

RESEARCH PAPER

Taxonomy and distribution of desmids in Karapuzha Dam, Western Ghats, Kerala

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Abstract

During the studies of algae in the Wayanad district, a notable diversity of desmids observed in the Karapuzha dam, Kerala, India. Karapuzha Dam is 700 to 2061 metres above sea level and is a part of Western Ghats. Thirty-nine taxa of desmids were identified from Karapuzha Dam of Wayanad district from June 2019 to May 2020. The collection comprises ten genera of 39 desmids, including 24 species of *Cosmarium*, 5 *Staurastrum*, 2 *Closterium*, 2 *Euastrum*, 1 *Gonatozygon*, 1 *Triplastrum*, 1 *Penium*, 1 *Spondylosium*, 1 *Micrasterias* and 1 *Arthrodesmus*. Among these, *Cosmarium regnesi* var. *montanum* is new to India, 8 taxa are new to Kerala and 2 taxa are new to South India. Some rare and high altitude distributed species are found in the study. This desmid diversity relates to the oligotrophic nature of the dam. This paper is a pioneer attempt to document the desmid flora of Karapuzha Dam, Kerala.

KEYWORDS

Algae, Diversity, Flora, New report, Wayanad

1 | INTRODUCTION

Kerala is a state on the southwest corner of the Indian peninsula gifted with 44 rivers. Dams have been built across all the major river systems of Kerala in the southern parts of the Western Ghats, creating around 53 reservoirs (Harikumar & Rajendran, 2007). Despite this fact, algal studies are few in the dams of Kerala. In a phycological perspective, only Idukki reservoir (Sebastian & Thomas, 2016), Kanhirapuzha dam (Palaniswamy et al., 2019) and algae from 12 reservoirs of Kerala (Ray et al., 2021) were studied.

At all Indian level, many dams studied for algae. Dams in Maharashtra (Shastri & Pendse, 2001, Nandan & Kumavat, 2003, Chaudhari & Nandan, 2003, Nandan & Aher, 2005, Nandan & Jain, 2006, Shahare & Cherian, 2012, Mahadik & Jadhav, 2014, Tambe & Tapale, 2020), Tamil Nadu (Sreenivasan, 1970), Eastern India (Das & Chakrabarty, 2007), Madhya Pradesh (Kushwaha et al., 2018), Rajasthan (Vyas & Kumar, 1968), Orissa (Das & Adhikary, 2012) and

Chattisgarh (Shrivastava et al., 2014) studied for algae. Desmids in the dams of Maharashtra (Patil & Kumawat, 2014, Bansod & Patil, 2019) and Karnataka (Kiran, 2016) were attempted.

During the studies of algae in the Wayanad district, a notable diversity of desmids observed in Karapuzha dam. According to Fritsch's Classification, desmids belong to class Chlorophyceae. They are an ecologically diverse group of green microalgae and indicate unpolluted natural water-body (Lee, 2008). They exhibit high physiological sensitivity (Prescott, 1948). Besides, they are K-strategists, which prefer an oligotrophic habitat and require high demands for their existence (Coesel & Kooijman-Van Blokland, 1991). As they show distinct geographical features, they indicate the trophic status of freshwaters (Coesel, 1983). Thus undoubtedly study of desmids in an area turns to be valuable and relevant. Desmids can diverse in unpolluted freshwater bodies like dams. In addition to that, higher altitudes (more than 1000m above sea level) contribute to their high diversity and distribution (Barinova et al., 2013). Karapuzha

Dam is at a higher altitude (700 to 2061 metres above sea level). It is a part of the Western Ghats, a hotspot and a significant centre of diversity and endemism for freshwater species (Molur et al., 2011). Despite this predictable diversity, algal exploration is meagre in the district. A genus-level algal identification carried out in Pookot Lake (Nirmala et al., 1991), and after that, no remarkable algal studies reported in Wayanad. So we decided to ascertain desmids in Karapuzha dam.

2 | MATERIAL AND METHODS

2.1 | Study area

Wayanad is known for its varied climatic and topographical features. Wayanad district is on the southern end of the Deccan plateau comprising the Western Ghats with altitudes ranging from 700 to 2100 meters blessed with rich water resources (Hosagoudar & Sabeena, 2014). Banasura Sagar Dam and Karapuzha Dam are the two dams in Wayanad. Karapuzha Dam (11°6'22.3816"N latitude and 76°17'01.75"E longitude) is one of the biggest earth dams of India on Karapuzha River, a tributary of Kabini River. The reservoir has a gross storage capacity of 76.50 Million Cubic Meter. Karapuzha Dam is at a higher altitude (700 to 2061 metres above sea level) and is a part of the Western Ghats.

2.2 | Study plan

For the algal investigation, random water samples collected from June 2019-May 2020. Algal samples are taken from different dam sites and preserved by adding 4% formalin for further observations (Welch, 1948). The stems and leaves of plants submerged in water squeezed into bottles. Photomicrographs obtained with the help of MICAPS digital camera attached to the LABOMED LX 400 microscope and transferred to the computer for further analysis. Identification made using standard literature, scientific papers and online databases.

3 | RESULTS

Desmids belong to Phylum Charophyta, Class Zygnematophyceae and Order Desmidiiales. Thirty-nine taxa of desmids belonging to 10 genera identified from Karapuzha Dam. Out of these 24 *Cosmarium*, 5 *Staurastrum*, 2 *Closterium*, 2 *Euastrum*, 2 *Gonatozygon*, 1 *Triplastrum*, 1 *Penium*, 1 *Spondylosium*, 1 *Micrasterias* and 1 *Arthrodesmus* are identified. Taxonomic account and distribution of desmids are given below.

(L denotes length, W denotes width, and I denote isthmus length)

Family: Gonatozygaceae West

Genus: *Gonatozygon* De Bary

1. *Gonatozygon brebissonii* De Bary

West and West, 1904. vol. 1, p. 31, pl. 1, figs. 8-11.

L:210, W at apex:5, W at centre:6. Plate 1-B.

Longer than the diameter, poles are subcapitate, cell wall densely granulate.

Distribution in India: West Bengal (Sau & Gupta, 2005); Tamil Nadu (Jemi & Balasingh, 2011).

Family: Peniaceae Haeckel

Genus: *Penium* Brébisson ex Ralfs

2. *Penium margaritaceum* Brébisson

West and West, 1904. vol. 1, p. 83, pl. 8, figs. 32-35.

L:100, W:18. Plate 1-A.

Fusiform or cylindrical with rounded truncate ends, rough with granules arranged in longitudinal lines.

