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Cover: *Euphaea pseudodispar* shot at Kalindi River, Thirunelly, Wayanad district, Kerala. © Muneer P.K.

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COMMUNICATION

The study of algal diversity from fresh water bodies of Chimmony Wildlife Sanctuary, Kerala, India

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Abstract: The algal diversity of the freshwater ecosystem is very significant because they are the primary energy producers in the food web. The study for the algal diversity was conducted at Chimmony Wildlife Sanctuary, Thrissur, Kerala, India, from selected sampling sites (Pookoyil thodu, Kidakkapara thodu, Viraku thodu, Nellipara thodu, Anaporu thodu, Kodakallu thodu, Odan thodu, Mullapara thodu, Payampara thodu, Chimmony dam). The identified algal species belong to four different classes: Chlorophyceae, Euglenineae, Rhodophyceae, and Cyanophyceae. Sixty-one algal species were identified, represented by 37 genera, 22 families, and 14 orders. Among the four, Chlorophyceae was the dominant class.

Keywords: Biodiversity, Chlorophyceae, conservation, Cyanophyceae, Euglenineae, freshwater, Rhodophyceae, taxonomy, Thrissur.

Editor: Anonymity requested.

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Author contributions: JJ did the experimental design, field data collection and the data analysis. JX has supervised the work and preparation of final manuscript.

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INTRODUCTION

Algae are the most abundant aquatic organisms present in the freshwater ecosystem. Algae were responsible for the beginning of multicellular life on our planet and could be the key to our future survival. They are an essential source for producing fine chemicals, natural pigments, vitamins, polysaccharides, bioflocculants, and growth promoters. Algae are also a significant producers of oxygen than plants (Rai et al. 2000).

The freshwater ecosystems are mainly categorized into two types: lotic and lentic. The rivers, streams, waterfalls, canals fall into the lotic type, and the stagnant waters like pools, lakes, reservoirs and paddy fields fall into the lentic type. The freshwater algal diversity varies from unicellular phytoplankton to colonial and much larger multicellular algae. The algal biodiversity depends upon the physicochemical parameters of the water bodies. In the food chain of aquatic ecosystems, algae are the primary producers, making them very important. So the conservation and knowledge about algal biodiversity are necessary for maintaining a healthy aquatic ecosystem.

The information regarding species diversity is an essential component to realize life in its fullness and conserve it for future generations (Pandey 1995). Therefore, there is a strong demand for research on biodiversity in developing countries (Briji 2005; Tessy & Sreekumar 2017). Generally, the taxonomy is considered an outdated science that cannot keep up with the present biodiversity crisis (De Clerck et al. 2013). But for the future development in biodiversity research, systematics and taxonomy are important (Koen & Segers 2005).

The study of biodiversity as the present one opens new opportunities to understand the different algal forms in their respective natural habitat. The large algal species in the freshwater ecosystem depict its diversity. In the current scenario, hardly a few genera are used in the industry, giving a broad scope for other potential obtainable algae. Even though plenty of literature is available on fresh water algal diversity of Kerala, there is no published record available on the algal diversity of Chimmony Wildlife Sanctuary. Hence the study.

MATERIALS AND METHODS

Study area

The study was conducted in Chimmony Wildlife Sanctuary (CWS; Figure 1), which is situated in the Thrissur District of Kerala state. It belongs to Mukundapuram taluk and within geographical limits of 10.40° & 10.48° E and 76.41° & 76.56° N. CWS has an area extent of 85.067 km^2 and water spread area of 10.1 km^2. The sanctuary consists of more than 250 streams, which drains into the Chimmony Reservoir (George 2012; Velayudhan et al.

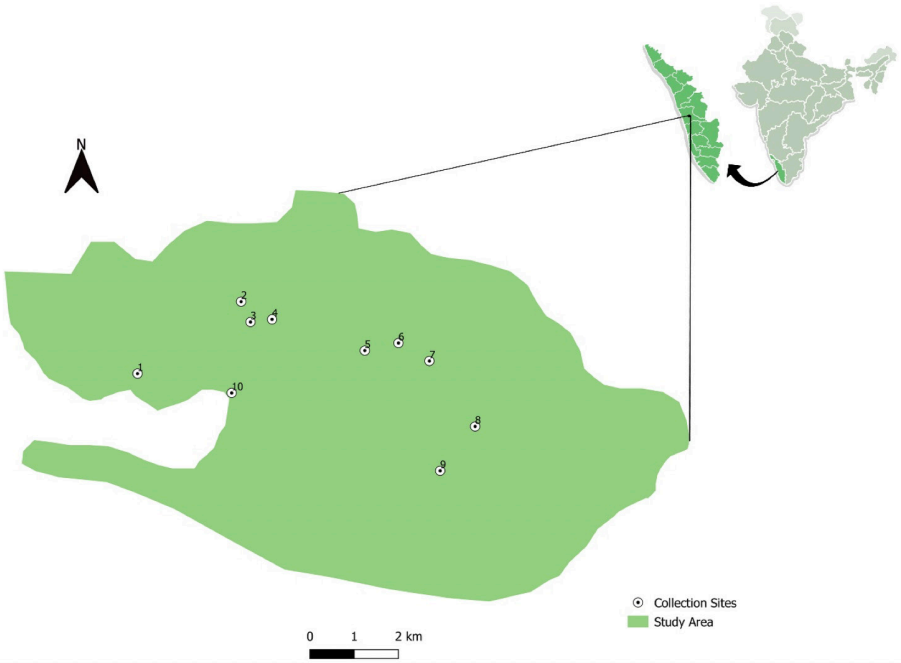

Figure 1. Location of sampling sites in Chimmony Wildlife Sanctuary.

2021). In this study, 10 different streams were selected to study the algal flora (Table 1).

Sampling

The algal samples were collected from 10 different stations using forceps, scalpel, and blade. The collections were made from the surface level, the underside of rocks, mucilage masses attached to dripping rocks, and tree trunks. 4% formalin solution was used for preservation. The collected specimens were observed under a microscope by preparing wet mounts within 48 hours. The algal specimens were identified using standard literature, monographs and research papers (Ralfs 1848; Turner 1892; Desikachary 1959; Randhawa 1959; Prescott 1961; Pal & Kundu 1962; Ramanathan 1964; Philipose 1967; Hindak 1977; Hirose et al. 1977; Hindak 1984; West & West 1904; Kouwets & Coesel 1984; Prasad & Misra 1992; Wolowski 1998; Wotowski & Hindak 2005).

RESULTS

In the study conducted in CWS, 61 algal species were recorded, which belongs to four different classes (Chlorophyceae, Euglenineae, Rhodophyceae, and Cyanophyceae). These species are represented by 37 genera, 22 families, and 14 orders (Table 2). The class Chlorophyceae represents 33 taxa under 22 genera, the class Euglenineae represents seven taxa under four genera, the class Rhodophyceae represents one taxa under one genera, and the class Cyanophyceae represents 20 taxa under 10 genera.

Class: Chlorophyceae
Order: Volvocales
Family: Chlamydomonadaceae
Genus: *Chlamydomonas* Ehrenberg

1. *Chlamydomonas globosa* Snow (Image 1)

Prescott, 1961, p.71, pl.1, figs. 8,9

The cells are globose, enclosed in a hyaline, gelatinous sheath. The cell is 3–5 µm in diameter and 5–10 µm long. The cell consists of a parietal cup-shaped chloroplast with basal pyrenoid and a contractile vacuole at the anterior end. The cell is covered with a smooth membrane and two flagella at the anterior end. The pigment spot is small and inconspicuous.

Family: Volvocaceae
Genus: *Gonium* Mueller

2. *Gonium pectorale* Mueller (Image 2)

Prescott, 1961, p. 75, pl.1, fig. 22

The colony consists of 16 ellipsoid to subspherical cells arranged in a flat quadrangular plate. This quadrangular plate consists of four inner cells covered by 12 marginal cells. The anterior ends of marginal cells were projecting outwards. Each cell is enclosed in an individual sheath and the cells are 5–20 µm in diameter.

Order: Tetrasporales
Family: Tetrasporaceae
Genus: *Tetraspora* Link

3. *Tetraspora gelatinosa* (Vauch.) Desvaux (Image 3)

Prescott, 1961, p. 88, pl.5, figs. 3,4

The thallus is a macroscopic attached floating cylindrical sac where each cell are irregularly arranged. The thallus is globular and bullate, in which spherical cells are arranged in a tetrad manner. The thallus is covered in a thick mucilaginous sheath, and the cells are 6–10 µm in diameter.

Order: Chlorococcales
Family: Chlorococcaceae
Genus: *Chlorococcum* Fries

4. *Chlorococcum humicola* (Naeg.) Rabenhorst (Image 4,5)

Prescott, 1961, p. 212, pl.45, fig. 1

The colony is unicellular, non-motile, with spherical cells in various small clumps. Each cells consist of a completely filled spherical chloroplast with a single pyrenoid. The cell is 7–10 µm in diameter.

