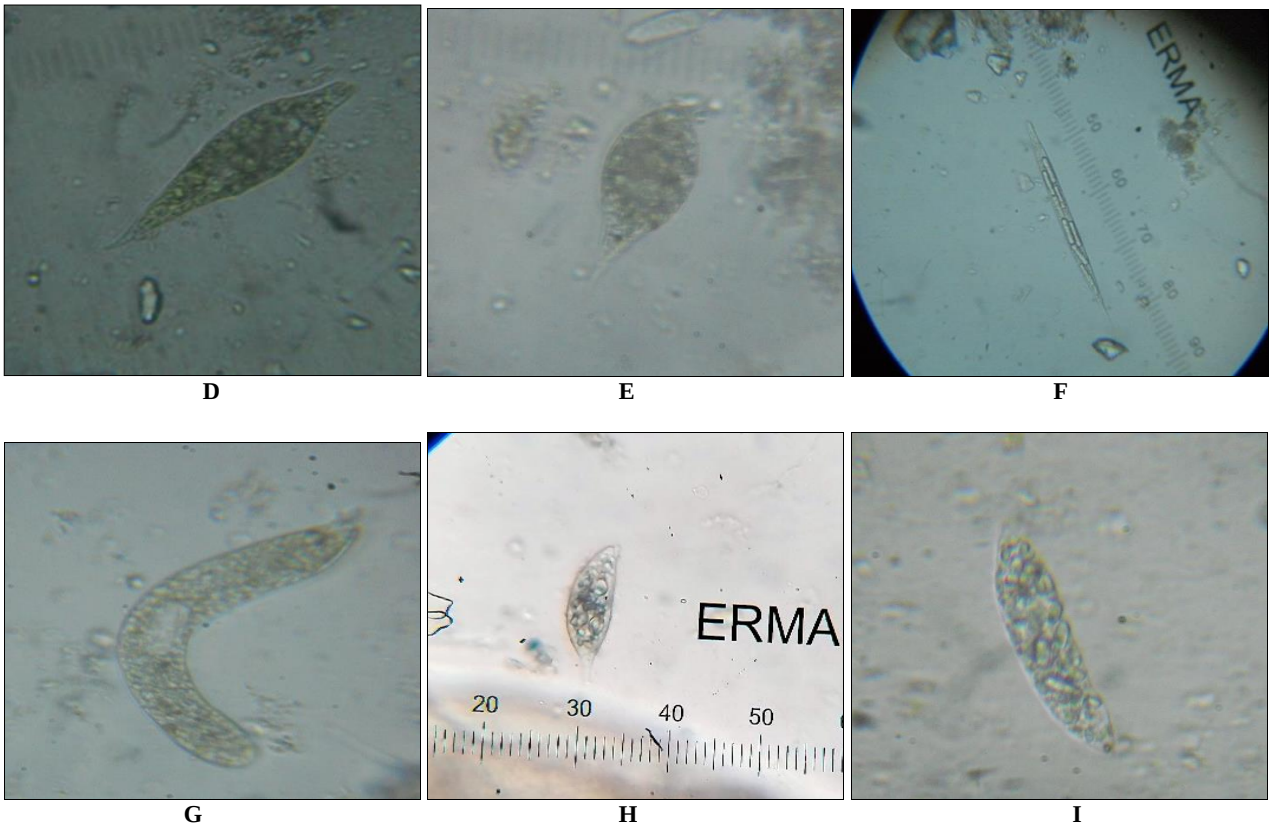
***Euglena acus* var. *rigida* Huebner 1886 (Fig. R, Pl. II)**
Cell spindle shaped, narrow, elongate, tapering abruptly posteriorly in to sharply pointed tail piece, paramylon 2, rod shaped, chloroplast numerous, plate like, and ovoid bodies, length 107.6µm, width 16.6µm, pl 85, fig. 27, page 391, G. W. Prescott, 1962 [15].

Discussion
In the present study a total of 18 taxa of *Euglena* was reported from all the selected wetlands of Bhagalpur District. The presence of taxa like *Euglena acus, E. texta, E. gracilis*, and *E. viridis* were present frequently and commonly reported from all the selected wetlands. The other *Euglena* species were less abundant and were rare like *E. anabaena, E. tuberculata, E. granulate,* and *E. sanguinea.* The presence of Euglenophytes were highest number of count in summer season while minimum number of count was recorded during monsoon season. The high number of euglenoids in the water bodies indicates organic pollution (Wolowski 1998, 2011). According to Palmer (1969) [11] the presence of species like *Euglena viridis, E. gracilis, E. oxyuris, E. acus, E. deses, E. pisciformis* and *E. proxima* were evidence of high organic pollution. The occurrence of Euglenophytes in selected wetlands also indicates that it may proceed towards eutrophic condition as they acts as good pollution indicators. The reason for euglenophytes bloom are activities like entry of huge sewage, cattle washing, fishing, runoff from surrounding residential areas and other anthropogenic pollution. The abundant development of euglenoids is also known to indicate high water temperature (Wolowski *et al*. 2013). Therefore, knowledge of the euglenophyte flora can be useful in the assessment of water quality and also be helpful in deriving the conservational strategies for protection of these wetlands.

