

SUPPLEMENTARY MATERIAL

Taxonomic interpretation of non-heterocystous Cyanobacteria (Oscillatoriales) from eastern India with special emphasis on *Lyngbya-* *Plectonema* complex

Sreemanti Banerjee^{1*}, Akanksha Singh², Ruma Pal³

¹ Department of Botany, Diamond Harbour Women's University, Diamond Harbour Road,
Sarisha, South 24 parganas, Pin- 743368

² Department of Biotechnology, Indian Institute of Technology Kharagpur, Kharagpur-721302.

³ Department of Botany, University of Calcutta, 35 Ballygunge Circular Road, Kolkata-19

*Author for correspondence-sreemantibanerjee@gmail.com

Taxonomic descriptions

Order-Oscillatoriales

Family-Pseudanabaenaceae

Leptolyngbya valderiana* (Gomont) Anagnostidis et Komarek **Fig. 7-8*

Komarek and Anagnostidis 2005, fig. 260

Thallus expanded, slippery. Filaments variously curved, flexuous, densely packed and entangled. Sheaths thin, firm, diffluent, mucilaginous, sometimes indistinguishable. Trichomes pale to bright blue-green, feebly constricted at the cross-walls, not attenuated at the ends, straight. Cells $2.5-7.5 \times 1.5-2 \mu\text{m}$; cell content homogeneous. Apical cells \pm rounded, without calyptra or thickened outer cell wall.

Habitat- Brackish water in the mangrove region.

Voucher Number- CUH/AL/MW/CYANO-174, CUH/AL/MW/CYANO-172

***Limnothrix vacuolifera* (Skuja) Komárek ex G.McGregor Fig. 11**

Komarek and Anagnostidis 2005, fig. 84

Filaments solitary, free-floating, \pm straight or slightly and irregularly waved or coiled, long.

Sheaths are acceptable, colorless, thin, firm and smooth, overlapping the trichome ends.

Trichomes not or very slightly and indistinctly constricted at crosswalks, not attenuated towards the ends, wide. Cells $1.3-2 \times 3-23 \mu\text{m}$, blue-green, with aerotopes at crosswalls. Apical cells are rounded, without calyptra or thickened cell walls.

Habitat- Hotspring

Voucher Number- CUH/AL/FW/CYANO-104

Family-Phormidiaceae

***Planktothrix pseudagardhii* Suda Fig. 5-6**

Komarek and Anagnostidis 2005, fig. 500 b,d

Trichomes pale blue-green or yellow-green, solitary, sometimes entangled, straight, not constricted at cross-walls. Cells with aerotopes, $1.2-4.2 \times 3.0-6.4 \mu\text{m}$; apical cells rounded, tapered, bluntly-conical.

Habitat- Suburban areas.

Voucher Number- CUH/AL/FW/CYANO-98, CUH/AL/FW/CYANO-96

***Phormidium autumnale* [Agardh] Trevisan ex Gomont Fig. 13-14**

Komarek and Anagnostidis 2005, fig. 707

Thallus brownish-green. Filaments were straight, primarily entangled. Sheaths are thin, distinct, amorphous, and mucilaginous. Trichomes are dirty green, sometimes slightly constricted at the frequently granulated cross-walls, attenuated somewhat at the ends. Cells $2-4 \times 4-6 \mu\text{m}$. Apical cells are frequently somewhat elongated.

Habitat- Suburban areas.

Voucher Number- CUH/AL/FW/CYANO-94

***Desertiflum* sp.** Dadheech & Krienitz **Fig. 12**

Dadheech *et al.* 2012, pg 260, fig. 1-8

Thallus bright blue-green, filaments solitary, filaments slightly constricted at cross walls, trichome 2.0–7.0 µm wide, attenuated at the ends, cells cylindrical, isodiametric or up to 2× longer than wide, sometimes slightly barrel-shaped, cell content homogenous, gas vacuole absent, apical cells long–conical and rounded apex, curved.

