



RESEARCH ARTICLE

New records of desmids from Ropar wetland (a Ramsar Site) of Punjab, India

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ABSTRACT

This study deals with exploration of freshwater desmids for the first time from Ropar wetland (Ramsar site) of Punjab (India) to assess their taxonomic aspects and bio-geographical distribution. During this study, samples of planktonic, epiphytic and epilithic desmids were collected from littoral zone and were observed under light microscope for their morphometric characteristics based identification. Total 21 desmids species belonging to 4 genera of 2 families (Closteriaceae and Desmidiaceae) were identified from the collected samples. Among them, *Cosmarium* with 11 species (*C. awadhense*, *C. bioculatum*, *C. trilobatum*, *C. divergens*, *C. granatum*, *C. moniliforme*, *C. nitidulum*, *C. subtumidum*, *C. reniforme*, *C. undulatum* and *C. obtusatum*) was found to be most abundant followed by *Closterium* with 7 species (*C. acerosum*, *C. diana*, *C. incurvum*, *C. leibleinii*, *C. lunula*, *C. pritchardianum* and *C. aciculare*), *Euastrum* with 2 species (*E. spinulosum* and *E. platycerum*) and *Staurastrum* with 1 species (*S. crenulatum*). The geographic distribution of identified desmid taxa in India has been also recorded. All the desmid taxa identified during this study are new record for the Punjab state of India. The results of this study provide significant baseline data for the future taxonomic and ecological studies from the similar habitats.

Introduction

Globally, wetlands are recognized as one of the most biologically diverse and unique habitats for various plant and animal species (1). Wetlands are also considered as important aquatic environments that provides valuable ecosystem services by supporting high rates of primary production (1, 2). In spite of their importance, most of the world's wetlands are under threat due to the increased human interference including deforestation, change in land use practices, domestic and industrial pollution etc. in their catchment areas and watershed (1, 3). As a result the hydrology, hydraulic patterns and geomorphology of most of the wetlands have been influenced that directly impact their biodiversity and other ecosystem services (1, 2). At the same time, it has been recognized that proper protective and conservation efforts have not been implemented for such important ecosystems due to lack of knowledge about their ecological values and benefits (2, 5) Therefore, the assessment of biodiversity and its role becomes important for the better understanding of services and functions of wetlands (6, 7). Algae, as main primary producers, play important role in functions of

wetlands and can be the key indicators for their ecological conditions (2). Algae often are conspicuous feature of both estuarine and freshwater wetlands throughout the world (2). On the basis of cell structure algae are mainly two types: prokaryotic (Blue green algae) and eukaryotic (all other algal forms including desmids). Desmids are microscopic, unicellular, eukaryotic organism belong to class Zygnematophyceae (Phylum Charophyta) of algae (8-10). The cells of majority of the desmids taxa are transversally curved by constriction (*sinus*) into two symmetrical semi-cells connected by an *isthmus* (8, 9). The desmids taxa consist symmetrical semi cells and isthmus with pores are known as true desmids (placoderm), whereas smooth walled taxa, without pores and a median constriction are termed as false desmids (saccoderm) (11, 12). Desmids are vulnerable groups of aquatic organisms due to their sensitivity to the fluctuations in the environment. Thus, desmids are increasingly used as bioindicator for the monitoring and management of aquatic ecosystems (11, 13-15). Due to this, the taxonomic and floristic explorations of these organisms become important to understand their complex association with environment.

The diversity of desmids from different regions of the world has been explored by many workers (16-27). In India, many studies have been reported from different parts, like from Dehradun (28), Ladakh (29, 30), Uttar Pradesh (31), Karnataka (32, 33), Maharashtra (12, 14, 34-39), Western Himalayas (40), Himachal Pradesh (41), Eastern Himalaya (42), West Bengal (43) etc. Although, algal diversity from different water bodies of Punjab has been explored by various workers (44-49) but, according to available literature, detailed taxonomic studies on desmids are not been carried out till date leading to a gap in knowledge about the diversity of this important group of algae. Keeping this situation in mind, present study was undertaken to explore the desmids flora from Ropar Wetland of Punjab for the first time.

Materials and Methods

Study Area

Ropar wetland, manmade fresh water wetland, situated on river Sutlej at 31°01'N latitude and 76°30' E longitude in the Shivalik foothills covering an area of 13.65 sq. km (Fig. 1). This wetland came in to existence in 1952 after the construction of water barrage on river Sutlej at Ropar (Rupnagar district, Punjab). The

main reason behind constructing this wetland was to store and divert water through canals for various purposes like irrigation, industrial and drinking water supply (50, 51). This was considered as Ramsar site in year 2002, due to its vital role in providing habitat to number of threatened and endangered species of plants and animals (50). This area falls under semi-arid zone and relatively less warm region of Punjab and it receives mean annual rainfall of 1518 mm (52). This wetland is very significant from ecological, economic and social heritage point of view. It also serves as significant staging and latent ground for migratory water fowl. The major threats for this wetland are weed invasion by *Parthenium* and *Lantana*, siltation, water pollution through anthropogenic activities and grazing etc. (53, 54). Previous studies from this wetland have reported the declining status of its water quality and ecological conditions (51-54). These water quality conditions may causes serious alterations in various abiotic and biotic components of this wetlands. As desmids are considered as good indicator and are sensitive to the fluctuations in water chemistry of any freshwater ecosystem. Thus, it becomes important to evaluate the diversity of desmids from this wetland that may be helpful in future for formulation of any management plan/program for its conservation and rehabilitation.

