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MORPHO-TAXONOMY OF THE FAMILY MERISMOPEDIACEAE, CHROOCOCCALES, CYANOPROCARYOTE

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ABSTRACT

Among unicellular and colonial Cyanobacteria the family Merismopediaceae is characterized by having solitary cells or one layered flat or spherical or irregular colonies with or without central mucilaginous stands or stalks. Cells characteristically, divide in two planes and they are at right angle to each other. Further, daughter cells reach to original size and shape before next division takes place. At the global level, there are about 15 genera and 190 species in the family. The well established genera of the family are *Synechocystis, Aphanocapsa, Merismopedia, Coelosphaerium* and *Gomphosphaeria.* The genus *Microcrocis* appears to be quite distinct in having elongated cells, and longer axis perpendicular to the plane of the colony but is of rare occurrence. Validity of certain other genera remains doubtful and need critical culture studies. The genera like *Pannus, Mantellum, Cyanotetras, Coccopedia* of sub-family Merismopedioideae appear to be the stages of *Merismopedia* or *Coelosphaerium*. Certain other genera like *Coelomoron, Coelosphaeriopsis, Snowella, Woronichinia* and *Siphonosphaera* of sub-family Gomphosphaerioideae may also be the growth stages of *Coelosphaerium* or *Gomphosphaeria*.

Keywords : Taxonomy, morphology, Merismopediaceae, Chroococcales, Cyanoprokaryote

Introduction

Unicellular and colonial Cyanobacteria have been classified in various ways into three (Chroococcales, Dermocarpales and Pleurocapsales), two (Chroococcales & Pleurocapsales) or just one order (Chroococcales) in Geitler (1932), in Bergey's Mannual (2001) and Komárek & Anagnostidis (1998) respectively. The basic criteria in division of unicellular and colonial Cyanobacteria include pattern of cell division, polarity and formation of baeocytes. The family Merismopediaceae as defined by Komárek & Anagnostidis (1998) is based on pattern of cell division in two planes, which are perpendicular to each other and that daughter cells reach to original size and shape before next division takes place. In family Merismopediaceae the thallus may consists of solitary cells or one layered flat or spherical or irregular colonies with or without central mucilaginous stalks. The present study include culture studies of four genera viz. *Synechocystis*, *Aphanocapsa*, *Merismopedia* and *Coelosphaerium* and comparison of various stages observed under different culture conditions. In the present study, cultures of six strains of four genera viz., *Synechocystis* (2), *Aphanocapsa*

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(2), *Merismopedia* (1) & *Coelosphaerium* (1) have been studied in detail.

Material & Methods

Samples of unicellular and colonial Cyanobacteria were collected from different Indian habitats and enrichment cultures were raised in nitrogen deficient and nitrogenous BG-11 medium (Stanier *et al*., 1971). The isolation of organisms was carried out by streaking method (Kaushik, 1987) and samples were incubated for 15 days at 28 ± 2℃ and 4-6 K Lux light intensity. Total six strains of 4 genera were isolated in culture from water samples collected from the different locality of the country. The axenic cultures of all the six strains were cloned from a single; few (2-4) celled colonies and maintained in BG 11 medium (Stanier *et al*., 1971) in liquid as well as solid agar media. BG 11 medium was modified for four different series of observations: (i) BG 11 (normal medium), (ii) BG 11 medium without combined nitrogen source (nitrogen deficient), (iii) BG 11 medium without PO_4 source (PO_4 deficient), and (iv) BG 11 medium with double amount of combined nitrogen source (nitrogen rich).

All growth experiments were performed in 150 ml flask filled with 75 ml liquid medium, and maintained in growth chamber, lighted by both fluorescent and incandescent source (4 K Lux light, 14:10 LD, temp. 30±2 ℃). Observations were made with the help of Leica DMLB microscope and digital camera with Leica Quin image system. All the isolated six strains of four genera of the family Merismopediaceae are deposited in Cyanobacterial Culture Collection, Department of Botany, University of Allahabad, Allahabad.

Obervations

Synechocystis Sauvageau **Strain Nos. ACC 11701 (Figs. 2 & 6** after Skuja 1964**)**

In culture, they form solitary cells and division pattern of cells was quite characteristic to the family Merismopediaceae by two planes which are at right angle to each other. Occasionally two celled or four celled, colonies were present.

Aphanocapsa Nägeli **Strain Nos. ACC 10101 & 10102 (Figs. 1 & 9)**

In cultures, these strains produce small microscopic mucilaginous colonies without any distinct boundary or envelope. A colony may have 32 - 64 or about 100 cells. Cells are rounded and division pattern is similar to other members of Merismopediaceae.

