



A Morphotaxonomic account of cyanobacterial diversity of Indian Sundarbans

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Abstract

In a regular survey of 30 islands of Indian Sunderbans for 3 years in CSIR- NIMTLI program, a total 37 cyanobacterial taxa were collected, their identification done, voucher numbers assigned at Calcutta University Herbarium (CUH) and taxonomic data were recorded. Among them, 3 were unicellular, represented by *Gloeocapsa* and *Synechocystis*, 2 were colonial, represented by *Merismopedia* and the rest were trichomatous or filamentous taxa. The Sundarbans flora was mainly represented by the members cyanobacteria of non-heterocystous filamentous type, mainly represented by *Phormidium* (1), *Leptolyngbya* (4), *Oscillatoria* (6), *Arthrospira* (1), *Spirulina* (2) *Lyngbya* (5) and *Scytonema* (1). The heterocystous genera include *Nostoc* (3), *Anabaena* (3) and *Calothrix* (1).

Introduction

Cyanoprokaryotic members, commonly known as 'Cyanobacteria' occupy a broad range of habitats across the world being widespread in freshwater, marine and terrestrial ecosystems (Kulasooriya 2011). Since early times, diversity study of Cyanoprokaryotic (Cyanobacteria) population have been investigated based on morphological characters and growth patterns by several authors using the nomenclature 'Cyanophyta' and published different monographs (Gomont 1892a and 1892b; Geitler 1932; Desikachary 1959). Smith (1950) described Cyanophyceae members of United States. In Indian subcontinent cyanobacterial diversity study was popular since early times. From North India, Drouet (1938) worked on this group, whereas Parukuty (1940) studied cyanobacterial diversity from South India. From Eastern part of India, Bruhl and Biswas (1922) and Biswas (1925) worked on cyanobacterial diversity in early time.

Sundarbans (21°13'-22°40' North and 88°05'-89°06' East) - one of the World's largest mangrove forest of South Eastern Asia, is exposed to diurnal tidal cycle showing a prominent salinity gradient. The algal community of Sundarbans is composed of several members of different groups forming a thick mat on the forest floor of the islands. Prain (1903) described the algal flora of the mangrove forest of the Ganges-Brahmaputra delta. Seidensticker and Hai (1983) reported a total of 334 plant species in the Bangladesh part of this delta including more than 100 algal species. A more recent examination of the composition and structure of the mangrove vegetation including algal flora and fauna of the Indian Sundarbans have been made by Sen et al. (2003) and Mandal and Naskar (1994). But no detail morphotaxonomic documentation of cyanobacterial flora of Indian

Sundarbans is available till date. In the present investigation cyanobacterial diversity from 30 islands of Indian Sundarbans have been reported together with their taxonomic enumerations.

Materials and Methods

Vast area of Indian Sundarbans was explored once a month for 2 years (2011-13) including 30 islands. Major area explored were, Canning, Malancha, Basanti, Jharkhali, Minakha, Bhagabatpur, Lothian Island, Henry Island, Dabu, Morahero Island, Narayanitala, Chermatla, Jammudwip and Aamarboni Island Hamanbere Island, Bakkhali, Sushni Island, Suryamoni Island, Kala jungle, Dobanki, Sudhanyakhali, Sarberia, Dhamakhali, Sandeskhali, Namkhana, Fraserganj etc. The explored area lies between 21°31' to 22°53' N and 88°37' to 89° 09' E of the south-eastern part of Bay of Bengal (Fig. 1) and covers 30 islands with dense mangrove forest and inner island area. The sampling sites includes from fresh water region brackish to marine waters.

Cyanobacterial samples were collected, brought to laboratory with plastic bag, washed with distilled water and voucher specimens were prepared. For isolation agar stab were used and unialgal cultures were raised using BG-11 medium and maintained in culture room at 22°C. For morphotaxonomic study, slides were prepared and microscopic images were taken and identified with proper monographs (Gomont 1892, Geitler 1932, Desikachary 1959). For 16sRRNA analysis unialgal cultures were raised in serial dilution technique. The list of recorded taxa and their locations are mentioned in Table 1 and the photographs major taxa are represented in Plate 1.

