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Diversity of Chlamydomonadales (Chlorophyceae) in the foot hills of Eastern Himalayas

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ABSTRACT

Foot Hills of the Himalayan region represents a rich floral and faunal diversity, but it has been least attended for the exploration of algal biodiversity. Koch Bihar District in the north of West Bengal is situated in the 'Tarai' region of the foot hills of Eastern Himalayas. In view of this, we have undertaken a detailed study on the algal biodiversity in this region. In continuation with earlier works 13 taxa under following 11 genera viz., *Burkillia* W. et G. S. West, *Chlorococcum* Meneghini emend. Starr, *Cylindrocapsa* Reinsch, *Eudorina* Ehrenberg, *Gonium* Müller, *Kentrosphaera* Borzi, *Pandorina* Bory, *Selenastrum* Reinsch, *Sphaerocystis* Chodat, *Tetraspora* Link, *Volvox* L. of the order Chlamydomonadales of Chlorophyceae have been presented in this work. Out of these taxa *Burkillia cornuta* W. et G. S. West, *Kentrosphaera bristolae* G. M. Smith, *Pandorina cylindricum* Iyengar and *Tetraspora lacustris* Lemmermann are new records for Eastern India while *Selenastrum bibraianum* Reinsch, *Selenastrum gracile* Reinsch and *Volvox carteri* Stein are new records for West Bengal.

Key-words: Chlamydomonadales, new records, tarai region, eastern Himalayas, West Bengal, India.

INTRODUCTION

Being one of the megadiversity zones of the World, eastern Himalayas and its Tarai region is well known for its magnificent floral and faunal diversity. The overwhelming beauty of the macro flora and fauna attracted the attention of field biologists. Probably due to this fact, studies on micro flora and fauna were virtually neglected. This fact prompted the present authors to attend its algal diversity. Koch Bihar District of West Bengal is the centre of focus of this work. In this account, besides two contributions by present authors (Keshri et al. 2013, Das & Keshri 2015) on dinoflagellates, *Scenedesmus* and related genera and one contribution on limnology (Sanigrahi & Mandal 1997) of the region have so far been published.

Thirteen species belonging to eleven genera of Chlamydomonadales (Green Algae) are systematically described in this present work. The circumscription and systematic position of taxa are presented as per algae base (Guiry M. D. & Guiry G. M. 2017).

MATERIAL AND METHODS

The algal samples were collected from all the blocks of Koch Bihar District (Text Figure 1) through frequent visits during different seasons to understand the change of their size, habitat and reproductive stages. The sample were collected from ditches, ponds, river, small water body, rice fields, big trees, damp wall, water reservoir, streams, moist soil and sewage. The collected samples were preserved in FAA or 5% Formalin at the collection spot in plastic bags with zipper. Later on,

samples were tagged and ecological notes like colour of samples, pH, attached condition, temperature, habitat, habit were recorded at the time of collection. After bringing the collected specimen in the laboratory all the sample were stored in 60 ml amber coloured vials with proper labeling for further workout. All the preserved samples are deposited in Algae herbarium of Botany Department, The University of Burdwan (BURD). For observation, small amount of specimens were mounted in dry slide 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.

RESULTS

During this investigation following algae were identified under the order Chlamydomonadales of Chlorophyceae:

Burkillia cornuta West et. West

[Philipose 1967, p. 234, f. 143; Komárek & Fott 1983, p. 156, pl. 44, f. 2]

(Plate 1, Fig. A)

Description: Colony of 8 radially arranged cells; cells spherical with thick membrane and a bent, lamellate horn; chloroplast stellate. Length of the cell: 4.54 µm – 7. 57 µm; Breadth of the cell: 6 µm – 8 µm; Length of the horn: 11 µm – 16 µm.

Collection No. & Ecological notes: MD- 094, 01. 07. 2012, Dewanhat, Koch Bihar, found in a small water body (pH- 5.5, Temp. 28^{0}C).

Distribution in India: Andhra Pradesh (West & West 1907, Sarojini 1996). *B.cornuta* is a rare taxon and is probably the first report of the taxon from eastern India.

Chlorococcum humicola (Nägeli) Rabenhorst

[Philipose 1967, p. 73, f. 3]

(Plate 1, Fig. B)

Description: Cells solitary, spherical; chloroplast filling the whole cell and with a pyrenoid. Diameter of the cell: 17 µm – 22 µm.