Merismopedia Meyen **Strain No. ACC 11101: (Figs. 5 & 10)**

It has been studied in culture conditions. It is planktonic and grows profusely to produce bloom by imparting colour to the medium. Microscopic colonies of 4-8-16-32 cells are flat, single layered tabular sheet like in appearance. Cells are arranged in rows at right angle to each other.

Coelosphaerium Nägeli **Strain No. ACC 10601 (Figs. 3, 4 & 11)**

It has been studied in culture. It forms 50 ìm to 1mm or upto 2-3 mm mucilaginous colonies. The cells are arranged in periphery and in a single layer. The cells are blue-green with homogeneous content and measure 2-4 ìm in diameter.

Coccopedia Troickaja **(Fig. not available)**

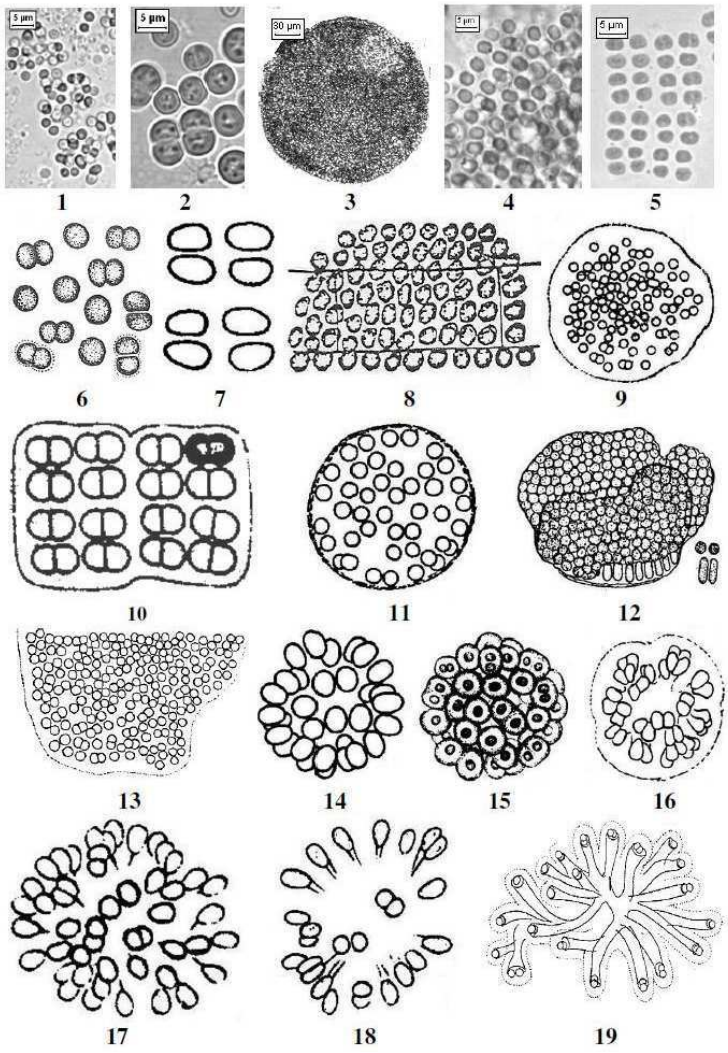
Colonies microscopic, mucilaginous, flat, tabular. Mucilage colourless. Cells spherical, without individual envelope. Cells divide by two planes.

Coelomoron Buell **: (Fig. 14)**

Colonies microscopic, more or less spherical and free floating. Cells oval or slightly elongated. Cells divide by two planes.

Coelosphaeriopsis Lemmermann**: (Fig. 15)**

Colonies microscopic, more or less spherical enveloped by colourless, fine homogeneous



EXPLANATION OF FIGURES:

Figures 1-5. Growth behavior of the organisms in culture conditions (**1**. Cells arrangement in *Aphanocapsa*; **2.** Cells arrangement in *Synechocystis;* **3.** A single colony of *Coelosphaerium*; **4.** Cells arrangement in *Coelosphaerium;* **5.** Cells arrangement in tabular colony of *Merismopedia*); **Fig. 6.** *Synechocystis* after Skuja (1964); **7.** *Cyanotetras* after Komárek (1994); **8.** *Mantellum* after Dangeard (1941); **9.** *Aphanocapsa* after Hindák & Moustaka (1988); **10.** *Merismopedia* after Hindák (1992); **11.** *Coelosphaerium* after Komárek (1958); **12.** *Microcrocis* after Koninskaja from Kondrateva *et al*. (1984); **13.** *Pannus* after Hindák (1992); **14.** *Coelomoron* after Komárek (1958); **15.** *Coelosphaeriopsis* after Skuja (1964); **16.** *Gomphosphaeria* after Komárek and Komárková (1992); **17.** *Snowella* after Komárek & Komárková-Legnerová (1992); **18.** *Woronichinia* after Komárek & Komárková-Legnerová (1992); **19.** *Siphonosphaera* after Hindák (1988)

mucilage. Cells spherical or oval and surrounded by gelatinous envelope. Cells divide by two planes.

