

A systematic account of scenedesmaceae (sphaeropleales) from Periyar River, Kerala

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Abstract

The present study deals with the systematic account of 28 taxa of family Scenedesmaceae, order Sphaeropleales, (formerly belonging to the order Chlorococcales), collected from Periyar River in Kerala. They include the genera, namely, *Acutodesmus* (1), *Desmodesmus* (7), *Scenedesmus* (7), *Tetradesmus* (4), *Westella* (1), *Coelastrum* (5) *Hariotina* (1), *Asterarcys* (1) and *Dimorphococcus* (1). Out of these, three taxa are new to Kerala and most of them are new records from Periyar River.

Keywords: Chlorococcales, chlorophyceae, freshwater algae, biodiversity, new report to Kerala

1. Introduction

The Chlorococcales comprises of an interesting group of green algae represented by non-motile unicellular or colonial forms. Most of the members are aquatic and microscopic in nature but some may be macroscopic forms. Among planktonic Chlorococcales, Scenedesmaceae is one of most diversified and ubiquitous families in freshwater ecosystems. On the basis of morphology, Komárek & Fott included Scenedesmaceae in the order Chlorococcales (Chlorophyceae), while the family was transferred to the order Sphaeropleales based on molecular phylogeny by Krienitz *et al* [29, 30]. Moreover, the family Coelastraceae was included in Scenedesmaceae by Hegewald *et al.* with support of molecular data [22].

The genus *Scenedesmus* was circumscribed into several genera such as *Acutodesmus* (Hegewald) Tsarenko; *Chodatodesmus* (Chodat) Hegewald, Bock & Krienitz; *Desmodesmus* (R.Chodat) An, Friedl & Hegewald; *Pectinodesmus* (Meyen) Hegewald, Wolf, Keller, Friedl & Krienitz; *Scenedesmus* Meyen; *Tetradesmus* (G.M.Smith) Wynne and *Verrucodesmus* Hegewald by several taxonomists around the globe [29, 64, 21, 22]. In India, the genera have been studied by a number of researchers [48, 64, 29, 39, 27, 17, 63, 54, 46, 40, 26, 05, 11, 50, 47]. Periyar River with a length of approx. 244 kms is the longest river in Kerala and the present study is based on the collection from the river.

2. Materials and Methods

Twelve sites across the Periyar River were selected for the present study, and each of the four consecutive sites was pooled together as upstream, midstream and downstream. The algal samples were collected from selected sites of the river seasonally (pre-monsoon, monsoon and post-monsoon) for a period of two years (2017-2019). The phytoplanktons were collected with help of plankton mesh net (size 0.5mm) and submerged plants were squeezed to obtain the epiphytic forms. The samples were preserved in modified Formalin Acetic Acid (FAA) solution. The specimens were viewed under Leitz microscope (Germany) and photomicrographs were taken for their identification using Nikon Coolpix Camera. The algal taxa were identified using standard literature [49, 48, 64, 29, 27, 09, 40, 44, 06, 35, 26, 05, 11, 50]. The collected

samples were deposited in the Phycology Division, Department of Botany, Sacred Heart College, Thevara, Kochi, Kerala.

3. Results and Discussion

A total of twenty-eight taxa have been collected during the study period. They belong to the genera *Acutodesmus* (1), *Desmodesmus* (7), *Scenedesmus* (7), *Tetradesmus* (4), *Westella* (1), *Coelastrum* (5) *Hariotina* (1), *Asterarcys* (1) and *Dimorphococcus* (1). Out of this, three taxa are new reports to Kerala and most of them are new records from Periyar River.

Systematic Enumeration

Phylum: Chlorophyta
Subphylum: Chlorophytina
Class: Chlorophyceae
Order: Sphaeropleales
Family: Scenedesmaceae

1. *Acutodesmus acutiformis* (Schröder) Tsarenko & D.M. John, 2011

Philipose, 1967. p.260, fig.169 a, b.

Basionym: *Scenedesmus acutiformis* Schröder, 1897

Synonym: *Scenedesmus acutiformis* Schröder; *Enallax acutiformis* (Schröder) Hindák.

Colonies usually 4 celled sometimes 2-8 celled, flat; cells arranged in a linear series, each cell fusiform, cylindrical with acute apices and a lateral longitudinal ridge; poles without teeth or spines; cell wall smooth.

Dimension: Cells 12-22.4 μm long, 3.8-8 μm broad.

Distribution in India: Telengana, Madhya Pradesh [48], Kerala [40, 44], Maharashtra [05, 50], Jharkhand [35].

2. *Desmodesmus abundans* (Kirchner) E. H. Hegewald, 2000

Philipose, 1967. p.279, fig.184 a-d.

Basionym: *Scenedesmus caudatus* f. *abundans* Kirchner, 1878

Synonym: *Scenedesmus caudatus* f. *abundans* Kirchner; *Scenedesmus quadricauda* f. *abundans* (Kirchner) Lagerheim; *Scenedesmus caudatus* var. *abundans*

(Kirchner) Wolle; *Scenedesmus quadricauda* var. *abundans* (Kirchner) Hansgirg; *Scenedesmus abundans* (O. Kirchner) Chodat.

Colonies usually 2-4 celled, rarely 8 celled; cells arranged in linear series, each cell ovoid to oblong-ovoid. External cells with one or more median lateral spines from the outer face in addition to spines from four corners of the colony. Internal cells with 1-2 spines from their poles, rarely without spines.

Dimension: Cells 6-15 μm long, 2-7 μm broad. Spines 3.5-8 μm long.

Distribution in India: Andhra Pradesh, Karnataka [48], Kerala [26, 27], Maharashtra [05, 50].