Habitat- Suburban areas

Voucher Number- CUH/AL/FW/CYANO-260

***Planktothrix* sp.** Anagnostidis et Komarek **Fig. 15-16**

Komarek and Anagnostidis 2005, fig. 354

Trichomes solitary, free-floating, ± straight constricted at cross-walls, gathered (after reaching a particular concentration) into accessible, irregular clusters, 3-12 µm wide; false branching absent. Cells cylindrical, rarely ± slightly barrel-shaped, usually a little shorter than wide or up to ± isodiametric, seldom longer than wide; thylakoids ± radially arranged, aerotopes (groups of gas vesicles) distributed obligatorily over the whole protoplast. Apical cells are widely rounded.

Habitat- Suburban areas

Voucher Number- CUH/AL/FW/CYANO-104

Family-Oscillatoriaceae

Lyngbya aestuarii Liebman ex Gomont **Fig. 26**

Komarek and Anagnostidis 2005, fig. 947-948

Thallus ± widely expanded, dark blue-green to black, mostly attached to the substrate. Filaments long, almost straight, entangled, 14-30 µm wide. Sheaths are thin, smooth, yellow-brown, and lamellated. Trichomes olive-green, 10-21 µm wide, not constricted at the granulated cross-walls,

cylindrical, not attenuated at the ends. Cells short, discoid, $2-2.5 \times 8-10 \mu\text{m}$. Apical cells are flat-rounded with thickened outer cell walls.

Habitat- Brackish water in mangrove region.

Voucher number- CUH/AL/MW/CYANO-136

***Oscillatoria princeps* Vaucher ex Gomont Fig. 25**

Komarek and Anagnostidis 2005, fig. 883

Thallus blackish blue-green \pm thin, free-floating, forming small clusters of filaments. Trichomes dark blue-green, slightly constricted at ungranulated cross walls, not attenuated at the ends. Cells $0.5-1 \times 15-20 \mu\text{m}$. Apical cells are flat and rounded.

Habitat- Aquatic habitat in northern hilly areas.

Voucher Number- CUH/AL/FW/CYANO-72

***Oscillatoria sancta* Kutzing ex Gomont Fig. 9**

Komarek and anagnostidis 2005, fig. 890

Thallus dark black-blue. Trichomes greyish to brown-violet, $7-18.5 \mu\text{m}$ wide, straight, sometimes slightly constricted at the granulated cross-walls, not attenuated at the ends. Cells discoid, $1-2 \times 5-6 \mu\text{m}$. Apical cells are hemispherical with thickened calyptroid outer cell walls.

Habitat-Suburban areas

Voucher Number- CUH/AL/FW/CYANO-89

***Plectonema tomasinianum* Bornet ex Gomont Fig. 23,24,27**

Komarek and Anagnostidis 2005, fig. 984

Filaments densely entangled, blue-green. Filaments $11-18 \mu\text{m}$ wide, rich or sparse, scotoma-like pseudoranch; branches single or in pairs, fasciculate erect, diverged. Sheaths are initially thin, hyaline colorless. Trichomes are green, mostly constricted at the sometimes granulated cross

walls, not attenuated at the ends. Cells discoid, $3-9 \times 11-22 \mu\text{m}$. Apical cells are rounded, without calyptras or thickened cell walls.

Habitat- Aquatic habitat in lateritic soil area.

Voucher Number- CUH/AL/FW/CYANO-138, CUH/AL/FW/CYANO-121,
CUH/AL/FW/CYANO-127

***Lyngbya birgei* G.M. Smith Fig. 17-22**

Komarek and Anagnostidis 2005, fig. 954

Filaments straight or curved, solitary, free-swimming, $20-24 \mu\text{m}$ wide; sheaths firm, colorless, $0.5-4 \mu\text{m}$ wide; trichomes not constricted at the cross-walls, not attenuated at the ends, cells $2-2.5 \times 18-23 \mu\text{m}$ long, sometimes with aerotopes, apical cells widely rounded.

Habitat- Aquatic habitat in northern hilly areas, lateritic soil, and suburban areas.