Distribution in India: Madhya Pradesh (Agarkar & Agarkar, 1977); Eastern Himalaya (Das & Keshri, 2012); Kerala (Sindhu & Panikkar, 1995b, Nasser & Sureshkumar, 2014a); Odisha and Eastern Himalaya (Bhakta & Adhikary, 2014); Maharashtra (Babar & Raje, 2016).

Family: Closteriaceae Bessy

Genus: *Closterium* Nitzsch ex Ralfs

3. *Closterium parvulum* Nägeli

West and West, 1904. vol. 1, p. 133, pl. 15, figs. 9-12.

L:100-120, W:10. Plate 1-F.

Cells curved, acutely rounded apices, cell wall smooth, terminal vacuoles with moving granules.

Distribution in India: Bihar (Saha & Wujek, 1989, Das & Maurya, 2015); Orissa (Jena et al., 2008); Uttarakhand (Misra et al., 2008, Kumar et al., 2012); Maharashtra (Patil et al., 2012); Karnataka (Purushothama et al., 2011, Ramesha & Sophia, 2013); Bhopal (Bhat et al., 2015, Aisang & Lakshman, 2016); Tripura (Das et al., 2010); West Bengal (Bhosale et al., 2010, Das et al., 2015, Reddy & Chaturvedi, 2017); Jharkhand (Sharan & Sinha, 2010); Tamil Nadu (Suresh et al., 2012); Kerala (Nasser & Sureshkumar, 2014a); Rajasthan (Goyal, 2018).

4. *Closterium venus* Kützing ex Ralfs

West and West, 1904. vol. 1, p. 137, pl. 15, figs. 15-20.

L:55-70, W:5-10. Plate 1-E.

Cells small, strongly curved, acutely rounded apices, cell wall smooth.

Distribution in India: Sikkim (Keshri & Das, 2013); Andhra Pradesh (Suxena & Venkateswarlu, 1966); Karnataka (Rao & Madhyastha, 1990); Kerala (Sindhu & Panikkar, 1994a); Uttarakhand (Misra et al., 2008); Goa (Kanolkar & Kerkar, 2009); Uttar Pradesh (Sharma & Jaiswal, 2012, Bajpai et al., 2019); Orissa (Mohapatra & Patra, 2012); Maharashtra (Gadewar & Lambat, 2011); Chattisgarh (Singh et al., 2011); West Bengal (Mohanty & Adhikary, 2013); Rajasthan (Barupal, 2019).

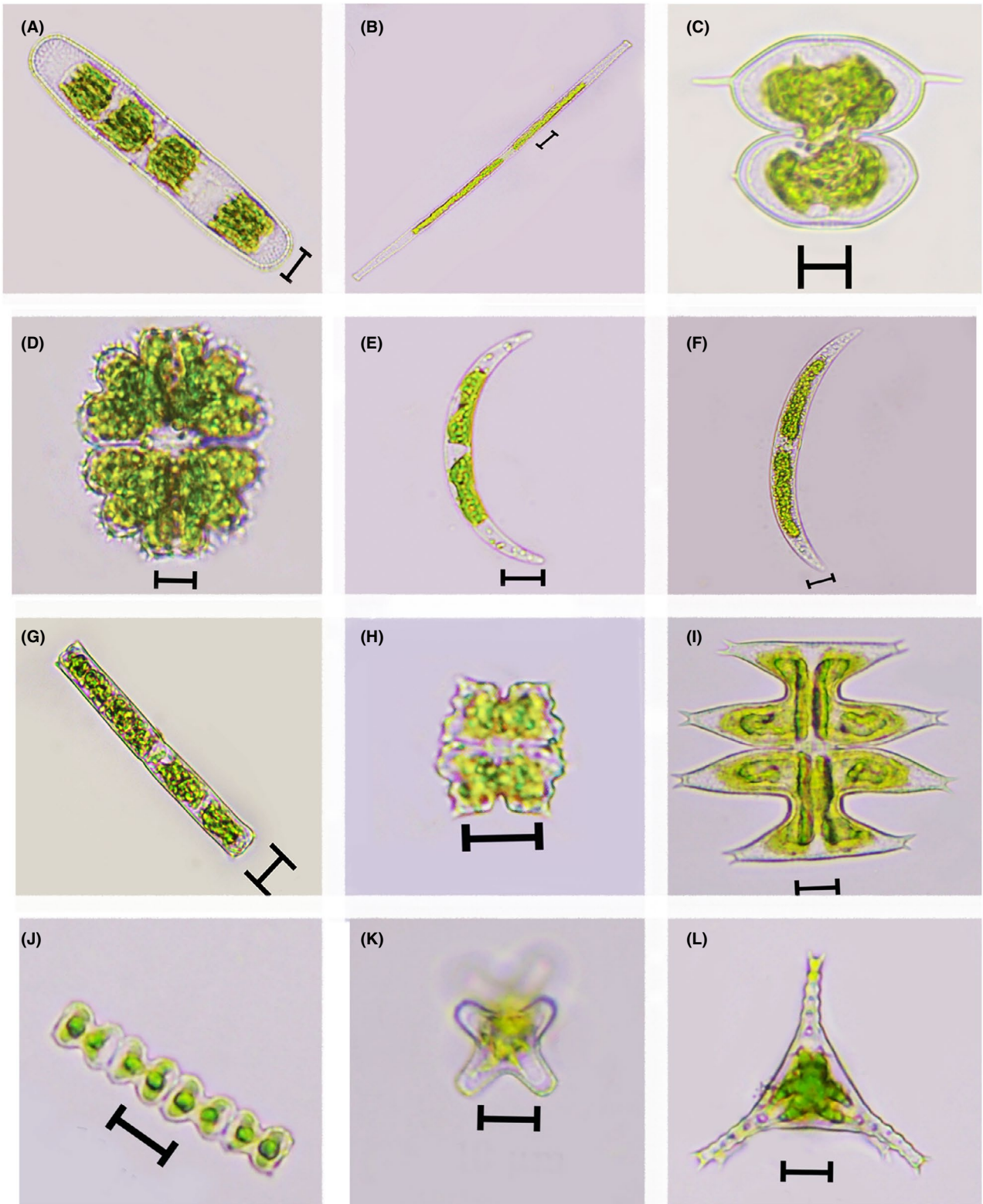


PLATE 1 A) *Penium margaritaceum* Brébisson B) *Gonatozygon brebissonii* De Bary C) *Arthrodesmus convergens* Ehrenberg ex Ralfs D) *Euastrum spinulosum* Delponte E) *Closterium venus* Kützing ex Ralfs F) *Closterium parvulum* Nägeli G) *Triplastrum abbreviatum* (Turner) Iyengar & Ramanathan H) *Euastrum denticulatum* F. Gay I) *Micrasterias pinnatifida* Ralfs J) *Spondylosium planum* (Wolle) West & G.S.West K) *Staurastrum disputatum* West & G.S.West L) *Staurastrum spiniceps* var. *trifidum* A.M.Scott & Prescott

Family: Desmidiaceae Ralfs

Genus: *Arthrodesmus* Ehrenberg ex Ralfs

5. *Arthrodesmus convergens* Ehrenberg ex Ralfs

Scott & Prescott, 1961. p. 74, pl. 34, figs. 7–10.