3. *Desmodesmus armatus* (Chodat) EH Hegewald, 2000

Philipose, 1967. p.261, fig.171 a-c.

Basionym: *Scenedesmus hystrix* var. *armatus* Chodat, 1902
Synonym: *Scenedesmus hystrix* var. *armatus* Chodat; *Scenedesmus hystrix* f. *armatus* (Chodat) Volk; *Scenedesmus armatus* (Chodat) Chodat.

Colonies usually 4 celled, rarely 2 or 8 celled arranged in linear series; cells oblong-ellipsoid with acute spines. Terminal cells with a single long spine from each pole; cell with median lateral longitudinal ribs, sometimes indistinct or distinct only at either end of the cell.

Dimension: Cells 7-16 μm long, 3-8 μm broad. Four celled colony 12-25 μm in length.

Distribution in India: Assam, Odisha, Andhra Pradesh [48], Kerala [01, 52].

4. *Desmodesmus armatus* var. *bicaudatus* (Guglielmetti) EH Hegewald, 2000

Philipose, 1967. p.262, fig.171 d-f, m.

Basionym: *Scenedesmus acutiformis* var. *bicaudatus* Guglielmetti, 1910

Synonym: *Scenedesmus acutiformis* var. *bicaudatus* Guglielmetti; *Scenedesmus armatus* var. *bicaudatus* (Guglielmetti) Chodat.

Colonies 2-4 celled arranged in linear series. Cells oblong-ellipsoid with acute apices. Long spines from one of the poles of terminal cells alternating with each other. Longitudinal ribs usually seen only in internal cells.

Dimension: Cells 8.3-12 μm long, 2.5-4.6 μm broad. Four celled colonies 10-18.5 μm long. Spines 3.5-8.8 μm long.

Distribution in India: Odisha, Andhra Pradesh [48], Kerala [26, 48], Madhya Pradesh [48, 65].

5. *Desmodesmus brasiliensis* (Bohlin) E.Hegewald, 2000

Philipose, 1967. p.261, fig.170 a-c.

Basionym Synonym: *Scenedesmus brasiliensis* Bohlin, 1897
Colonies usually 4 celled, sometimes 2 or 8 celled. Cells cylindrical or oblong-ellipsoid with attenuate apices and with a longitudinal ridge extending from pole to pole on each side of the cell. Ends of cell with 1-4 teeth.

Dimension: Cells 11-28 μm long, 2-8.5 μm broad.

Distribution in India: Manipur, Maharashtra, Telengana, Karnataka [48], Assam [24, 48], Sikkim [09], Maharashtra [05, 50], Gujarat [28], Kerala [26, 67], Sikkim [10], Odisha [06, 48], West Bengal [07].

6. *Desmodesmus denticulatus* (Lagerheim) S.S.An, T. Friedl & E. Hegewald, 1999

Philipose, 1967. p.269, fig.176 a-c.

Basionym & Synonym: *Scenedesmus denticulatus* Lagerheim, 1882.

Colonies usually 4 celled arranged in a cruciate or subalternating series. Cells ovoid-oblong to ellipsoid with 1-4 (usually 2) teeth from each pole, sometimes absent from one end of the inner cells.

Dimension: Cells 6-17 μm long, 4-11 μm broad.

Distribution in India: Odisha, Madhya Pradesh, Tamil Nadu, Bihar [48], Maharashtra [05], Kerala [01, 26, 40, 48].

7. *Desmodesmus opoliensis* (P.G. Richter) E. Hegewald, 2000

Philipose, 1967. p.275, fig.181 a-b.

Basionym: *Scenedesmus opoliensis* P.G. Richter, 1895

Synonym: *Scenedesmus opoliensis* P.G. Richter; *Scenedesmus quadricauda* var. *opoliensis* (P.G. Richter) West & G.S. West.

Colonies 2-4 celled; cells cylindrical to sub fusiform arranged in linear series. Adjacent cells contact only along about one third of their length. Internal cells tumid in the median region and attenuated towards the ends. Terminal cells often narrower and rectangular. Terminal cells with long, more or less recurved spines.

Dimension: Cells 17-28 μm long, 4.8-8 μm broad. Spines 15-28 μm long.

Distribution in India: Odisha, Madhya Pradesh, Andhra Pradesh, Telengana, Tamil Nadu [48], Maharashtra [05, 50], West Bengal [37], Kerala [01, 26, 27, 45], Rajasthan [04].

8. *Desmodesmus perforatus* (Lemmermann) E. Hegewald, 2000

Philipose, 1967. p.280, fig.186 a-b, g.

Basionym & Synonym: *Scenedesmus perforatus* Lemmermann, 1903

Colonies usually 8 celled, sometimes 4 celled; cells with capitates ends; outer face of external cells slightly convex, inner face concave; poles curved outwards and with a long recurved spine; internal cells with concave sides and with linear to lenticular perforations between adjacent cells; cell membrane smooth or punctuate.

Dimension: Cells 10-28 μm long, 3-10 μm broad. Spines 10.6-25 μm long. Perforations 1.5-3.6 μm broad.

Distribution in India: Odisha [48], Kerala [26, 40, 45, 48], Uttar Pradesh [53], Maharashtra [12, 42, 50], West Bengal [10].

9. *Scenedesmus arcuatus* (Lemmermann) Lemmermann, 1899

Prescott, 1951, p.275, pl.62, figs.8; Philipose, 1967. p.256, fig.166 a-c.

Basionym & Synonym: *Scenedesmus bijugus* var. *arcuatus* Lemmermann, 1898

Colonies usually 8 celled, rarely 4 or 16 celled, curved with small intercellular spaces. Cells in eight colonies in two series, oblong-ovoid, sometimes slightly angular at the base due to mutual pressure; cellwall smooth, without teeth or spines.

