On growth, reproduction and perennation of *Pleurocapsa aurantiaca* Geitler, Hyellaceae, Cyanoprokaryota

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Abstract
The present communication deals with the description and life cycle pattern of *Pleurocapsa aurantiaca* Geitler. Our continuous observations of the organism throughout its growth period, indicated a different type of life cycle pattern and at any stage of growth it may liberate cells or packets to develop new thalli. As for as baeocytes are concerned the cells may undergo multiple fission to produce primary baeocytes (4-8-16) and liberate to form new thalli but if conditions are not favourable they go for perennation and next when conditions are conducive the cells may undergo for multiple fission again and produce numerous baeocytes. It appears to be inherent propensity of the present organism to undertake perennation and multiple fission as and when required in natural habitat. It may be a new record from India.

Kew words: Baeocytes, multiple fission, perennation, *Pleurocapsa aurantiaca*.

Introduction

Among coccoid cyanobacteria, the family Hyellaceae shows complex morphology and they possess both binary fission for vegetative growth as well as multiple fission for reproduction. Simultaneous multiple fissions result into formation of several to numerous baeocytes or nanocytes. It is in this group, certain genera produce an additional third fibrous layer which help in maintenance of definite shape of cells and topology during enlargement and formation of baeocytes. Although the concept of the genus *Pleurocapsa* Thuret is quite different in Bergey's Manual (Boone & Castenholz, 2001) as it is designated as provisional "*Pleurocapsa*-group" which include three genera viz., *Pleurocapsa*, *Hyella* and *Solentia*. The present communication deals with description of *Pleurocapsa aurantiaca* Geitler as described in Komarek & Anagnostidis 1998. The study is based on continuous observations of the organism for three years from the material of natural habitat and here it revealed a different type of life cycle pattern.

Material and Methods

The organism was found as lithophyte on side walls in a cemented Lilly pond in Department of Botany, University of Allahabad, Allahabad 211002, India. GPS- Alt: 88.6m Lat/Long: N25^{0}27'42.1"/ E81^{0}51'10.8". It was studied continuously for three years (2009-2011) from the material collected from the natural habitat. Throughout the study only water mounts without any staining were observed under Leica DMLB microscope with DC 300 camera and its quin imaging system. However, efforts of growing it in BG-11 medium (Stanier et al., 1971) were not successful because of very slow growth and every time the inocula were overgrown by other associated organisms and bacteria.

Observations

The mucilaginous growth of the organism looked blue-green, yellowish or dark brown and spreaded as smooth and flat stratum all over the sidewalls of the pond. The growth was more pronounced, where it was receiving the direct sunlight. Based on observations of various growth stages of the same population during last three years, it was possible to segregate distinct four stages of life cycle and they are described below:
***Stage 1*.** This stage was difficult to locate because the mucilaginous stratum is made of complex colonies. During March and September, when its growth was found as a pioneer on a fresh clean spot, it revealed that vegetative thalli appear as uniseriate or multiseriate cluster of pseudo-dichotomously branches or spreaded into fan-like structure. The developmental stages from one to many celled colonies were also observed (**Figs. 1-8; 15-16**) in fresh spots.