Family: Selenastraceae
Genus: *Monoraphidium* Komarkova - Legnerova

5. *Monoraphidium griffithii* (Berkeley) Komarekova - Legnerova (Image 6)

Table 1. Latitude and Longitude of sampling sites

	Sampling sites	Latitude (E) and Longitude (N)
1	Pookoyil thodu	10.4600, 76.4744
2	Kidakkapara thodu	10.4641, 76.4658
3	Viraku thodu	10.4497, 76.4444
4	Nellipara thodu	10.4458, 76.4638
5	Anaporu thodu	10.4300, 76.5069
6	Kodakallu thodu	10.4388, 76.5141
7	Odan thodu	10.4522, 76.5047
8	Mullapara thodu	10.4558, 76.4983
9	Payampara thodu	10.4544, 76.4913
10	Chimmony dam	10.4605, 76.4722

Table 2. Algal species identified from Chimmony Wildlife Sanctuary.

	Class	Order	Family	Genus	Species
1	Chlorophyceae	Volvocales	Chlamydomonadaceae	*Chlamydomonas*	*globosa* Snow
2			Volvocaceae	*Gonium*	*pectorale* Mueller
3		Tetrasporales	Tetrasporaceae	*Tetraspora*	*gelatinosa* (Vauch.) Desvaux
4		Chlorococcales	Chlorococcaceae	*Chlorococcum*	*humicola* (Naeg.) Rabenhorst
5			Selenastraceae	*Monoraphidium*	*griffithii* (Berkeley) Komarekova - Legnerova
6					*indicum* Hindak
7			Scenedesmaceae	*Scenedesmus*	*quadricauda* var. *maximus* West & West
8		Ulotrichales	Ulothrichaceae	*Ulothrix*	*aequalis* Kuetzing
9		Cladophorales	Cladophoraceae	*Pithophora*	*oedogonia* (Mont.) Wittrock
10		Chaetophorales	Trentepohliaceae	*Trentepohlia*	*aurea* (L.) Martius
11		Oedogoniales	Oedogoniaceae	*Oedogonium*	*areschougii* Wittrock
12					*croasdaleae* Jao
13		Zygnematales	Zygnemataceae	*Mougeotia*	*scalaris* Hassall
14				*Zygnema*	*carinatum* Taft
15				*Spirogyra*	*acanthophora* (Skuja) Czurda
16					*condensata* (Vauch.) Kuetzing
17					*decimina* (Mueller) Kuetzing
18					*fuellebornei* Schmidle
19					*micropunctata* Transeau
20					*novaeangliae* Transeau
21					*rhizobrachialis* Jao
22			Mesotaeniaceae	*Cylindrocystis*	*brebissonii* (Ralfs) De Bary
23				*Netrium*	*digitus* (Ehrbg.) Itzigs. & Rothe
24			Desmediaceae	*Actinotaenium*	*silvae-nigrae* (Rabanus) Kouwets & Coesel
25				*Closterium*	*ehrenbergii meneghinii* var. ehrenbergii
26					*moniliferum* Ehrenberg ex Ralfs
27					*tumidulum* Gay
28				*Cosmarium*	*botrytis* Meneg
29					*subtumidum* Nordst
30				*Micrasterias*	*radians* Turn var. *bogoriensis* (Breb) G.S West
31				*Pleurotaenium*	*trabecula* (Ehrbg) Nag
32				*Staurastrum*	*zonatum* Borges var. *majus* Presc.
33		Charales	Characeae	*Nitella*	*furcata* (Roxburgh *apud* Bruzelius) Agardh
34	Euglenineae	Euglenales	Astasiaceae	*Euglena*	*elastica* Prescott
35					*minuta* Prescott
36				*Phacus*	*curvicauda* Swirenko
37					*obolus* Pochmann
38					*orbicularis* var. *caudatus* Skzortzow
39				*Lepocinclis*	*acus* (Muller) marin and Melkonian
40				*Trachelomonas*	*hispida* var. *papillata* Skvortzow
41	Rhodophyceae	Batrachospermales	Batrachospermaceae	*Sheathia*	*boryana* (Sirodot) Salomaki & M.L.Vis

	Class	Order	Family	Genus	Species
42	Cyanophyceae	Chroococcales	Chroococcaceae	*Aphanocapsa*	*pulchra* (Kutz) Rabenh
43				*Microcystis*	*aeruginosa* Kutz.
44		Nostocales	Microchaetaceae	*Microchaete*	*uberrima* Carter, N
45			Oscillatoriaceae	*Oscillatoria*	*limosa* Agardh ex Gomont
46					*subbrevis* Schmidle
47					*vizagapattensis* Rao, C. B
48				*Phormidium*	*abronema* Skuja
49					*hansgirgi* Schmidle
50					*microtomum* Skuja
51					*molle* (Kutz.) Gomont
52					*retzii* (Ag.) Gomont
53					*truncicola* Ghose
54					*usterii* Schmidle
55			Nostocaceae	*Anabaena*	*anomala* Fritsch
56					*sphaerica* Bornet et Flahault
57				*Cylindrospermum*	*stagnale* (Kutz.) Born.et Flah
58			Rivulariaceae	*Gloeotrichia*	*echinulata* (J. E. Smith) P. Richter
59				*Scytonema*	*ocellatum* Lyngbye ex Born. et Flah
60					*rivulare* Borzi ex Born. et Flah
61		Stigonematales	Nostochopsidaceae	*Nostochopsis*	*lobatus* Wood em. Geitler

Hindak, 1984, p. 219, pl. 79, figs. 5,8

The cell is straight and fusiform, having a tapering from the centre towards the pointed ends. The cell is 45–50 µm long and 2–3 µm broad.

6. *Monoraphidium indicum* Hindak (Image 7)

Hindak, 1977, p.105, pl.44

The cells are very thin and are accurately curved. The cell has a tapering towards the end and it is pointed. The cell is 40–45 µm long and 1.5–2 µm broad.

Family: Scenedesmaceae

Genus: *Scenedesmus* Meyen

7. *Scenedesmus quadricauda* var. *maximus* West & West (Image 8)

M. T Philipose, 1967, p. 283, fig. 187 g

The colonies are usually four-celled with much larger cells. The cell is 25–30 µm long and 10–11 µm in diameter. The spines are 25–35 µm long.

Order: Ulotrichales

Family: Ulothrichaceae

Genus: *Ulothrix* Kuetzing

8. *Ulothrix aequalis* Kuetzing (Image 9)

K.R Ramanathan, 1964, p.36, pl.9 I-L

The thallus is non-branching, filamentous with cylindrical cells. The cells are 12–14 µm broad and 24–28 µm long. The cells consist of a striated cell wall, girdle shaped broad chloroplast covering half of the wall surface with one or more pyrenoids.

Order: Cladophorales

Family: Cladophoraceae

Genus: *Pithophora* Wittrock

9. *Pithophora oedogonia* (Mont.) Wittrock (Image 10, 11; Image 12, 13)

Prescott, 1961, p.140, pl.22, figs. 7–10

The filaments are slender 50–60 µm in diameter with solitary branching. Each cell are cylindrical and long. The akinetes are cylindrical and slightly swollen and acuminate at the terminal. Akinetes are 55–140 µm in diameter and 90–350µm long.

Order: Chaetophorales

Family: Trentepohliaceae

Genus: *Trentepohlia* Martius

10. *Trentepohlia aurea* (L.) Martius (Image 14,15,16)

Prescott, 1961, p.133, pl.67, figs. 6–9

The cells are rusty-brown in colour sometimes the thallus shows yellow colour in shaded regions. The cells are slightly swollen but slightly reduced in diameter towards apices. The cell has a smooth wall, and it is 4–10