Dimension: Cells 8.5-18 μm long, 3.5-9.5 μm broad.

Distribution in India: Gujarat [28], Assam, Andhra Pradesh [48], Maharashtra [02, 05, 42, 50, 60], Himachal Pradesh [25], Uttarakhand [18], Sikkim [32], Orissa [48, 51], Kerala [40, 45, 48, 67], Himachal Pradesh [31], Tamil Nadu [59], Rajasthan [04].

10. *Scenedesmus bijugatus* var. *graevenitzii* (C. Bernard) Philipose, 1967

Philipose, 1967. p.254, fig.164 a-b.

Basionym: *Steiniella graevenitzii* C. Bernard, 1908

Colonies 4-8 celled arranged in alternating series with adjacent cells touching a small portion of their length. Cells fusiform, ellipsoid, oblong-ellipsoid to ovoid with obtuse poles. Colonies frequently aggregated in syncoenobia by broken remains of parent cell wall.

Dimension: Cells 10-16.7 μm long, 4.5-7.9 μm broad.

Distribution in India: West Bengal, Tamil Nadu [48], Maharashtra [05], Kerala [26, 43].

11. *Scenedesmus naegelii* Brébisson, 1856

Philipose, 1967. p.273, fig.180 b-e.

Synonym: *Scenedesmus quadricauda* var. *naegelii* (Brébisson) Rabenhorst; *Scenedesmus longus* var. *naegelii* (Brébisson) G. M. Smith.

Colonies 2-4-8 celled arranged in linear or sub linear series. Cells more or less oblong to cylindrical to sub pyriform with rounded ends. Terminal cells with long recurved spine from one pole and a long or short, straight or slightly curved spine from the other pole. Internal cells with short or long erect or recurved spine usually from one pole only, but sometimes with rudimentary spines from other pole also.

Dimension: Cells 10.6-33 μm long, 5.3-11 μm broad.

Distribution in India: West Bengal, Odisha, Madhya Pradesh, Andhra Pradesh [48], Uttar Pradesh [38], Maharashtra [05], Kerala [01], Jharkhand [35].

12. *Scenedesmus platydiscus* (GM Smith) Chodat, 1926

Philipose, 1967. p.256, fig.165.

Basionym: *Scenedesmus arcuatus* var. *platydiscus* G.M.Smith, 1916

Colonies 8 celled, flat with oblong-elliptic cells arranged in a double series. Interstices between cells minute or absent altogether.

Dimension: Cells 8-17 μm long, 4.5-7.5 μm broad.

Distribution in India: West Bengal, Odisha, Karnataka, Kerala [48], Madhya Pradesh [65], Sikkim [09], Rajasthan [4].

13. *Scenedesmus bijugatus* Kützing, 1834

Philipose, 1967. p.252, fig.164 c,e,f.

Colonies 2-4-8 cells arranged in single linear series, flat or slightly curved. Cells oblong-ellipsoid to ovoid with broadly rounded ends.

Dimension: cells 7-23 μm long, 3.5-7 μm broad.

Distribution in India: Bengal, Odisha, Telengana [48], Uttar Pradesh [38], Madhya Pradesh [16, 65], Tamil Nadu [59], Maharashtra [05, 23, 34, 42, 48], Kerala [26, 45], Assam [24, 48].

14. *Scenedesmus quadricauda* (Turpin) Brébisson in Brébisson & Godey, 1835

Philipose, 1967. p. 283, fig.187 a. Basionym: *Achnanthes quadricauda* Turpin, 1828 Colonies 2-4-8 celled arranged in linear series. Cells oblong, cylindrical with rounded end. Outer cells with two long curved spines at each pole. Cell wall smooth without ridges.

Dimension: Cells 9-18.5 μm long, 3-7 μm broad. Spines 6.5-15 μm long. Distribution in India: Gujarat [28], Manipur, West Bengal, Odisha, Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar [48], Madhya Pradesh [48, 65], Kerala [26, 45, 48], Rajasthan [57], Maharashtra [48, 50].

15. *Scenedesmus quadricauda* var. *bicaudatus* Hansgirg, 1890

Philipose 1967. p. 284, fig. 187 k-l.

Colonies 2-4-8 celled arranged in a single linear series. Cells cylindrical uniform, terminal cells with a long spine from one pole only. Internal cells without spines from their poles.

Dimension: Cells 8-12 μm long, 4-5 μm broad. Spines 7-8.8 μm long.

Distribution in India: Odisha, Andhra Pradesh, Tamil Nadu [48], Maharashtra [05, 08, 50], West Bengal [10, 24], Kerala [40, 43, 45].

16. *Tetradesmus dimorphus* (Turpin) MJ Wynne, 2016

Philipose 1967. p. 249, fig. 160 a-c.

Basionym: *Achnanthes dimorpha* Turpin, 1828

Synonym: *Scenedesmus obliquus* var. *dimorphus* (Turpin) Hansgirg; *Scenedesmus acutus* var. *dimorphus* (Turpin) Rabenhorst; *Achnanthes dimorpha* Turpin; *Scenedesmus dimorphus* (Turpin) Kützing; *Acutodesmus dimorphus* (Turpin) P. M. Tsarenko.

Colonies 4-8 celled arranged in a linear or sub-alternating series (in 8 celled colony). Cells fusiform, external cells more or less lunate or curved, internal cells straight and more or less hexagonal in shape. Cell apices sharp and acute, without teeth and spines.

Dimension: Cells 14-35 μm long, 2-8 μm broad.

Distribution in India: Manipur, Tamil Nadu, Odisha, Telengana [48], West Bengal [10, 37, 48], Maharashtra [05, 50], Gujarat [28], Madhya Pradesh [48, 65], Rajasthan [04, 58], Kerala [26, 40, 43, 44, 48].