Cyanotetras Hindák**: (Fig. 7)**

Colonies microscopic, free floating, flat, tabular. Cells oval, arranged in twos or flat tetrads. Cells divide by two planes.

Gomphosphaeria Kützing**: (Fig. 16)**

Colonies microscopic, free living, irregular with diffluent gelatinous stalks. Cell elongated and radially situated at the end of stalk, attached from the centre with the radiating, dichotomously branched mucilaginous stalks. Cells divide by two planes.

Mantellum Dangeard**: (Fig. 8)**

Cells solitary or in groups, small, more or less spherical and attached on the substrate or epiphytic on other algae. Cells divide by two planes.

Pannus Hickel **(Fig. 13)**

Colonies microscopic, free floating, hollow, flattened, wavy or hemispherical, clathrate, Cells spherical, with or without gas vesicles. Cells divide by two planes.

Siphonosphaera Hindák**: (Fig. 19)**

Colonies microscopic, free floating, more or less spherical, composed of radially tube like, colourless stalk. Cells spherical attached with mucilaginous stalk at the end. Cells divide by two planes.

Snowella Elenkin**: (Fig. 17)**

Colonies microscopic, free floating, more or less spherical with homogeneous, colourless and wide mucilaginous envelopes. Cell spherical or slightly elongated and attached from the centre with the radiating mucilaginous stalks. Cells divide by two planes.

Woronichinia Elenkin**: (Fig. 18)**

Colonies microscopic, free living, more or less spherical. Cell slightly elongated and attached from the centre with the radiating, dichotomously branched mucilaginous stalks. Cells divide by two planes.

Microcrocis Richter **: (Fig. 12)**

Colonies microscopic to macroscopic, flat, tabular and mucilaginous. Cells elongated, ellipsoidal, oval or rod shaped with rounded end. Cells divide by two planes.

Discussion

Among Chroococcales, the family Merismopediaceae is known to have two plane divisions at right angles to each other. Further, daughter cells reach to original size and shape before next division takes place. The family Merismopediaceae also includes two subfamilies: Merismopedioideae and Gomphosphaerioideae. The sub-family Merismopediaceae has solitary cells or irregular or tabular, one layered colonies. However, the member of the sub-family Gomphosphaerioideae has spherical colonies with cells arranged peripherally or radically attached on mucilaginous stalks (Komarek & Aganostidis 1998.)

At the global level, there are about 15 genera and 190 species in the family. Total genera of the family include *viz*. *Aphanocapsa, Coccopedia, Coelomoron, Coelosphaeriopsis, Coelosphaerium, Cyanotetras, Gomphosphaeria, Mantellum, Merismopedia, Microcrocis*, *Pannus, Siphonosphaera, Snowella, Synechocystis Woronichinia.* But, the well established genera of the family are *Synechocystis*, *Aphanocapsa*, *Merismopedia*, *Coelosphaerium* and *Gomphosphaeria*. The genus *Microcrocis* appears to be quite distinct in having elongated cells, and longer axis perpendicular to the plane of the colony but it is rare in occurrence. Validity of certain other genera remains doubtful and need critical culture studies. The genera like *Pannus*, *Mantellum, Cyanotetras, Coccopedia* of sub-family Merismopedioideae appear to be the stages

of *Merismopedia* or *Coelosphaerium*. Certain other genera like *Coelomoron*, *Coelosphaeriopsis*, *Snowella*, *Woronichinia* and *Siphonosphaera* of sub-family Gomphosphaerioideae may also be the growth stages of *Coelosphaerium* or *Gomphosphaeria*. Comparison of various stages observed in different culture conditions indicated that *Synechocystis*, *Aphanocapsa*, *Merismopedia* and *Coelosphaerium* are quite distinct genera of the family of Merismopediaceae.

Based on modern approach, Komárek and Anagnostidis (1998) revised the entire group of coccoid cyanoprokaryotes (Cyanobacteria) and rearranged them in a new phylum Cyanoprokaryota and included all forms in a single order Chroococcales. Their concept and classification up to genera level of the members of family Merismopediaceae is given below based on the above work in the form of keys:

Order Chroococcales: Unicells or colonies with loose, compact packets, psuedofilamentous or pseudoheterotrichous thalli reproducing by cell division or forming nanocytes, baeocytes, exocytes etc.