Collection No. & Ecological notes: MD- 018, 05. 02. 2011, Rasamoti, Pundibari, Koch Bihar, found in small ditch (pH- 6, Temp. 22^{0}C); MD- 049, 16. 04. 2011, Haldibari, Koch Bihar, terrestrial, growing on wet rice field (pH- 6, Temp. 22^{0}C).

Distribution in India: Andaman & Nicobar Islands (Prasad & Misra 1992); Bihar (Kachroo 1959, Kumar & Saha 1993); Delhi (Dutta & Venkataraman 1958); Karnataka (Gonzalves & Yalawigi 1959, Bharati 1965, Bongale 1981); Kerala (Maya et al. 2000); Maharashtra (Gonzalves & Gangla 1949, Marathe & Sontakke 1977, Barhate & Tarar 1981, Likhitkar & Tarar 1996, Tarar & Bodkhe 1998, Patil 2015); Meghalaya (Biswas 1934); Rajasthan (Pandey et al. 1998, Tiwari & Chauhan 2007); Mizoram (Adhikary et al. 2010); Uttarakhand (Gupta 2005); Uttar Pradesh (Mitra 1951, Tiwari et al. 2001); West Bengal (Kachroo 1959, Sau & Gupta 2008, Gupta 2010).

Chlorococcum infusionum (Schrank) Meneghini

[Philipose 1967, p. 73, f. 1; John et al. 2002, p. 337, pl. 82, L]

(Plate 1, Fig. C)

Description: Cell solitary, spherical; chloroplast hollow sphere with a pyrenoid. Diameter of the cell: 28 µm - 31 µm.

Collection No. & Ecological notes: MD- 174, 30. 04. 2013, Nakkati, Koch Bihar; aquatic (pH- 6, Temp. 24^{0}C).

Distribution in India: Andhra Pradesh (Sarojini 1994, 1996); Bihar (Kumar & Saha 1993); Gujarat (Brahmbhatt & Patel 2012); Kerala (Joseph & Joseph 1999); Maharashtra (Tarar & Bodkhe 1998); Punjab (Sharma et al. 1983); Rajasthan (Habib 2013); Tamil Nadu (Christi et al. 2014); Uttar Pradesh (Chadha & Pandey 1978, Habib & Chaturvedi 2001, Habib 2012, Habib et al. 2014); West Bengal (Sau & Gupta 2008).

Cylindrocapsa geminella Wolle

[Ramanathan 1964, p. 143, pl. 40, A – F]

(Plate 1, Fig. D)

Description: Thallus filamentous, unbranched; cells arranged in a single series and covered by thick, stratified cell membrane; cell globose to oblong; chloroplast stellate, filling the cell. Length of the cell: 27 µm; Breadth of the cell: 16 µm; Thickness of sheath: 4 µm.

Collection No. & Ecological notes: MD-129, 26.10.2012, Mathabhanga, Koch Bihar; aquatic, attached and lodged on aquatic plants (pH- 6, Temp. 29°C).

Distribution in India: Assam (Nandi & Rout 2000); Bihar (Mahato et al. 2000); Maharashtra (Kamat 1963); Punjab (Sharma & Bala 1985); Tamil Nadu (Iyengar 1939); Uttar Pradesh (Kamat 1973, 74, Srivastava & Sarma 1981), Uttarakhand (Khan 1970b, Khare & Suseela 2007); West Bengal (Kargupta 1987).

Eudorina elegans Ehrenberg

[Iyengar & Desikachary 1981, p. 429, f. 252, 254, John et al. 2002, p. 317, pl. 81, f. G]

(Plate 1, Fig. E)

Description: Colony spherical, 32 celled; cells arranged in tiers of 4, 8, 8, 8, 4 cells; envelope of the colony is smooth; cells spherical with cup shaped chloroplast having a single pyrenoid. Diameter of the cell: 11.73 µm; Diameter of the colony: 70.38 µm.

Collection No. & Ecological notes: MD- 099, 01. 07. 2012, Dewanhat, Koch Bihar; found in small water body, full with monsoom water (pH- 5.5, Temp. 28°C); MD- 234, 16. 08. 2013, Kalakata, Koch Bihar; aquatic (pH- 6, Temp. 34°C); MD- 313, 09. 02. 2014, Vatkuar par, Koch Bihar, aquatic (pH- 6, Temp. 18°C).