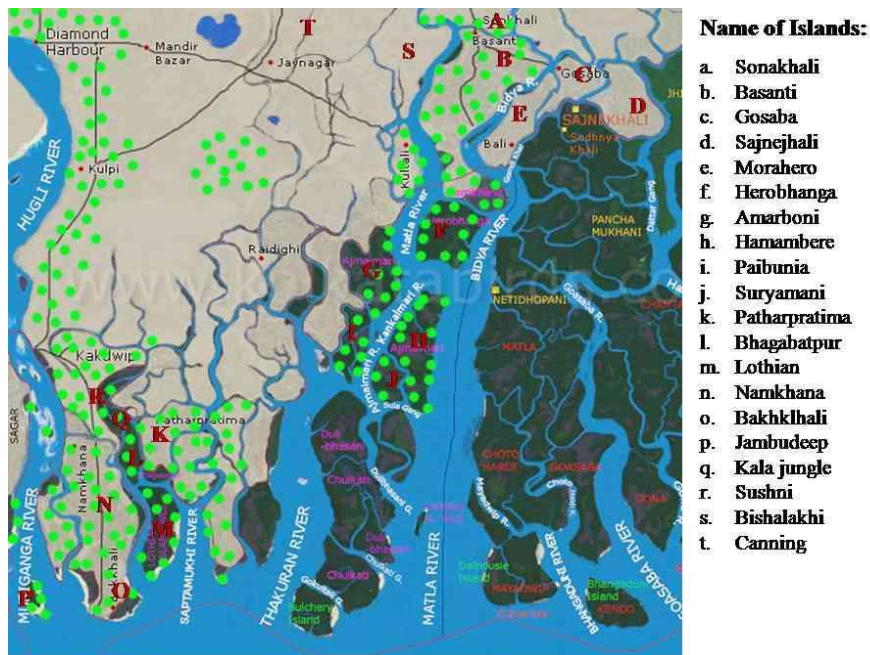


Fig. 1. Showing sampling sites.

Results

Cyanobacterial population of Sundarban was comparatively less diverse representing 37 taxa, which was much less than that of green algal diversity as already reported by the present group (Satpati et. al. 2011, 2012, 2013; Satpati and Pal, 2015). They are distributed in freshwater, brackish water and marine habitat of different islands, showing an

extensive bloom of brackish water species of *Lyngbya birgei*. Non-heterocystous genera like, *Leptolyngbya* and *Lyngbya* appeared as the dominant taxa of entire Sundarban area. The list of recorded taxa, their location and the assigned voucher numbers are represented in Table 1. Systemic accounts together with morphotaxonomic descriptions are given below-

Table -1. List of Cyanobacterial taxa recorded and their location.

Name of the taxa	Place of collection
1. <i>Gloeocapsa punctata</i>	Basanti, Jharkhali
2. <i>Synechocystic pevalekii</i>	Dabu, Morahero Island
3. <i>Synechocystic aquatilis</i>	Sudhanya khali, Dhama Khali
4. <i>Merismopedia glauca</i>	Basanti, Jharkhali, Dhama khali
5. <i>Merismopedia minima</i>	Basanti, Jharkhali, Sushni Island, Sujyamani Island
6. <i>Merismopedia punctata</i>	Basanti
7. <i>Phormidium rubroterricola</i>	Basanti, Chhera Matla, Kalrjungal, Herobhanga
8. <i>Arthospira platensis</i>	Bakkhali
9. <i>Microcoleus paludosus</i>	Herobhanga, Kholnar khal

10. <i>Microcoleus chthonoplastes</i>	Amrabani, Basanti, Chheramatla, Hammambere,
11. <i>Microcoleus lacustris</i>	Bakkhali, Kalar jungle
12. <i>Spirulina subsalsa</i>	Jharkhali, Zambudweep, Lothian Island
13. <i>S. laxissima</i>	Amrabani, Basanti, Lothian Island, Chheramatla, Herobhanga, Hammambere, Kholnar khal
14. <i>S. meneghiniana</i>	Gangasagar, Zambudweep
15. <i>Planktolyngbya minor</i>	Bakkhali, Herobhanga
16. <i>Leptolyngbya foveolarum</i>	Amarboni, Morahero island, Basanti, Jharkhali
17. <i>L. frigida</i>	Basanti, Jharkhali
18. <i>L. valderiana</i>	Basanti, Chheramatla, Bakkhali, Herobhanga, Kholnar Khal
19. <i>L. tenuis</i>	Bakkhali, Bhagabatpur, Herobhanga
20. <i>Lyngbya sordida</i>	Basanti, Jharkhali
21. <i>L. majuscula</i>	Sarberia
22. <i>L. birgei</i>	Basanti, Bakkhali, Sarberia
23. <i>L. martensiana</i>	Basanti, Lothian Island, Herobhanga, Bhagabatpur
24. <i>L. rubida</i>	Basanti, Bhagabatpur, Hammambere
25. <i>L. confervoides</i>	Basanti, Bakkhali
26. <i>Oscillatoria princeps</i>	Amrabani, Bakkhali, Chheramatla, Hammambere
27. <i>O. acuta</i>	Jharkhali
28. <i>O. subbreveis</i>	Amrabani, Chheramatla, Basanti, Bhagabatpur, Hammambere
29. <i>O. obscura</i>	Basanti, Hammambere, Herobhanga
30. <i>Scytonema bohneri</i>	Amrabani, Basanti, Chheramatla, Kholnar khal
31. <i>Nostoc ellipsosporum</i>	Basanti, Sarberia
32. <i>N. commune</i>	Basanti, Sarberia
33. <i>N. cerneum</i>	Basanti, Sarberia
34. <i>Anabaena sphaerica</i>	Basanti, Sarberia, Jharkhali
35. <i>A. flos-aquae</i>	Basanti, Sarberia
36. <i>A. variabilis</i>	Amrabani, Bakkhali, Bhagabatpur, Chheramatla, Kalar jungle
37. <i>Calothrix clavata</i>	Basanti

