

Algal diversity in foot hills of Eastern Himalayas-I (Cyanoprokaryota: Chroococcales)

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ABSTRACT

In spite of being extremely rich in floristic and faunal diversity, algal diversity of Himalayan tarai region escaped attention of plant biologists. Koch-Bihar a district of West Bengal, situated in the 'Tarai' region of eastern Himalaya is one such region where algal exploration works need to be done. The present authors attempted to explore its algal biodiversity systematically. In this account 11 taxa of coccoid cyanoprokaryotes were observed belonging to following 5 genera viz. *Aphanothece* Nägeli (2 taxa), *Chroococcus* Nägeli (3 taxa), *Eucapsis* Clements et Shantz (1 taxa), *Merismopedia* Meyen (2 taxa) and *Microcystis* Kützing ex Lemmermann (3 taxa). *Chroococcus aphanocapsoides* Skuja, *Eucapsis alpina* F. E. Clements & H. L. Schantz and *Microcystis smithii* Komárek & Anagnostidis are the first record from India while *Microcystis lamelliformis* Holsinger is the first report from Eastern India.

Key words: Eastern Himalayas, Cyanoprokaryotes, Chroococcales, West Bengal, first report

INTRODUCTION

Cyanoprokaryotes possess prokaryotic cells and happens to be the most primitive group of algae. Though it is microscopic and simple in structure, it plays important roles not only in Earth's past life but also in present day in human perspective. Members of Chroococcales are the unicellular or colonial thallus without forming any true filaments, sometimes polarization occurs in some forms. Members of this group have been worked out by various workers in West Bengal mostly from taxonomic point of view.

Brühl and Biswas, (1922a 1922b, 1923) recorded Cyanophyceae from Bengal filter beds. Banerjee (1936) observed the Chroococaceae of undivided lower Bengal. Biswas (1942) studied the algal community in drinking water obtained from Hoogly river. Gupta, (1965) while studying blue-greens of West Bengal recorded 2 taxa new to India. Gupta (1975) made new records of a few more species of Cyanophyceae from West Bengal. Sinha and Mukherjee, (1975a, 1975b, 1984a, b) while studying the blue-green algae from paddy-fields of Bankura district of West Bengal. Mukhopadhyay & Chatterjee (1981) made of checklist of blue-green algae from paddy fields of West Bengal. Pal *et al.*, (1986) reported 33 taxa of green and blue-green algae from Murshidabad, 2 of which are new records from India and 16 are addition to the West Bengal flora. Gupta and Sen, (1987a, 1987b) enumerated the blue-green algae of some parts of Hooghly and Burdwan districts of West Bengal. Santra (1993) did comprehensive work on the BGA of West Bengal paddy fields. Gupta and Kumar, (2005) worked out the bloom of *Microcystis aeruginosa* in Malda district. Haldar and Sinha (2013) recorded certain coccoid blue green algae with some new reports. Dey (2012) worked on the members of Chroococcales in Darjeeling district. Mukhopadhyay & Naskar (2013) made investigation on algae from Metiaburz area. Roy *et al.*, (2014a, 2014b) worked on Cyanobacterial flora of Bakreswar, Panifala geothermal spring. Datta and Keshri, (2014) published a paper on Soil and Sub Aerial Blue-green algae from Burdwan and total 22 taxa where were investigated.