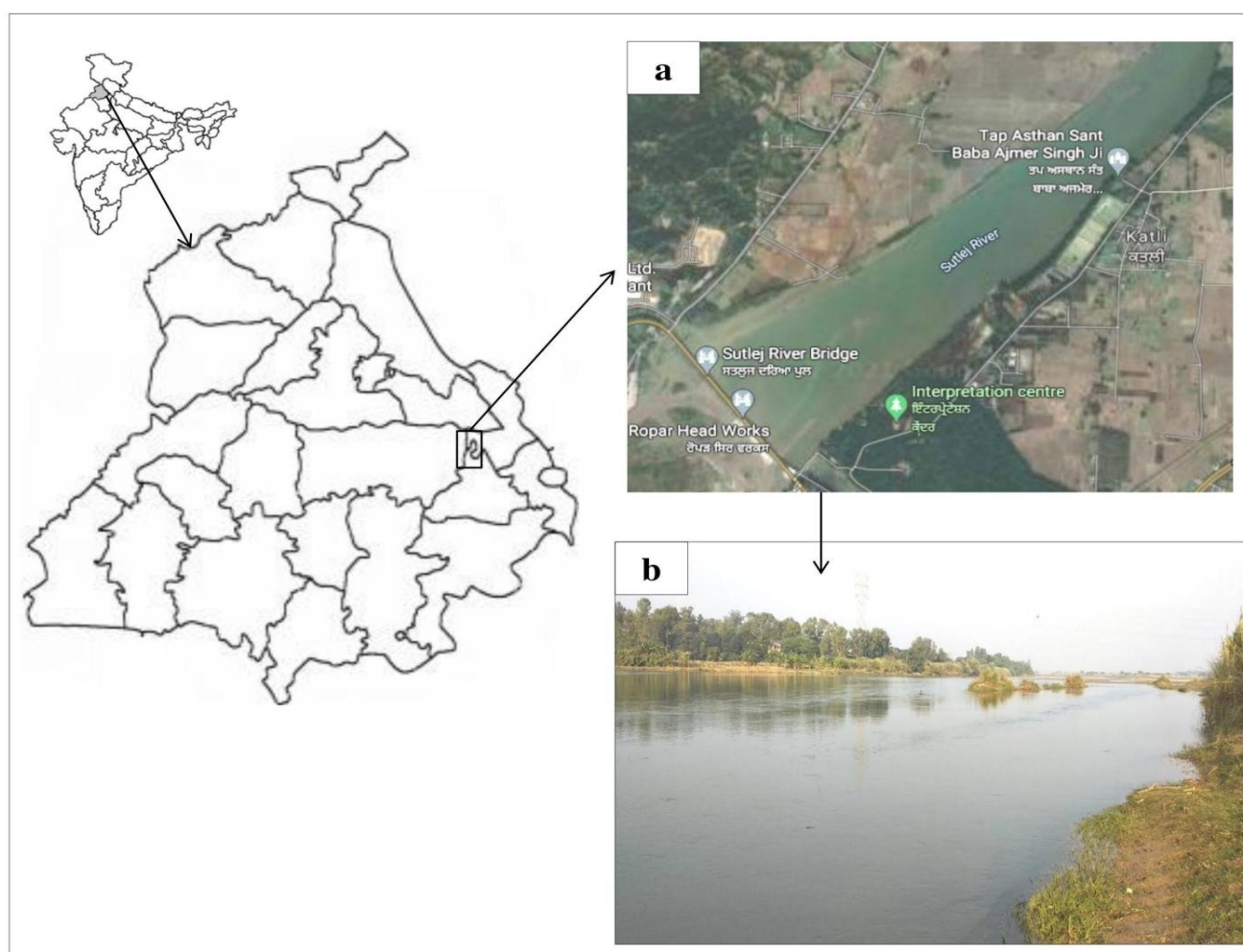


Fig. 1. Map showing Ropar Wetland of Punjab, India (a): Satellite view (Source: www.maps.google.com), (b): Field photograph at the time of sample collection.

Sample Collection and Identification

Samples of planktonic, epiphytic and epilithic desmids were collected from littoral zone of study area (Fig. 2). Collected samples were preserved in formalin solution (4%) in wide mouth glass bottles and for further analysis were brought to the

Results

In the present study, a total of 21 desmids taxa belonging to 4 genera (*Closterium*, *Cosmarium*, *Euastrum* and *Staurastrum*) of 2 families (Closteriaceae and Desmidiaceae) have been reported