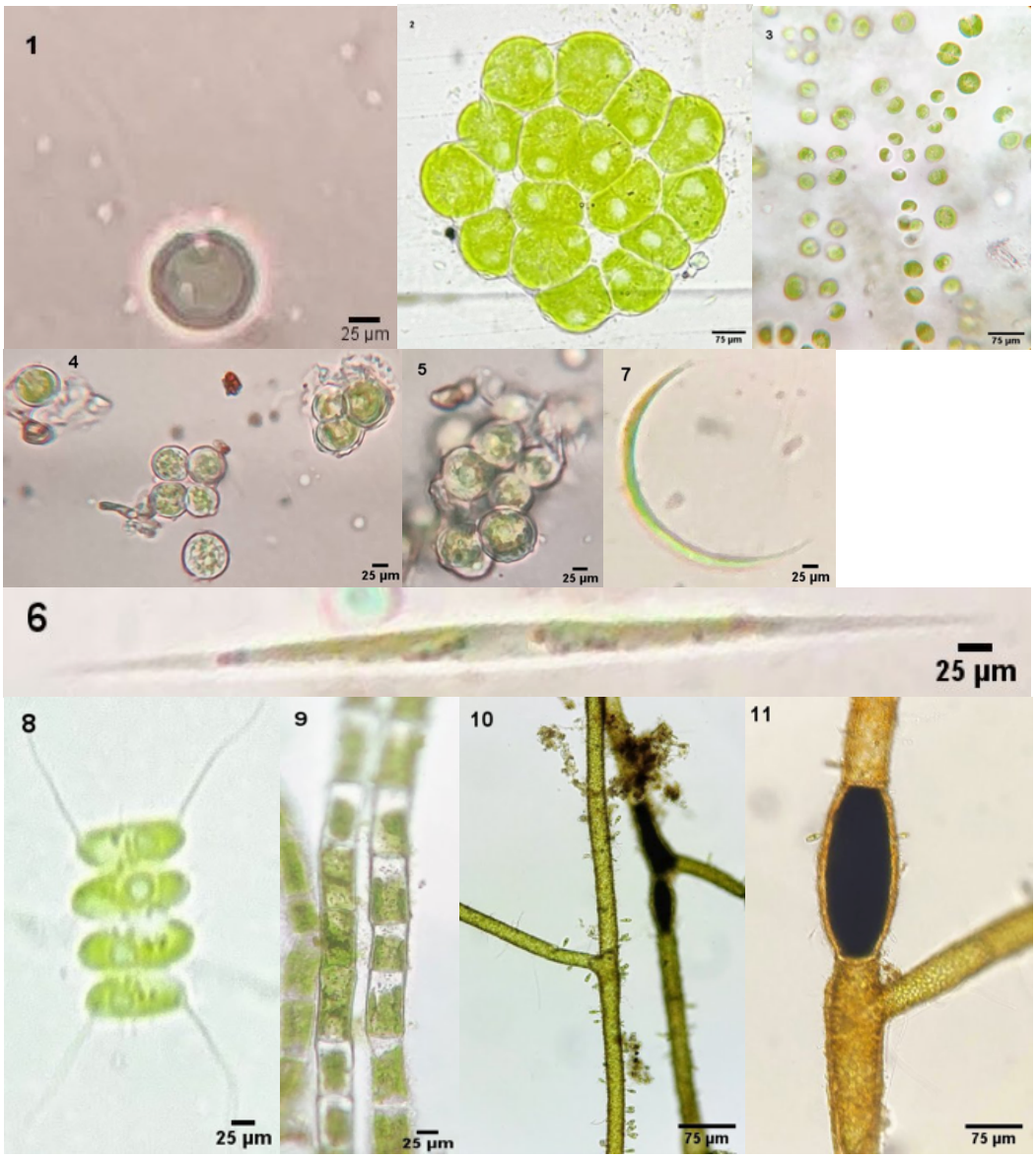

Image 1–11. 1—*Chlamydomonas globosa* | 2—*Gonium pectorale* | 3—*Tetraspora gelatinosa* | 4, 5—*Chlorococcum humicola*| 6—*Monoraphidium griffithii* | 7—*Monoraphidium indicum* | 8—*Scenedesmus quadricauda* var. *maximus* | 9—*Ulothrix aequalis* | 10, 11—*Pithophora oedogonia*. (© Joel Jose)

µm in diameter. The sporangia are generally terminal on curved cells with 15–20 µm in diameter. The gametangia are not frequently observed, and they will be the same size as the sporangia.

Order: Oedogoniales
Family: Oedogoniaceae
Genus: *Oedogonium* Link

11. *Oedogonium areschougii* Wittrock (Image 17)

Prescott, 1961, p. 204

The filament is nannandrous & gynandrosporous. The filaments are cylindrical in shape with a 10–12 µm diameter and 35–28 µm long. The oogonia is pyriform globose shaped and operculate with 30-35µm diameter and 36–40 µm long. The smooth-walled oospore is not completely filled inside the oogonia. The diameter of the oospore is 23–25 µm. The dwarf males are unicellular attached near or on the oogonia with 6–7 µm diameter and 13–15 µm long.

12. *Oedogonium croasdaleae* Jao (Image 18, 19)

Prescott, 1961, p.204, pl.41, fig. 11

The filament is nannandrous and gynandrosporous. The vegetative cells are cylindrical 25–30 µm in diameter

and 150–200 µm long. The oogonia are two in a series, 60–70 µm in diameter and 80–113 µm long. The dwarf males are 9–17 µm in diameter and 48–55 µm long.

Order: Zygnematales
Family: Zygnemataceae
Genus: *Mougeotia* C.A. Agardh

13. *Mougeotia scalaris* Hassall (Image 20)
Prescott, 1961, p. 304, pl.71, figs. 6,7

The filaments are 14–20 µm in diameter and 34–182 µm long. The chloroplast consists of 4–6 pyrenoids. The zygospores are globose to ovate with smooth walls and formed in the tube due to scalariform conjugation. The zygospore measures up to 30–35 µm in length and 26–30 µm in diameter.

Genus: *Zygnema* Agardh

14. *Zygnema carinatum* Taft (Image 21)
Randhawa 1959, p.225, fig. 160

The filaments are greenish and unbranched. The cells are rectangular to square in shape. Presence of two star-shaped chloroplasts. The cell is 11–15 µm long and 10 µm broad. The scalariform conjugation results in the formation of globose shaped zygospore in the tube. The globose zygospore is formed at the right angle of the tube, and it measures 13–16 µm in length and 15–20 µm in breadth.

Genus: *Spirogyra* Link

15. *Spirogyra acanthophora* (Skuja) Czurda (Image 22)
Randhawa, 1959, p.376, fig. 413

The filaments are 300–328 µm long and 60–65 µm wide. The zygospores are 37–42 µm in diameter and 50–62 µm in length.

16. *Spirogyra condensata* (Vauch.) Kuetzing (Image 3: 23)
Prescott, 1961, p. 312, pl.72, figs. 5,6

The filaments are 111–153 µm long and 40–53 µm wide. Smooth walled zygospores were formed due to conjugation, and it measures up to 35–37 µm in diameter and 52–60 µm in length.

17. *Spirogyra decimina* (Mueller) Kuetzing (Image 24, 25)
Prescott, 1961, p. 313

The filaments are 130–133 µm long and 20–24 µm wide. Presence of two chloroplasts. The zygospores are cylindrical to ovate with a smooth wall that measures up to 32–38 µm in diameter to 30–35 µm in length.

18. *Spirogyra fuellebornei* Schmidle (Image 26)
Randhawa. 1959. P. 316, fig. 291

The filaments are long and cylindrical having 238–376 µm long and 26–31 µm broad. Presence of two chloroplast, having 3–4 turns in a cell. The zygospores are 30–39 µm in diameter and 58–65 µm in length.

19. *Spirogyra micropunctata* Transeau (Image 27)
Prescott, 1961, p. 317, pl.73, fig. 9

The filaments are 243–300 µm long and 29–35 µm wide. The scalariform conjugation produces an ellipsoidal zygospore, which measures up to 35–40 µm in diameter and 60–72 µm long.

20. *Spirogyra novaeangliae* Transeau (Image 28)
Prescott, 1961, p. 318, pl.75, figs. 1-3

The filaments are 200–230 µm long and 58µm wide. The zygospore is ovate to ellipsoidal. The zygospore exhibits a brown colour which measures up to 50–60 µm in diameter and 85–90 µm in length.

21. *Spirogyra rhizobrachialis* Jao (Image 3: 29)
Prescott, 1961, p. 320, pl.76, figs. 1, 2

The filaments are 43–50 µm in diameter and 120–211 µm long. Presence of two crenate and deeply toothed chloroplast. The fertile cylindrical cells form zygospores through conjugation. The zygospore is ellipsoidal brown, which measures up to 40–50 µm in diameter and 111 µm in length.

Family: Mesotaeniaceae
Genus: *Cylindrocystis* De Bary

22. *Cylindrocystis brebissonii* (Ralfs) De Bary (Image 30, 31)
W. West & G.S. West, 1904, pl. 4, figs. 23–32, pl.5, fig. 10

The cells are cylindrical with round apices. The chloroplast consists of a few large radiating prolongations. The cell body is 35–40 µm long and 22–28 µm in broad.

Genus: *Netrium* (Nageli) Itzigsohn & Rothe in Rabenhorst

23. *Netrium digitus* (Ehrbg.) Itzigs. & Rothe (Image 32)
W. West & G. S. West, 1904, pl. 6, fig. 14–16

The cell is generally large and elliptic to oblong in shape. The cell is gradually attenuated from the centre towards the apices, which is rounded and truncated. The chloroplast is axile with deeply notched free margins. The cell body is 150–160 µm long and 40–45 µm in diameter.