L:35-50, Wcsp:60-62, Wssp:40, l:11-18. Plate 1-C.

Cells are smooth, broader than long, deep constriction, each semi cell elliptic with one lateral spine on each side. Some semi cells with maturing or without lateral spines seen.

Distribution in India: Eastern India (Turner, 1892); Karnataka (Bharati, 1965); Maharashtra & Karnataka (Bharati, 1966); Jharkhand (Sinha & Mishra, 1967); Andhra Pradesh (Suxena & Venkateswarulu, 1968); Madhya Pradesh (Agarkar, 1971); Tamil Nadu (Bharati & Pai, 1972); Maharashtra (Kamat, 1975a); Madhya Pradesh (Habib, 1991); Uttar Pradesh (Habib, 1993, Habib, 2009); West Bengal (Mukherjee & Srivastava, 1993); Uttarakhand (Misra et al., 2008, Habib & Chaturvedi, 2012); Sikkim (Das & Keshri, 2013); Kerala (Nasser & Sureshkumar, 2014a, Ajayan & Kumar, 2017); Meghalaya (Hajong & Papiya, 2018).

Genus: *Micrasterias* C. Agardh ex Ralfs

6. *Micrasterias pinnatifida* Ralfs

Scott & Prescott, 1961. p. 51, pl. 12, fig. 6 & pl. 14, figs. 17, 18.

L:60, W:65, l:15. Plate 1-I.

Cells broader than long, pinnatifid, lateral lobes and terminal lobes are present and separated by deeply curved incision, lateral lobes separated by sub-acute incision, terminal and lateral extremities bidentate.

Distribution in India: North India (Turner, 1892); Tamil Nadu (Iyengar & Vimala Bai, 1941, Maheswari & Baluswami, 2017, Perumal & Anand, 2008, Palanivel et al., 2018); Kerala (Sindhu & Panikkar, 1995a, Paul & Sreekumar, 2007, John & Francis, 2013); Andhra Pradesh (Suxena & Venkateswarlu, 1966); Madhya Pradesh (Agarkar, 1969); Uttarakhand (Misra et al., 2008); Assam (Deka et al., 2011); Maharashtra (Bandgar & Papdiwal, 2013).

Genus: *Spondylosium* Brébisson ex Kützing

7. *Spondylosium planum* (Wolle) West & G.S. West

Scott & Prescott, 1961. p. 121, pl. 60, figs. 6-8.

L:10, W:8-10, l:3. Plate 1-J.

Tiny cells, slightly longer than broad, semi cells elliptic with truncate apices, cells united to form filaments.

Distribution in India: Madhya Pradesh (Agarkar & Agarkar 1977); Kerala (Shaji & Patel, 1990); Southern Himachal Pradesh (Dwivedi et al., 2009); Chattisgarh (Singh et al., 2011); Jharkhand (Toppo & Suseela 2013); West Bengal (Das et al., 2015).

Genus: *Euastrum* Ehrenberg ex Ralfs

8. *Euastrum spinulosum* Delponte

Scott and Prescott, 1961. p. 40, pl. 10, fig. 3.

L:50-55, W:45-47, l:10-11. Plate 1-D.

Semicells pyramidate with convex sides, apex rounded-truncate, margins of all lobes are with short, sharp spines.

Distribution in India: Karnataka (Ramachandra et al., 2012); Uttarakhand (Misra et al., 2008); Goa (Kanolkar & Kerkar 2009); Gujarat (Nagar 2011); Chattisgarh (Singh et al., 2011); Jharkhand (Kumar & Sahu 2012); Chattisgarh (Bhakta & Adhikary 2012); Maharashtra (Kshirsagar et al., 2012); Bihar (Dey et al., 2014); Kerala (Nasser & Sureshkumar 2014b, Vijayan & Ray 2015); Bhopal (Bhat et al., 2015); Maharashtra (Shahare & Cherian 2012, Reddy & Chaturvedi 2017, Ghule & Halwe, 2017); Madhya Pradesh (Unni & Pawar 2000); Tamil Nadu (Palanivel et al., 2018).

9. *Euastrum denticulatum* F. Gay

Scott & Prescott, 1961. p. 25, pl. 13, fig. 10.

L:20, W:15, l:5. Plate 1-H.

Tiny cells, deeply constricted, sinus narrowly linear with dilated extremity, semi cells subquadrate, basal angles rounded with denticulations, semi cell has granules, acute apex with a granulated protuberance at each side near the base.

Distribution in India: Madhya Pradesh (Agarkar & Agarkar, 1977, Agarkar et al., 1979); Kerala (Paul & Sreekumar, 2013); West Bengal (Das et al., 2015); Meghalaya (Hajong & Papiya, 2018).

Genus: *Triplastrum* Iyengar & Ramanathan

10. *Triplastrum abbreviatum* (Turner) Iyengar & Ramanathan

Iyengar & Ramanathan, 1942.

L:75, W:9. Plate 1-G.

Cells small, longer than broad, semi cells were straight, median constriction shallow, end inflated, lobed, lobes short, each short spine.

Distribution in India: North India (Iyengar & Ramanathan, 1942).

Genus: *Staurastrum* Meyen ex Ralfs

11. *Staurastrum disputatum* West & G.S. West

West and West, 1912. vol. 4, p. 176, pl. 126, fig. 19.

L:18-20, W:18-20. Plate 1-K.

Cells small, moderately constricted, sinus widely open, cell wall smooth but granulated at angles.

Distribution in India: Karnataka and Goa (Bharati & Hegde, 1982); Kerala (Shaji & Patel, 1990).

12. *Staurastrum punctulatum* Brébisson

Scott & Prescott, 1961. p. 104, pl. 52, fig. 14.