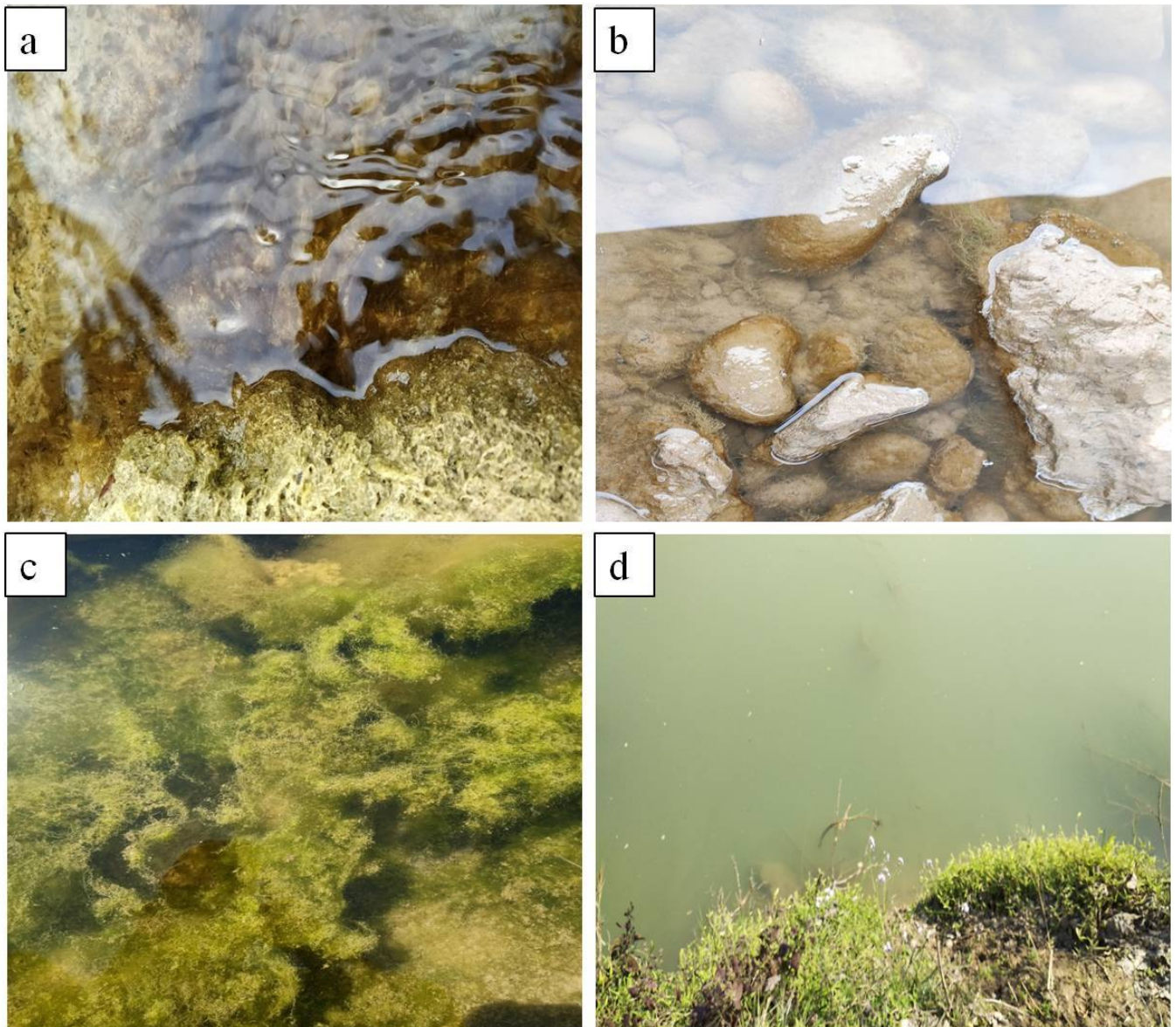


Fig. 2. Field photographs showing different algal habitat in littoral zone of the study area.

laboratory. The voucher specimens of collected samples were assigned with herbarium number (WUA) of Sri Guru Granth Sahib World University, Fatehgarh Sahib (Punjab). The temperature and pH of water were recorded on the spot with digital thermometer (Perfit, India) and digital pH meter (Hanna Instruments, India) at the time of sampling. For the identification of collected material, temporary slides were prepared by mounting sample in Glycerin to study the morphometric characteristics using light microscope (Olympus CH20i). The species identification was done following standard literatures (55-61) and the geographic distribution of identified desmids taxa was analyzed from referred literature.

for the first time from Ropar Wetland, Punjab. The microphotographs of studied desmid taxa are given in Fig. 3 & Fig. 4.

The identification key and detailed taxonomic descriptions of identified taxa are given below:

1. Cell solitary, small to large2,3,5
1. Cell solitary.....4
2. Straight, curved, elongate-cylindric to elongate-fusiform, tapering at ends, ends acute, rounded or truncate, chloroplast two with numerous pyrenoids.....*Closterium*....6
3. Semicells circular, subcircular, elliptic, reniform, pyramidate, quadrate in apical view, shallow to deep constriction, cell wall smooth, ornamented