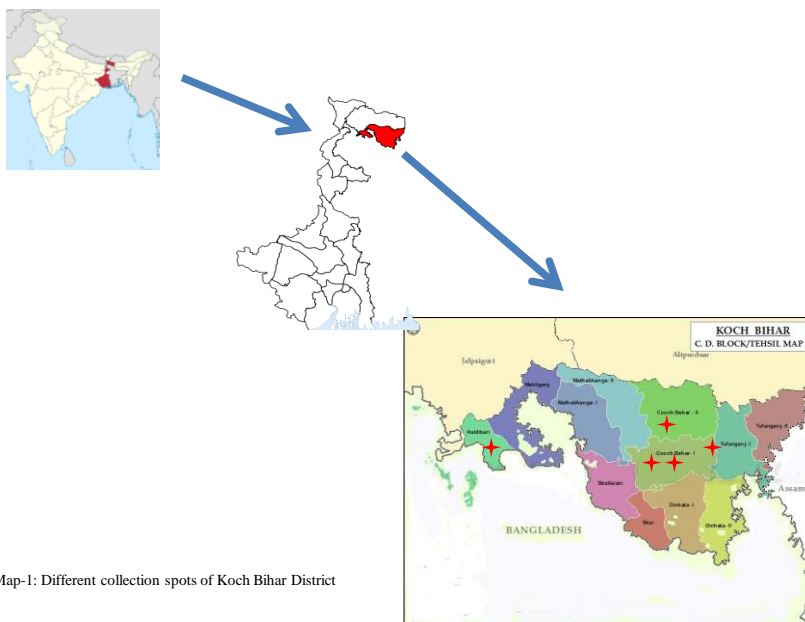
MATERIAL AND METHODS

The algal samples were collected from ditches, ponds, river, small water body, rice fields, big trees, damp wall, water reservoir, streams, moist soil, and sewage of all the blocks of Koch Bihar district through frequent visits whole the year round (Map-1). The collected samples were preserved in FAA/ 5% formalin at the collection spot in plastic bags with zipper. Then the samples were tagged and also ecological notes like colour of samples, pH, attached condition, temperature, habitat, habit were taken at the time of collection. All the preserved samples are deposited in Algae herbarium of Botany Department, The University of Burdwan (BURD). After bringing the collected specimens in the laboratory all the samples were stored in 60 ml amber coloured vials with proper labeling for further workout. Proper figures of the desired algal samples were drawn under appropriate magnifications with the help of a drawing prism considering all the features present there in. Measurements were taken properly with an ocular scale fitted within the

eyepiece of the microscope, previously standardizing for this purpose. Standard procedure was followed in the preparation of the mounting specimen as permanent slides. Small amount of specimens were mounted in dry slide (Blue star) using GFW [Glycerin: Formalin: Distilled water 1:1:1 - (Bando, 1988)] as mounting medium and covered by cover glass (Bluestar). The slides were sealed with synthetic enamel paint and kept for drying whole day inside a petridish to avoid dust. After drying a second coating was applied. Third coating is also required for long time storage. Photomicrographs were taken from the permanent slides using Carl Zeiss Axiostar plus research microscope with Nikon SLR model (D60) digital camera attachment system.

All the collections have been kept in the Algal Herbarium of the department of Botany, The University of Burdwan (BURD).

Identifications of the workout taxa were done properly consulting the standard literature and several monographs.



Map-1: Different collection spots of Koch Bihar District

Result and Discussion:

In this investigation total 11 taxa of Chroococcales of Cyanoprokaryota were found from the Koch Bihar district at the foot hills of Eastern Himalayas.

i. *Aphanothece microscopica* Nägeli

[Desikachary 1959, p. 142, pl. 22, f. 4, 5, 9; Komárek & Anagnostidis 1999, p. 84, f. 72, 73]

(Pl. 1; Fig. 1; Pl. 2, Fig. 1)

Colony macroscopic, formless amorphous, blue-green, mucilaginous with several number of cells, densely arranged in the colony; cells oval to cylindrical in shape, blue-green in colour.

Length of the cells: 4 μm – 11 μm ; Breadth of the cells: 3 μm – 5 μm .

Collection No. & Ecological notes: MD- 055, 19. 10. 11, Panisala, Koch Bihar; aquatic, free-floating in a small ditch (pH- 5.5, Temp. 30°C).