Distribution in India: Andaman & Nicobar Islands (Prasad & Misra 1992); Andhra Pradesh (Venkataswarlu 1976); Bihar (Kumar & Saha 1993); Gujarat (Kamat 1962); Karnataka (Jayangoudar 1964, Raghavendra et al. 2015); Maharashtra (Kamat 1975, Jawale et al. 2009, Patil et al. 2011, Bhosale & Dhumal 2012); Odisha (Adhikary et al. 2009); Punjab (Singh 1966); Rajasthan (Pandey et al. 1998); Tamil Nadu (Iyengar 1933, 1937, Iyengar & Venkataraman 1951, Anuja & Chandra 2012; Christi et al. 2014a); Uttarakhand (Khan 1970, Gupta 2005); Uttar Pradesh (Singh 1960, Srivastava 2009); West Bengal (Dutta et al. 1954, Kachroo 1959).

Gonium pectorale Müller

[Iyengar & Desikachary, 1981, p. 411, f. 236, 237]

(Plate 1, Fig. F)

Description: Colony square with rounded ends with 16 celled; chloroplast cup shaped with single pyrenoid. Length of the cells: 7.57µm – 10.61µm; Breadth of the cell: 7.01µm - 11µm.

Collection No. & Ecological notes: MD- 095, 01. 07. 2012, Dewanhat, Koch Bihar, found in small water body (pH- 5.5, Temp. 28°C).

Distribution in India: Andaman & Nicobar Islands (Prasad & Misra 1992); Andhra Pradesh (Seenayya 1972); Gujarat (Patel 1967); Karnataka (Raghavendra et al. 2015); Maharashtra (Kamat 1968, 1975, Jawale et al. 2009, Patil et al. 2011, Bhosale & Dhumal 2012); Northern India (Turner 1892); Odisa (Philipose 1967); Punjab (Singh 1966); Tamil Nadu (Iyengar & Desikachary 1981); Uttarakhand (Gupta 2005); West Bengal (Kachroo 1959).

Kentrosphaera bristolae Smith

[Philipose 1967 p. 96 f. 21; Komárek & Fott 1983, p. 162, pl. 46, f. 1]

(Plate 1, Fig. G)

Description: Cells are globose, ellipsoid with cell membrane which is irregularly thickened; chloroplast single, parietal with many lobes. Length: 57 µm - 78.2 µm; Breadth: 26 µm - 43.01µm.

Collection No. & Ecological notes: MD- 313, 09. 02. 2014, Vatkuar par, Koch Bihar, aquatic (pH- 6, Temp. 18°C).

Distribution in India: Uttar Pradesh (Chadha & Pandey 1978). This is a very rare taxon and probably the first report of the taxon from Eastern India.

Pandorina cylindricum Iyengar

[Iyengar & Desikachary 1981, p. 420, f. 245, 246]

(Plate 1, Fig. H)

Description: Colony cylindrical with 16 celled arranged in four tiers; each tier contain four celled; chloroplast cup shaped with single pyrenoid. Colony

39.1μm long and 27.37μm broad; Length of the cells: 4.55μm – 6.82μm; Breadth of the cell: 4.55μm – 7.58μm.

Collection No. & Ecological notes: MD- 254, 20. 10. 2013, Maranadir Kuthi, Koch Bihar; aquatic, lodged on aquatic plants (pH- 6, Temp. 22°C).

Distribution in India: Maharashtra (Jawale et al. 2009, Patil et al. 2011); Tamil Nadu (Iyengar & Desikachary 1981); Uttarakhand (Kumar et al. 2012); Uttar Pradesh (Srivastava 2009). This is probably the first report of the taxon from Eastern India.

Selenastrum bibraianum Reinsch

[Philipose 1967, p. 219, f. 127; Komárek & Fott 1983, p. 688, pl. 194, f. 3 as *Ankistrodesmus bibraianus* (Reinsch) Kors. 1953; John et al. 2002, p. 399, pl. 98, f. D]

(Plate 1, Fig. I)

Description: Colony with 16 celled; cell sickle-shaped with pointed ends; chloroplast parietal with single pyrenoid. Length of the cell: 18 μm – 38 μm; Breadth of the cell: 3 μm – 5 μm.

Collection No. & Ecological notes: MD- 313, 09. 02. 2014, Vatkuar par, Koch Bihar; aquatic (pH- 6, Temp. 18°C).