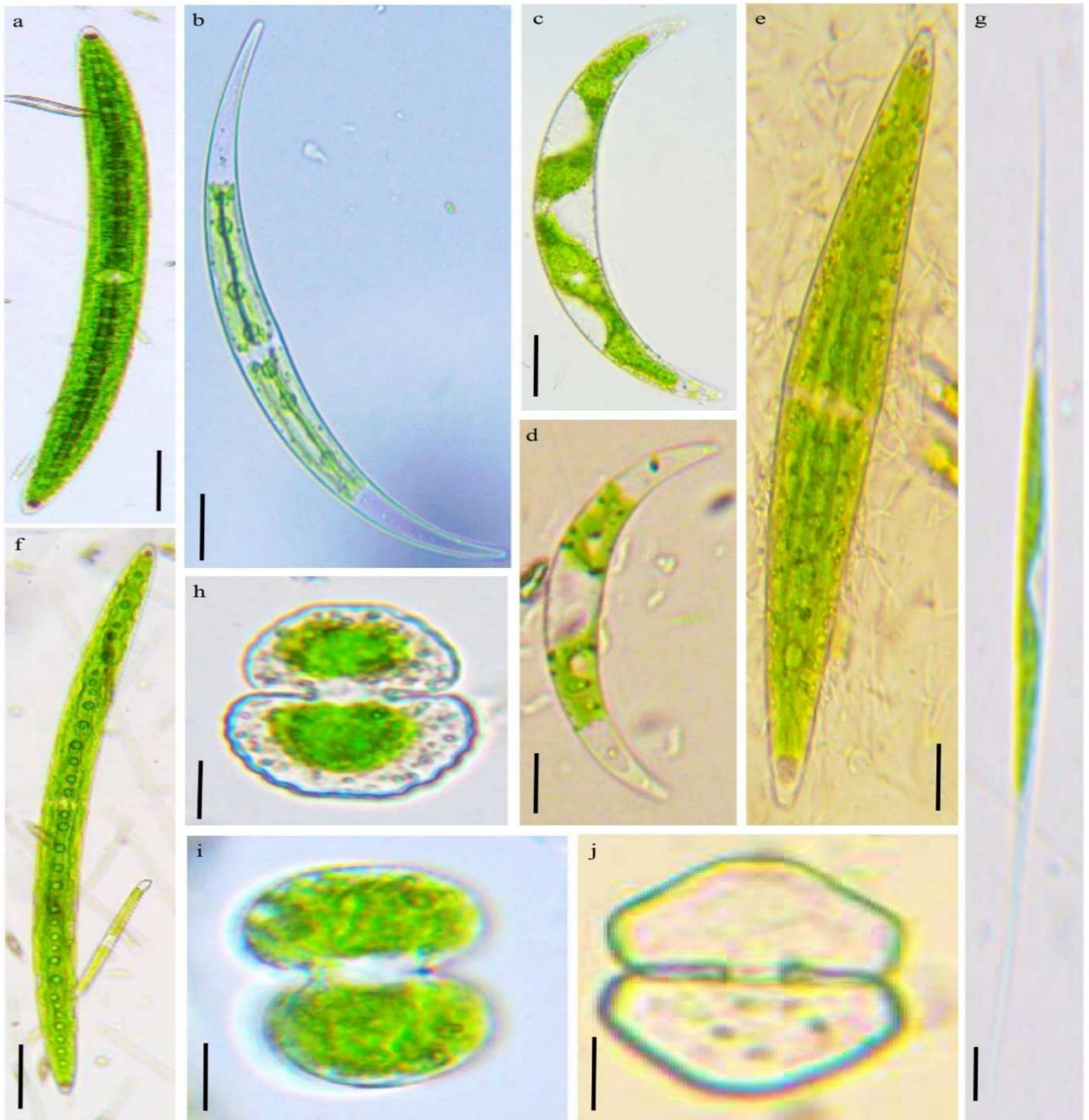


Fig. 3. Micro-photograph of identified desmid taxa from study area. (a): *Closterium acerosum* Ehrenberg ex Ralfs; (b): *Closterium dianae* Ehrenberg ex Ralfs; (c): *Closterium incurvum* Brébisson; (d): *Closterium leibleinii* Kützing ex Ralfs; (e): *Closterium lunula* (Muell.) Nitzsch; (f): *Closterium pritchardianum* W. Archer; (g): *Closterium aciculare* T. West; (h): *Cosmarium awadhense* B. N. Prasad & R. K. Mehrotra; (i): *Cosmarium bioculatum* Brébisson ex Ralfs; (j): *Cosmarium trilobatum* Reinsch. (Scale bar = 20 µm).

- with granules, each semicell with one to more chloroplast.....*Cosmarium*...12
- 4. Semicells with apical and lateral lobes, smooth cell wall with ornamentations.....*Euastrum*...29
- 5. Each semi-cell with hollow processes deep median constriction, processes with two or more outmost spinules.....*Staurastrum*...33
- 6. Cells narrowly fusiform.....7
- 6. Cells lunated.....8
- 7. Apices rounded and truncate...*Closterium acerosum*

- 8a. Apices subacute.....*Closterium dianae*
- 8b. Apices pointed and rounded..*Closterium incurvum*
- 9. Cells strongly curved.....10
- 9. Cells slightly curved11
- 9. Cells large and nearly straight.....11
- 10a. Apices nearly recurved.....*Closterium leibleinii*
- 10b. Apices attenuate.....*Closterium aciculare*