Image 12–21. 12, 13—*Pithophora oedogonia* | 14, 15, 16—*Trentepohlia aurea* | 17—*Oedogonium areschougii* | 18, 19—*Oedogonium croasdaleae* | 20—*Mougeotia scalaris* | 21—*Zygnema carinatum*. (© Joel Jose)

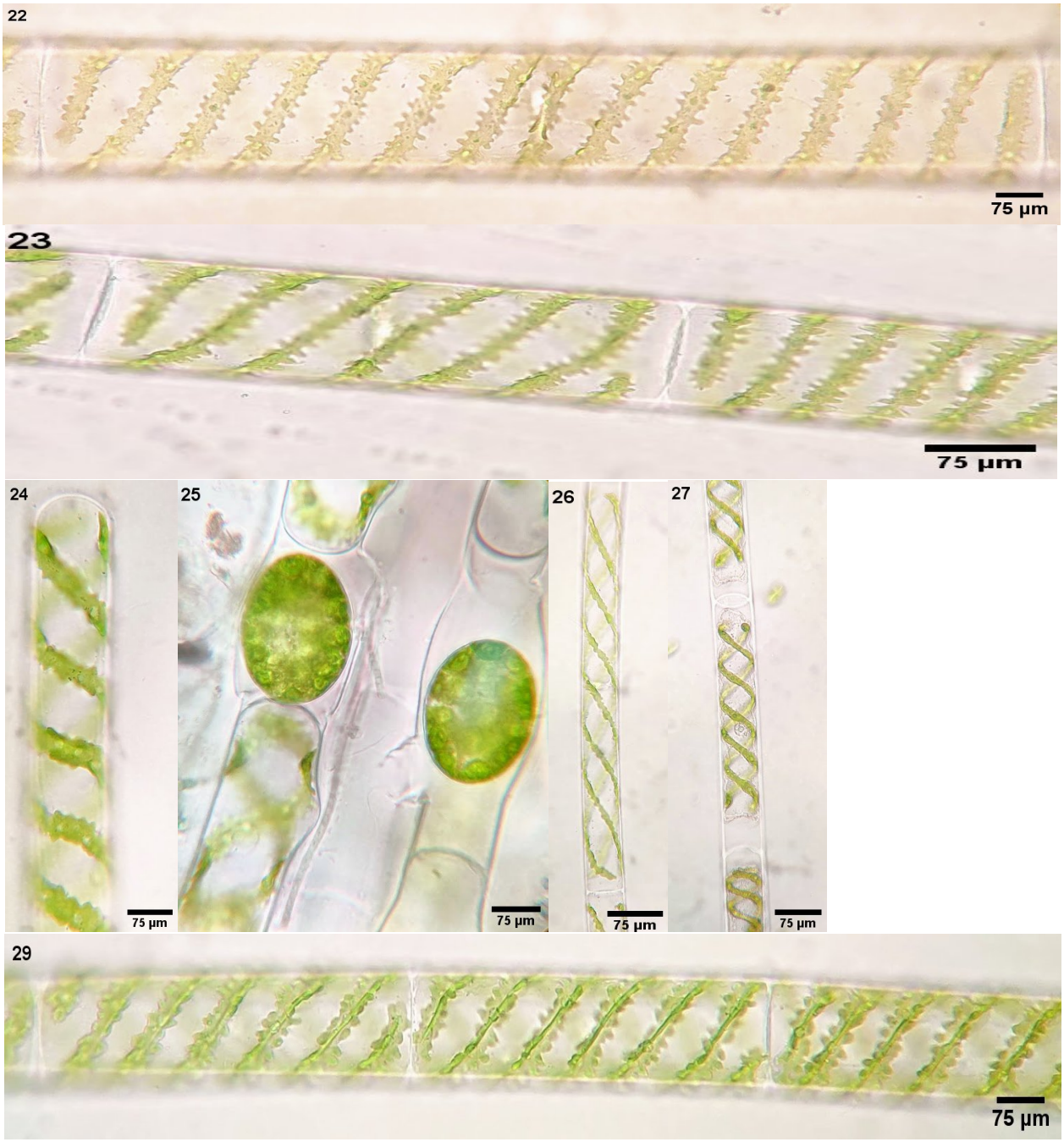

Image 22–29. 22—*Spirogyra acanthophora* | 23—*Spirogyra condensata* | 24, 25—*Spirogyra decimina* | 26—*Spirogyra fuellebornei* | 27—*Spirogyra micropunctata* | 29—*Spirogyra rhizobrachialis*. (© Joel Jose)

Family: Desmediaceae

Genus: *Actinotaenium* (Nageli) Teiling

24. *Actinotaenium silvae-nigrae* (Rabanus) Kouwets & Coesel (Image 33)

Kouwets & Coesel, 1984, p. 555–562, fig. 23

The cell is cylindrical with broadly rounded ends with a smooth cell wall. The cell is 60–65 µm long and 20–25 µm wide.

Genus: *Closterium* Nitzsch ex Ralfs

25. *Closterium ehrenbergii Meneghinii* var. *Ehrenbergii* (Image 34)

Hirose, H, et al., 1977

The cell body is large and bulged at the centre with a smooth cell wall. The chloroplasts consist of 4–7 laminae with many scattered pyrenoids. The cell body is 250–890 µm long and 50–165 µm wide.

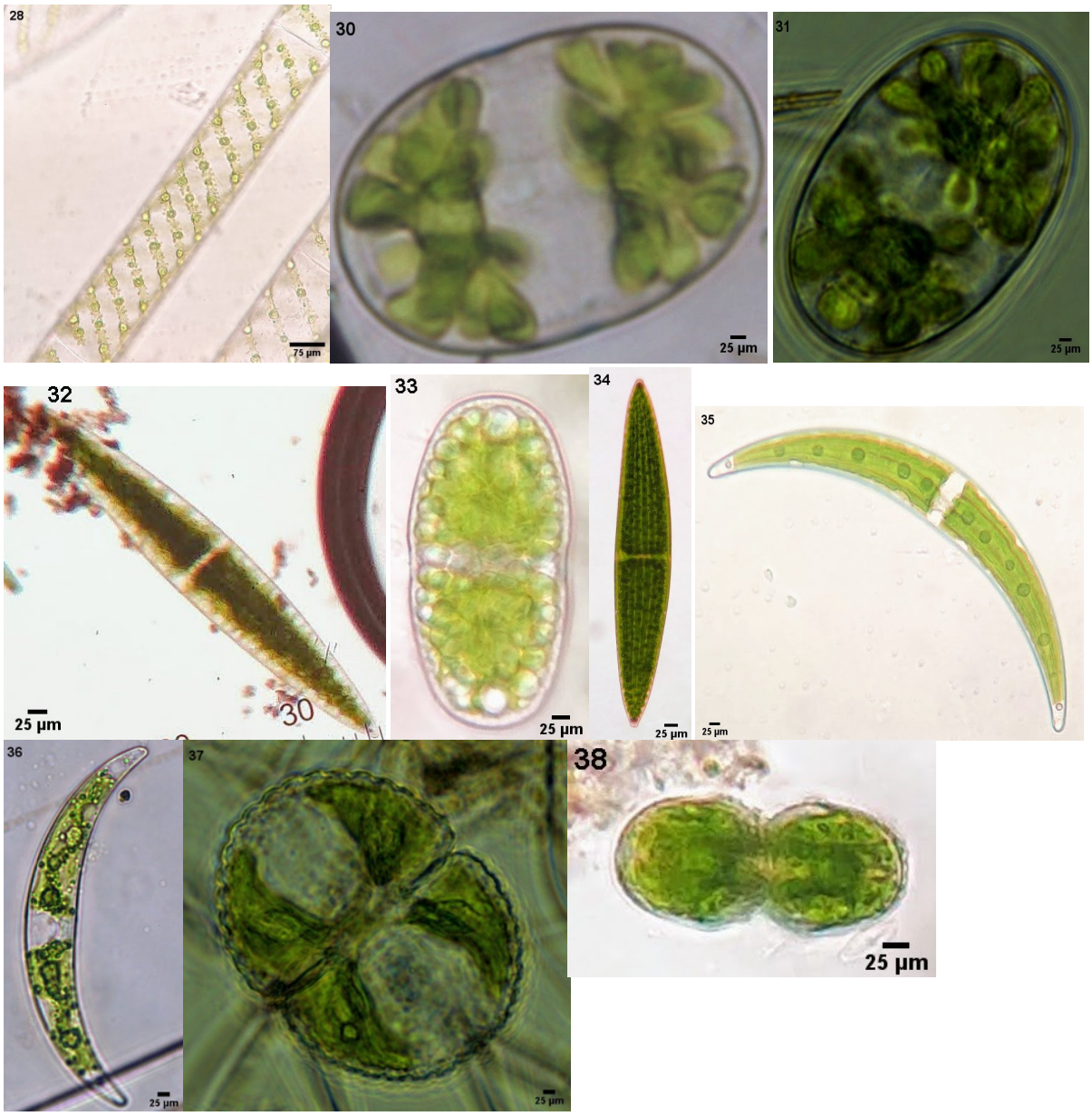

Image 28–38. 28—*Spirogyra novaeangliae* | 30, 31—*Cylindrocystis brebissonii* | 32—*Netrium digitus* | 33—*Actinotaenium silvae-nigrae* | 34—*Closterium ehrenbergii* | 35—*Closterium moniliferum* | 36—*Closterium tumidulum* | 37—*Cosmarium botrytis* | 38—*Cosmarium subtumidum*. (© Joel Jose)

26. *Closterium moniliferum* Ehrenberg ex Ralfs (Image 35)

Prasad & Misra, 1992, p. 113, pl. 12, fig. 4.

The cell is curved with rounded apices. The chloroplast consists of 7–10 pyrenoids arranged in a median series. The cell is 140–155 µm long and 7–20 µm broad.