Conclusion
This study was to explore the diversity of euglenoids of some of the selected wetlands of Bhagalpur district. From the result it may be concluded that the ecological conditions of the wetlands support rich diversity of euglenoids in Bhagalpur.

Plate – I

A **B** **C**

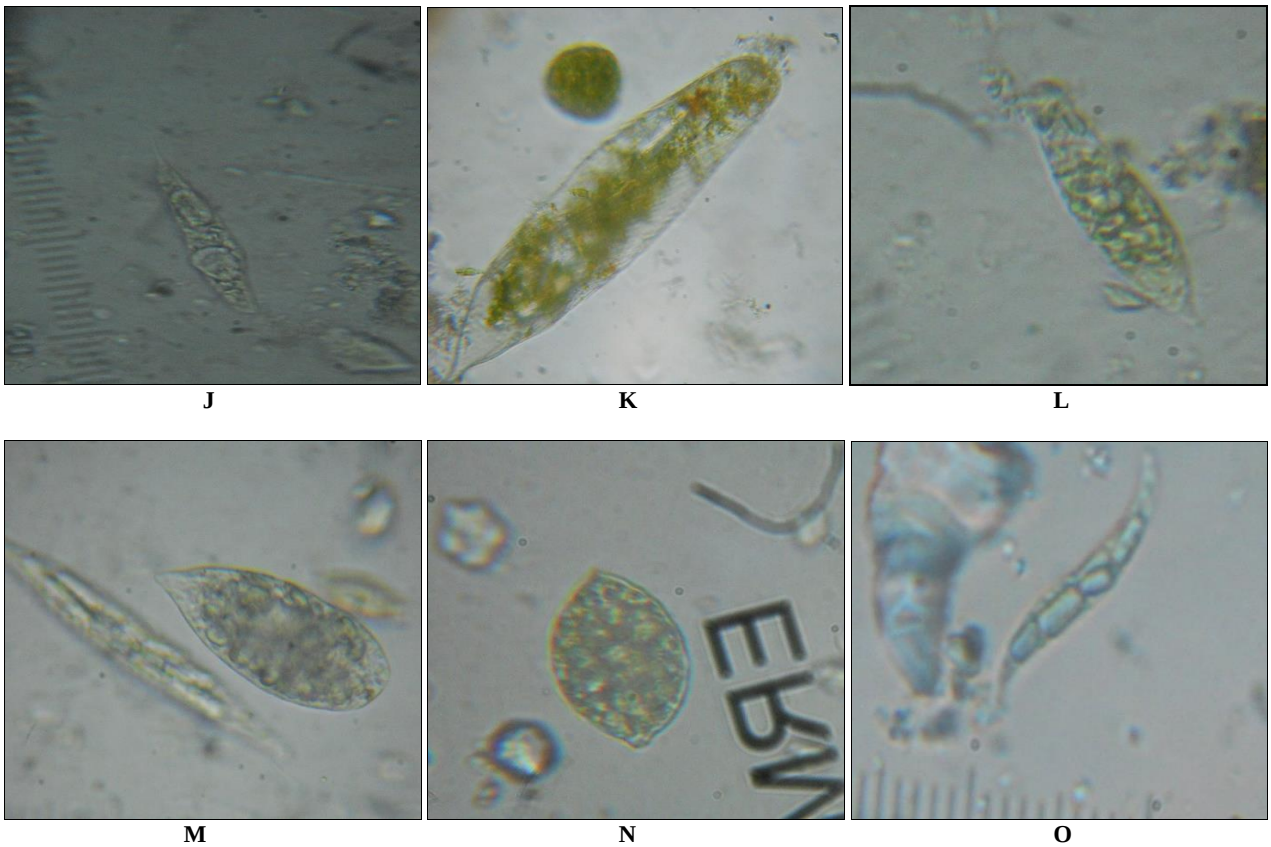


D E F

G H I

Fig 2: (A) *Euglena oxyuris* var. *minor*, (B) *Euglena gracilis* (C) *Euglena limnophila*, (D) *Euglena viridis* (E) *Euglena clavata*, (F) *Euglena acus*, (G) *Euglena gaumei*, (H) *Euglena proxima*, (I) *Euglena deses*, (Scale 45µm).

Plate -2



J K L

M N O

P **Q** **R**

Fig 2: (J) *Euglena rostrifera,* (J) *Euglena sanguinea,* (L) *Euglena pisciformis,* (M) *Euglena granulate,* (N) *Euglena texta,* (O) *Euglena mutabilis,* (P) *Euglena anabaena,* (Q) *Euglena tuberculate,* (R) *Euglena acus* var. *rigida.* (Scale 45µm).

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Author's Contribution
Shadia Rahman (1st author) and Braj Nandan Kumar (3rd author) contributed in laboratory analysis, taxonomic identification of Euglena species and collected the data.1st and 3rd author contributed in the preparation and writing of the manuscript. Sunil Kumar Choudhary (2nd 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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