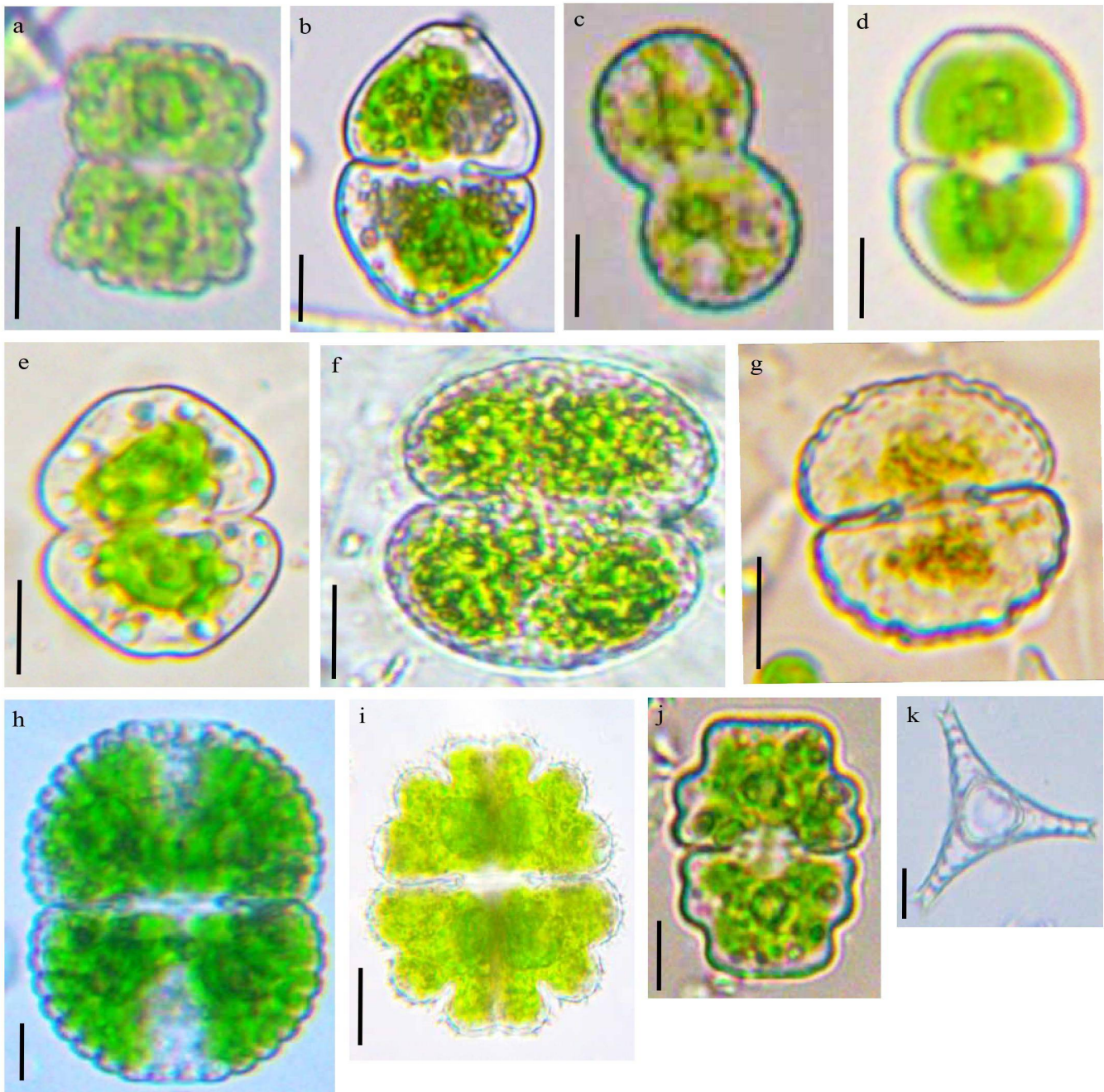


Fig. 4. Micro-photograph of identified desmid taxa from study area. (a): *Cosmarium divergens* Krieger; (b): *Cosmarium granatum* Brébisson ex Ralfs; (c): *Cosmarium moniliforme* Ralfs; (d): *Cosmarium nitidulum* De Notaris; (e): *Cosmarium subtumidum* Nordstedt; (f): *Cosmarium reniforme* (Ralfs) W. Archer; (g): *Cosmarium undulatum* Corda ex Ralfs; (h): *Cosmarium obtusatum* (Schmidle) Schmidle; (i): *Euastrum spinulosum* Delponte; (j): *Euastrum platycerum* Reinsch; (k): *Staurastrum crenulatum* (Nägeli) Delponte. (Scale bar= 20 µm).

- | | |
|--|---|
| 11a. Apices truncate and faintly recurved.....
..... <i>Closterium pritchardianum</i> | 14. Median deep constriction with narrowly linear
sinus.....16,18 |
| 11b. Cell reduced to slightly truncate apices
..... <i>Closterium lunula</i> | 14. Closed and deep sinus.....17 |
| 12. Cells small.....13,15 | 15. Deep constriction with narrow sinus.....
.....18,19 |
| 12. Cells longer than broad.....
.....14 | 16. Semi-cells semicircular.....
..... <i>Cosmarium awadhense</i> |
| 13. Profound constriction with narrowly linear
sinus.....16 | 16. Semi-cells nearly elliptic
..... <i>Cosmarium bioculatum</i> |
| 13. Little median deep constriction with widely open
acute sinus.....17 | 17. Semi-cells circular.....
..... <i>Cosmarium moniliforme</i> |
| | 17. Semi-cells elliptical.....20 |

18. Semi-cells truncate-sub semicircular21
18. Semi-cells pyramid-semicircular.....
.....*Cosmarium subtumidum*
19. Semi-cells sub-semicircular with 6-7 undulations ...
.....21
20. Coarsely scrobiculated cell wall.....
.....*Cosmarium trilobatum*
20. Cell wall finely punctuate.....
.....*Cosmarium divergens*
- 21a. Punctate cell wall.....
.....*Cosmarium nitidulum*
- 21b. Cell wall smooth*Cosmarium undulatum*
22. Cells medium sized.....23,24
23. Deep constriction with closed sinus25
23. Deep constriction with narrow to linear sinus
.....25
24. Middle constriction with linear sinus26
24. Deep constriction with linear sinus26
25. Semi-cells trapezoid.....27
25. Semi-cells reniform27
26. Semi-cells sub-semicircular28
26. Semi-cells sub-rhombic to elliptic.....28
27. Punctate cell wall.....*Cosmarium granatum*
27. Granulate cell wall.....*Cosmarium reniforme*
28. Smooth to slightly punctate cell wall
.....*Cosmarium obtusatum*
28. Finely punctate cell wall.....*Cosmarium divergens*
29. Cells small.....30
29. Cells medium.....30
30. Deep constriction with narrow sinus.....31
30. Sinus slightly open.....31
31. Semi cells with 5 lobed rounded angles.....32
31. Semi cell with circular patch of granules
.....*Euastrum platycerum*
32. Cell wall with short spines
.....*Euastrum spinulosum*
33. Cells with short and slightly divergent processes,
semi-cells oval or sub-fusiform, shallow median
constriction cell wall crenate to denticulate
.....*Staurastrum crenulatum*

Closterium acerosum

Ehrenberg ex Ralfs 1848: 164, pl. XXVII [27]: Fig. 2 a, b, d-e.

Narrowly fusiform cells, 160-175 µm long, 13 µm wide; outer margin curved with gradually tapering to narrow inner margin; apices rounded and truncate, 4 µm broad; cell wall smooth, without any colour, with median girdle; chloroplast without ridges and having 3-5 pyrenoids in a medium series (Fig. 3, a).

Collection no.: WUA 18, WUA 34, WUA 14 and WUA 43.

Ecological notes: From the water squished from other algal samples. pH 7.7, Temp. 21 °C.

Indian distribution: Kerala (62), Western Himalaya (40), Tamil Nadu (63); Maharashtra (12, 39); Jodhpur, Rajasthan (64, 65), Madhya Pradesh (66).

Closterium diana Ehrenberg ex Ralfs 1848: 168, figs 5a, 5c; pl. XXVIII [28].

Lunated cell, 160-188.6 µm long and 12.5 µm wide; a strongly curved outer margin, inner margin slightly swollen, with subacute apices; Smooth cell wall; chloroplast having 6-8 pyrenoids in a row (Fig. 3, b).

Collection no.: WUA 22, WUA 26, WUA 47 and WUA 31.

Ecological notes: In association with green algal filaments growing attached on stones. pH 7.8, Temp. 24 °C.