27. *Closterium tumidulum* Gay (Image 36)

Turner, 1892, p.19, pl.1, fig. 20

The cell is small and curved with an acute tip. The cell is 90–100 µm long and 10–15 µm broad.

Genus: *Cosmarium* Ralfs

28. *Cosmarium botrytis* Meneg (Image 37)

Ralfs, 1848, p.99, pl. 16, fig. 1

The cell has denticulate margins with a deeply constricted linear notch at the centre. The cell is 54.1–77.6 µm long and 40.6–60.6 µm broad.

29. *Cosmarium subtumidum* Nordst (Image 38)

Prescott, 1961, p. 70, pl. 29, figs. 12, 13

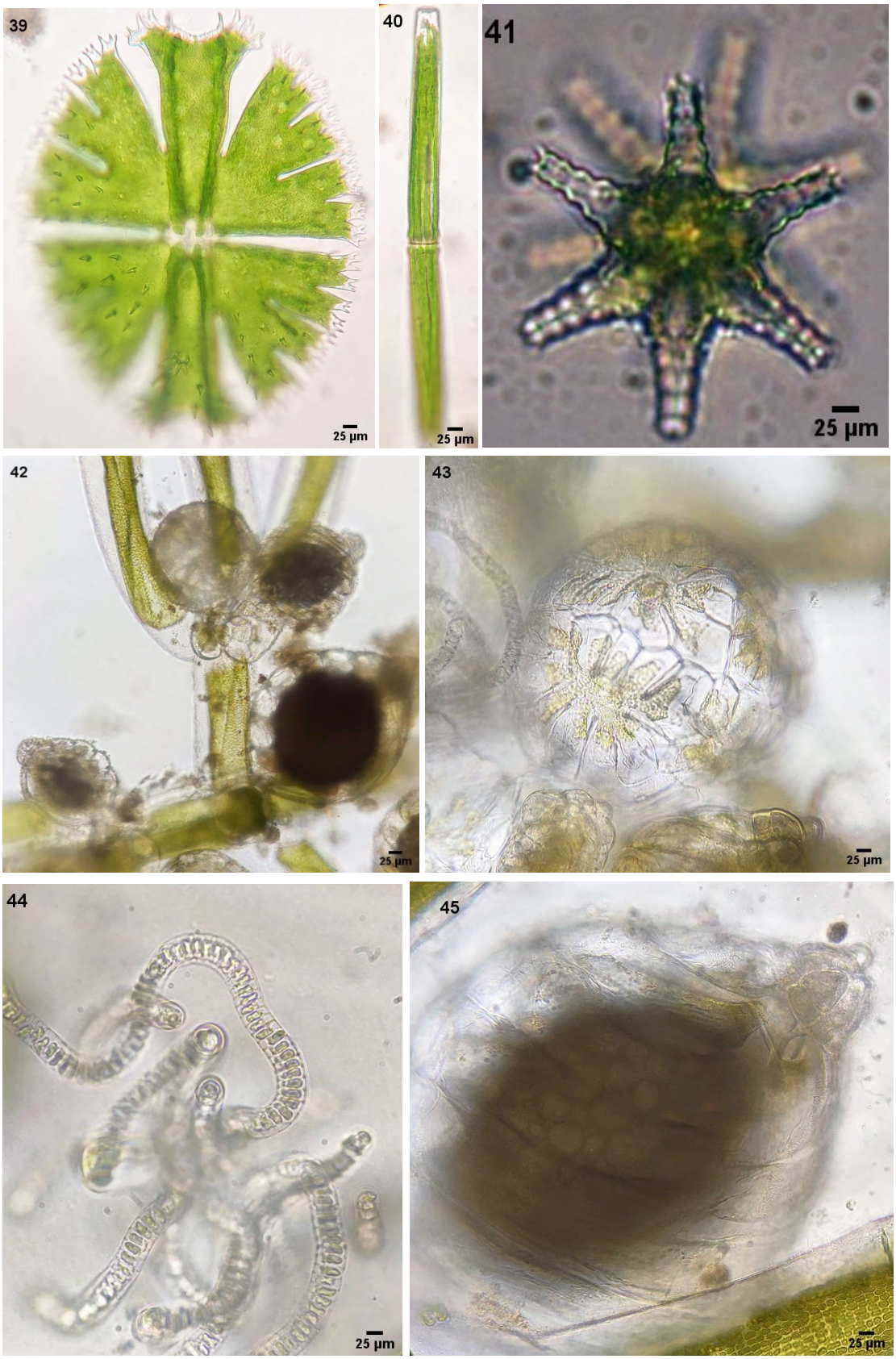

Image 39–45. 39—*Micrasterias radians* var. *bogoriensis* | 40—*Pleurotaenium trabecula* | 41—*Staurastrum zonatum* var. *majus* | 42–45—*Nitella furcata*. (© Joel Jose)

The cell body is 30–43 µm long, 14–19 µm wide and isthmus is 12–14 µm.

Genus: *Micrasterias* C. Agardh

30. *Micrasterias radians* Turn var. *bogoriensis* (Breb) G.S. West (Image 39)

Prescott, 1961, p.51, pl.23, figs. 2, 3

The cell body is 121–206 µm long, 126–170 µm wide and the isthmus is 14–17 µm wide

Genus: *Pleurotaenium* Nageli

31. *Pleurotaenium trabecula* (Ehrbg) Nag (Image 40)

Prescott, 1961, p. 18, pl. 3, fig. 4

The cylindrical cell body is 400–434 µm long and 30–40 µm in diameter. The cell is constricted at the centre, with a slight bulge at the base semi cell. The chloroplast is elongated with 3–4 laminae.

Genus: *Staurastrum* (Meyen) Ralphs

32. *Staurastrum zonatum* Borges var. *majus* Presc. (Image 41)

Prescott, 1961, p.119, pl. 46, fig. 8

The semi cells consist of five long dentate ends with rings of granules and the apex biundulate with some tiny teeth. The cell body is 40–70 µm long, 81–90 µm wide and the isthmus is 13–16 µm.

Order: Charales

Family: Characeae

Genus: *Nitella* C. Agardh

33. *Nitella furcata* (Roxburgh apud Bruzelius) Agardh (Image 42–45)

B.P. Pal et al., 1962, p.62, figs. 76-79

The plant is monoecious. The stem is 600–1,000 µm thick and antheridia is terminal, which is 200–250 µm in diameter. The oogonia are 1–2, together, which are 230–240 µm long and 210–310 µm in diameter. Spiral cells showing 7–8 convolutions and the coronula are 70–100 µm high and 70 µm at the base.

Class: Euglenineae

Order: Euglenales

Family: Astasiaceae

Genus: *Euglena* Ehrenberg

34. *Euglena elastica* Prescott (Image 46)

Prescott, 1962, p. 392, pl.86, figs. 10–12

The cells have the potential to change shape regularly, when in motion. Usually the cells are spindle-shaped but often swollen in the mid-region and slightly tapered to the apices. The cell consists of many irregularly ovoid-shaped chloroplasts. The cell is 10–11 µm in diameter and 80–90 µm long.

35. *Euglena minuta* Prescott (Image 47)

Prescott, 1962, p. 393, pl.85, figs. 23, 25

The cells are highly active, which are fusiform to pyriform in shape. The smooth membraned cell consists of one plate-like chloroplast with a pyrenoid. The cell is 14–16 µm long and 2–6 µm broad.

Genus: *Phacus* Dujardin

36. *Phacus curvicauda* Swirenko (Image 48)

Prescott, 1962, p.399, pl.87, fig. 14, pl.88, fig.21

The cells are ovoid and slightly spiral, which causes the caudus to curve slightly to the left. The cell consists of numerous ovoid chloroplasts. The cell is 40–48 µm in diameter and 48–60 µm long.

37. *Phacus obolus* Pochmann (Image 49)

Wolowski, 1998, p.78, figs. 270–272

The cells are broadly oval and slightly narrower at the anterior end with straight, conical cauda at the posterior end. The cell consists of numerous ovoid-globular chloroplasts. Cells are 34–42 µm long and 22–35 µm broad

38. *Phacus orbicularis* var. *caudatus* Skzortzow (Image 50)

Prescott, 1962, p.401, pl.87, fig. 12, pl.88, fig.15

Cells are ovoid with a long, straight , sharply pointed caudus. 1–2 paramylon bodies are present. Cells are 38–41 µm in diameter and 50–70 µm long.

Genus: *Lepocinclis* Perty

39. *Lepocinclis acus* (Muller) Marin & Melkonian (Image 51)

Wotowski & Hindak, 2005, p. 28, figs. 5–8 The cells are long, elongate, thin and spindle-shaped, gradually tapering to apices which forms a sharp tail. Numerous disc-shaped chloroplasts are present, and two paramylon bodies are present. The cells are 10–12 µm diameter and 150 µm long.