Distribution in India: Andaman & Nicobar Islands (Prasad and Srivastava, 1992); Andhra Pradesh (Venkateswarlu, 1976; Sarojini, 1994); Assam (Saikia and Bordoloi, 1994; Ahmed, 2001; Das A. K. and Sarma, 2010); Gujarat (Kamat, 1967); Himachal Pradesh (Kamat, 1968); Jammu & Kashmir (Subba Raju, 1963; Ara and Rather, 2005); Karnataka (Bharati and Bongale, 1975; Bongale and Bharati, 1980; Somashekar, 1983); Kerala (Anand N. and Shantha kumar Hopper, 1995); Madhya Pradesh (Agarkar, 1967); Maharashtra (Schmidle, 1900; Kamat, 1974; Barhate and Tarar, 1983); North India (Prasad and Mehrotra, 1979); Manipur (Amita Devi *et al.*, 1999); Mizoram (Singh N. I. *et al.*, 1996); Odisa (Rao, 1939a); Punjab (Sharma and Kanta, 1978; Sharma *et al.*, 1979); Rajasthan (Vaidya and Patel, 1968; Jain *et al.*, 2012); Sikkim (Das S. K. and Adhikary, 2014); Tamil Nadu (Desikachary, 1959; Anand N. and Subramanian, 1994; Muthukumar *et al.*, 2007; Ramasamy and Chandran, 2015); Uttar Pradesh (Gupta and Nair, 1962; Prasad and Srivastava, 1968; Bendre and Kumar, 1975; Prasad and Mehrotra, 1979; Pandey U. C.

and D. C. Pandey, 1982; Singh A. *et al.*, 2014); West Bengal (Sinha and Mukherji, 1975a; Mukhopadhyay and Chatterjee, 1981; Halder and Sinha, 2013).

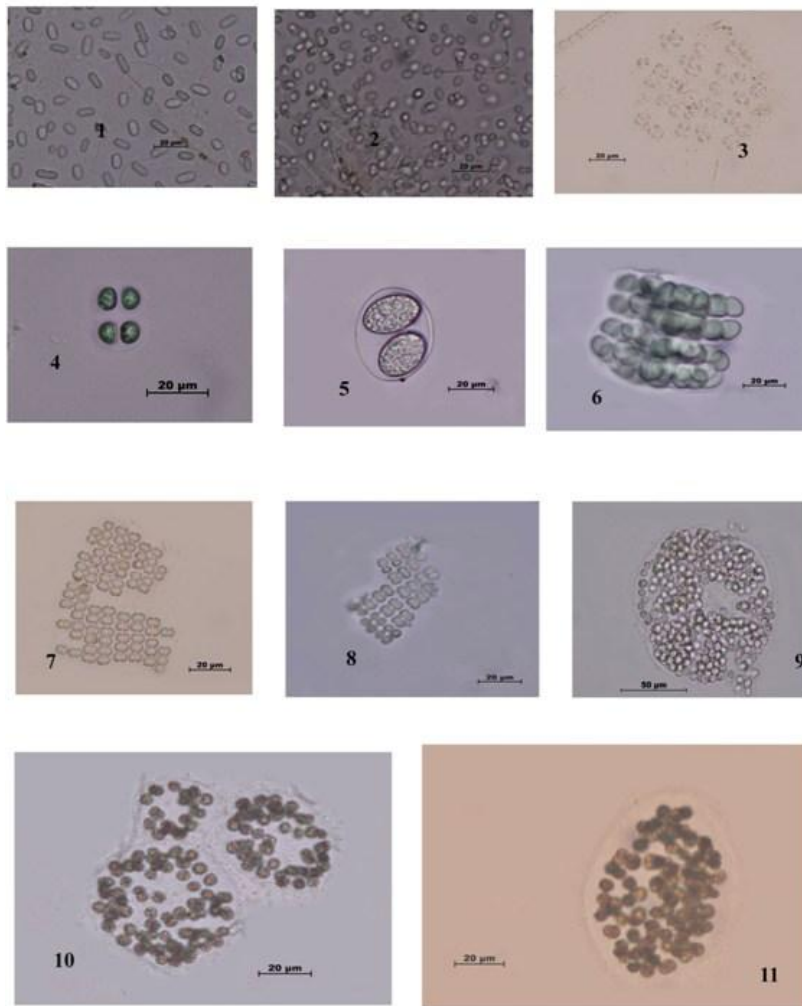


Plate-11. 1. *Aphanothece microscopica* Nägeli, 2. *Aphanothece stagnina* (Sprengel) A. Braun in Rabenhorst 3. *Chroococcus aphanocapsoides* Skuja. 4. *Chroococcus minutus* (Kützing) Nägeli 5. *Chroococcus turgidus* (Kützing) Nägeli. 6. *Eucapsis alpina* F. E. Clements & H. L. Schantz 7. *Merismopedia convoluta* Brébisson in Kützing. 8. *Merismopedia elegans* A. Braun in Kützing 9. *Microcystis flos-aquae* (Wittrock) Kirchner. 10. *Microcystis smithii* Komárek & Anagnostidis. 11. *Microcystis lamelliformis* Holsinger