Voucher Number- CUH/AL/FW/CYANO-74, CUH/AL/FW/CYANO-161,
CUH/AL/FW/CYANO-134, CUH/AL/FW/CYANO-124, CUH/AL/FW/CYANO-120,
CUH/AL/FW/CYANO-111

***Lyngbya semiplena* J.Agardh ex Gomont Fig. 28**

Komarek and Anagnostidis 2005, fig. 929

Thallus yellowish-green. Filaments entangled, coiled, $7-15 \mu\text{m}$ wide. Sheaths are colorless, somewhat mucilaginous, homogeneous when young, and lamellated when aged. Trichomes blue-green, olive-green or yellowish-green, $7-10 \mu\text{m}$ wide, not constricted at the often granulated cross-walls, sometimes slightly attenuated at the ends. Cells are concise, $1/3-1/6$ as long as wide, $2-3 \times 6-7 \mu\text{m}$. Apical cells are rounded-conical, with depressed-conical or rounded calyptra.

Habitat-Brackish water in mangrove region

Voucher Number- CUH/AL/MW/CYANO-246

***Phormidium formosum* (Bory ex Gomont) Anagnostidis & Komárek Fig. 4**

Komarek and Anagnostidis 2005, fig. 602

Thallus dull blue-green. Trichomes \pm straight, long, 4-6 μm wide, slightly or sometimes not (with the exception of the cells at the ends) constricted at the usually finely granulated, sometimes ungranulated cross-walls, slightly attenuated at the ends and bent. Sheaths thin, rarely developed, usually missing. Cells nearly isodiametric or up to 2 \times shorter than wide, 2.5-5.6 μm long; cell content finely granulated, or sometimes with large cyanophycin granules. Apical cells obtuse-conical, rounded-conical or acutely-rounded, not capitate, without calyptra or thickened outer cell wall.

Habitat-Suburban areas

Voucher Number- CUH/AL/FW/CYANO-248

Table S1-A partial similarity matrix (P distance) generated using 16S-23S ITS region (Family- Pseudanabaenaceae)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
1	MN640091 <i>Leptolyngbya valderiana</i> RPL2																		
2	MN640090 <i>Leptolyngbya tenuis</i> RPL1	100																	
3	MW393862 <i>Limnothrix</i> sp. BKR	63	63																
4	MW238348 <i>Leptolyngbya</i> sp. BKR	62	62	51															
5	HQ891921 <i>Leptolyngbya</i> sp. clone GEN(H)	86	86	61	60														
6	HQ891919 <i>Leptolyngbya</i> sp. clone GEN(F)	86	86	61	60	82													
7	HQ891920 <i>Leptolyngbya</i> sp. clone GEN(G)	80	80	61	60	82	82												
8	HQ891918 <i>Leptolyngbya</i> sp. clone GEN(E)	83	83	62	62	84	84	95											
9	MF084981 <i>Leptolyngbya</i> sp. CENA553	80	80	58	56	78	78	77	82										
10	MF084983 <i>Leptolyngbya</i> sp. CENA555	80	80	59	56	77	77	77	82	99									
11	MF084982 <i>Leptolyngbya</i> sp. CENA554	80	80	59	56	78	78	78	83	100	100								
12	KY197458 <i>Leptolyngbya tenuis</i> BDU 92362	80	80	64	60	80	80	76	80	81	81	81							
13	KU958145 <i>Phormidium tenue</i> BDU	80	80	64	60	80	80	76	80	81	81	81	100						
14	MN551904 <i>Limnothrix</i> sp. CENA217	65	65	99	51	65	65	64	66	64	71	72	68	68					
15	KJ735458 <i>Geitlerinema amphibium</i> BCCUSP	64	64	96	49	64	64	62	65	63	63	63	67	67	85				
16	KP726239 <i>Limnothrix planktonica</i> KLL-C001	63	63	96	49	64	64	63	65	64	63	64	67	67	97	96			
17	LT600739 <i>Limnothrix planctonica</i>	64	64	94	48	63	63	61	63	63	63	63	67	67	96	95	96		
18	MT135017 <i>Limnothrix</i> sp. GIHE-M2	65	65	95	50	64	64	62	65	65	65	65	70	70	96	95	96	96	