L:35, W:25, l:10. Plate 2-A.

Semicells rough with granules, elliptic, broadly rounded angles, and slightly concave sides.

Distribution in India: Uttar Pradesh (Pandey et al., 1987); Uttarakhand (Misra et al., 2008); Maharashtra (Radhakrishn, 2016).

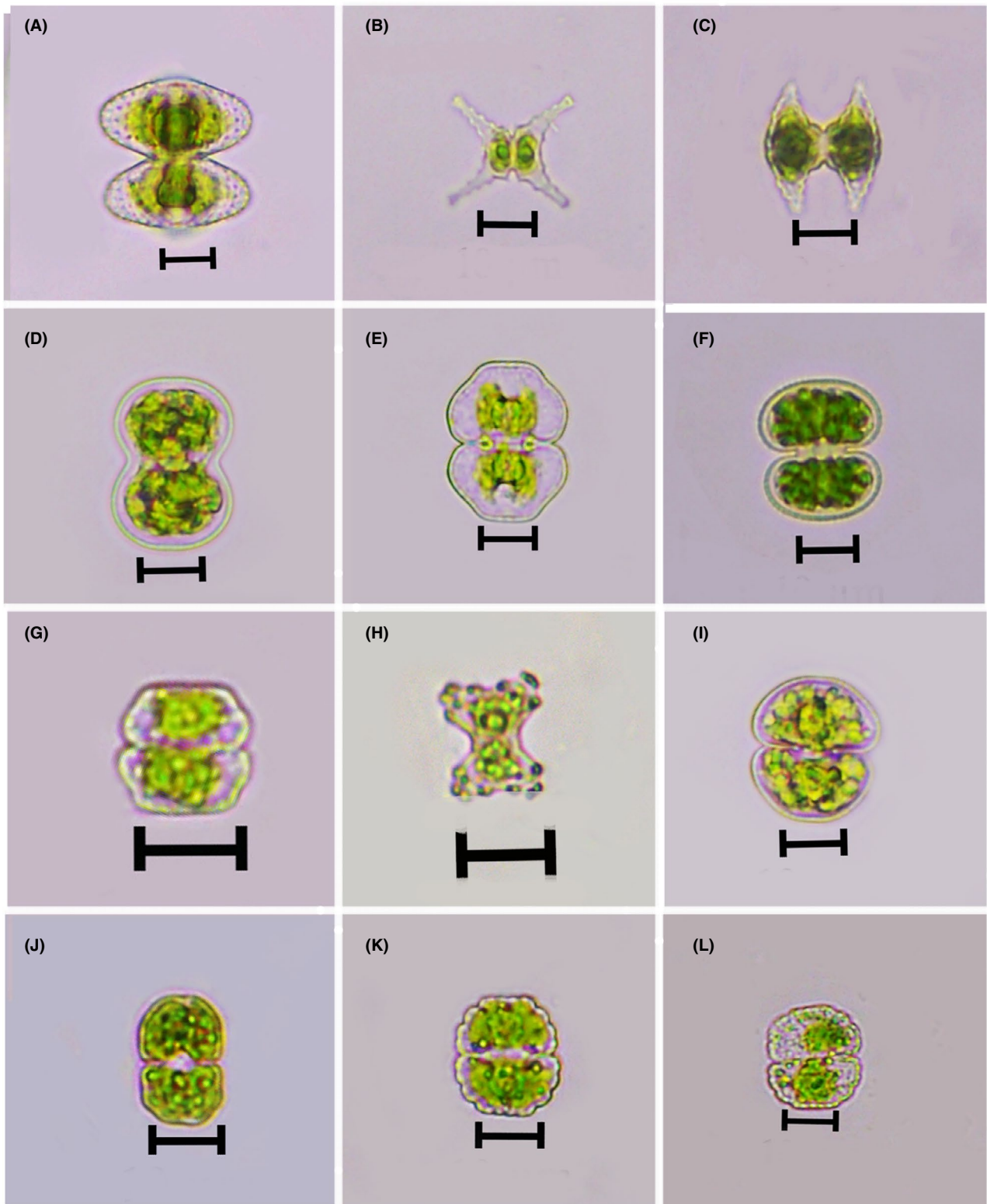


PLATE 2 A) *Staurastrum punctulatum* Brébisson B) *Staurastrum tetracerum* Ralfs ex Ralfs C) *Staurastrum crenulatum* (Nägeli) Delponte D) *Cosmarium globosum* var. *minus* (Hansgirg) West & G.S.West E) *Cosmarium hammeri* Reinsch var. *protuberans* West & G.S.West. F) *Cosmarium bioculatum* Brébisson ex Ralfs G) *Cosmarium subretusiforme* var. *crassum* Scott & Prescott ex Kouwets H) *Cosmarium regnesi* var. *montanum* Schmidle I) *Cosmarium subtumidum* Nordst. J) *Cosmarium meneghinii* Brébisson ex Ralfs K) *Cosmarium blyttii* Wille L) *Cosmarium sexnotatum* Gutw.var.*tristriatum* (Lutkem.) Schmidle

13. *Staurastrum spiniceps* var. *trifidum* A.M.Scott & Prescott

Scott & Prescott, 1961. p.108, pl. 58, fig 5.

L:45, W:50. Plate 1-L.

Short processes, triradiate, granules in serrate margins of the processes.

Distribution in India: Kerala (Arulmurugan et al., 2010).

14. *Staurastrum crenulatum* (Nägeli) Delponte

Scott & Prescott, 1961. p. 88, pl. 59, fig. 10.

L:23, W with processes:30, l:8. Plate 2-C.

Cells small, as long as broad, sinus acute, semi cells broadly oval, processes with denticulate undulate margins.

Distribution in India: Kerala (Shaji & Patel, 1990); Tamil Nadu (Perumal & Anand, 2008);

Madhya Pradesh (Bhat et al., 2015).

15. *Staurastrum tetracerum* Ralfs ex Ralfs

Scott & Prescott, 1961.p.112, pl.57, fig. 12.

L:20, W:20, l:5. Plate 2-B.

Cells minute, as long as broad, Semi cells rough, four slender diverging processes entirely at the apex.

Distribution in India: South India (Zafar, 1986); Telagana (Rao, 1975, Reddy & Chaturvedi, 2017); Kerala (Ajayan & Kumar, 2015, Ajayan & Kumar, 2017); Maharashtra (Reddy & Chaturvedi, 2017); Rajasthan (Barupal, 2019).