**SYSTEMATIC ACCOUNT OF
CYANOPROKARYOTES RECORDED FROM
SUNDARBANS (Komarek et Anagnostidis 1995)**

Cyanoprokaryota I

Order -Chroococcales

**Family –Gloeobacteraceae Komarek et Anagnostidis
1995**

1. *Gloeocapsa punctata* Naegeli (Pl. 1, Fig. U)

(Geitler 1932; Desikachary 1959; Komarek and Anagnostidis 1999, p. 239, fig. 309)

Plant mass blue – green, floating, consisting of small aggregated of 8 – 16 individuals which are spherical and enclosed by thick sheaths; cells 2 μ in diameter; contents blue – green, homogenous.

**Family- Synechococcaceae Komarek et Anagnostidis
1995**

2. *Synechocystis pevalekii* Ercegovic (Pl. 1, Fig. A)

(Geitler 1932, Desikachary 1959, p. 126, pl 25, fig. 11; Komarek?)

Thallus indefinite, among other algae; cells spherical, after division hemispherical, 2.5-3.5 μ broad, single or two together, contents blue green homogenous.

3. *S. aquatilis* Sauv. Sauvageau

(Desikachary, 1959; Komarek and Anagnostidis, 1999, p. 172, fig. 222)

Planktonic, cells spherical, single or in rows, 5-6 μ broad, pale blue green color.

Family-Merismopediaceae

4. *Merismopedia glauca* Ehrenb. Nag. (Pl. 1, Fig. X)

(Desikachary 1959; p.154 pl 29, fig. 5)

Colony small with 16-64 cells, cells spherical, closely arranged, 3-5 μ broad.

5. *M. minima* Beck (Pl. 1, Fig. Y)

(Geitler 1932; Desikachary 1959; Komarek and Anagnostidis, 1999, p. 174, fig. 217)

Planktonic, pale blue green in color, 4- many cells in colony, 0.5-0.6 μ broad.

6. *M. punctata* Meyen (Pl. 1, Fig. Z)

(Geitler 1932; Desikachary 1959; Komarek and Anagnostidis 1999, p. 175, fig. 222)

Colonies flat, pale blue green in color, mucilaginous, 32 celled, cells spherical, individual gelatinous sheath absent, 2.8-3 μ in diameter.

Cyanoprokaryota – II

Order - Oscillatoriales

Family Phormidiaceae

**7. *Phormidium rubroterricola* Gardner 1927 (unrevised
by Komarek) (Pl. 1, Fig. G)**

(Desikachary 1959, p. 260, pl 43, fig. 3)

Trichome with straight ends, cross wall not constricted, 2.2-2.4 μ diameter, cells quadrate, somewhat longer, end cells obtuse-conical, sheath distinct

8. *Arthrospira platensis* Gomont ex Gomont (Pl.1, Fig. R)

(Desikachary 1959, p. 190, pl 36, fig. 1; unrevised by Komarek)

Thallus blue green; slightly constricted at the cross walls, 6-8 μ broad, not attenuated at the ends, more or less regularly spirally coiled. Spirals 26-36 μ broad, distance between the spirals 43-57 μ ; cells nearly as long as broad, or shorter than broad, distance between the spirals 43-57 μ ; cells nearly as long as broad, or shorter than broad, 2-6 μ long, cross walls granulated; end cells broadly rounded.