17. *Tetradesmus incrassatulus* (Bohlin) MJ Wynne, 2016

Philipose 1967, p. 252, fig. 163

Basionym: *Scenedesmus incrassatulus* Bohlin, 1897

Synonym: *Scenedesmus incrassatulus* Bohlin; *Acutodesmus incrassatulus* (Bohlin) Tsarenko.

Colonies of 2-4 celled arranged in linear or sub altering series. Cells fusiform, curved with the outer side convex and inner side more or less straight or slightly concave. Ends of cell stumpy and with apical nodules.

Dimension: Cells 12-28 μm long, 5-10 μm broad.

Distribution in India: West Bengal [10], Maharashtra [05, 50], Rajasthan [57]. New report to Kerala.

18. *Tetradesmus lagerheimii* M. J. Wynne & Guiry, 2016

Philipose 1967, p. 251, fig. 161 a-b

Synonym: *Selenastrum acuminatum* Lagerheim; *Scenedesmus acuminatus* (Lagerheim) Chodat; *Acutodesmus acuminatus* (Lagerheim) P.M.Tsarenko; *Tetradesmus acuminatus* (Lagerheim) M.J.Wynne.

Colonies usually 4 celled sometimes 8 celled curved cells. Cells fusiform, lunate with sharp pointed ends. External cells usually sharply lunate, internal cells sometimes flat. Rarely, all cells in the same plane. Cell wall smooth, without teeth or spines.

Dimension: Cell 12-48 μm long (between apices), 2-7 μm broad. Distribution in India: Assam [48], Kerala [01, 43, 45, 48, 52], Madhya Pradesh [65], West Bengal [07, 37], Rajasthan [04], Maharashtra [50], Odisha [06, 24, 48].

19. *Tetradesmus obliquus* (Turpin) M. J. Wynne, 2016

Philipose 1967, p. 249, fig. 159 a-c.

Basionym: *Achnanthes obliqua* Turpin, 1828

Synonym: *Achnanthes obliqua* Turpin; *Scenedesmus obliquus* (Turpin) Kützing; *Acutodesmus obliquus* (Turpin) Hegewald & Hanagata.

Colonies 2-8 celled, usually 4 celled arranged in linear or sublinear series. Cells fusiform with acute or slightly rounded ends and usually with straight sides. Outer side of terminal cell concave or slightly convex. Cell wall smooth without terminal teeth or spines.

Dimension: Cells 6-23 μm long, 2.7-9 μm broad.

Distribution in India: Gujarat, Odisha^[48], West Bengal^[07, 10, 37, 48], Assam^[48, 24], Sikkim^[09], Maharashtra^[05, 48], Madhya Pradesh^[65], Rajasthan^[04, 57], Kerala^[27, 45, 52].

Phylum : Chlorophyta

Subphylum: Chlorophytina

Class: Chlorophyceae

Order: Sphaeropleales

Family: Scenedesmaceae

Subfamily: Scenedesmoideae

20. *Westella botryoides* (West) De Wildeman, 1987

Philipose, 1967. p. 203, fig. 114.

Basionym & Synonym: *Tetracoccus botryoides* west, 1892

Colonies of irregular shape, about 40-80 cells. Cells usually small, spherical arranged in groups of 4 to 8. Chloroplast single cup shaped with or without pyrenoid.

Dimension: Cells 3-9 μm in diameter, colonies 30-84 μm in diameter

Distribution in India: Kerala^[27, 47], West Bengal, Orissa^[48], Maharashtra^[02, 14], Himachal Pradesh^[25].

Phylum : Chlorophyta

Subphylum: Chlorophytina

Class: Chlorophyceae

Order: Sphaeropleales

Family: Scenedesmaceae

Subfamily: Coelastroideae

21. *Coelastrum astroideum* De Notaris, 1867

Komárek and Fott 1983, p. 725, fig. 202.4

Synonym: *Coelastrum microporum* f. *astroidea* (De Notaris) Nygaard

Spherical to irregular colonies, 8-16 cells joined directly through the cell wall (without processes connectives). Ovoid cells in lateral view, circular in apical view. Intercellular spaces reduced or even absent; slightly thickened cell wall on the free face; chloroplast 1, parietal, 1 pyrenoid present.

Dimensions: Cells 5-6.5 μm diameter. Colonies 18-22.5 μm diameter.

Distribution in India: West Bengal^[20], Odisha^[06, 15 24], Haryana^[61], Kerala^[67], Meghalaya^[19].

22. *Coelastrum cambricum* W. Archer, 1868

Philipose 1967, p. 230, fig. 138a

Colonies spherical, usually 32-celled, sometimes 8, 16, 64 or 128 celled. Cells spherical and thickened at the poles, 10-12 sided when seen from the apex, connected to each other by 4-6 short gelatinous flat truncate projections. Interspaces between cells circular to triangular.

Dimensions: Cells 6-12 μm diameter. Colonies upto 70 μm diameter.

Distribution in India: Assam, Maharashtra^[48], Haryana^[61], Meghalaya^[19], Rajasthan^[04], Kerala^[66].

23. *Coelastrum microporum* Nägeli, 1855

Philipose, 1967. p. 228, fig. 135

Colonies spherical, 8-16-32 cells joined directly through its walls; spherical cells without connective processes, small intercellular spaces triangular or rectangular; smooth cell wall, without apical thickening, parietal chloroplast present. Dimensions: Cells 6.2-8.8 μm diameter. Colonies 30-38 μm diameter.