Genus: *Cosmarium* Corda ex Ralfs

16. *Cosmarium speciosum* var. *australianum* Nordstedt

West and West, 1908. vol. 3, p. 247, pl. 89, figs. 1–3.

L:40-45, W:30-35, l:10. Plate 3-E.

Semi cells oblong, constricted with narrow linear sinus, apex sub truncate, sides slightly convex, margin crenate, granules arranged in regular concentric series, delicately granulated at poles, side view subovate.

Distribution in India: Uttarakhand (Misra et al., 2008); Uttar Pradesh (Tiwari & Chauhan, 2007); Tamil Nadu (Perumal & Anand, 2008); Maharashtra (Patil et al., 2012, Ghule & Halwe, 2017); Kerala (Paul & Sreekumar, 2015, Vijayan & Ray, 2015).

17. *Cosmarium auriculatum* Reinsch

Scott & Prescott, 1961. p. 54, pl. 26, fig. 4.

L:40, W:45, l:20. Plate 3-I.

Cells as long as broad, semi cells ellipsoidal with protruding lateral ends.

Distribution in India: Bengal (Turner, 1892); Manipur (Bruhl & Biswas, 1926); Delhi (Singh, 1966); Andhra Pradesh (Suxena & Venkateswarulu, 1968, Kaparapu & Geddada, 2015); Gujarat (Patel, 1969, Asoka Kumar and Patel, 1988); Madhya Pradesh (Agarkar, 1969, Patel & Satyanarayan, 1976, Mishra, 2007); Maharashtra (Kamat, 1975a, Kamat, 1975b, Freitas & Kamat, 1979); Rajasthan (Patel & Rao, 1975); Uttar Pradesh (Prasad &

Mehrotra, 1977, Pandey & Pandey, 1980); Bihar (Saha & Choudhary, 1984); Karnataka (Somashekar, 1984, Hegde & Isaacs, 1988, Bongale, 1989, Miranda & Krishnakumar, 2015); Kerala (Shaji et al., 1988, Sindhu & Panikkar, 1995b, Paul & Sreekumar, 2015, Vijayan & Ray, 2015, Nasser & Sureshkumar, 2014a); West Bengal (Nandi et al., 2019).

18. *Cosmarium bioculatum* Brébisson ex Ralfs

West and West, 1905. vol. 2, p. 165, pl. 61, figs. 3-7.

L:18-20, W:15-20, l:7-10. Plate 2-F.

Cells minute, as long as broad, constriction deep, cell elliptic and smooth.

Distribution in India: Uttar Pradesh (Prasad et al., 1987); Bihar (Saha & Wujek, 1989); Meghalaya (Kalita et al., 2015, Hajong & Papiya, 2018); Sikkim (Das & Keshri, 2012); Delhi (Chopra et al., 2017); Tamil Nadu (Radha & Uma Rani, 2018); West Bengal (Nandi et al., 2019); Maharashtra (Patil et al., 2012, Shahare & Cherian, 2012, Reddy & Chaturvedi, 2017, Ghule & Halwe, 2017).

19. *Cosmarium contractum* O.Kirchner

West and West, 1905. vol. 2, p. 170, pl. 61, figs. 23–25.

L:35, W:20, l:5. Plate 3-K.

Cells longer than broad deeply constricted in the middle, semi cells elliptic, apex narrow with rounded angles, cell wall smooth.

Distribution in India: Bengal and North India (Turner, 1892); Maharashtra (Kamat, 1975a, Bhosale et al., 2010, Shahare & Cherian, 2012); Gujarat (Asoka Kumar & Patel, 1988); Meghalaya (Sharma, 1995); Kerala (Sheeba & Ramanujan, 2005, Nasser & Sureshkumar, 2014b, Paul & Sreekumar, 2015, Ray et al., 2021); Tamil Nadu (Perumal & Anand, 2008, Palanivel & Uma Rani, 2016); Jharkhand (Kumar & Sahu, 2012); Karnataka (Ramachandra et al., 2012); Orissa & West Bengal (Bhakta & Adhikary, 2012); Rajasthan (Goyal, 2018); West Bengal (Nandi et al., 2019).

20. *Cosmarium cucurbita* Brébisson ex Ralfs

West and West, 1908. vol. 3, p. 106, pl.74, fig. 3.

L:40-45, W:23-18, l:20. Plate 4-B.

Cells small, almost cylindrical, almost twice as long as broad, slightly constricted, semi cells subquadrate, apex convex.

Distribution in India: Kerala (Sindhu & Panikkar, 1995b); Meghalaya (Ramanujam & Siangbood, 2009); North Eastern Region (Bhakta & Adhikary, 2014).

21. *Cosmarium globosum* var. *minus* (Hansgirg) West & G.S.West

West and West, 1908. vol. 3, p. 29, pl. 68, figs. 3-5.

L:20-23, W:13-15, l:10-13. Plate 2-D.

Small, subcircular, scarcely compressed, slightly constricted, acute sinus, circular semi cells.