9. *Microcoleus paludosus* (Kutz.) Gomont

(Desikachary 1959; Komarek and Anagnostidis 2008, p. 533, fig. 803)

Filaments form, a green stratum, sheath slightly gelatinous, trichomes not granulated at cross walls. 5-7 μ broad, cells nearly as long as or twice as long as broadened cell conical.

10. *M. chthonoplastes* Thuret ex Gomont (Pl. 1, Fig. V)

(Desikachary 1959; Komarek and Anagnostidis 2008, p. 535, fig. 806)

Dark green lamellated thallus, coiled, having many closely grouped trichomes, trichome constricted at cross walls, cells 1-2 times as long as broad, 3.6 -10 μ long; end cell pointed

11. *M. lacustris* (Rabenh) Farlow

(Desikachary 1959; Komarek and Anagnostidis 2008, p. 533, fig. 802)

Thallus blackish blue green, filaments contorted, many trichomes in sheath, trichomes distinctly constricted at cross wall, 4-5 μ broad, cells cylindrical, 1-3 times as long as broad, bright blue green, end cells more or less rounded.

Family-Pseudoanabaenaceae

12. *Spirulina subsalsa* Oerst. ex Gomont (Pl. 1, Fig. Q)

(Geitler 1932; Desikachary 1959; Komarek and Anagnostidis 2005, p. 150, fig. 176)

Trichomes reddish violet to blue green 1-2 μ broad, , mostly somewhat irregularly densely spirally coiled, rarely regular coiled, forming a bright blue green or yellowish-green thallus, or single other among algae, spirals very close to each other, 3-5 μ broad.

13. *S. laxissima* West, G. S. (Pl. 1, Fig. W)

(Desikachary 1959, p.194, pl 36, fig. 5; unrevised by Komarek)

Freshwater, trichome 0.7-0.8 μ broad, spirals very loose, but regular 4.5 -5.3 μ broad, end cell rounded

14. *S. meneghiniana* Zanardini ex Gomont (Pl. 1, Fig. S)

(Komarek and Anagnostidis 2008, p. 149, fig. 172)

Compact blue green thallus, trichomes bright blue green, regularly screw like coiled, thallus 1-2 -1-8 μ wide, not constricted at cross wall, marine in habitat.

15. *Planktolyngbya minor* (Geitler) Komarek et Kornberg 2001

(*Lyngbya lymnetica* Desikachary 1959, p. 295, pl 50, fig. 11; Komarek and Anagnostidis 2008, p. 165, fig. 199)

Filament straight, single, slightly curved or coiled, free floating, sheath thin narrow, cells 1-1.5 μ broad, not constricted at the cross walls, end cell rounded.

16. *Leptolyngbya foveolarum* (Rabenhorst ex Gomont)

(*Phormidium foveolarum*, Gomont 1892; Anagnostidis et Komarek 1988, fig. 229)

Thallus thin fine gelatinous, usually dark green or blue green, Filaments variously curved or straight. Sheaths thin, firm attached to the trichome, colorless, or soft, mucilaginous forming an amorphous gelatinous mass. Trichomes pale to bright blue green, 0.5-2.5 μ wide not attenuate at the ends. Cells monoliform, slightly barrel shaped isodiametric, 0.8-2.2 μ long, apical cells rounded, almost hemispherical, without calyptras.

17. *L. frigida* Fritsch

(*Phormidium frigid* Fritsch 1912; Anagnostidis and Komarek 1988, fig. 55)

Thallus thin, fine, membranaceous. Trichomes multicelled, more or less curved, 0.8-1.8 μ wide, with mucilaginous, clearly constricted at the cross walls, not attenuated at the ends; cells cylindrical with rounded ends, as long as wide or up 2 times longer than wide.

18. *L. valderiana* Gomont (Pl. 1, Fig. F)

(*Phormidium valderiana* Gomont 1892, Anagnostidis and Komarek, 1988, fig. 260)

Thallus lubricous, expanded firm, leathery, slippery upto 3 cm thick, lamellated, on the superior layers dull green to yellow green, rarely blue green. Filaments variously curved, to 3 μ thick. Sheaths thin firm, mucilaginous. Trichomes pale to bright blue green, 1.2-2.8 μ wide, not attenuated at the ends, straight. Cells isodiametric, upto 1.5 times longer than wide, 2.5-7.5 μ long; cell content homogenous with one or more granules on either side of the walls. Apical cells more or less rounded, sometimes hemispherical, not capitates.