This is more or less commonly occurring taxon.

ii. ***Aphanothece stagnina*** (Sprengel) A. Braun *in* Rabenhorst

[Desikachary 1959, p. 137, pl. 21, f. 10; Komárek & Anagnostidis 1999, p. 86, f. 75]

(Pl. 1; Fig. 2; Pl. 2, Fig. 2)

Colony small, spherical, blue-green with several number of cells, arranged loosely throughout the mucilage; oval in shape.

Length of the cells: 3 µm – 8 µm; Breadth of the cells: 3 µm – 4 µm.

Collection No. & Ecological notes: MD- 082, 20. 02. 2012, Gouranga Bazar, Koch Bihar, found in small river likewater body (pH- 5.5, Temp. 28^oC).

Distribution in India: Andhra Pradesh (Laloraya and Mitra, 1973); Bihar (Laloraya and Mitra, 1973; Jha *et al.*, 1986); Jammu and Kashmir (Kant and Gupta, 1998; Ara and Rather, 2005); Karnataka (Bongale and Bharati, 1980; Bongale, 1981; Somashekar, 1983); Kerala (Parukutty, 1940; Verma, 1965; Anand N. and Shanthakumar Hopper, 1986); Maharashtra (Patil and Neelima, 2013); Manipur (Amita Devi *et al.*, 1999); Odisha (Laloraya and Mitra, 1973; Sahu, 2000); Punjab (Grover and Pandhol, 1975; Pandhol and Grover, 1976; Sharma *et al.*, 1979); Rajasthan (Gupta

R. S. and Kumar, 1968; Jain R. *et al.*, 2012), Sikkim (Kumar S. *et al.*, 2005; Das S. K. and Adhikary, 2014); Tamil Nadu (Tiwari, 1972; Anand N., 1980; Anand N. and Revathi, 1987; Anand N., 1989; Nedumaran and Manokaran, 2009; Perumal and Anand N., 2009); Uttar Pradesh (Kumar H., 1970; Singh K. P. and Chaturvedi 1970; Bendre and Kumar 1975; Pal 1975), West Bengal (Banerji, 1936; Sinha and Mukherjee, 1975; Mazumdar and Chandra, 1987; Sen and Gupta, 1987a; Santra, 1993; Sen, 2006; Roy *et al.*, 2012; Mandal and Rath, 2013; Mukhopadhyay and Naskar, 2013, Halder and Sinha, 2013).