Distribution in India: Andhra Pradesh, Bihar, Karnataka, Orissa, Tamil Nadu^[48], Uttar Pradesh^[17, 39, 54, 62], Gujarat^[41], Kerala^[01, 26, 36, 46, 47, 48, 67], Maharashtra^[02, 12], Bihar^[55], Himachal Pradesh^[25], Rajasthan^[04, 58], Meghalaya^[19], Madhya Pradesh^[48, 65], West Bengal^[15, 37, 48].

24. *Coelastrum proboscideum* Bohlin, 1896

Philipose 1967, p. 229, fig. 137(a); Komárek and Fott 1983, p. 726, fig. 203.1.

Coenobia more or less pyramidal, cells in lateral and apical views subtriangular, 8-16 celled joined by 3 processes, intercellular spaces usually large and polygonal, cells truncate and six-sided with the lateral sides slightly concave, poles of thickened, smooth cell wall, margins straight to slightly concave, parietal chloroplast present.

Dimensions: cells 11.5-13.5 μm diameter. Colonies 30-36.5 μm diameter.

Distribution in India: Assam, Karnataka^[48], West Bengal^[37], Odisha^[24, 48], Kerala^[26]

25. *Coelastrum pseudomicroporum* Korshikov, 1953

Das and Adhikary, 2014, p. 152, pl.12, Fig. 6

Colonies spherical; 8, 16 or 32 cells joined 5-6 processes. Ovoid to cuneiform cells in lateral view, spherical cells in apical view. Intercellular spaces triangular, cell wall smooth, parietal chloroplast present.

Dimensions: cell 10-14 μm diameter, colonies 35-60 μm diameter.

Distribution in India: West Bengal^[15, 37]. New report to Kerala.

26. *Hariotina reticulata* P. A. Dangeard, 1889

Philipose 1967, p. 232, fig. 142(a); Komárek and Fott 1983, p.737, fig. 206.1.

Synonym: *Coelastrum reticulatum* (P.A. Dangeard) Senn, 1899

Colonies spherical, 8, 16 or 32 cells covered by a mucilaginous envelope. The cells are also spherical, without wart-like truncate processes, and interconnected to adjacent cells by 1-3 long and slender finger-like processes; intercellular spaces large. Often multiple coenobia held by remains of mother cell walls.

Dimension: Cells are 6-15 μm in diameter. Colonies upto 100 μm diameter.

Distribution in India: Meghalaya^[19], West Bengal^[15], Tamil Nadu^[48], Kerala^[67], Madhya Pradesh^[65], Odisha^[06, 48].

27. *Asterarcys quadricellularis* (K.Behre) E. Hegewald & A. W. F. Schmidt, 1992

Tiwari, & Pandey, 1971. p.43, fig. 27-40.

Basionym: *Coelastrum quadricellulare* K. Behre, 1956

Synonym: *Coelastrum quadricellulare* K. Behre; *Suxenella crucigeneiformis* P. Srivastava & Nizam; *Crucigenia mitrae* G.L. Tiwari & D.C. Pandey; *Asterarcys cubensis* Comas Gonzales;

Suxenella mitrae (G. L. Tiwari & D. C. Pandey) Fott.

Colonies flat four-celled, sometimes 16-celled or with multiple colonies with angular disposition of cells. Cells

oval, cordate or triangular with rounded corners. Chloroplast single, parietal with a central pyrenoid. Reproduction by one or two autocolonies formed in each parent cell.

Dimension: cells 8-16 μm long, 8-18 μm broad. Colonies with sheath 20-54 μm and without sheath 16-40 μm in diameter.

Distribution in India: Uttar Pradesh ^[63], Maharashtra ^[03]. New report to Kerala.

28. *Dimorphococcus lunatus* A. Braun, 1855

Philipose, 1967. p. 205, fig. 115.

Colonies irregular. Cells in groups of four and arranged alternatively in a zigzag fashion. Outer cells of each group reniform or crescent shaped, inner cells elongate-ovoid to ellipsoid. Ends of cell rounded. Parietal chloroplast present. Dimension: Cells 9-25 μm long, 4-15 μm broad. Colonies up to 100 μm in diameter.

Distribution in India: Kerala ^[46, 47, 48], Assam, Orissa, Andhra Pradesh, Karnataka ^[48], Maharashtra ^[14], Bihar ^[55], Uttar Pradesh ^[17].