19. *L. tenuis* Gomont (Pl. 1, Fig. E)

(*Phormidium tenue* [Meneghini] Gomont ex Gomont 1892; Anagnostidis and Komarek, 1988, fig. 272)

Thallus pale to bright blue-green, thin membranous, expanded. Filaments long straight. Trichomes pale to bright blue-green or emerald green to olive green, 0.7-2.4 μ wide, slightly constricted at the cross walls, non-granulated cross walls. Apical cells more or less elongated bent acute-conical without calyptras.

Family Oscillatoriaceae

20. *Lyngbya sordida* (Zanard) Gomont

(Desikachary 1959; Anagnostidis & Komarek, 2008, p. 624; fig. 949)

Thallus fasciculate, expanded, dark or dirty yellow green, mostly black violet when dried, upto 3 cm high. Filaments

more or less straight, erect. Sheaths smooth, thin, colorless. Trichomes cylindrical, olive green to blue green, not attenuated or slightly attenuated at the ends. Apical cells rounded, without calyptras or thickened outer cell wall.

21. *L. majuscula* Harvey ex Gomont (Pl. 1, Fig. L)

(Desikachary 1959; Komarek and Anagnostidis 2005, p. 623, fig. 950)

Thallus wide expanded, up to several 5-7 cm in length, dark blue green or black green. Filaments very long, often strongly curved or wavy. Sheaths colourless, upto 15 μ thick. Trichomes cylindrical blue green blackish, dull green, 15-60 μ wide, not attenuated at the ends. Cells very short discoid, 2-8 μ long; apical cells rounded without calyptra.

22. *L. birgei* Smith, G. M. (Pl. 1, Fig. K)

(Desikachary 1959; Komarek and Anagnostidis 2008, p. 626, fig. 954)

Filaments straight, seldom coiled, free floating; sheath firm, colourless, mostly unlamellated; trichome not constricted at the cross walls, ends rounded, not attenuated, not capitates; cells shorter than broad, 2.5 μ long.

23. *L. martensiana* Menegh. ex Gomont (Pl. 1, Fig. H)

(Desikachary 1959; Komarek and Anagnostidis 2008, p. 615, fig. 931)

Thallus blue green, when dried violet, filaments long, more or less flexible, sheath colorless, trichome 6-10 μ broad, 1.7 – 3.3 μ in length, not constricted at cross wall.

24. *L. rubida* Frey (Pl. 1, Fig. I)

(Desikachary 1959, p. 306, pl 53, fig. 10; synonym, *Phormidium rubidium* by Komarek and Anagnostidis 2008, p. 458)

Thallus purplish in color, expanded, filaments straight, stiff, up to 3 cm long, cells 4-4.5 μ broad, not constricted at cross walls, end cell round, calyptra absent.

25. *L. confervoides* C. Agardh ex Gomont (Pl. 1, Fig. J)

(Desikachary 1959; Komarek and Anagnostidis 2008, p. 620, fig. 945)

Thallus fasciculate, blackish green, upto 6 cm in length. Filaments straight, entangled, 12-30 μ wide, sheath colorless, cells very short discoid 1/5 as long as wide, 2-4 μ long.

26. *Oscillatoria princeps* Voucher ex Gomont (Pl. 1, Fig. C)

(Desikachary 1959; Komarek and Anagnostidis 2005, p. 590, fig. 883)

Thallus dark blue green to blackish blue green in color and attached. Trichomes olive green to dark blue green, Cells discoid, short 5-6 μ long 15-50 μ wide, mostly straight or slightly curved, rigid very long, not constricted at the cross walls. Apical cells rounded hemispherical without calyptras.

27. *O. acuta* Bruhl et Biswas, orth. mut. Geitler

(Bruhl & Biswas 1922, p. 11, fig. 6a and 6b; Geitler 1932)

Trichomes solitary, blue green to pale green, 3.9-10.5 μ wide, usually straight, attenuated at the end. Cells shorter than wide, 1-2 μ long, not granulated at the cross walls. Apical cells acute without calyptras.

28. *O. subbrevis* Schmidle (Pl. 1, Fig. B)

(Desikachary 1959; Komarek and Anagnostidis 2005, p. 587, fig. 878)

Pale green thallus with straight trichomes, 7-8 μ broad, end cell not capitates, cross wall not constricted.

29. *O. obscura* Bruhl et Biswas (Pl. 1, Fig. D)

(Desikachary 1959, p. 207, pl 37, fig. 2)

Trichome slightly bent or nearly straight, not constricted at cross wall, 4 μ broad, 1/5 as long as broad, cross walls granulated.