Indian distribution: Manipur (67), Bhopal (68), Maharashtra (9, 39), Madhya Pradesh (66), Arid region, Rajasthan (65).

Closterium incurvum Brébisson 1856: 150, pl. 2: Fig. 47.

Cell lunated, 50-87.5 µm long and 7.5-11.5 µm wide, apex nearly 2.7-2.9 µm wide; convex dorsal margin, concave ventral margin, pointed-rounded poles; smooth, hyaline to brownish cell wall, with or without polar thickening; chloroplast is axial, 3 lamella, 2-5 pyrenoids in median series (Fig. 3, c).

Collection no.: WUA 10, WUA 17 and WUA 43.

Ecological notes: Attached with cyanobacterial filaments. pH 8, Temp. 23 °C.

Indian distribution: Andaman and Nicobar (28), Eastern Himalayas, Assam (69), Manipur (67), Kerala (70), Karanja, Maharashtra (9, 71).

Closterium leibleinii Kützing ex Ralfs 1848: 167, pl. XXVIII [28]: fig. 4 c-h, k-l.

Cell strongly curved, 58 µm long and 10.2 µm wide; outer margin with 115-120 degrees of arc; middle part inflated and inner margin deeply concave, nearly recurved apices; smooth cell wall; chloroplast having serially arranged numerous pyrenoids in each semi cell (Fig. 3, d).

Collection no.: WUA13, WUA 07 and WUA 09.

Ecological notes: Slimy mass growing benthic near the wetland area. pH 7.9, Temp. 23 °C.

Indian distribution: Madhya Pradesh (72), Andaman and Nicobar (28), Ladakh (30), Western Himalayas (40), Bhopal (68), Maharashtra (8, 39, 71, 73, 75) Rajasthan (57, 58).

Closterium lunula Ehrenberg & Hemprich ex Ralfs 1848: 163, pl. XXVII [27]: Fig. 1.

Large sized cells, nearly straight, about 6 times longer than broad, 200-220 µm long and 30 µm wide; outer margin is more convex than inner, cell gradually reduced to slightly truncate apices; smooth cell wall; chloroplast with 5 ridges with numerous scattered pyrenoids (Fig. 3, e).

Collection no.: WUA 37, WUA 26, WUA 37 and WUA 41.

Ecological notes: Attached with other filamentous algae. pH 7.9, Temp. 23 °C.

Indian distribution: Karnataka (72-74), Western Himalaya (40), Jammu and Kashmir (76), Maharashtra (9, 39, 77), Madhya Pradesh (66).

Closterium pritchardianum W. Archer 1862: 250, pl. XII [12]: Fig. 25-27.

Cell medium sized, nearly 10 times longer than broad, 98 µm long and 5-6 µm wide, weakly curved, outer margin with 24-40 degree of arc, inner margin slightly concave; cell gradually narrowed toward apex, apices truncate and faintly recurved; smooth cell wall; chloroplast with 5-6 ridges with and 8-10 rows of pyrenoids (Fig. 3, f).

Collection no.: WUA 19, WUA 07, WUA 18 and WUA 25.

Ecological notes: In association with mosses with mucilaginous mass. pH 8, Temp. 24 °C.

Indian distribution: Madhya Pradesh (78), Karnataka (79), Goa (80), Andaman and Nicobar (28), Western Himalaya (40), Himachal Pradesh (41), Maharashtra (39).

Closterium aciculare T. West 1860: 153, Fig. 16; pl. VII [7].

Cells slightly curved, 80-90 times longer than wide, 200-230 µm long and 4-6 µm wide; slightly curved in apical region, nearly straight dorsal and ventral margins, attenuated apex with pointed poles; colorless, smooth cell wall; chloroplast axial with serially organized 4-6 pyrenoids in median (Fig. 3, g).

Collection no.: WUA 22, WUA 06 and WUA 14.

Ecological notes: In association with cyanobacterial filaments. pH 7.7, Temp. 21 °C.

Indian distribution: Gujarat (81), Kerala (82), Bihar (83), Maharashtra (76, 84).

Cosmarium awadhense B.N.Prasad & R.K. Mehrotra 1977: 55.

Small cell, a little longer than broad, 28 µm long and 24 µm wide, 4 µm wide isthmus; profound constriction; narrowly linear sinus towards apex and slightly open outwards; semicircular semi cells, truncate apex with more or less straight margin; smooth cell wall; one massive chloroplast in each semi cell (Fig. 3, h).

Collection no.: WUA 05, WUA 59 and WUA 53.

Ecological notes: Attached with Benthic algal samples. pH 8, Temp. 24 °C.

Indian distribution: Andaman and Nicobar (28), Ladakh (30), Western Himalaya (40), Himachal Pradesh (41), Jammu and Kashmir (76), Kerala (70), Maharashtra (39, 85), Maharashtra (12).

Cosmarium bioculatum Brébisson ex Ralfs 1848: 95, pl. XIV [14]: Fig. 5.

Cells slightly longer than broad, 27.5 µm long and 25 µm wide, 4.5 µm wide isthmus; median deep constriction; little dilated apex with narrowly linear sinus; semi cells nearly elliptic in shape in apical view and subcircular in lateral view, upper margin more

convex than the ventral, lateral margins rounded; colorless, smooth cell wall; each semi cell with axile chloroplast having single pyrenoid (Fig. 3, i).

Collection no.: WUA 08, WUA 05 and WUA 24.

Ecological notes: In association with other phytoplanktons. pH 7.9, Temp. 19 °C.

Indian distribution: Maharashtra (8, 39), Karnataka (74), Kolkata (43), Karanja, Maharashtra (9).

Cosmarium trilobatum Reinsch 1866: 118, pl. XXII [22]: Fig. A: II: 1-6.