Distribution in India: Bihar (Saha & Pandit, 1987); Gujrat (Patel et al. 1980); Himachal Pradesh (Jha et al. 1985); Jammu & Kashmir (Anand 1975); Karnataka (Philipose 1967); Maharashtra (Frietas 1980, Jawale et al. 2009, Patil et al. 2011); N. E. India (Turner 1892); Odisha (Das & Adhikary 2012); Sikkim (Das & Keshri 2012); Tamil Nadu (Iyengar & Desikachary 1981); Uttarakhand (Kumar et al. 2012); Uttar Pradesh (Srivastava 2009). This is the first report of *S. bibraianum* from West Bengal.

Selenastrum gracile Reinsch

[Philipose 1967, p. 219, f. 128; Komárek & Fott 1983, p. 688, pl. 107, f. 2 as *Ankistrodesmus gracilis* (Reinsch) Kors 1953; John et al. 2002, p. 399, pl. 98, f. E]

(Plate 1, Fig. J)

Description: Colony with 16 cells, cell sickle-shaped with pointed ends; cell narrow in proportion to their length; chloroplast without pyrenoid. Length of the cell: 18 μm – 35 μm; Breadth of the cell: 2 μm – 4 μm.

Collection No. & Ecological notes: MD- 208, 04. 05. 2013, Purbo Barochoki, Koch Bihar; aquatic (pH- 6, Temp. 27°C).

Distribution in India: Bihar (Laal 1976, Saha & Pandit 1987, Kumar & Choudhary 2009); Jammu & Kashmir (Anand 1975); Karnataka (Jayangoudar 1964, Philipose 1967, Hegde & Bharati 1983, Airsang & Lakshman 2015); Maharashtra (Gonzalves & Joshi 1946, Frietas 1980, Tarar & Bodkhe 1998, Patil et al. 2011, Bhosale & Dhumal 2012); N. E. India (Turner 1892); Rajasthan (Srivastava & Odhwani 1990, 1993, Tiwari & Chauhan 2007); Sikkim (Das & Keshri 2012); Tamil Nadu (Anuja & Chandra 2012, Christi et al 2014b); Uttarakhand (Habib et al. 1998, Habib & Chaturvedi 2000, Shukla et al. 2007, Habib & Barkha 2013); Uttar Pradesh (Pandey & Gangwar 1986, Chaturvedi & Habib 1993, 1995, Dwivedi et al. 2008).

This is probably the first report of the taxon from West Bengal.

Sphaerocystis schroeteri Chodat

[Prescott 1962, p. 83, f. 6, 7; Komárek & Fott 1983, p. 94, pl. 20, f. 3; John et al. 2002, p. 402, pl. 86, f. H]

(Plate 1, Fig. K)

Description: Colony spherical with undivided spherical cells; cells enclosed individually with envelops within the colonial envelop. Diameter of the cells: 11 μm – 16 μm; Diameter of the colony: 148 μm – 152 μm.