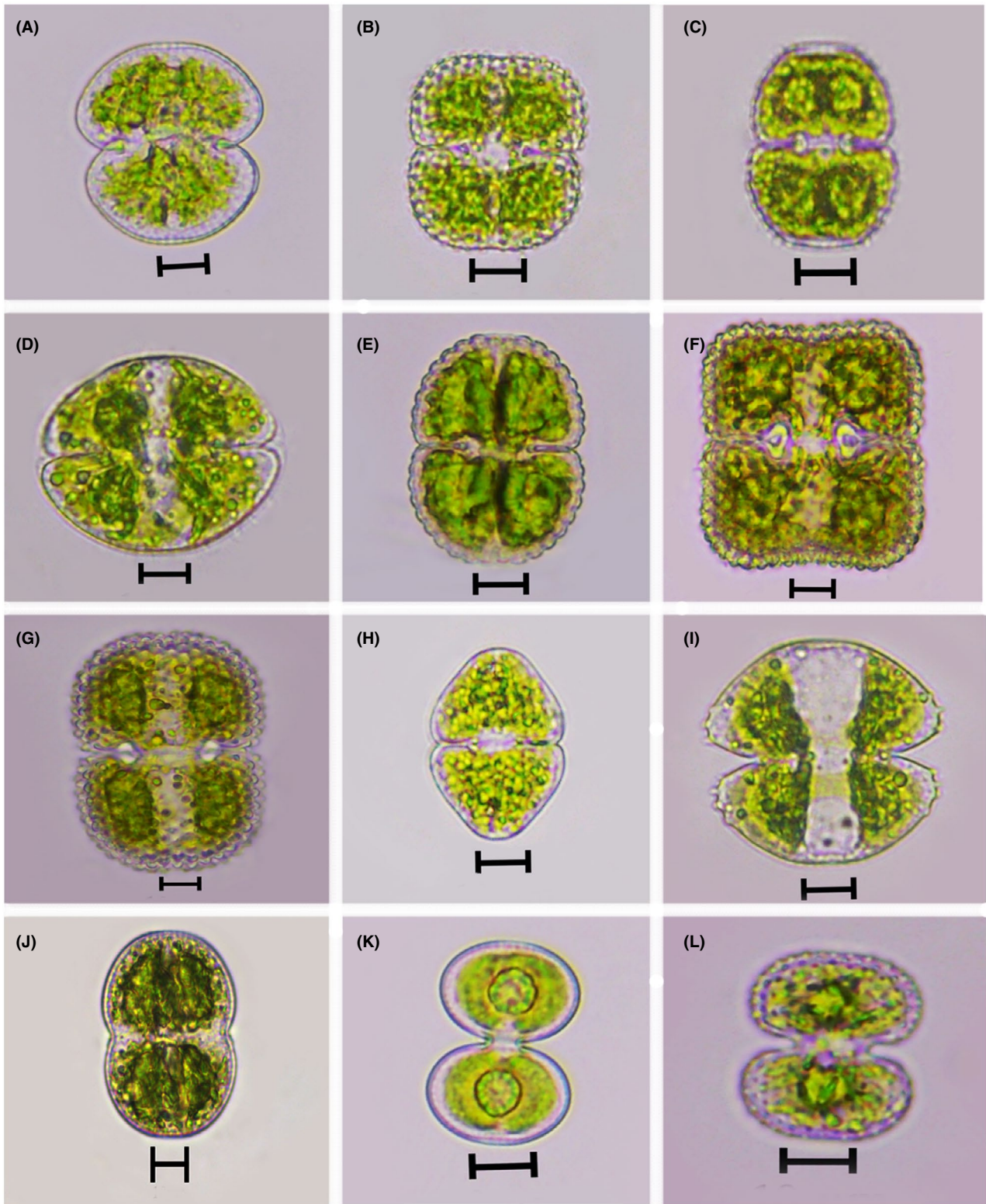


PLATE 3 A) *Cosmarium medioscrobiculatum* West & G.S.West B) *Cosmarium pseudobroomei* Wolle. C) *Cosmarium quadri verrucosum* West & West. D) *Cosmarium obsoletum* (Hantzsch) Reinsch. E) *Cosmarium speciosum* var. *australianum* Nordstedt F) *Cosmarium scabrum* W.B.Turner G) *Cosmarium binum* Nordstedt H) *Cosmarium granatum* Brebisson I) *Cosmarium auriculatum* Reinsch J) *Cosmarium pseudoconnatum* Nordst. K) *Cosmarium contractum* O.Kirchner L) *Cosmarium portianum* Arch

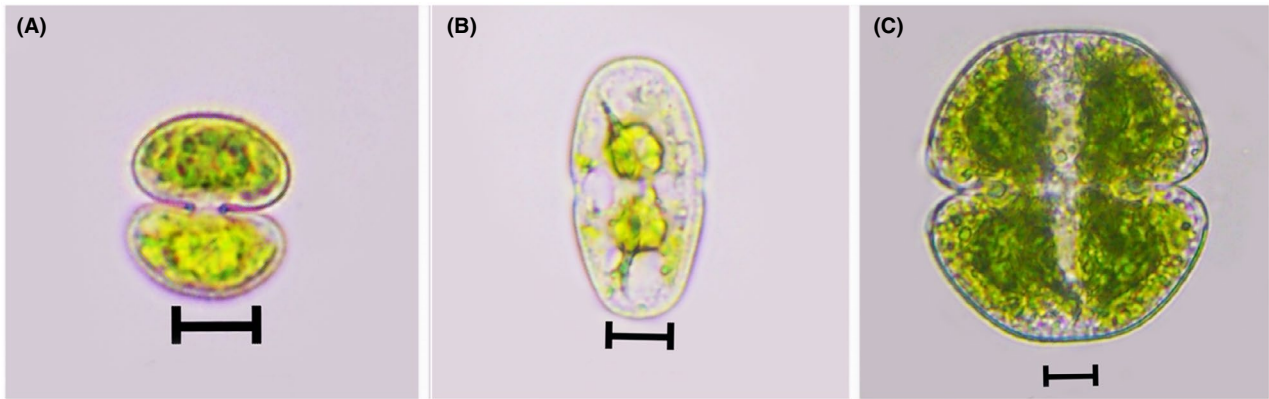


PLATE 4 A) *Cosmarium phaseolus* Breb. B) *Cosmarium cucurbita* Brébisson ex Ralfs C) *Cosmarium lundellii* var. *corruptum* (W.B.Turner) West & G.S.West

Distribution in India: Uttar Pradesh (Pandey & Habib, 1986, Chaturvedi et al., 1987); Meghalaya (Ramanujam & Siangbood, 2009); Maharashtra (Reddy & Chaturvedi, 2017).

22. *Cosmarium binum* Nordstedt

West and West, 1908. vol. 3, p. 246, pl. 88, figs. 10–14.

L:48-75, W:38-50, I:10-15. Plate 3-G.

Cells as long as broad, very narrowly linear sinus, semi cells pyramidate trapeziform, basal angles rounded sub-rectangular, apex widely truncate and crenate, margins granulate.

Distribution in India: Maharashtra (Freitas & Kamat, 1979, Kamat, 1975a, Ghule & Halwe, 2017); Madhya Pradesh (Agarker & Agarkar, 1977, Agarkar et al., 1983); Karnataka (Somashekar, 1984); Gujarat (Asoka Kumar & Patel, 1988); Kerala (Shaji et al., 1988, Paul & Sreekumar, 2015); Bihar (Das et al., 1990); Tamil Nadu (Perumal & Anand, 2008).

23. *Cosmarium lundellii* var. *corruptum* (W.B.Turner) West & G.S.West

Scott & Prescott, 1961. p. 60, pl. 25, fig. 6.

L:50-60, W:47-60, I:20-25. Plate 4-C.

Cells medium-sized, subcircular, deeply constricted, semi cells pyramidate and semi-circular, basal angles broadly rounded, scrobiculations near margins of semi cells.