Cyanoprokaryota –III, Heterocystous Genera

Order Nostocales

Family- Scytonemataceae

30. *Scytonema bohneri* Schmidle (Pl. 1, Fig. T)

(Desikachary 1959, p. 457, pl 87, fig. 1; Komarek 2013, p. 85, fig. 54)

Blackish blue green color green; false branches mostly single, cells rectangular, 6 μ broad; constriction absent at the cross wall short at the apices; heterocyst compressed, rectangular, longer than broad, wall hyaline.

Family: Nostocaceae

31. *Nostoc ellipso sporum* (Desm.) Rabenh. ex Born. et Flah. (Pl. 1, Fig. M)

Thallus gelatinous irregularly expanded attached attached by the lower surface, reddish brown; filamentous flexuous, loosely entangled; trichome about 4 μ broad light blue green or olivaceous; cells cylindrical, 6-14 μ long; heterocystous sub spherical, or oblong, 6-7 μ broad, 6-14 μ long.

32. *N. commune* Vaucher ex Born. et Flah. (Pl. 1, Fig. N)

(Geitler 1932, p. 845, fig. 536, 537; Desikachary 1959, p. 387; pl 68, fig.3; Komarek 2013, p. 979, fig. 1272-73)

Gelatinous globose Thallus, blue green, olivaceous or brownish color, inside the thallus more or less distinct, but hyaline; trichome 4.5-6 μ broad, cells short barrel shaped or nearly spherical, about 7 μ broad.

33. *N. carneum* Ag. ex Born. et Flah.

(Geitler 1932, p. 839, fig. 530; Desikachary 1959, p.381; pl 69, fig. 6)

Thallus when young globose, later irregularly expanded, gelatinous, reddish brown, filaments loosely contorted, trichome 3.5-4 μ broad

34. *Anabaena sphaerica* Bournet & Flah. (Pl. 1, Fig. P)

(Komarek 2013, p.796, fig. 992)

Thallus blue green; 5-6 μ broad, with an indistinct mucilaginous sheath; cells spherical to short barrel shaped; end cells rounded; Heterocyst spherical, akinetes present in one or both side of heterocyst 6-7 μ broad, 12-18 μ long.

35. *A. flos-aquae* (Lyngb.) Breb. ex Born. et Flah

(Geitler 1932, p. 890, fig. 571a, b; Desikachary 1959, p. 414)

Thallus frothy, gelatinous, lubricous, free floating, bluish in colour; trichomes circinate, 4-8 μ broad, without sheath; cells ellipsoidal, seldom spherical, as long as broad or longer, 6-8 μ long, mostly with the gas vacuole; heterocysts ellipsoidal, 4-9 μ broad and 6-10 μ long.

36. *A. vairabilis* Kutzing ex Born. et Flah. (Pl. 1, Fig. O)

(Geitler 1932, p. 876, fig. 558; Desikachary 1959, p. 410, pl 71, fig. 5)

Thallus gelatinous, dark green; trichome without any sheath, flexuous, 4-6 μ broad, more often 4.2-5 μ broad slightly constricted at the cross walls, end cells conical, obtuse; cells barrel shaped, sometimes with gas vacuoles, 2.5-6 μ long; heterocysts spherical or oval, 6 μ broad, upto 8 μ long; spores formed centrifugally, not contiguous with the heterocysts, barrel shaped, in series, 7-9 μ broad, 8-14 μ long, epispore smooth, or with fine needles, colorless or yellowish brown.

37. *Calothrix clavata* West, G. S.

(Geitler 1932, p. 609, fig. 382b-c; Desikachary 1959, p. 542-543, pl 114, fig. 2)

Filaments single, up to 100 μ long, straight, or slightly bent; sheath close to the trichome, very thin, trichomes 2-6 μ broad and 2-3 times as long as broad.

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References

1. Anagnostidis, K. and Komarek, J. 1988. Modern approach to the classification of cyanophytes. 3. Oscillatoriales. Arch. Hydrobiol. Suppl. 80, *Algalogical Studies*, 50/53: 327-472.
2. Biswas, K. 1925. Road slime of Calcutta. *J. Dept. Sci. Calcutta Univ*, 7: 1-10.
3. Bruhl, P. and K. Biswas 1922. Algae of Bengal Filter beds. *J. Dept. Sci. Calcutta Univ*, 4: 1-17.
4. Desikachary, T. V. 1959. Cyanophyta. Indian Council of Agricultural Research, New Delhi, 71-619 pp.
5. Drouet, F. 1938. Myxophyceae of the Yale North India Expedition collected by G. E. Hutchinson. *Trans. Am. Microsc. Soc.* 57(2): 127-131.
6. Fritsch, F. E. 1912. Freshwater algae collected in the South Orkneys by Mr. R. N. Rudmose Brown, B.Sc. of the Scottish National Antarctic Expedition, 1902-04. *J. Linnean Soc. London Bot.* 40: 293-338.