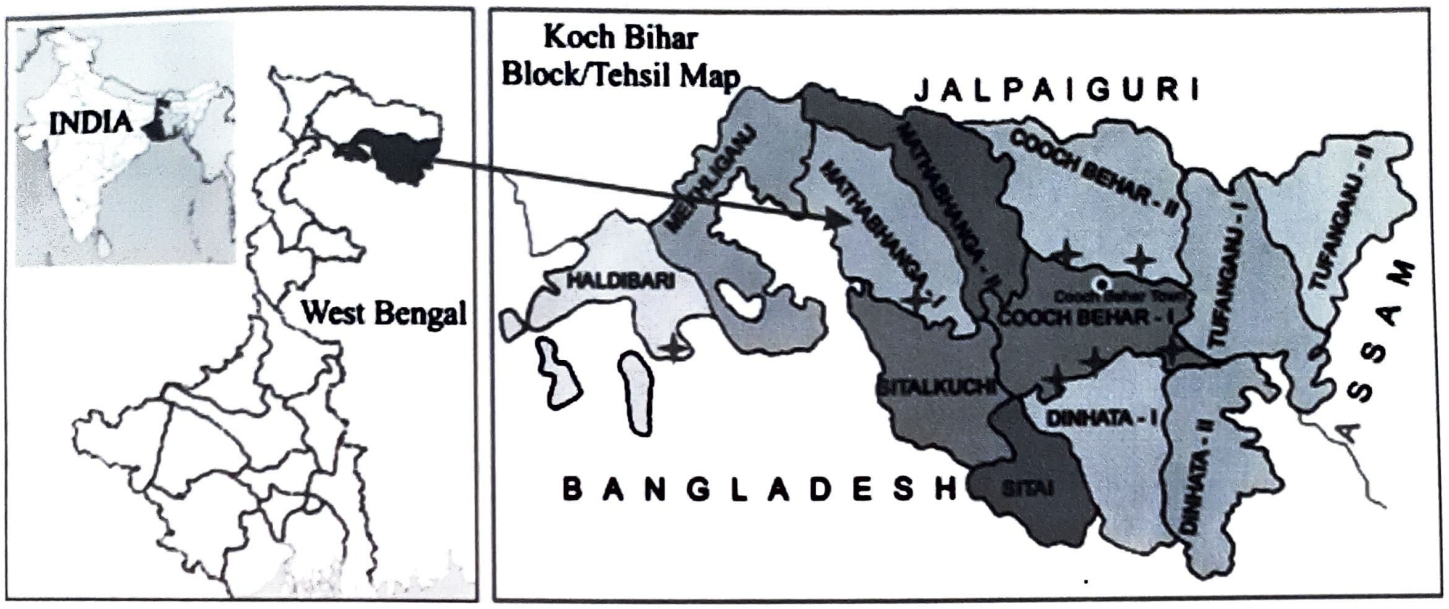
Collection No. & Ecological notes: MD- 094, 01. 07. 2012, Dewanhat, Koch Bihar; found in a small water body (pH- 5.5, Temp. 28°C); MD- 354, 16.02. 2014, Balarampur, Koch Bihar; aquatic, attached and lodged on aquatic plants (pH- 6, Temp. 24°C).

Distribution in India: Andaman & Nicobar Islands (Prasad & Misra 1992); Andhra Pradesh (Seenayya 1972); Himachal Pradesh (Suseela & Toppo 2009); Jammu & Kashmir (Subba Raju 1963); Kerala (Maya et al. 2000); Maharashtra (Kamat 1974, 1975); Uttar Pradesh (Shukla 1971, Srivastava 2009); West Bengal (Das et al. 2011).

Tetraspora lacustris Lemmermann

[Prescott 1962, p. 88, pl. 5, f. 11]

(Plate 1, Fig. L)



Text Figure 1. Map of Koch Bihar District (West Bengal) showing the sampling sites (Not to scale).

Description: Thallus a free-floating, spherical, or elongate & irregularly shaped; microscopic gelatinous colony containing relatively few spherical cells; the long pseudocilia usually clearly evident; cells arranged in groups of two. Diameter of the cell: 4.39µm - 8.78 µm.

Collection No. & Ecological notes: MD- 018, 05. 02. 2011, Rasamoti, Pundibari, Koch Bihar; found in small ditch (pH- 6, Temp. 22^{0}C).

Distribution in India: Maharashtra (Kamat 1975).

Volvox carteri Stein

[Iyengar & Desikachary 1981, p. 464, f. 272: 4-6]

(Plate 1, Fig. M)

Description: Colony spherical, rounded with 1200 celled; cells are globose, ovoid in shape; chloroplast cup shaped with a single pyrenoid. Colony 246.33µm in diameter; Cells are 3.91µm in diameter.

Collection No. & Ecological notes: MD- 099, 01. 07. 2012, Dewanhat, Koch Bihar; found in small water body, full with monsoon water (pH- 5.5, Temp. 28^{0}C).

Distribution in India: Bihar (Kumar & Choudhary 2009); Tamil Nadu (Iyengar & Desikachary 1981).

CONCLUSION

In this contribution on the algal flora we have recorded the distribution pattern of thirteen species belonging to Order Chlamydomonadales. Several species have been recorded for the first time from this region which also appears to be new to West Bengal and eastern India. Since there is no record of algal diversity from this region (except by the present authors), it can be inferred that such contribution may reveal the actual distribution pattern of algal biodiversity in this region. This type of study should be utilized in near future for bioprospecting of algal resources.