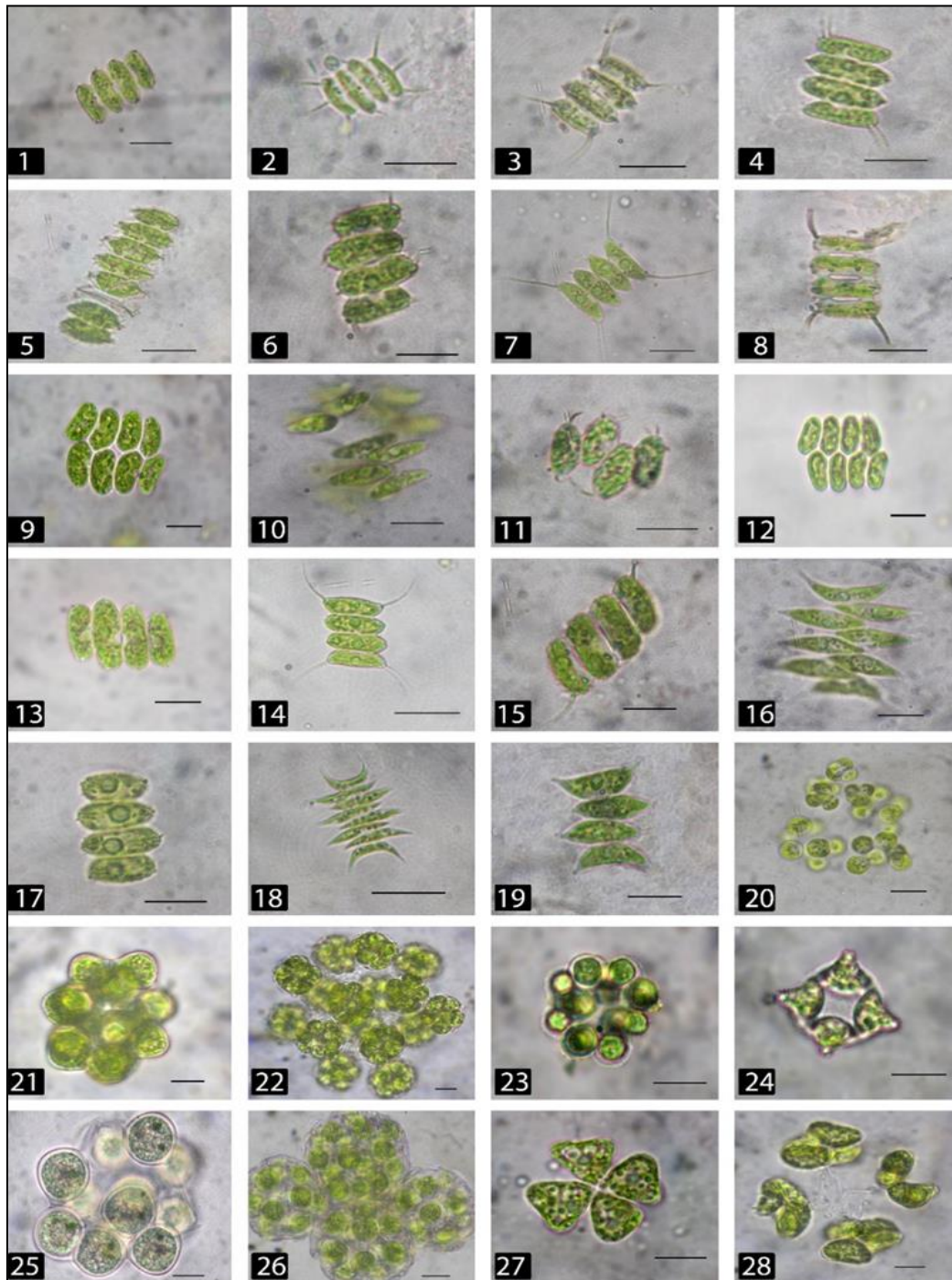


Fig 1: 1. *Acutodesmus acutiformis* 2. *Desmodesmus abundans* 3. *Desmodesmus armatus* 4. *Desmodesmus armatus* var. *bicaudatus* 5. *Desmodesmus brasiliensis* 6 *Desmodesmus denticulatus* 7. *Desmodesmus opoliensis* 8. *Desmodesmus perforates* 9. *Scenedesmus arcuatus* 10. *Scenedesmus bijugatus* var *graevenitzii* 11. *Scenedesmus naegelii* 12. *Scenedesmus platydiscus* 13. *Scenedesmus bijugatus* 14. *Scenedesmus quadricauda* 15. *Scenedesmus quadricauda* var. *bicaudatus* 16. *Tetradasmus dimorphus* 17. *Tetradasmus incrassatulus* 18. *Tetradasmus lagerheimii* 19. *Tetradasmus obliquus* 20. *Westella botryoides* 21. *Coelastrum astroideum* 22. *Coelastrum cambricum* 23. *Coelastrum microporum* 24. *Coelastrum proboscideum* 25. *Coelastrum pseudomicroporum* 26. *Hariotina reticulata* 27. *Asterarcys quadricellularis* 28. *Dimorphococcus lunatus*

4. Conclusion

Taxa belonging to family Scenedesmaceae are capable of surviving in extreme environmental conditions and, hence used as water quality indicators. Most of the members poses carotenoids and lipids which make them a potential source of bioactive compounds and biodiesel production. The present work enumerates 28 taxa of family Scenedesmaceae, order Sphaeropleales, (formerly belonging to the order Chlorococcales) from Periyar River in Kerala with three new reports to Kerala. This study enriched the algal biodiversity of Periyar River.