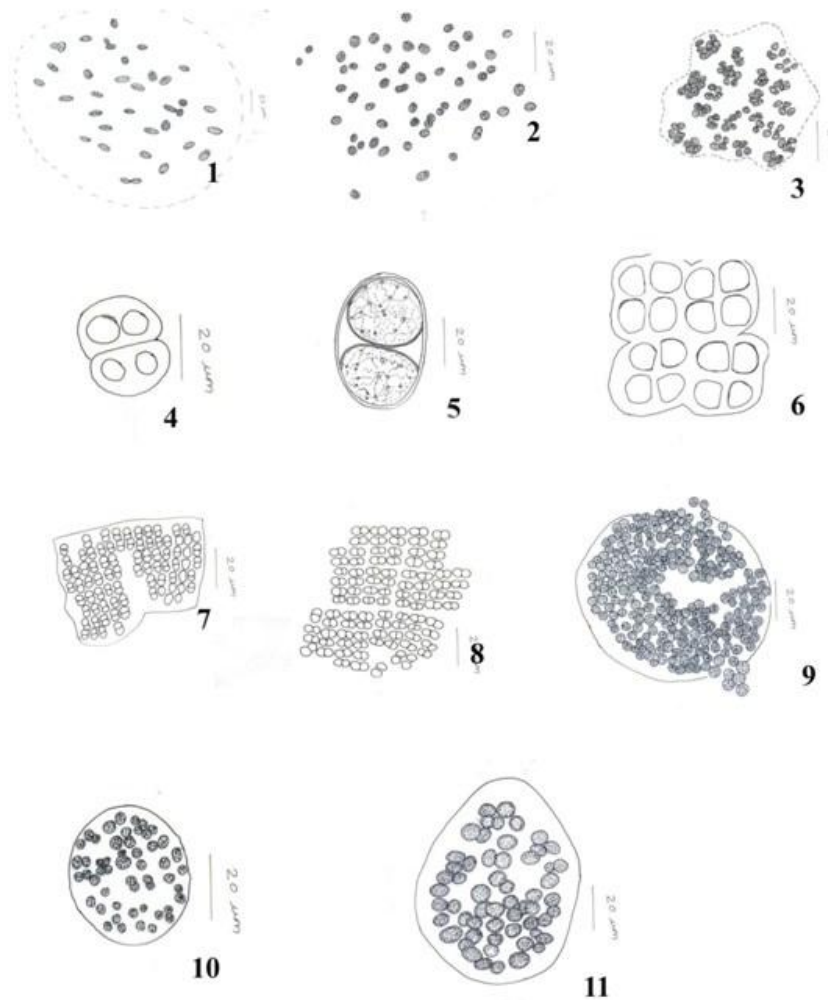


Plate-2. 1. *Aphanothece microscopica* Nägeli, 2. *Aphanothece stagnina* (Sprengel) A. Braun in Rabenhorst. 3. *Chroococcus aphanocapsoides* Skuja. 4. *Chroococcus minutus* (Kützing) Nägeli. 5. *Chroococcus turgidus* (Kützing) Nägeli. 6. *Eucapsis alpina* F. E. Clements & H. L. Schantz. 7. *Merismopedia convoluta* Brébisson in Kützing. 8. *Merismopedia elegans* A. Braun in Kützing

9. *Microcystis flos-aquae* (Wittrock) Kirchner. 10. *Microcystis smithii* Komárek & Anagnostidis. 11. *Microcystis lamelliformis* Holsinger

This is a commonly encountered species of the genus.

iii. ***Chroococcus aphanocapsoides*** Skuja

[Komárek & Anagnostidis 1999, p. 284, f. 368]

(Pl. 1; Fig. 3; Pl. 2, Fig. 3)

Colony irregular – rounded in shape; arranged in 4 or 8 celled aggregates within the common, colourless, hyaline, mucilaginous colony; oval to hemispherical and without individual envelopes.

Diameter of colony: 74 µm – 76 µm; Length of the cells: 3 µm – 5 µm; Breadth of the cells: 2 µm – 4 µm.

Collection No. & Ecological notes: MD- 100, 01. 07. 2012, Dewanhat, Koch Bihar; found in a small water body, full with monsoon water (pH- 5.5, Temp. 28^oC).

Distribution in India: This is probably the first report of the taxon from India.

iv. ***Chroococcus minutus*** (Kützing) Nägeli

[Desikachary 1959, p. 103, pl. 24, f. 4 & pl. 26, f. 4, 15; Komárek & Anagnostidis 1999, p. 296, f. 391]

(Pl. 1; Fig. 4; Pl. 2, Fig. 4)

Colony with 4 celled, small; cells spherical or oval, bluish-green in colour, pale blue-green in colour.

Length of the colony: 30 µm – 32 µm; Breadth of the colony: 22 µm – 24 µm; Diameter of cells: 5 µm – 8 µm.

Collection No. & Ecological notes: MD- 053, 19. 10. 11, Panisala, Koch Bihar; aquatic, lodged on aquatic plants (pH- 5.5, Temp. 30^oC).