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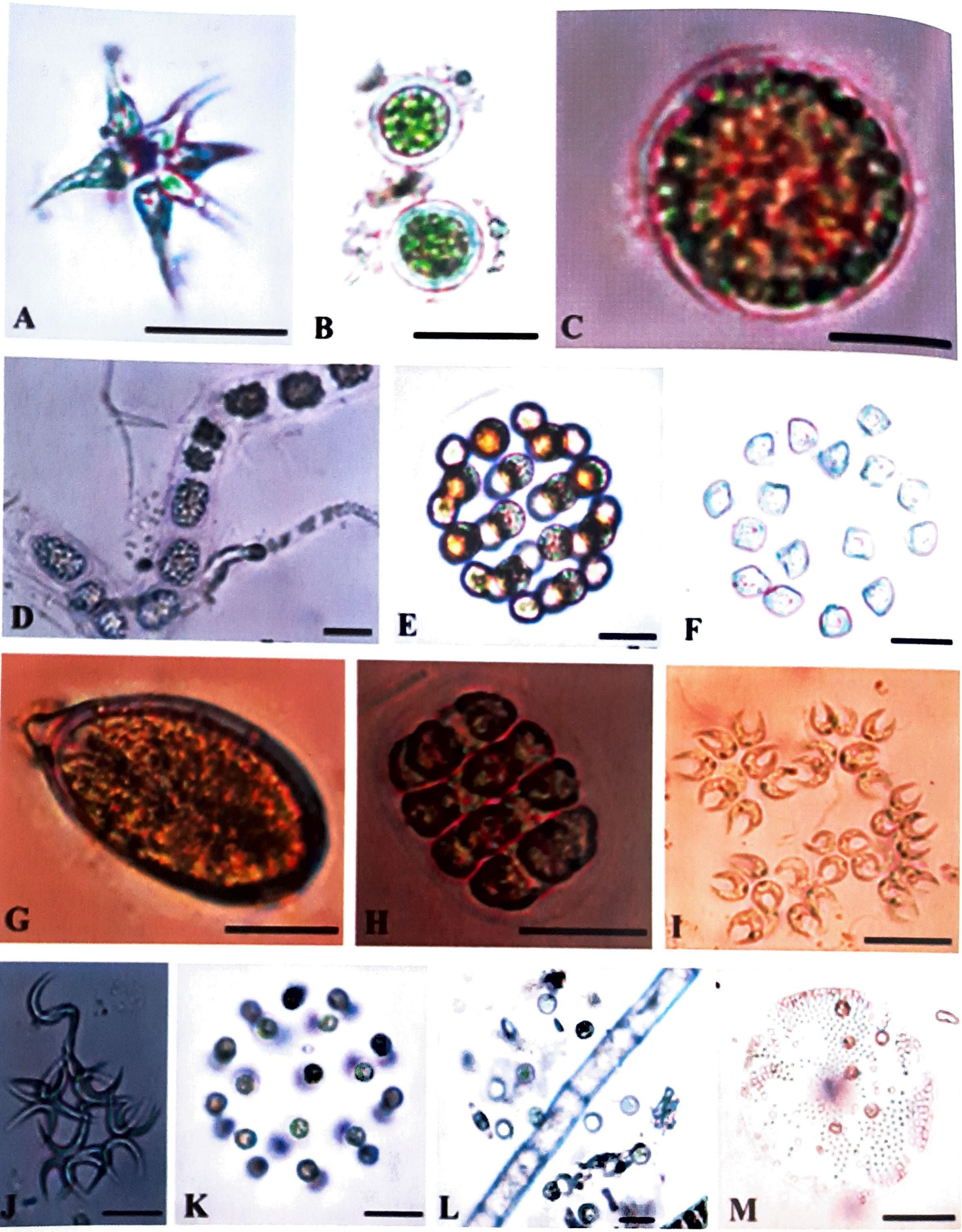

Plate 1

A. *Burkillia cornuta* West et. West, B. *Chlorococcum humicola* (Nägeli) Rabenhorst, C. *Chlorococcum infusionum* (Schrank) Meneghini, D. *Cylindrocapsa geminella* Wolle, E. *Eudorina elegans* Ehrenberg, F. *Gonium pectorale* Müller, G. *Kentrosphaera bristolae* Smith, H. *Pandorina cylindricum* Iyengar, I. *Selenastrum bibraianum* Reinsch, J. *Selenastrum gracile* Reinsch, K. *Sphaerocystis schroeteri* Chodat, L. *Tetraspora lacustris* Lemmermann, M. *Volvox carteri* Stein. (Scale Bar = 20μm)

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