Genus: *Trachelomonas* Ehrenberg

40. *Trachelomonas hispida* var. *papillata* Skvortzow (Image 52)

Prescott, 1962, p. 414, pl. 84, fig. 7

The cell is 25–30 µm in diameter and 35–40 µm long. The wall is brown smooth except for a few minute spines near the flagellum aperture.

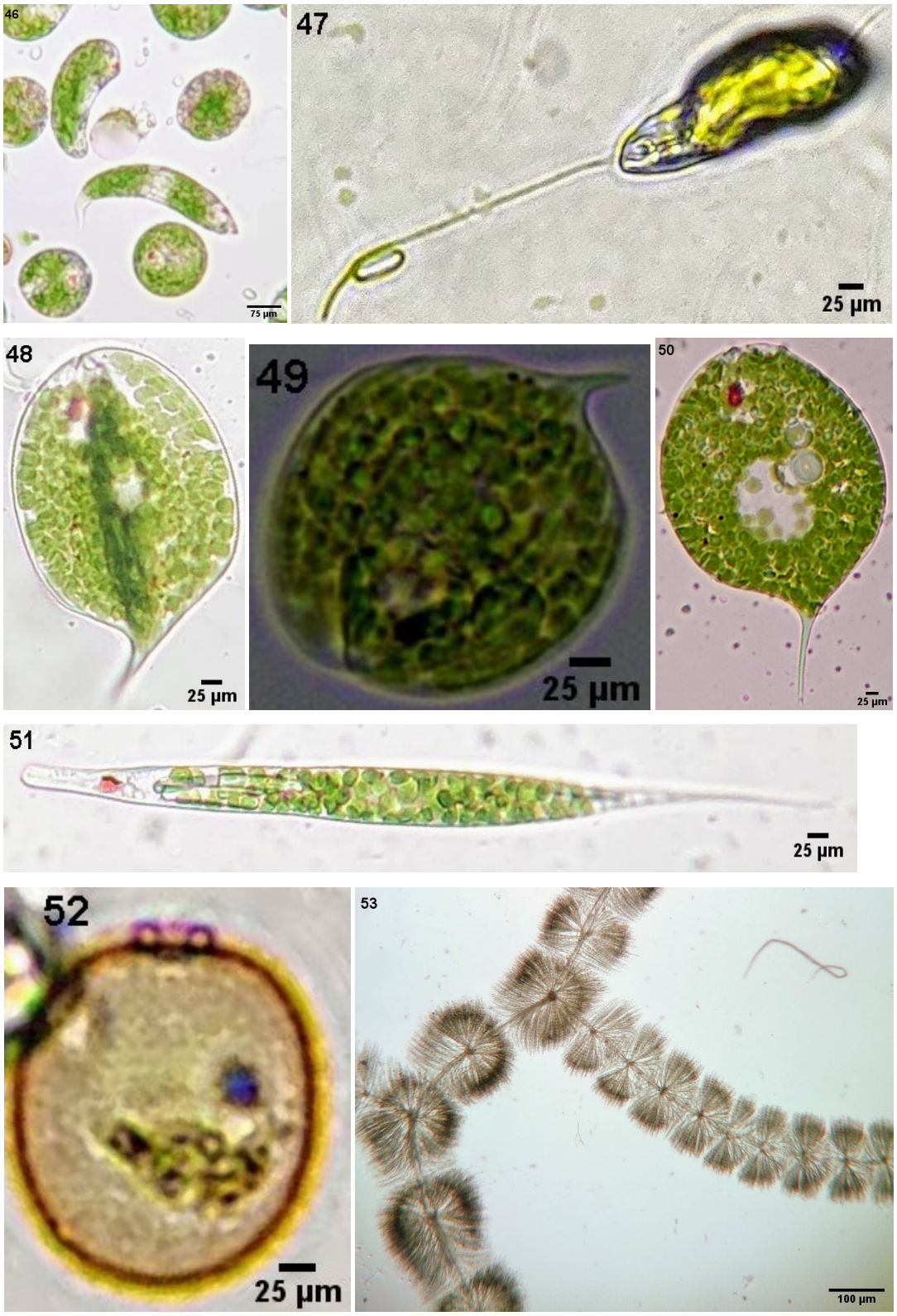

Image 46–53. 46—*Euglena elastica* | 47—*Euglena minuta* | 48—*Phacus curvicauda* | 49—*Phacus obolus* | 50—*Phacus orbicularis* var. *caudatus* | 51—*Lepocinclis acus* | 52—*Trachelomonas hispida* var. *papillata* | 53—*Sheathia boryana*. (© Joel Jose).

Class: Rhodophyceae
Order: Batrachospermales
Family: Batrachospermaceae
Genus: *Batrachospermum* Roth

41. *Sheathia boryana* (Sirodot) Salomaki & M.L.Vis (Image 53; Image 54)

Prescott, 1962, p.567, pl. 136, fig. 4; Sheath & Hymes, 1980, p.1306, figs. 31–36; John & Francis, 2013, p. 237.

The plant is 5–9 cm high and has a highly mucilaginous thallus, which is brown to green. The central axes are 90–105 µm wide, and glomeruli are ellipsoidal to globular. The lateral branches have short internodes. The carpogonia are 4–5 µm wide at the basal portion and 25–30 µm long. The trichogyne are elongate, club-shaped and embrace the carpogonia. The carposporophyte is globular and scattered close to the periphery. The carposporophyte measures 14–150 µm in diameter.

Class: Cyanophyceae
Order: Chroococcales
Family: Chroococcaceae
Genus: *Aphanocapsa* Nag

42. *Aphanocapsa pulchra* (Kutz) Rabenh (Image 55)

T.V. Desikachary, 1959, p.132, pl. 21, fig. 2

The thallus is gelatinous and blue-green. The cells are spherical, loosely arranged in single or sometimes doubles with individual sheaths. The cells are 6–7 µm in diameter.

Genus: *Microcystis* Kutzing

43. *Microcystis aeruginosa* Kutz. (Image 56)

T.V Desikachary, 1959, p. 93, pl. 17, fig. 1, 2, 6

The colonies are free-floating and attaining a macroscopic size with a mucilaginous envelope. The cells in the colony are spherical with distinct hyaline colonial mucilage. The colonies are light brown and round with 5–7 µm in diameter. Gas vacuoles are present.

Order: Nostocales
Family: Microchaetaceae
Genus: *Microchaete* Thuret

44. *Microchaete uberrima* Carter, N (Image 57, 58)

T.V. Desikachary, 1959, p.511, pl. 104, figs. 5-7, 10, 13, 16, 18

The trichomes were long up to 4 mm, with cylindrical cells having a firm sheath. The filaments were 10–15 µm broad with intercalary heterocyst.

Family: Oscillatoriaceae
Genus: *Oscillatoria* Vaucher

45. *Oscillatoria limosa* Agardh ex Gomont (Image 59)

T.V. Desikachary, 1959, p.206, pl. 42, fig.11

The thallus is blue-green with a straight trichome that is slightly constricted. The trichomes are 12–13 µm broad and 2–4 µm long.

46. *Oscillatoria subbrevis* Schmidle (Image 60, 61)

T. V. Desikachary, 1959, p.207, pl. 37, fig. 2, pl. 40, fig. 1

The trichomes are single, straight and not attenuated with round cell, calyptra absent. The trichome is 5–6 µm broad, and the cells are 3–4 µm long. The trichomes are blue-green, and they exhibit an oscillating movement at the apex.

47. *Oscillatoria vizagapattensis* Rao, C.B. (Image 62)

T.V. Desikachary, 1959, p.205, pl. 39, figs. 16, 18.

The cells are much shorter than the broad and form a broadly rounded cap with a slightly thickened outer wall. The trichome is blue-green in colour and 8–10 µm broad.

Genus: *Phormidium* Kutz.

48. *Phormidium abronema* Skuja (Image 64)

T.V. Desikachary, 1959, p.257.

The thallus is blackish-green to light bluish. The trichomes consist of the hyaline mucilaginous sheath. The cells are cylindrical or barrel-shaped. The trichome is 3–4 µm broad and 16–17 µm long.

49. *Phormidium hansgirgi* Schmidle (Image 63; Image 65)

T.V. Desikachary, 1959, p.272, pl. 43, fig. 20

The filaments are straight with a very thin mucilaginous sheath. The trichomes are cylindrical and not capitate. The hormogones are short. The trichomes are 12–14 µm broad and 2–3 µm long.

50. *Phormidium microtomum* Skuja (Image 66)

T.V. Desikachary, 1959, p.257, pl. 43, fig. 16, 17

The trichomes are greyish-brown, straight with a thin colourless sheath. The ends of trichomes are attenuated, and cells are well constricted at the cross wall. The trichome is 6–8 µm broad with apical rounded hyaline calyptra.

51. *Phormidium molle* (Kutz.) Gomont (Image 67)

T.V. Desikachary, 1959, p.255, pl. 59, fig. 8

The trichomes are thin, straight, constricted at

cross walls and not attenuated at the ends. The cells are quadrate or barrel-shaped with rounded ends and calyptra absent. The trichome is 2–3 µm broad and 8–7 µm long.