Distribution in India: Maharashtra (Kamat, 1975a); Madhya Pradesh (Agarker & Agarkar, 1977); Gujarat (Asoka Kumar & Patel, 1988); Kerala (Shaji & Patel, 1990); Goa (Gaunker & Kerkar, 2004); Uttar Pradesh (Pandey et al., 1987, Tiwari & Chauhan, 2007); Karnataka (Begum et al., 2010).

24. *Cosmarium medioscrobiculatum* West & G.S.West

Scott & Prescott, 1961. p. 63, pl. 26, fig. 3.

L:45, W:40, I:21. Plate 3-A.

Cells large, slightly longer than broad, deep constriction, semi cells semi-circular to trapeziform, apical

margin convex to flat, basal angles rounded, cell wall with scrobiculations and granules.

Distribution in India: Karnataka (Shiddamallayya & Pratima, 2007); Kerala (Jayalakshmi & John, 2019).

25. *Cosmarium obsoletum* (Hantzsch) Reinsch.

Scott & Prescott, 1961. p. 63, pl. 26, fig. 1.

L:40-50, W:50-55, I:20. Plate 3-D.

Cells transversely elliptic, a little broader than long, sinus narrowly linear, apex slightly flattened.

Distribution in India: East India (Turner, 1892); Karnataka (Isaacs & Hegde, 1986); Uttar Pradesh (Tiwari & Chauhan, 2007); Kerala (Sindhu & Panikkar, 1995b, Jose & Francis, 2007, Paul & Sreekumar, 2015); Tamil Nadu (Perumal & Anand, 2008, Kerkar & Lobo, 2009); Goa (Kanolkar & Kerkar, 2009); Ahmedbad (Kumar et al., 2012); West Bengal (Nandi et al., 2019); Assam (Sharma et al., 2019);.

26. *Cosmarium pseudoconnatum* Nordst.

West and West, 1908. vol. 3, p. 26, pl. 67, figs. 19-21.

L:55-60, W:40-50, I:35-45. Plate 3-J.

Cells moderate size, long as broad, very slightly constricted by wide sinus, semi cells elliptic, slightly narrowed base.

Distribution in India: Karnataka (Bongale, 1989, Ramachandra et al., 2012, Miranda & Krishnakumar, 2015); Goa (Kerkar & Lobo, 2009); Kerala (Paul & Sreekumar, 2015); Arunachal Pradesh (Das, 2016).

27. *Cosmarium phaseolus* Breb.

West and West, 1905. vol. 2, p. 158, pl. 60, figs. 12-14.

L:21-35, W:20-25, I:12. Plate 4-A.

Cells small, as long as broad, deeply constricted semi cells narrowly reniform.

Distribution in India: Maharashtra (Dixit, 1937, Patil et al., 2012, Bansod & Patil, 2019); Madhyapradesh (Agarkar et al., 1979); Eastern Himalaya (Das & Keshri, 2012); West Bengal (Nandi et al., 2019).

28. *Cosmarium portianum* Arch.

Scott & Prescott, 1961. p. 65, pl. 28, fig. 8.

L:25-30, W:20-25, I:10. Plate 3-L.

Cells relatively small, deeply constricted, isthmus slightly elongated, semi cells elliptic and granulate, granules rounded and arranged in series all over the semi cells.

Distribution in India: East India (Turner, 1892); Maharashtra (Freitas & Kamat, 1979, Kamat, 1975a, Kamat, 1975b, Patil et al., 2012, Ghule & Halwe, 2017, Bansod & Patil, 2019); Madhya Pradesh (Agarkar et al., 1983); Gujarat (Asoka Kumar & Patel, 1988, Bihar (Das et al., 1990); Kerala (Shaji & Patel, 1990, Jose & Francis, 2007, Arulmurugan et al., 2010, Paul & Sreekumar, 2015); Tamil Nadu (Perumal & Anand, 2008, Jemi & Balasingh 2011); Goa (Kerker & Lobo, 2009); Karnataka (Purushothama et al., 2011); Eastern & Sikkim Himalaya (Das & Keshri, 2013).

29. *Cosmarium pseudobroomei* Wolle.

West and West, 1912. vol.4, p.22, pl. 100, figs.7, 8.

L:35-40, W:30-35, I:7-10. Plate 3-B.

Cells as long as broad, very deeply constricted sinus, semi cells oblong rectangular, slightly rounded angles, sides convex, apex slightly convex and semi cells granulated.

Distribution in India: East India (Turner, 1892); Andhra Pradesh (Suxena & Venkateswarlu, 1966); Maharashtra (Kamat, 1975b); Kerala (Shaji & Patel, 1990, Paul & Sreekumar, 2015); Tamil Nadu (Perumal & Anand, 2008); West Bengal (Nandi et al., 2019).

30. *Cosmarium scabrum* W.B.Turner

Scott & Prescott, 1961. p. 68, pl. 29, fig. 3.

L:50, W:50, I:10. Plate 3-F.

Cells long as broad, densely granulate, deeply constricted, narrow sinus, semi cells rectangular with angles rounded, apex straight.

Distribution in India: East India (Turner, 1892); Karnataka (Gurudeva et al., 1983); Kerala (Tessy Paul & Sreekumar, 2015).

31. *Cosmarium sexnotatum* Gutw.var.*tristriatum* (Lutkem.) Schmidle

West and West, 1908. vol. 3, p. 228, pl. 86, figs. 8, 9.

L:19-20 W:16-17 I:4-6. Plate 2-L.

Cells small, deeply constricted, semi cells, sub-semi-circular with a flat base, sides are convex and crenate, margin with a series of granules.

Distribution in India: Maharashtra (Radhakrishn, 2016); Kerala (Prasanthkumar et al., 2017).

32. *Cosmarium blyttii* Wille

West and West, 1908. vol. 3, p. 225, pl. 86, figs. 1-4.

L:18-19, W:12-15, I:6-7. Plate 2-K.

Cells tiny, slightly longer than broad, deeply constricted, semi cells trapeziform semi-circular, sides crenate. This species is very much similar to *C.sexnotatum* despite the pyramidal semi cells.

Distribution in India: Uttar Pradesh (Pandey & Habib, 1986, Chaturvedi et al., 1987) ; Tamil Nadu (Perumal & Anand, 2008); Chhattisgarh (Toppo & Suseela, 2009); Kerala (Nasser & Sureshkumar, 2014b, Tessy Paul & Sreekumar, 2015, Vijayan & Ray, 2015, Krishnan & Pushkaran, 2017); West Bengal (Nandi et al., 2019).

33. *Cosmarium hammeri* Reinsch var.*protuberans* West & G.S.West.