5. Acknowledgements

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6. References

- Arulmurugan P, Nagaraj S, Anand N. Biodiversity of fresh water algae from temple tanks of Kerala. Recent Research in Science and Technology. 2010; 2(6):58-71.
- Ashtekar PV, ND Kamat. Chlorococcales of Aurangabad, Maharashtra. Phytos. 1980; 14(182):77-79.
- Balakrishnan MS, Deore LT. Occurrence of *Crucigenia mitrii* Tiwari et Pandey, from Poona. Current Science. 1983; 52(23):1145-1145.
- Barupal GK, Narayan P. Chlorophycean flora of Kaylana Lake, Jodhpur (Rajasthan), India. Journal of Algal Biomass Utilization. 2016; 7(1):1-11.
- Beherepatil KH, LT Deore. Genus *Scenedesmus* from different habitats of Nashik and it's Environments (M.S.) India. International Journal of Bioassays. 2013; 02(04):727-734.
- Bhakta S, Adhikary SP. Algal Diversity in two major rivers of Eastern India and physiological assessment of their pollution. The Ecoscan. 2012; 1:01-04.
- Bose R, Nandi C, Roy AS, Gorain PC, Pal R. Floristic survey of microplanktonic cyanobacteria and chlorophyta from different ecological niches of West Bengal, India. Phytomorphology. 2016; 66(3&4):77-93.
- Dalal LP, RS Nisal, P F Dhanarde. Biodiversity of Freshwater algae of Mahakali water Reservoir of Wardha District of Maharashtra State, India. Bionano Frontier. 2012; 5(2-11):202-205.
- Das D, Keshri JP. Coccal Green algae from Bitang-cho Lake (a high-altitude lake in Eastern Himalaya). Indian Hydrobiology. 2012; 15(2):171-182.
- Das M, Keshri JP. *Scenedesmus* Meyen & related genera in foot hills of Eastern Himalaya, India. Phytos. 2015; 45(1):75-84.
- Das SK, Adhikary SP. Freshwater Algae of Eastern India. Astral International Pvt. Ltd., New Delhi, 2014, 453.
- Deshmukh BS, Gunale VK. A systematic account of Chlorococcales from Ahmednagar district, Maharashtra. Indian Hydrobiology. 2007; 10(2):359-369.
- Deshmukh SB, JR Gonjari. Diversity of plankton in Birnal Reservoir with special reference to Phytoplankton. Indian streams Research Journal. 2014; 4(6):1-5.
- Freitas JF. A checklist of Chlorococcales of Nagpur, Maharashtra. Phytos. 1980; 19(1):111-114.
- Garai PK, Mitra PK, Sil SK. Assessment on Phytoplankton Diversity from English Bazaar Block of Malda District. Journal of Agroecology and Natural Resource Management. 2018; 5(2):108-121.
- Garg J, HK Garg. Nutrient loading and its consequences in a lake ecosystem. Tropical Ecology. 2002; 43(2):355-358.
- Habib I, Chaturvedi UK. A systematic account of Chlorococcales from Mahoba, India. Phytos. 2001; 40(1 &2):107-113.
- Habib I, JC Ghildiyal, KS Negi, UK Chaturvedi. A systematic account of Chlorococcales from Kotdwar, Garhwal. Phytos. 1998; 37(1 & 2):125-129.
- Hajong P, Ramanujam P. Seasonal variation in algal diversity and productivity in Dachi Lake, Meghalaya. Journal of Algal Biomass Utilization. 2018; 9(2):9-24.
- Halder N. Taxonomy and periodicity of *Chlorococcum* fries, *Coelastrum* Näg. and *Scenedesmus* Meyen in Hooghly, West Bengal, India. Mesopotamia Environmental Journal. 2016; 2(2):47-56.
- Hegewald E, Bock C, Krienitz L. A phylogenetic study on Scenedesmaceae with the description of new genera *Verrucodesmus* and *Chodatodesmus* (Chlorophyta, Chlorophyceae). Fottea. 2013; 13(2):149-164.
- Hegewald E, Wolf M, Keller A, Friedl T, Krienitz L. ITS2 Sequence-structure phylogeny in the *Scenedesmus* with special reference to *Coelastrum* (Chlorophyta, Chlorophyceae), including the new genera *Comasiella* and *Pectinodesmus*. Phycologia. 2010; 49(4):325-335.
- Jaiswal AG, Gavit UG, Pathak RP. Study of algal flora of Navapur, District Nandurbar, Maharashtra, India. International multidisciplinary research Journal. 2012; 2(12):01-04.
- Jena M, Adhikary SP. Chlorococcales (Chlorophyceae) of eastern and north-eastern states of India. Algae. 2007; 22(3):167-183.
- Jha BC, DK Kaushal, Y Rama Rao. Chlorococcales of Govindsagar reservoir, H.P. India. Phytos. 1985; 24(1 & 2):27-32.
- John J, Francis MS. An illustrated algal flora of Kerala. Vol. I. Idukki district. Green Carmel Scientific Books, Kochi, 2013, 281.
- Jose L, Patel RJ. A systematic account of Chlorococcales new to Kerala. Phytos. 1992; 31(1&2):95-101.
- Kamat ND. Chlorophyceae of Ahmedabad, India. Hydrobiologia. 1962; 20(3):248-279.
- Komárek J, Fott B. Chlorophyceae (Grün algen), Ordnung: Chlorococcales. In: Huber-Pestalozzi G. (ed.), Das Phytoplankton des Süßwassers, Die Binnengewässer. 1983, 16(7/1):1-1044.
- Krienitz L, Wolf M, Hegewald E, Hepperle D. Systematics of coccoid green algae: morphology vs. 18S rRNA gene phylogeny. Journal of Phycology. 2002; 38:19-20.
- Kumar R, MK Seth, MR Suseela. Chlorophyceae of District Kangra of Himachal Pradesh. Phytos. 2012; 42(2):35-38.
- Kumar S, SK Rai. Contribution to the algal flora (Chlorophyceae) of Namchi, Sikkim Himalayas. Our Nature. 2005; 3:50-55.