Distribution in India: Andhra Pradesh (Mohan and Reddy, 1986; Johnson, 2006; Kumaraswami *et al.*, 2013); Bihar (Singh R. N., 1939; Kumar S. and Saha, 1993); Jammu & Kashmir (Anand V. K., 1979; Ara and Rather, 2005); Karnataka (Somashekar, 1983); Kerala (Shaji and Panikkar, 1994, Anand N. and Shantha Kumar Hopper, 1995; Madhusoodanan and Dominic, 1995; Vijayan and Roy, 2015); Madhya Pradesh (Agarkar, 1967; Jain N., 2015), Maharashtra (Barhate and Tarar, 1983; Kamat, 1974; Suryavanshi *et al.*, 2010; Bhosale and Dhumal, 2012; Patil and Neelima, 2013); Manipur (Amita Devi *et al.*, 1999); Rajasthan (Srivastava and Nigam, 1980, Pandey J. *et al.*, 1998), Tamil Nadu (Ramkrishnan and Kannan, 1992; Anand N. and Subhranian, 1994; Muthukumar *et al.*, 2007; Jeyachitra *et al.*, 2013; Ramasamy and Chandran, 2015), Uttarakhand (Srivastava, 1967; Khare and Suseela, 2007; Kumar M. *et al.*, 2011); Uttar Pradesh (Singh K. P. and Chaturvedi, 1970; Pal S. and Yadav, 1974; Prasad and Mehrotra, 1979; Singh A. *et al.*, 2014); West Bengal (Banerji, 1936; Mazumdar and Chandra, 1987; Sen, 2006; Gupta, 2010; Roy *et al.*, 2014).

v. ***Chroococcus turgidus*** (Kützing) Nägeli

[Desikachary 1959, p. 101, pl. 26, f. 6; Komárek & Anagnostidis 1999, p. 306, f. 407]

(Pl. 1; Fig. 5; Pl. 2, Fig. 5)

Colony microscopic 2 celled; cells are enclosed by common firm envelope; individual cell enclosed by hyaline, colourless sheath, widely oval in shape and bluish- green in colour.

Length of the colony: 60 µm – 62 µm; Breadth of the colony: 45 µm – 48 µm; Length of the cells: 24 µm – 28 µm; Breadth of the cells: 37 µm – 43 µm.

Collection No. & Ecological notes: MD- 313, 09. 02. 2014, Vatkuar par, Koch Bihar; aquatic, lodged on aquatic plants (pH- 6, Temp. 18^oC).

Distributions in India: Andhra Pradesh (Mohan and Reddy, 1986; Sarojini, 1996; Johnson, 2006); Arunachal Pradesh (Singh N. I. *et al.*, 1997a); Assam (Das A. K. and Sarma, 2010); Gujarat (Brahmbhatt and Patel, 2012); Jammu & Kashmir (Anand V. K., 1979; Ara and Rather, 2005); Karnataka (Somashekar, 1983); Kerala (Shaji and Panikkar, 1994; Vijayan and Roy, 2015); Madhya Pradesh (Jain N., 2015); Maharashtra (Thomas and Gonzalves, 1965; Kamat, 1974; Barhate and Tarar, 1983; Likhitkar and Tarar, 1996; Suryavanshi *et al.*, 2010; Bhosale and Dhumal, 2012; Patil *et al.*, 2011); Manipur (Amita Devi *et al.*, 1999); Odisha (Padhy *et al.*, 1992); Punjab (Sharma and Kanta, 1978); Rajasthan (Srivastava and Nigam, 1980); Tamil Nadu (Ramkrishnan and Kannan, 1992; Anand N. and Subhranian, 1994, Muthukumar *et al.*, 2007; Sivakamasundari and Rajendran, 2015); Uttarakhand (Srivastava, 1967; Gupta R. K., 2005; Bhardwaj *et al.*, 2011); Uttar Pradesh (Rao, 1937; Pal S. and Yadav, 1974; Prasad and Mahrotra, 1979; Tiwari *et al.*, 2001; Suseela and Toppo, 2010); West Bengal (Biswas, 1925 a; Roy *et al.*, 2012; Singha Roy and Pal, 2015).

vi. ***Eucapsis alpina*** F. E. Clements & H. L. Schantz

[Komárek & Anagnostidis 1999, p. 267, f. 352]

(Pl. 1; Fig. 6; Pl. 2, Fig. 6)

Cells are arranged in a cubic colony in three- dimensional rows; spherical to oval, pale, olive- green in colour, composed with 4 celled sub- colonies.