Cells longer than broad with closed and deep sinus, 27-30 µm long and 26-27 µm wide; 5.5-7 µm wide isthmus; Semi cells elliptical shaped with rounded angles, straight to slightly convex sides and slightly concave apex; small inflation present in apical view; coarsely scrobiculated cell wall; each semi cell with axile chloroplast having single pyrenoid (Fig. 3, j).

Collection no.: WUA 59, WUA 56, WUA 14 and WUA 07.

Ecological notes: Brownish mass of wooly substances lodged with pebbles. pH 8, Temp. 22 °C.

Indian distribution: Madhya Pradesh (86), Kerala (87), Gujarat (88).

Cosmarium divergens Krieger 1932: 175, pl. XI [11]: Fig. 20.

Medium sized cells with deep constriction, little longer than broad, 20-25 µm long, and 17-19 µm wide; 15.5 µm wide isthmus; linear sinus; cell wall finely punctate; semi cells sub-rhombic to elliptic in shape; apex and margins crenate; axile chloroplast (Fig. 4, a).

Collection no.: WUA 57, WUA 24 and WUA 48.

Ecological notes: In association with green filamentous algae. pH 8, Temp. 22 °C.

Indian distribution: Gujarat (88), Maharashtra (8, 75, 89).

Cosmarium granatum Brébisson ex Ralfs 1848: 96, pl. XXXII [32]: Fig. 6.

Cells medium, nearly 1.5 times long as broad, 35-40 µm long and 20-25 µm wide, 5-7 µm wide isthmus; deep constriction; sinus closed; semi cell trapezoid in shape; basal angles rounded; punctate cell wall; each semi cell with axile chloroplast (Fig. 4, b).

Collection no.: WUA 60, WUA 56 and WUA 05.

Ecological notes: Attached to benthic algal samples. pH 7.8, Temp. 23 °C.

Indian distribution: Maharashtra (8, 39, 75, 90, 91), Uttar Pradesh (31, 92) Assam (93, 94), Jammu and Kashmir (76, 95), Gujarat (88, 89, 96), Karnataka (74, 97-99), Madhya Pradesh (76), Himachal Pradesh (41), Punjab (100, 101), Tamilnadu (102, 103), Eastern Himalayas (40), Kerala (70), Maharashtra (39), Arid region, Rajasthan (65), Kolkata (43).

Cosmarium moniliforme Ralfs 1848: 107, pl. XVII [17]: Fig. 6.

Small cells, 17-19 µm long and 10-12 µm wide, 2-3 µm wide isthmus, semi cells circular in shape; cell wall finely punctate, little deep median constriction; widely

open acute sinus; rounded apex; axial chloroplast with central pyrenoid (Fig. 4, c).

Collection no.: WUA 53, WUA 26 and WUA 41.

Ecological notes: In association with other phytoplanktons. pH 8, Temp.: 22 °C.

Indian distribution: East India (58), Andhra Pradesh (94), Madhya Pradesh (72, 86, 104), Maharashtra & Karnataka (8, 74, 98), Uttar Pradesh (105), Kashmir (29), Central India (106), Uttar Pradesh (107, 108), Gujarat (109), Pithoragarh (110), Uttar Pradesh (111), Uttaranchal (112), Western Himalaya (40), Karnataka (113, 114), Chhattisgarh (115), Tamil Nadu (63), Assam (116), Eastern Himalaya (117), Kolhapur, Maharashtra (77), Kolkata (43).

Cosmarium nitidulum De Notaris 1867: 42, pl. III [3]: Fig. 26.

Cell small, little longer than broad, 24-28 µm long and 24 µm wide, 8 µm wide isthmus, constriction deep; narrowly linear sinus; apex is slightly dilated; truncate-sub semicircular semi cells, straight margin, rounded apex; punctate cell wall; axial chloroplast with one pyrenoid (Fig. 4, d).

Collection no.: WUA 06 and WUA 08.

Ecological notes: In association with mosses and green algae. pH 7.9, Temp. 19 °C.

Indian distribution: Andaman and Nicobar (28), Western Himalaya (40), Himachal Pradesh (41), Maharashtra (39, 71, 73, 77).

Cosmarium subtumidum Nordstedt in Wittrock, Nordstedt & Lagerheim 1878: no. 172.

Cells are longer than broad having deep middle constriction, Cells are 18.7-25 µm long and 12-19.5 µm wide, 4-5 µm wide isthmus; nearly dilated apex with narrow linear sinus; pyramid-semicircular shape semi cells, rounded basal angles, convex lateral margin; axile chloroplast having single pyrenoid in each semi cell (Fig. 4, e).

Collection no.: WUA 06, WUA 18 and WUA 56.

Ecological notes: In association with other phytoplanktons. pH 7.7, Temp. 21 °C.

Indian distribution: Andhra Pradesh (118), Gujarat (119, 120), Ladakh (30), Maharashtra (39, 71), Kolkata (43).

Cosmarium reniforme (Ralfs) W.Archer 1874: 92

Cells medium sized, somewhat longer than broad, 32-35 µm long and 33 µm wide, 12 µm wide isthmus; constriction deep, narrow to linear sinus with widely opened margin; reniform semi cells; granulate cell wall, granules fairly regular; axile chloroplast (Fig. 4, f).

Collection no.: WUA 15, WUA 18, WUA 36 and WUA 24.

Ecological notes: In association with green filamentous algae. pH 7.9, Temp. 19 °C.

Indian distribution: Jammu and Kashmir (121), Gujarat (119), Andaman & Nicobar (28), Ladakh(30), Himachal Pradesh (41), Eastern Himalayas, Assam (69),

Karnataka (4), Rajasthan (64), Maharashtra (12, 39, 85).

Cosmarium undulatum Corda ex Ralfs 1848: 97, pl. XV [15]: Fig. 8.

Small cells with quadrate-elliptic shape, little longer than broad, 22.8 µm long and 19 µm wide, 3.5 µm long isthmus; deep constriction; narrow sinus with dilated margin; sub-semicircular semi cell with 6-7 undulations; smooth cell wall; chloroplast axile having single pyrenoid in each semicell (Fig. 4, g).