7. Geitler, L. 1932. Cyanophyceae in Rabenhorst's Kryptogamenflora, Leipzig 14: 1196 pp.
8. Gomont, M. 1892a. Monographie des Oscillarees, I. *Ann. Sci. nat. Bot. ser.* 7, 15: 263-368.
9. Gomont, M. 1892b. Monographie des Oscillarees, II. *Ibid.* 16: 91-264.
10. Komarek, J. and Anagnostidis, K. 1995. Nomenclature novelties in Chroococcalean Cyanoprokaryotes. *Perslia (Prague)*, 97: 15-23.
11. Komarek, J. and Anagnostidis, K. 1999. Cyanoprokaryota: Chroococcales In: *Subwasserflora von Mitteleuropa*. Gestv. Fischer, Jena: 19(1): 1-548.
12. Komarek, J. and Anagnostidis, K. 2005. Subwasserflora von Mitteleuropa 19/2, Cyanoprokaryota 2. Teil/Part 2: Oscillatoriales- In Budel, B., Gartner G., Krientz, L. & Schagest, M. (eds.). Spektrum Akademischer Verlag, 759 pp.
13. Komarek, J. and Anagnostidis, K. 2008. Subwasserflora von Mitteleuropa 19/2, Cyanoprokaryota 2. Teil/Part 2: Oscillatoriales- In Budel, B., Gartner G., Krientz, L. & Schagest, M. (eds.). Spektrum Akademischer Verlag, 759 pp.
14. Komarek, J. 2013. Subwasserflora von Mitteleuropa. Cyanoprokaryota: 3rd part: heterocystous genera. Vol. 19 pp. [i]-xviii, [1]-1130. Heidelberg: Springer.
15. Kulasooriya, S. A. 2011. Cyanobacteria: Pioneers of Planet Earth, *Ceylon J. Sci.* 40(2): 71-88.
16. Parukuty, P. R. 1940. The myxophyceae of the Travancore State, India. *Proc. Indian Acad. Sci.* 11:117-124.
17. Mandal, R. N. and Naskar, K. R. 1994. Studies on the periphytic algae on the aerial roots of the mangrove swamps of Sundarban in West Bengal- In *Environmental Pollution & Impact of Technology on life*. Malabika Roy (Ed.). Recent researches in Ecology, Environment and pollution, (Viswabharati, Santiniketan, Birbhum). 9: 91-104.
18. Prain, D. 1903. Flora of Sundarbans. Records of the Botanical Survey of India. 2: 231-390.
- Satpati, G. G., Barman, N., Chakraborty, T. and Pal, R. 2011. Unusual habitat of algae, *J. Algal Biomass Utln.* 2 (4): 50-52.
19. Satpati, G. G., Barman, N. and Pal, R. 2012. Morphotaxonomic account of some common seaweeds from Indian Sundarbans mangrove forest and inner island area, *J. Algal Biomass Utln.* 3(4): 45-51.
20. Satpati, G. G., Barman, N. and Pal, R. 2013. A study on green algal flora of Indian Sundarbans mangrove forest with special reference to morphotaxonomy. *J. Algal Biomass Utln.* 4 (1): 26-41.
21. Satpati, G. G. and Pal, R. 2015. *Trentepohlia sundarbanensis* sp. nov. (Trentepohliaceae, Ulvophyceae, Chlorophyta), a new chlorophyte species from Indian Sundarbans. *Phykos* 45(1): 1-4.
22. Seidensticker, J. and Hai, M. A. 1983. The Sundarbans Wildlife Management Plan: conservation in the Bangladesh coastal zone. IUCN, Gland, Switzerland, 120 pp.
23. Sen, N., Naskar, K. R., Chakraborty, S. and Santra, S. C. 2003. New Benthic algae from Indian Sunderbans, *Phykos*. IARI Delhi.
24. Smith, G. M. 1950. The freshwater algae of the United States. Mc. Graw- Hill, New York, USA.