Length of the cells: 12 µm - 16 µm; Breadth of the cells: 10 µm – 12 µm.

Collection No. & Ecological notes: MD- 084, 20. 02. 2012, Gouranga Bazar, Koch Bihar; found in Small River like water body (pH- 5.5, Temp. 28^oC).

This is probably the first report of the taxon from India.

vii. ***Merismopedia convoluta*** Brébisson in Kützing

[Desikachary 1959, p. 152, pl. 29, f. 8, 12, 13; Komárek & Anagnostidis 1999, p. 180, f. 226]

(Pl. 1; Fig. 7; Pl. 2, Fig. 7)

Colony wavy plate-like with numerous cells; cells arranged in common, colourless mucilage, spherical to elongate in shape.

Length of the cells: 5 μm – 10 μm ; Breadth of the cells: 3 μm – 6 μm .

Collection No. & Ecological notes: MD- 255, 20. 10. 2013, Maranadir Kuthi, Koch Bihar; aquatic, lodged on aquatic plants (pH- 6, Temp. 34^oC).

Distribution in India: Andaman & Nicobar Islands (Prasad and Srivastava, 1992); Jammu & Kashmir (Anand V. K., 1979); Karnataka (Somasekar, 1983); Sikkim (Das S. K. and Adhikary, 2014); Tamil Nadu (Ramkrishnan and Kannan, 1992); Uttar Pradesh (Pandey U. C. and Pandey, 1982); Uttarakhand (Gupta R. K., 2005); West Bengal (Biswas, 1942; Sinha and Mukherjee, 1975).

viii. ***Merismopedia elegans*** A. Braun in Kützing

[Desikachary 1959, p. 156, pl. 20, f. 3; Komárek & Anagnostidis 1999, p. 180, f. 227]

(Pl. 1; Fig. 8; Pl. 2, Fig. 8)

Colony flat, rectangular in shape; cells olive- green in colour and densely arranged in perpendicular rows, elongated to oval in shape.

Length of the cells: 4 μm – 6 μm ; Breadth of the cells: 6 μm – 8 μm .

Collection No. & Ecological notes: MD- 011, 30. 10. 2010, Dewanhat, Koch Bihar; semi-aquatic, found in a rice field (pH- 6, Temp. 20^oC).

Distribution in India: Andhra Pradesh (Ghousuddin, 1937); Assam (Das and Sarma, 2010); Maharashtra (Kamat, 1975; Patil K. *et al.*, 2011; Bhosale and Dhumal, 2012); Odisha (Rath and Adhikary, 2005); Rajasthan (Jain R. *et al.*, 2012); Tamil Nadu (Sivakamasundari and Rajendran, 2015); Uttar Pradesh (Misra and Srivastava, 2005; Suseela and Toppo, 2010); West Bengal (Banerji, 1936; Biswas, 1942; Ghosh *et al.*, 2015).

ix. ***Microcystis flos-aquae*** (Wittrock) Kirchner

[Desikachary 1959, p. 94, pl. 17, f. 11 & pl. 18, f. 11; Komárek & Anagnostidis 1999, p. 228, f. 300, 301]

(Pl. 1; Fig. 9; Pl. 2, Fig. 9)

Colony microscopic with densely packed cells, embedded in mucilaginous envelope; envelope colourless, fine, hyaline and attached to the margin of cell clusters; cells spherical with aerotopes.

Diameter of the cells: 3 μm – 5 μm .

Collection No. & Ecological notes: MD- 051, 16. 04. 2011, Haldibari, Koch Bihar; aquatic, growing in a pond (Temp. 22^oC).