Collection no.: WUA 29, WUA 15 and WUA 18.

Ecological notes: Attached with other wooly algae on pebbles. pH 8, Temp. 22 °C.

Indian distribution: Manipur (73), Maharashtra (71, 85).

Cosmarium obtusatum (Schmidle) Schmidle 1898: 38, pl. 2: Fig. 5, 6.

Cells medium sized, longer than broad, 50-57.4 µm long and 35.6-38.4 µm wide, 10.6 µm wide isthmus; middle constriction; linear sinus with widely rounded lobes; smooth to slightly punctate cell wall; sub-semicircular semi cell with small 15-17 undulations, poles slightly flattened; each semi cells with having two chloroplasts with single pyrenoid (Fig. 4, h).

Collection no.: WUA 13, WUA 29, WUA 07 and WUA 53.

Ecological notes: From the water squished from other algal samples. pH 7.9, Temp. 19 °C.

Indian distribution: Jammu and Kashmir (121), Maharashtra (122), Madhya Pradesh (78), Nagpur (123), Ladakh (30).

Euastrum spinulosum Delponte 1876: 97, pl. VI [6]: Fig. 17, 18.

Cells small in size, longer than broad, 47-55.4 µm long and 30-35 µm wide, 18 µm wide isthmus; deep constriction, narrow sinus widely rounded lobes; each semi cells with 5 lobed rounded angles, big granules and acute indentations between them. Cell wall with short spines, above the isthmus 2 small lateral protuberances are present (Fig. 4, i).

Collection no.: WUA 30, WUA 18 and WUA 24.

Ecological notes: In association with filamentous green algae. pH 7.8, Temp. 23 °C.

Indian distribution: Chhattisgarh (124), Andaman and Nicobar (28), Western Himalaya (40), Jharkhand (125), Maharashtra (12, 39, 122), Gujarat (96, 119).

Euastrum platycerum Reinsch 1875: 85, pl. 12: Fig. 6.

Cells are of medium sized, longer than broader, 33-38 µm and 20-30 µm wide, isthmus 11 µm wide; sinus slightly open; semi cell with circular patch of granules with low median protrusion, Lateral margins are broadly rounded (Fig. 4, j).

Collection no.: WUA 53, WUA 07 and WUA 41.

Ecological notes: Attached with other wooly algae on substrate. pH 7.9, Temp. 19 °C.

Indian distribution: Karnataka (126), Himachal Pradesh (41).

Staurastrum crenulatum (Nägeli) Delponte 1877: 68 [reprint p. 164], pl. 12: Fig. 1-11.

Cells 25-27 µm long and 10.9-12.3 µm wide with processes, 6.7-8.5 µm isthmus wide, short and slightly divergent processes, tipped processes 2-3 spine; crenate to denticulate cell wall; oval or sub-fusiform semi cells, shallow median constriction (Fig. 4, k).

Collection no.: WUA 57, WUA 18 and WUA 14.

Ecological notes: In association with other phytoplanktonic sample. pH 8, Temp. 22 °C.

Indian distribution: Goa (79), Maharashtra (75), Bhopal (68).

Discussion

Present study is a first report from the study area and deals with the diversity of desmid from the Ropar wetland of Punjab, India. In this study, taxonomic position of observed desmid species was investigated on the basis of their phenotypic features and their distribution in India was also determined, the detailed limnological study has not been carried out during this work. A total of 21 taxa of desmids have been recorded during present investigation, earlier only three genera like *Closterium*, *Cosmarium* and *Penium* were reported only at genus level from Punjab (44, 45, 54). Thus, all the desmid taxa reported during this study are the first report from Ropar Wetland as well as from Punjab. Out of 21 taxa of desmids, fourteen taxa were belonging to family Desmidiaceae and seven taxa to family Closteriaceae. The genus *Cosmarium* exhibited high species diversity (11 species), followed by the genus *Closterium* (7 species) of the total diversity of study area. It has been observed that water of this wetland was slight alkaline (pH 7.7–8.0), which may cause low diversity of desmids in this wetland. According to previous reports (117, 127) the acidic condition of water favors more growth of desmids in comparison to alkaline water.

The comparison of observation of present study with other available reports from India (9, 12, 35-43) indicates low diversity of desmids in the study area. This may be due to different habitat nature and water quality conditions. As high desmid diversity has been observed from the wetlands habitat having abundant growth of macrophytes (128) and *Sphagnum* bog carpets (129). The desmid taxa, *C. acerosum*, *C. diana*, *C. moniliforme* and *E. platycerum* were observed to be widely distributed in different water bodies of India (9, 12, 35-43, 128) and results of current study further advocate the cosmopolitan nature of distribution of these taxa. According to reports (130), *C. acerosum* is a high nutrient tolerant species which indicates the eutrophic nature of water. It was also reported that *Closterium* spp. were dominated in polluted water (131). From the results of present study, it is suggested that the continue bio-monitoring studies with holistic assessment of water quality conditions are required to develop strategies and water quality improvement programmes for this wetland.

Conclusion

In this study, the desmid flora of the Ropar wetland, Punjab (India) has been studied for the first time. All species recorded in this work are new records for study area as well as from Punjab. The habitat of this wetland does not support luxuriant growth of desmids due to alkaline nature of water. A high nutrient tolerant taxon i.e. *C. acerosum* has also observed during this study which may be the first indication towards the deterioration of water of this wetland. The present study provides more information about the biological diversification of this wetland and will be helpful in future for further limnological analysis.

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Authors' contributions

YS and JISK provided conceptualization and resources, review and edited the manuscript. Komal investigated, analyzed data and wrote the initial draft of manuscript. YS and DPS reviewed and edited the manuscript. All authors have read and approved the manuscript for publication.

Conflict of interests

All authors declare no conflict of interest.

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