33. Lothar Krientz EH, Hepperle D. The systematics of coccoid green algae: 18S rRNA gene sequence data versus morphology. *Biologia*, Bratislava. 2003; 58(4):437-446.
34. Mahadik BB, MJ Jadhav. A preliminary study on algal Biodiversity of Ujani Reservoir (M.S.), India. *Bioscience Discovery*. 2014; 5(1):123-125.
35. Mahato AK, Nilima M. New records of the genus *Scenedesmus* from Jharkhand, India. *Advances in Plant Sciences*. 2012; 25(2):577-580.
36. Maya S, Prameela SK, Menon VS. A preliminary study on the algal flora of temple tanks of southern Kerala. *Phykos*. 2000; 39(1 & 2):77-83.
37. Nandi C, Basu P, Pal R. New insights into the diversity of planktonic Chlorophytes and Charophytes from West Bengal with reports of three novel taxa from India. *Phykos*. 2017; 47(2):135-149.
38. Pandey UC, GL Tiwari, DC Pandey. Additions to the Algal-flora of Allahabad VII. Chlorophyta, Chlorococcales. *Proceedings of Indian National Science Academy*. 1981; 2:255-259.
39. Pandey UC, Tiwari RK, Pandey DC. An enumeration of Chlorococcales from Allahabad, U.P., India. In: Cramer. *Bibliotheca Phycologia*. 1983; 66:115-126.
40. Panikkar MVN, R Jayalekshmi, A Jackson. Species diversity of two chlorococcalean colonial genera (*Pediastrum* Mayen and *Scenedesmus* Mayen) from the freshwater ecosystems of Kerala. *Indian Hydrobiology*. 2012; 14(2):117-125.
41. Patel RJ, George I, Daniel JK. Algae of fish ponds in Gujarat, India -1- Chlorococcales. *Phykos*. 1980; 19(1):83-88.
42. Patil SA. Genus *Scenedesmus* Meyen from Mangrul Dam Dist Jalgaon; Maharashtra; *Indian Journal of Fundamental and Applied Life Science*. 2013; 3(2):204-210.
43. Paul PT, Anu PK. Algal diversity of Guruvayur Temple Pond, Thrissur District, Kerala. *International Journal of Advanced Life Sciences (IJALS)*. 2016; 9(3):302-306.
44. Paul PT, Sreekumar R. Systematic account of *Scenedesmus* Meyen (Chlorophyceae, Chlorococcales) from the Kol wetlands of Thrissur, Kerala. *The Journal of Indian Botanical Society*. 2012; 91(1-3):146-152.
45. Paul PT. Studies on the algal flora of Kole lands of Thrissur district, Kerala. Ph.D. Thesis, Mahatma University, Kottayam, Kerala, 2012, 501.
46. Paul TP, Sreekumar R. Assessment of the biodiversity and seasonal variation of freshwater algae in the Thrissur Kol Wetlands (Part of Vembanad - Kol, Ramsar Site), Kerala. *Journal of Economic Taxonomic Botany*. 2009; 33(3):721-732.
47. Paul TP, Sreekumar R. Systematic account of Chlorococcales (Class: Chlorophyceae) from the Kole Lands of Thrissur, (part of Vembanad-Kol, Ramsar site), Kerala. *Phykos*. 2018; 48(1):10-17.
48. Philipose MT. Chlorococcales, *Indian Council of Agricultural Research*, New Delhi, India, 1967, 365.
49. Prescott GW. Algae of the Western Great Lakes Area. *Cranbrook Institute of Science. Bulletin*. 1951; 31:946.
50. Reddy BM, Chaturvedi A. *Scenedesmus* and related genera in riverine system of Chandrapur district, Maharashtra, India. *Phykos*. 2015; 45(2):19-28.
51. Samad LK, S P Adhikari. Diversity of micro-algae and Cyanobacteria on Building Facades and Monuments in India. *Algae*. 2008; 23(2):91-114.
52. Santhakumaran P, Kookal SK, Ray JG. Biomass yield and biochemical profile of fourteen species of fast-growing green algae from eutrophic bloomed freshwaters of Kerala, South India. *Biomass and bioenergy*. 2018; 119:155-165.
53. Sharma AR, S Saxena. Limnological studies of Neum River with special References to Phytoplankton Diversity. *Indian Journal of Biological Studies and Research*. 2012; 2(1):15-23.
54. Shukla SK, Misra PK, Shukla CP. Chlorococcalean algae from the foothills of Western Himalaya. *Journal of Indian Botanical Society*. 2007; 86(3 & 4):80-85.
55. Singh NK, Saha LC. Chlorococcales of Bhagalpur - 1, Bihar. *Journal of Economic Taxonomic Botany*. 1982; 3:197-200.
56. Smith GM. *Tetrademus*, a new four-celled coenobial alga. *Bulletin of the Torrey Botanical Club*. 1913; 40:75-87.
57. Srivastava P. Phycodiversity of Rajasthan-III. Aquatic Algal Flora: A Compilation. *Vegetos-An International Journal of Plant Research*. 2011; 24(2):186-201.
58. Srivastava PN, Odhwani BR. Additions to the Chlorococcalean flora of Jodhpur and its suburbs. *Phykos*. 1990; 29(1 & 2):149-154.
59. Suresh A, Kumar RP, Dhanasekaran D, Thajuddin N. Biodiversity of Microalgae in Western and Eastern Ghats, India. *Pakistan Journal of Bio Science*. 2012; 15(19):919-928.
60. Tarar JL, S Bodkhe. Studies on Chlorococcales of Nagpur. *Phykos*. 1998; 37(1 & 2):107-114.
61. Thakar MK, Luthra D, Khattar JS. Forensic studies of phytoplankton ecology of two water bodies of Kurukshetra area of Haryana, State in India. *Egyptian Journal of Forensic Sciences*. 2018; 8(1):38-52.
62. Tiwari A, Chauhan SVS. An enumeration of Chlorococcales from crop fields of Bichpuri, Agra. *Indian Hydrobiology*. 2004; 7(1 & 2):89-93.
63. Tiwari GL, Pandey DC. Observations on a new species of *Crucigenia* Morren Chlorococcales. *Phycologia*. 1971; 10(1):43-47.
64. Tsarenko PM, Petlevanny OA. Addition to the diversity of algae of Ukraine. *Algologia, Supplement*, 2001, 1-130.
65. Unni KS, Pawar S. The phytoplankton along a pollution gradient in the river Mahanadi (MP state) India—a multivariate approach. *Hydrobiologia*. 2000; 430(1-3):87-96.
66. Usmani MA, Suseela MR, Toppo K, Sheikh S. Algal Diversity in Different Habitats from Northern Region of Idukki District, Kerala, India. *The Journal of Indian Botanical Society*. 2016; 95(1&2):28-36.
67. Vijayan D, Ray JG. Green algae of a unique tropical wetland, Kuttanadu, Kerala, India, in relation to soil regions, seasons, and paddy growth stages. *International Journal of Science, Environment and Technology*. 2015; 4(3):770-803.