West and West, 1905. vol. 2, p. 181, pl. 62, figs. 20, 21.

L:28, W:20, I:8. Plate 2-E.

Cells of moderate size, semi cells truncate pyramidal, deeply constricted and narrow sinus, basal angles rounded, apex broadly truncate and straight.

Distribution in India: Uttar Pradesh (Chaturvedi et al., 1987); Uttarakhand (Misra et al., 2008); Maharashtra (Kshirsagar et al., 2012, Reddy & Chaturvedi, 2017); Sikkim (Das & Keshri, 2013); Karnataka (Kaparapu & Geddada, 2015); Kerala (Ajayan & Kumar, 2017); West Bengal (Nandi et al., 2019).

34. *Cosmarium subtumidum* Nordst.

West and West, 1905. vol. 2, p. 192, pl. 63, figs. 18-20.

L:30, W:20-25, I:8-10. Plate 2-I.

Cells small, long as broad, deeply constricted, dilated apex and narrow sinus, semi cells pyramidal-semi-circular, basal angle rounded, apex truncate and straight.

Distribution in India: Andhra Pradesh (Venkateswarlu, 1986); Bihar (Saha & Wujek, 1989); Karnataka (Begum et al., 2010); Maharashtra (Anekar et al., 2012); Kerala (Krishnan, 2018); West Bengal (Nandi et al., 2019).

35. *Cosmarium granatum* Brebisson

West and West, 1905. vol. 2, p. 186, pl. 63, figs.1-3.

L:35, W:25, I:10. Plate 3-H.

Cells are longer than wide, subrhomboid elliptic, deeply constricted, semi-cell truncate, pyramidal with basal angles rounded, the apex is narrowly truncate, and the cell wall is finely punctured, sinus linear, slightly dilated at the apex.

Distribution in India: Bengal (Turner, 1892); Assam (Biswas, 1934, Sharma, 2015); Maharashtra (Gonzalves & Joshi, 1946, Kamat, 1975a, Freitas & Kamat, 1979, Gadewar & Lambat, 2011, Patil et al., 2012, Kshirsagar et al., 2012, Reddy & Chaturvedi, 2017, Bansod & Patil, 2019); Uttar Pradesh (Chaturvedi et al., 1987, Prasad et al., 1987); Gujarat (Asoka Kumar & Patel, 1988, Kumar et al., 2012b); Karnataka (Bharati, 1966, Somashekar & Ramaswamy 1984, Ellaswamy et al., 2017); Andhra Pradesh (Suxena & Venkateswarlu, 1966, Suxena & Venkateswarlu, 1968); Punjab (Singh, 1966); Madhya Pradesh (Agarkar, 1969, Agarker & Agarkar, 1977,

Bhat et al., 2015); Hyderabad (Munawar, 1974); Bihar (Saha & Choudhary, 1984, Das et al., 1990); Kerala (Maya et al., 2000, Paul & Sreekumar, 2015, Vijayan & Ray, 2015); Tamil Nadu (Perumal & Anand, 2008); Chandigarh (Jindal, 2015); Uttarakhand (Misra et al., 2008); Himachal Pradesh (Dwivedi et al., 2009); Arunachal Pradesh (Kumaraswamy et al., 2013); Eastern Himalayan Region (Bhakta & Adhikary, 2014); Meghalaya (Hajong & Papiya, 2018).

36. *Cosmarium meneghinii* Brebisson ex Ralfs
West and West, 1908. vol. 3, p. 90, pl. 72, figs. 29-32.
L:20, W:10, I:5. Plate 2-J.

Very minute, relatively longer than broad, constriction linear, semi cells subquadrate, bicrenate side and ends smooth.

Distribution in India: Andhra Pradesh (Suxena & Venkateswarlu, 1966); Kerala (Sindhu & Panikkar, 1994b, Paul & Sreekumar, 2015); Maharashtra (Kamat, 1975b, Freitas & Kamat, 1979, Patil et al., 2012, Reddy & Chaturvedi, 2017); Bihar (Saha & Choudhary, 1984); Uttar Pradesh (Pandey et al., 1987, Chaturvedi et al., 1987); Gujarat (Asoka Kumar & Patel, 1988).

37. *Cosmarium regnesi* var. *montanum* Schmidle
West and West, 1908. vol. 3, p. 38, pl. 68, figs. 29-31.
L:15, W:13, I:6. Plate 2-H.

Rectangular cells, median elliptical incision on each side, smooth.

Rare and new record to India.

38. *Cosmarium subretusiforme* var. *crassum* Scott & Prescott ex Kouwets

Scott & Prescott, 1961. p. 70, pl. 32, fig. 16.
L:10-12, W:8-10, I:5. Plate 2-G.

Cells minute, longer than broad, semi cells are subrectangular, basal angles broadly rounded, apex truncated and straight.

Distribution in India: Chattisgarh (Singh et al., 2011).

39. *Cosmarium quadri verrucosum* West & West.
Scott & Prescott, 1961. p. 67, pl. 30, fig. 7.
L:30, W:25, I:8. Plate 3-C.

Cells small, semi cells depressed, truncate apex, lateral and apical margins undulate, short spines over the semi cells.

Distribution in India: Kerala (Paul & Sreekumar, 2015).

4 | DISCUSSION

Thirty nine desmids were revealed from the study. *Cosmarium regnesi* var. *montanum* is new to India. Two are new to South India, 8 are new to Kerala, and all are new to Wayanad. *Triplastrum abbreviatum* and *Cosmarium regnesi* var. *montanum* are new to South India. *Gonatozygon brebissonii*, *Triplastrum*

abbreviatum, *Staurastrum punctulatum*, *Cosmarium bioculatum*, *C. globosum* var. *minus*, *C. phaseolus*, *C. regnesi* var. *montanum*, *C. subretusiforme* var. *crassum* are new to Kerala. Among these, 4 species (*Triplastrum abbreviatum*, *Staurastrum spiniceps* var. *trifidum*, *Cosmarium quadri verrucosum*, *Cosmarium regnesi* var. *montanum*) are very rare in their distribution. Distribution of desmids shows that the flora shares distribution of some species that are common in high altitudes (*Penium margaritaceum*, *Cosmarium cucurbita*). Over and above, this desmid diversity clearly shows the oligotrophic nature of the water body (Rawson, 1956). This significant diversity demonstrates the Karapuzha dam as a desmid habitat. This diversity attribute to the altitude and water chemistry of the dam. The study suggests further inspection into the algal diversity of the dam for exploring the future prospectives of algae.

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