52. *Phormidium retzii* (Ag.) Gomont (Image 68)

T.V. Desikachary, 1959, p.268, pl. 44, figs. 13-15

The filaments are straight with a thin mucilaginous sheath. The trichomes are blue-green with a thin sheath. The ends are not attenuated and not capitate. The trichomes are 11–13 µm broad and 8–10 µm long.

53. *Phormidium truncicola* Ghose (Image 70)

T.V. Desikachary, 1959, p.258, pl. 59, fig. 9

The trichomes consist of thin membrane and are constricted at cross walls. The calyptra is absent. The trichomes are 6–8 µm broad and 2–3 µm long.

54. *Phormidium usterii* Schmidle (Image 69)

T.V. Desikachary, 1959, p.257.

Trichomes with thin mucilaginous sheath. The cells are shorter than broad with short rectangular cells with broadly round ends. The trichome is 3–4 µm broad and 5–6 µm long.

Family: Nostocaceae

Genus: *Anabaena* Bory de Bornet & Flahault

55. *Anabaena anomala* Fritsch (Image 71)

T.V. Desikachary, 1959, p.398, pl. 73, fig. 2

The thallus is thin and gelatinous. The cells are spherical, and apical cells are rounded. The trichome is blue-green, consisting of densely or irregularly aggregated rounded cells. The cell is 2–5 µm in diameter.

56. *Anabaena sphaerica* Bornet et Flahault (Image 72)

T.V. Desikachary, 1959, p.393, pl. 71, fig. 8

Gelatinous thin sheath present, Trichomes are pale blue-green in colour. Cells are barrel-shaped and 2–7 µm long. End cells are rounded. Heterocysts are 9–11 µm broad and 13–17 µm long with a smooth yellow outer wall.

Genus: *Cylindrospermum* Kutz

57. *Cylindrospermum stagnale* (Kutz.) Born.et Flah (Image 73, 74)

T.V. Desikachary, 1959, p.363, pl. 65, fig. 9

The thallus is blue-green with a mucilaginous sheath. The cells are constricted at the cross wall and nearly quadrant to cylindrical with spherical or oblong heterocyst. The trichomes are cylindrical and 2–5 µm broad.

Family: Rivulariaceae

Genus: *Gloeotrichia* Ag.

58. *Gloeotrichia echinulata* (J. E. Smith) P. Richter (Image 75, 76)

Prescott, 1962, p.557, pl. 134, figs. 1,2

The colonies are tiny macroscopic and opaque at the centre and translucent at the periphery. The colonies are free-floating, spherical and covered in a gelatinous sheath. The trichomes radiate from a common centre and are tapered from basal heterocyst to a fine hair-like end. The cells are cylindrical to barrel-shaped 6–9 µm wide, and the cells are joined end to end to form long chains.

Genus: *Scytonema* Ag.

59. *Scytonema ocellatum Lyngbye ex Born. et Flah* (Image 77)

T.V Desikachary, 1959, p.467, pl.92, fig.3

The thallus is cushion-like, brownish to reddish with false branching. The trichomes are covered in a firm mucilaginous sheath. The filaments are 11–15 µm broad.

60. *Scytonema rivulare Borzi ex Born. et Flah* (Image 78)

T.V Desikachary, 1959, p.452, pl.100, fig.2

The thallus is broad, with a thick mucilaginous sheath. The thallus is brownish to reddish with false branching. The cells are shorter than broad and 30 µm broad.

Order: Stigonematales

Family: Nostochopsidaceae

Genus: *Nostochopsis* Wood em. Geitler

61. *Nostochopsis lobatus Wood em. Geitler* (Image 79; Image 80, 81)

T.V. Desikachary, 1959, p.570, pl. 120, figs. 1-8

The thallus is irregularly lobed, blue-green with a thick mucilaginous matrix. The cells are barrel-shaped. The heterocyst are mostly lateral, spherical to ellipsoidal. The trichomes are 5–9 µm wide and 6–10 µm long.

DISCUSSION

The freshwater ecosystem holds the most biodiversity among all other ecosystem. The study of freshwater habitat is significant as it occupies only 0.5% of the earth surface, but is equally crucial because they are the cheapest natural source for domestic and industrial purposes (Norton et al. 1996).

The present study portraits the algal diversity of CWS. In our study, Chlorophyceae and Cyanophyceae

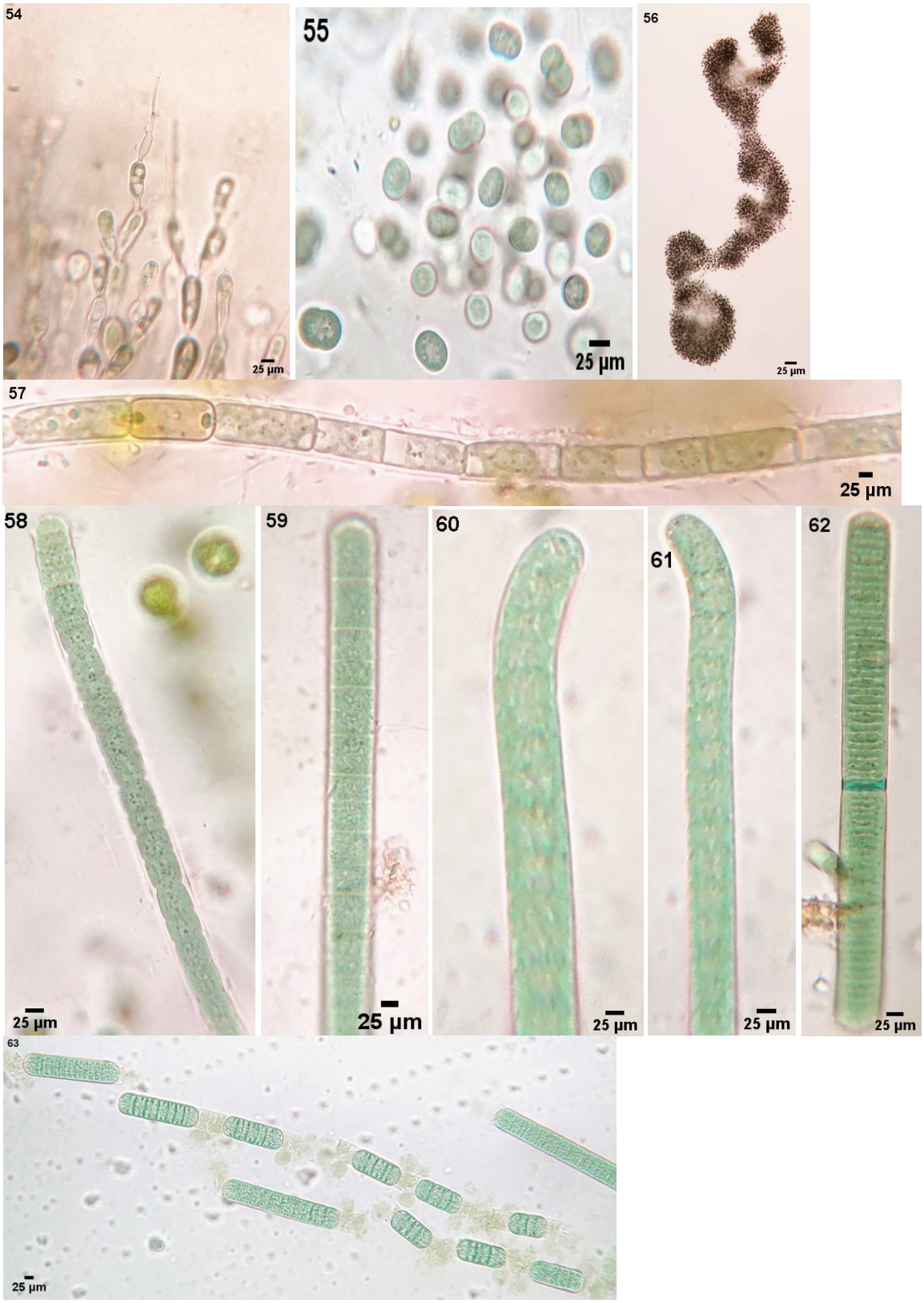

Image 54–63. 54—*Sheathia boryana* | 55—*Aphanocapsa pulchra* | 56—*Microcystis aeruginosa* | 57, 58—*Microchaete uberrima* | 59—*Oscillatoria limosa* | 60, 61—*Oscillatoria subbrevis* | 62—*Oscillatoria vizagapattensis* | 63—*Phormidium hansgirgi*. (© Joel Jose)