Family: Merismopediaceae Elenkin

Cells solitary or in regular or irregular colonies, mucilage present, cells spherical to rod-shaped, cell division in two planes and perpendicular to each other.

Sub-family:1. Mersimopedioideae Elenkin

Cell solitary or in colonies; colonies microscopic, usually free living, irregular or flat single layer; cells spherical to rod shaped; cell division in two planes, perpendicular to each other in successive generation.

Key to the genera of Sub-family Merismopedioideae (after Komárek & Anagnostidis 1998)

A. Cells solitary, free living
1. *Synechocystis*
A. Cell in groups B
B. Colonies mucilaginous, shapeless, cell irregularly disposed
2. *Aphanocapsa*
B. Colonies flattened, single layered, free or attached C
C. Colonies sessile, cells divide at right angel to substratum
3. *Mantellum*
C. Colonies free D
D. Cells elongate, oriented at right angle to plane of the colony
4. *Microcrocis*
D. Cells spherical or slightly longer E
E. Cells irregularly arranged in plane of the colony F
E. Cells arranged in plane of the colony and perpendicular rows G
F. Colonies tabular flat
5. *Coccopeida*
F. Colonies irregular
6. *Pannus*
G. Cells spherical or hemispherical
7. *Merismopedia*
G. Cells elongate, forming characteristic groups within the colonies
8. *Cyanotetras*

Sub-family:2. Gomphosphaeroideae (Elenkin) Komárek et Hindák

Colonies microscopic, rarely macroscopic, spherical or irregular, free floating, rarely sessile; cells located in periphery; cells radially oriented in one or more layers, spherical, oval, ellipsoidal, sometimes cordiform; in certain genera cells remain attached to thin or thick mucilaginous simple or dichotomously branched stalks; cell division by binary fission in two planes perpendicular to each other and to the surface of the colony in successive generations; reproduction by breaking of the colony or by liberation of solitary cells.

Key to the genera of Sub-family Gomphosphaeroideae (Elenkin) Komárek et Hindák (after Komárek & Anagnostidis 1998)

H. Cells arranged in periphery of mucilaginous colonies I

H. Cell arranged in periphery of the colony attached to end of thin or within the ends of thick stalk radiating from the centre of the colony K

I. Cells spherical, distant from each-other and arranged in 1 or 2 layers in periphery J

I. Cells oval, distant or densely packed in periphery of the colony in one to several layers

9. *Coelomoron*

J. Cells spherical, similar in size without individual envelopes

10. *Coelosphaerium*

J. Cells variable in size, surrounded by individual envelopes

11. *Coelosphaeriopsis*

K. Cells attached to the ends of thin pseudodichotomously branched stalks

12. *Snowella*

K. Cells located at the ends or within wide mucilaginous stalks L

L. Colonies irregular, cells slightly elongate, cells situated at the end of stalks M

L. Colonies oval or spherical, cells spherical or hemispherical, situated within the stalks

13. *Siphonosphaera*

M. Cells spherical, oval or obovoid, attached to ends of single stalks radiating from centre

14. *Woronichinia*

M. Cells ovoid, slightly club-shaped or cordiform situated to ends of colonies, pseudodichotomously branched stalk

15. *Gomphosphaeria*

Although, a lot of works have been carried on Indian cyanoprokaryotes/ cyanobacteria/ blue-green algae, particularly on heterocystous forms by various Indian workers, but non-heterocystous group, particularly unicellular and colonial forms of cyanoprokaryotes remain unexplored and few genera were studied in detail in culture conditions (Padmaja, 1972; Padmaja and Desikachary, 1967, 1968; Varma, 1965; Varma and Mitra, 1963). Several genera of Unicellular and colonial cyanoprokaryotes *viz*. *Aphanothece*, *Aphanocapsa*, *Asterocapsa*, *Chroococcus*, *Gloeocapsa*, *Xenococcus* and *Cyanoarbor* were studied in details in nature as well as in culture conditions and revealed various new developmental stages (Kant *et al*. 2003, 2004a-b, 2005a-d, 2006, 2008a-b; Kesharwani, 2008; Singh 2008, Tiwari *et al.*, 2007, 2009). Dwivedi *et al* (2011) have studied the genus *Gomphosphaeria* from material collected from natural habitats and reported various stages of different species in single sample of the genus. They also advocated that for the taxonomic settlement of the genus is required to study in detail from the material collected from the nature and from culture with molecular details.

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