Table S2-A partial similarity matrix (P distance) generated using 16S-23S ITS region (Family- Phormidiaceae)

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	MW238345 <i>Planktothrix</i> sp. DNK													
2	MW393863 <i>Planktothrix</i> sp. S41	92												
3	MW366802 <i>Planktothrix</i> sp. DNK2	53	49											
4	MN817999 <i>Phormidium</i> sp. AKS 1	79	77	49										
5	MW238346 <i>Phormidium</i> sp. RPL	54	51	76	49									
6	MW366801 <i>Desertifilum</i> sp. RPL	49	50	77	52	76								
7	EU196666 <i>Phormidium autumnale</i> CB-V	54	50	76	51	91	75							
8	U196665 <i>Phormidium autumnale</i> CB-V clone 1	54	51	76	52	91	75	99						
9	KU574116 <i>Planktothrix pseudogardhii</i> No1020	91	88	48	74	51	48	51	52					
10	KU574112 <i>Planktothrix tepida</i> PCC 9214	88	83	44	72	49	48	49	50	92				
11	KR269852 <i>Desertifilum salkalinema</i> CHAB7200	50	50	77	51	75	99	77	48	48	48			
12	KM438193 <i>Desertifilum</i> sp. NapGTcm17	50	50	77	51	75	99	77	48	48	48	100		
13	FJ158998 <i>Desertifilum tharense</i>	50	50	77	51	75	99	77	48	48	48	100	100	
14	MK424816 <i>Desertifilum tharense</i> UAM-C-S02-Churince	50	50	77	51	76	99	78	48	47	47	99	99	99

Table S3-A partial similarity matrix (P distance) generated using 16S-23S ITS region (Family- Oscillatoriaceae-genus *Oscillatoria*)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	MN630162 <i>Oscillatoria</i> sp.														
2	MW238347 <i>Oscillatoria</i> sp. MND	84													
3	EF178272 <i>Oscillatoria sancta</i> PCC 7515	96	84												
4	EU196674 <i>Oscillatoria</i> cf. <i>curviceps</i> Fkv-4	94	85	96											
5	MG250670 Uncultured <i>Oscillatoria</i> sp. clone 9cl1	84	99	84	85										
6	MG250673 Uncultured <i>Oscillatoria</i> sp. clone 10cl10	84	98	84	85	99									
7	EU196673 <i>Oscillatoria</i> cf. <i>curviceps</i> Fkv-3	84	98	98	85	85	85								
8	AY768378 <i>Oscillatoria sancta</i> PCC 7515	96	84	100	83	84	84	98							
9	MG250674 Uncultured <i>Oscillatoria</i> sp. clone 10cl11	84	99	84	85	100	99	85	84						
10	MG250672 Uncultured <i>Oscillatoria</i> sp. clone 10cl5	84	99	84	85	100	99	85	84	100					
11	MG250675 Uncultured <i>Oscillatoria</i> sp. clone 10cl	84	99	84	84	99	99	85	84	100	100				
12	MG250668 Uncultured <i>Oscillatoria</i> sp. clone 5cl4	83	99	83	84	100	99	84	83	100	100	99			
13	MG250653 Uncultured <i>Oscillatoria</i> sp. clone T3	85	99	84	84	98	98	84	84	98	98	98	98		
14	MG250650 Uncultured <i>Oscillatoria</i> sp. clone O3	85	99	84	84	98	98	84	84	98	98	98	98	99	
15	MG250660 Uncultured <i>Oscillatoria</i> sp. clone 15cl5	85	99	84	84	98	98	84	84	99	99	99	93	100	100

Table S5-A partial similarity matrix (P distance) generated using 16S-23S ITS region (Family- Oscillatoriaceae-genus *Lyngbya-Plectonema*(fresh water))