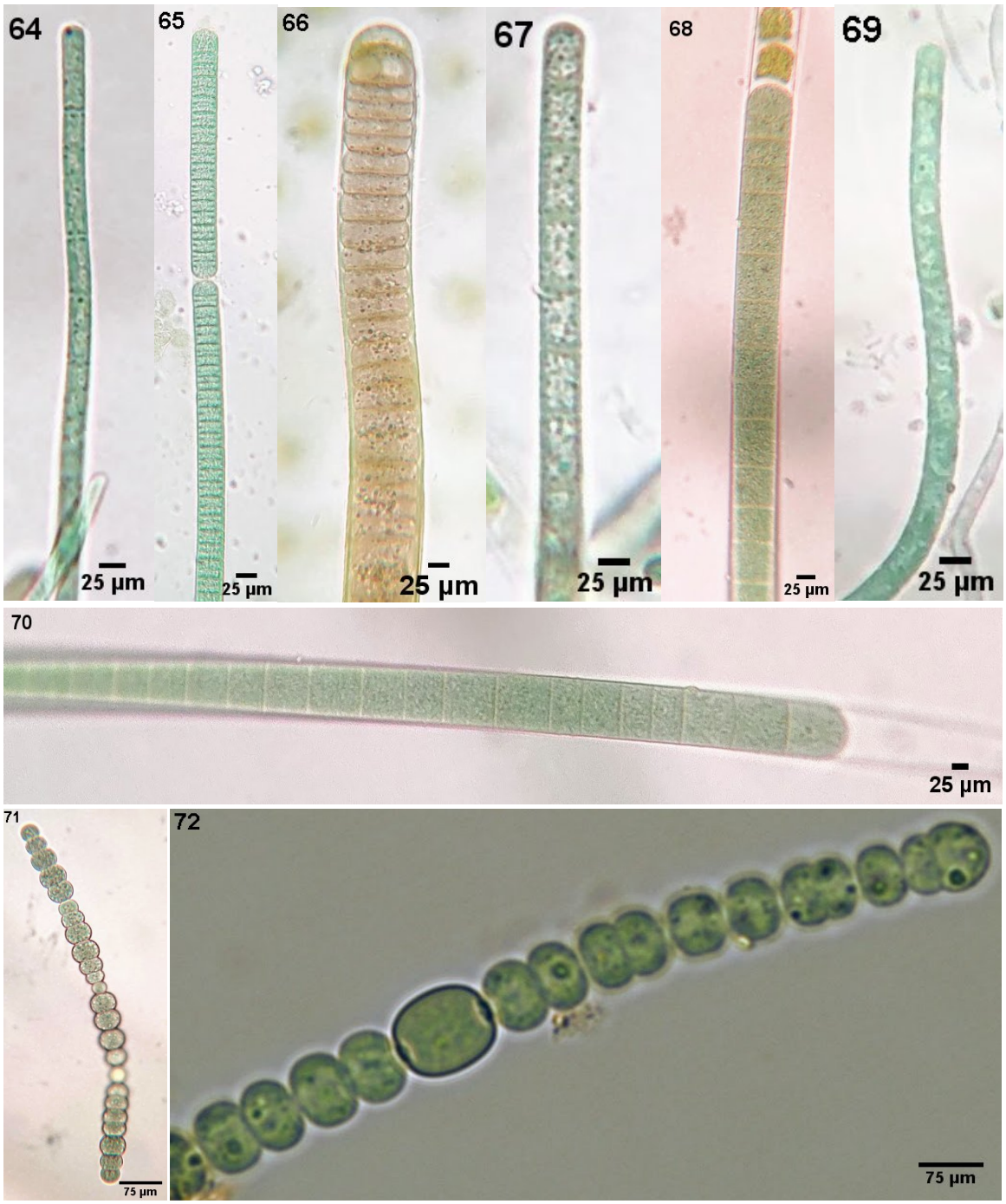

Image 64–72. 64—*Phormidium abronema* | 65—*Phormidium hansgirgi* | 66—*Phormidium microtomum* | 67—*Phormidium molle* | 68—*Phormidium retzii* | 69—*Phormidium usterii* | 70—*Phormidium truncicola* | 71—*Anabaena anomala* | 72—*Anabaena sphaerica*. (© Joel Jose)

algae were dominant. The preliminary study conducted in Kannam River, Kannur, Kerala for the diversity of algae has reported 40 algal species of which Chlorophyceae was dominant, followed by Cyanophycea (Girish et al. 2018). The algal population of Pennar River, Kottayam, has reported 61 algal species were Chlorophyceae was dominant (Joseph & Claramma 2010). In our study also, more algae were reported from the order Zygnematales, and *Spirogyra* was the most common genus. The algal species from order Nostocales of Cyanophyceae was dominant. A similar type of diversity was observed in the Gundur lake of Tamil Nadu. Out of 87 algal species reported from Gundur Lake, 37 species were Cyanophyta (Vijayan et al. 2014). The algae from Chlorophyceae and

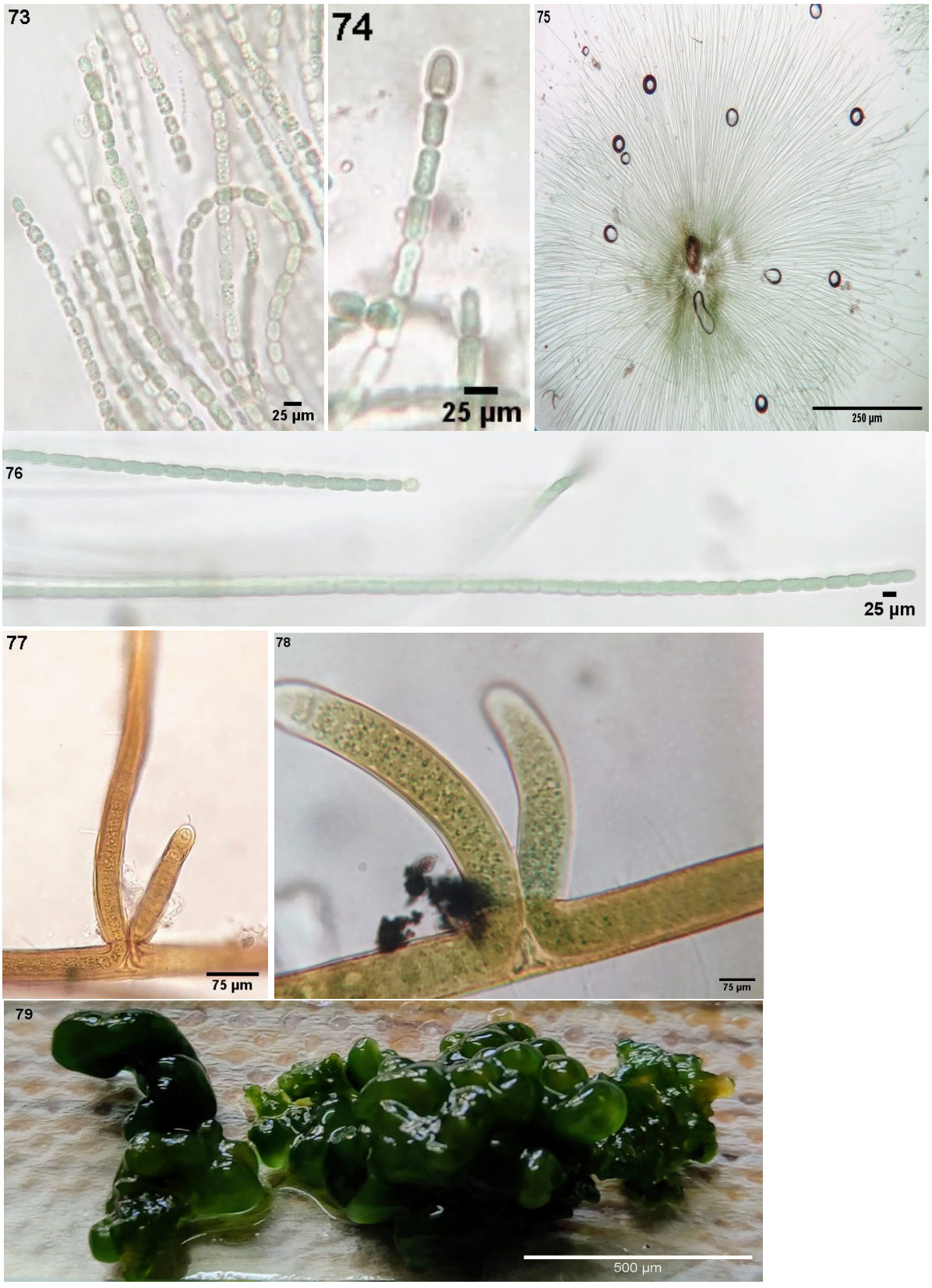

Image 73–79. 73, 74—*Cylindrospermum stagnale* | 75, 76—*Gloeotrichia echinulata* | 77—*Scytonema ocellatum* | 78—*Scytonema rivulare* | 79—*Nostochopsis lobatus*. (© Joel Jose)

Image 80–81. 80, 81—*Nostochopsis lobatus*. (© Joel Jose)

Cyanophyceae were dominant in species composition compared to other classes.

CONCLUSION

Overall, the biodiversity study conducted in Chimmony Wildlife Sanctuary shows a good presence of algae. The study also revealed that *Spirogyra* was dominant from Chlorophyceae, *Phacus* was dominant from Euglenineae, and *Phormidium* was dominant from Cyanophyceae. The algal diversity directly depends on season and the physicochemical parameters of the freshwater ecosystem. Therefore, extensive seasonal studies are required for acquiring more knowledge about algal diversity.

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