Distribution in India: Andhra Pradesh (Sarojini, 1994, 1996); Arunachal Pradesh (Singh N. I. *et al.*, 1997); Assam (Deka *et al.*, 2012; Hazarika, 2013); Bihar (Rao, 1939b; Kumar S. and Saha, 1993; Kumar B. N. and Choudhary, 2009); Chhattisgarh (Shrivastava, 2000) Karnataka (Bongale and Bharati, 1980; Somasekar, 1983); Jammu and Kashmir (Ara *et al.*, 2002); Kerala (Anand N. and Shantha Kumar Hopper, 1986); Maharashtra (Dixit, 1936; Kolte and Goyal, 1985; Bhosale and Dhumal, 2012; Patil K. *et al.*, 2011), Manipur (Amita Devi *et al.*, 1999); Mizoram (Adhikary *et al.*, 2010); Nagaland (Singh N. I. *et al.*, 1997c); Odisha (Padhy *et al.*, 1992); Punjab (Pandhol and Grover, 1976), Rajasthan (Vaidya and Patel, 1968; Trivedy, 1982; Pandey J. *et al.*, 1998); South India (Anand N., 1989), Sikkim (Das S. K. and Adhikary, 2014b); Tamil Nadu (Frèmy, 1942), Tripura (Singh N. I. *et al.*, 1997), Uttarakhand (Gupta R. K., 2005), Uttar Pradesh (Kumar H., 1970; Bendre and Kumar, 1975; Pandey U. C. and Pandey D. C., 1982; Chaturvedi and Habib, 1995; Singh A. *et al.*, 2014), West Bengal (Banerjee, 1936; Biswas, 1942; Sinha and Mukherjee, 1975; Mukhopadhyay and Chatterjee, 1981; Sen and Gupta, 1987a; Santra, 1993; Dey, 2012); Tamil Nadu and Kerala (Jeyachitra *et al.*, 2013).

This is a more or less common taxon.

x. ***Microcystis smithii*** Komárek & Anagnostidis

[Komárek & Anagnostidis 1999, p. 228, f. 299]

(Pl. 1; Fig. 10; Pl. 2, Fig. 10)

Colony microscopic with loosely arranged cells, are embedded in mucilaginous envelope; mucilage fine, hyaline, colourless; cells spherical, blue-green in colour with aerotopes.

Diameter of the cells: 2 μm – 5 μm .

Collection No. & Ecological notes: MD- 016, 03. 02. 2011, Sagar Dighi, Koch Bihar; growing in a pond (pH- 6, Temp. 16^oC).

Distribution in India: This is probably the first report of the taxon from India.

xi. ***Microcystis lamelliformis*** Holsinger

[Desikachary 1959, p. 91, pl. 19, f. 1, 2; Komárek & Anagnostidis 1999, p. 235]
(Pl. 1; Fig. 11; Pl. 2, Fig. 11)

Colony microscopic with closely arranged cells which are embedded in mucilaginous envelope; mucilage hyaline, slightly brownish in colour; cells spherical to oval in shape, brown in colour with gas vesicles.

Diameter of the cells: 4 µm – 8 µm.

Collection No. & Ecological notes: MD- 016, 03. 02. 2011, Sagar Dighi, Koch Bihar; attached with submerged stone (pH- 6, Temp. 16^oC).

Distribution in India: Assam (Deka *et al.*, 2012); Himachal Pradesh (Dwivedi *et al.*, 2008); Mizoram (Adhikary *et al.*, 2010).

Comment: It is close in morphology to *M. lamelliformis* Holsinger from which it differs in much bigger in size.

This is the first report of the taxon from Eastern India.

CONCLUSION

Blue-green algae constitutes important component of our biodiversity pool. Many of the nonheterocystous prokaryote recorded in this account actually reflects the situation of occurrence in the district. Three species of *Microcystis* were recorded in this account that actually appears alarming because they are indicators of trophic habitats. Other forms are not too many. It is due to the habitats where coccoid blue green algae actually do not form any dominance.

ACKNOWLEDGEMENT

The authors are thankful to the Head, Department of Botany, The University of Burdwan for laboratory facilities. Special thanks to PURSE (DST) for financial support to Mousumi Das.

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