		1	2	3	4	5	6	7	8	9
1	MN638845 <i>Lyngbya</i> sp. RAB									
2	MN817997 <i>Lyngbya</i> sp. HDA	99								
3	MN630164 <i>Lyngbya</i> sp. SHNTN	100	99							
4	MK224842 <i>Lyngbya</i> sp. PRLA	98	99	98						
5	MN818000 <i>Lyngbya</i> sp. MHN	99	100	99	99					
6	MN814324 <i>Plectonema</i> sp. AJY	100	100	100	99	100				
7	MN814325 <i>Plectonema</i> sp. KAS	99	100	99	100	100	99			
8	MN814326 <i>Plectonema</i> sp. KOP	99	100	99	99	100	100	100		
9	MT254994 <i>Lyngbya</i> sp. NB	99	100	99	100	100	100	100	100	
10	EU586734 <i>Blennothrix</i> sp.	97	96	96	95	96	97	96	96	97

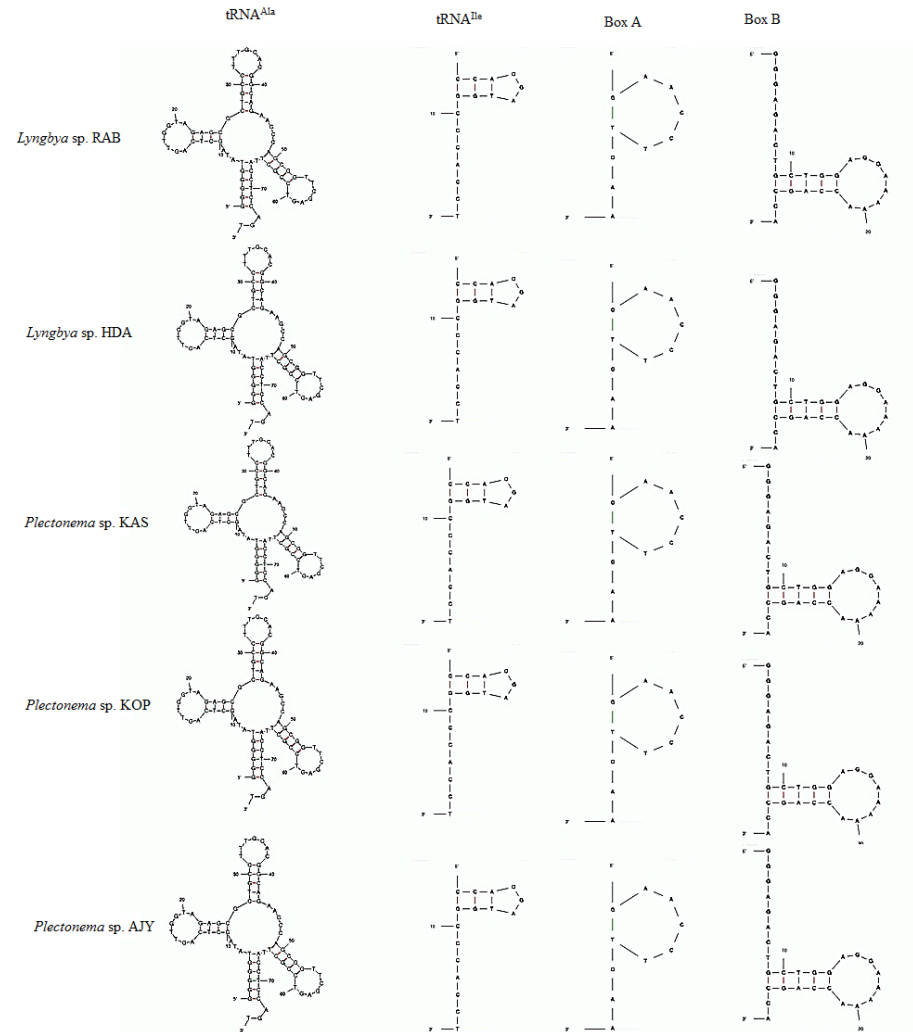


Figure S1- Secondary structures of 16S–23S internal transcribed spacer (ITS) sequences from the *Lyngbya* sp.HDA, *Lyngbya* sp.RAB, *Plectonema* sp. KOP, *Plectonema* sp. KAS and *Plectonema* sp. AJY.