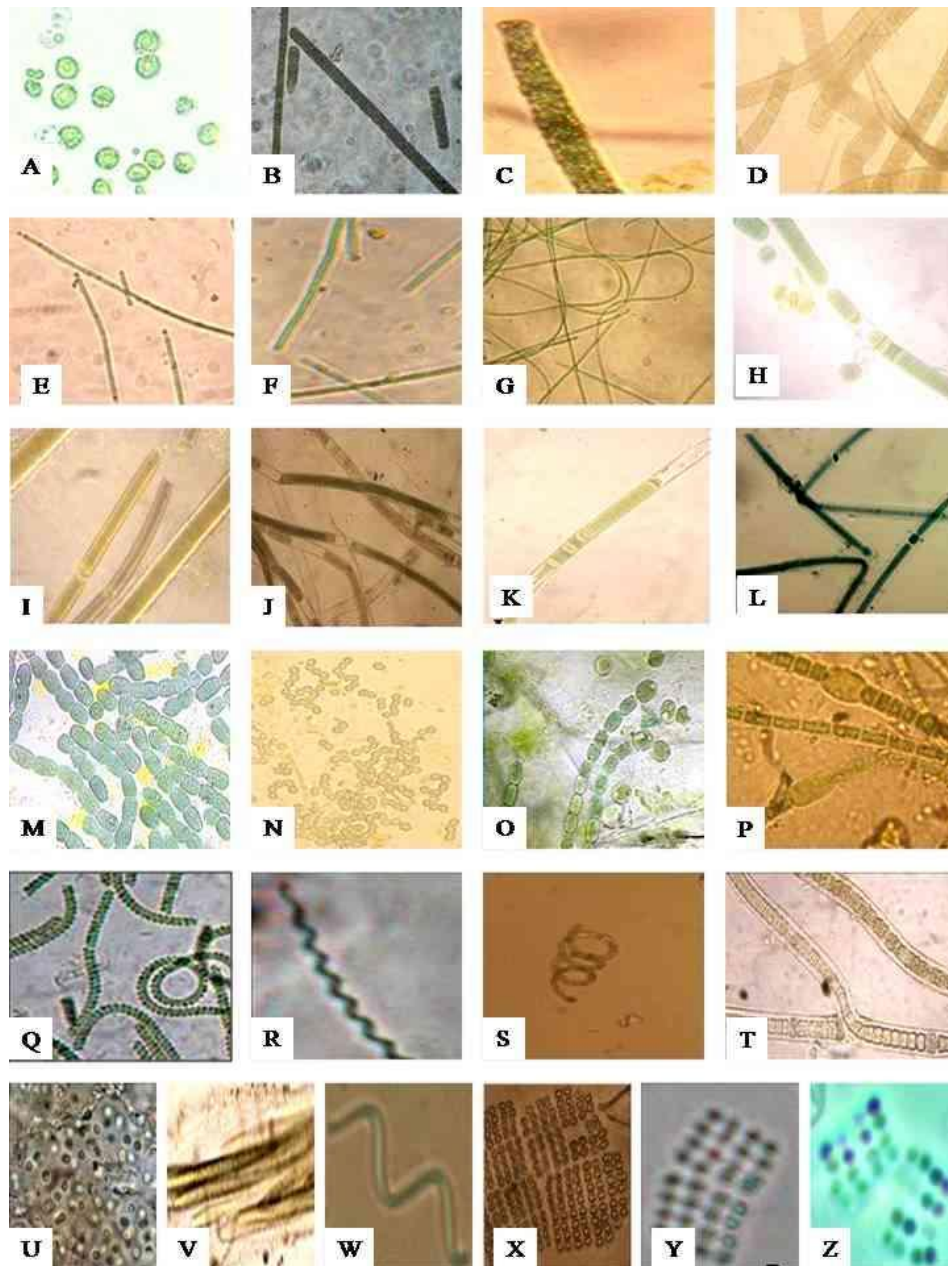


Plate 1. Microphotographs of A. *Synechocystis pevalekii*, B. *Oscillatoria subbrevis*, C. *O. princeps*, D. *O. obscura*, E. *Leptolyngbya tenuis*, F. *L. valderina*, G. *P. rubroterricola*, H. *L. martensiana*, I. *Lyngbya rubida* J. *L. confervoides*, K. *L. birgei*, L. *L. majuscula*, M. *Nostoc ellipsosporum*, N. *N. commune*, O. *Anabaena variabilis*, P. *A. sphaerica*, Q. *Spirulina subsalsa*, R. *Arthrospira platensis*, S. *S. Meneghiniana*, T. *Scytonema bohneri* U. *Gloeocasca punctata*, V. *Microcoleus chthonoplastes*, W. *S. laxissima*, X. *Merismopedia glauca* , Y. *M. Minima*, Z. *M. punctata*.