Figures: 1-14

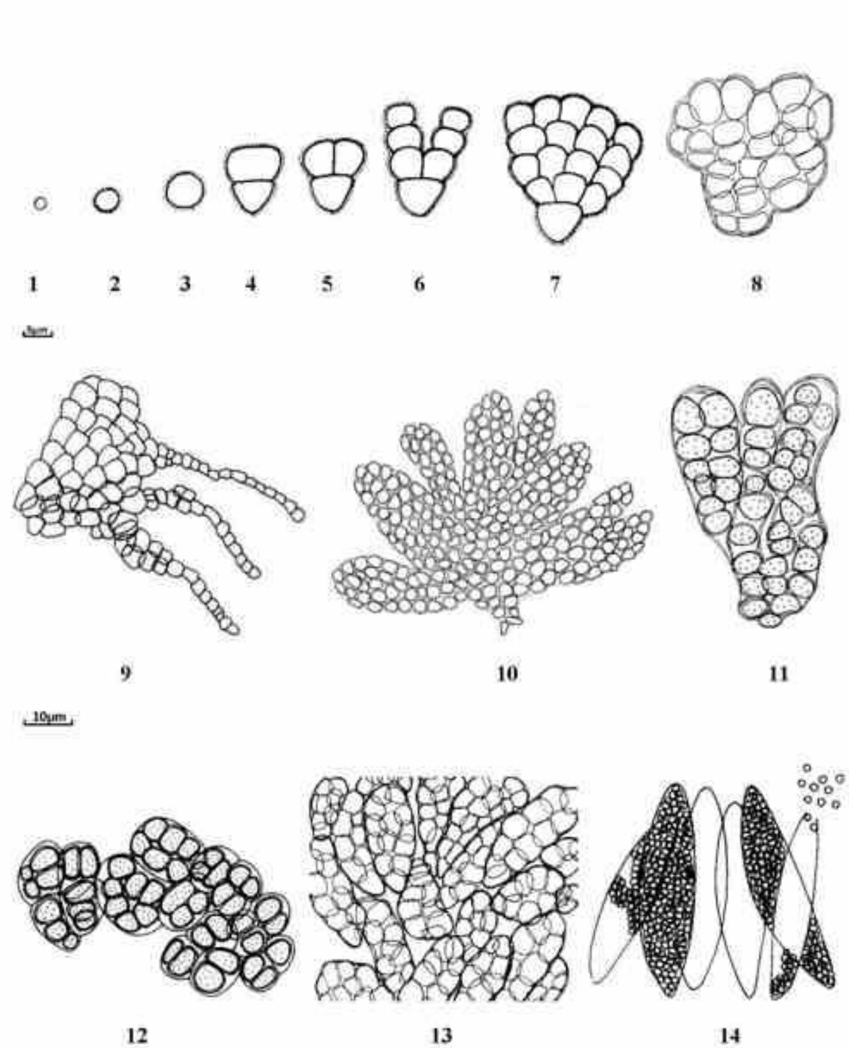

Plate 1. ***Pleurocapsa aurantiaca* Geitler** . Figs. 1-3: Various stages of baeocytes enlargement. Figs. 4-8: Young thalli showing pattern of branchingFig. 9: Pseudo-filamentous appendages formed from peripheral cells. Fig. 10: Single large thallus with fan-shaped appearance of cell packet. Figs. 11&12: Showing formation of cell packets with envelopes. Fig. 13: Stages showing formation of primary baeocytes. Fig. 14: Stages showing formation of secondary baeocytes. **Scale 5µm for Figs. 1-8 & 11-14**. **Scale 10µm for Figs. 9&10**

The cells divide by binary fission. Cells of these primary vegetative colonies were quadratic, rectangular or polygonal and they were closely packed. Individual cells were surrounded by hyaline thin sheath. The cells were 4-6-12µm in diameter and have fine granulated blue-green content. In rare cases some peripheral cells may divide mostly by single plane for some time and result into long uni-bi-seriate pseudofilamentous appendages (**Figs. 9 & 17**). However, the old growth which looked as flattened stratum on pond walls, contained many layers of overlapping colonies of various stages. It included not only dead and colourless colonies but very often associated with dense growth of non-heterocystous filamentous cyanobacteria (*Leptolyngbya angustissima* W. et G.S. West), a few coccoid green algae, protozoans, bacteria and also minute insects.

***Stage 2*.** As the colonies mature the cells become polygonal or rounded and get surrounded individually by thin hyaline layers of mucilage. Gradually in winter (December-January) with the change of pond conditions, the entire composite mass of colonies get segregated into well enveloped groups of 4-8 or more cells. The cells become highly granulated. Individual cells and groups of cells get surrounded by several layered thick, hyaline mucilage envelopes (**Figs. 10-12; 17-19; 20-23**). The colonies which are facing direct sunlight may turn yellow-brown due to colouration of sheath. It appears that groups of cells become fragile as they may be separated easily by mechanical disturbances and such groups may also form new colonies on germination **(Fig. 24)**.

Stage 3. As climatic conditions change and it become warmer during March, the cell becomes larger and blue-green and the content divide by simultaneous multiple fission and each cell may produce 8-16 primary baeocytes which remain enclosed in spindle-like clusters (**Fig. 13; 25-27**). However they are not liberated but increase in size a little and at this stage they measure 2-3.5µm in diameter.These primary baeocytes liberated may be liberated to form new thalli or remain dormant at this stage for another long spell of time (up to 5 months) and remain covered in brownish sheath. The mass becomes fragile and easily broken into small pieces.

Figures: 15-21

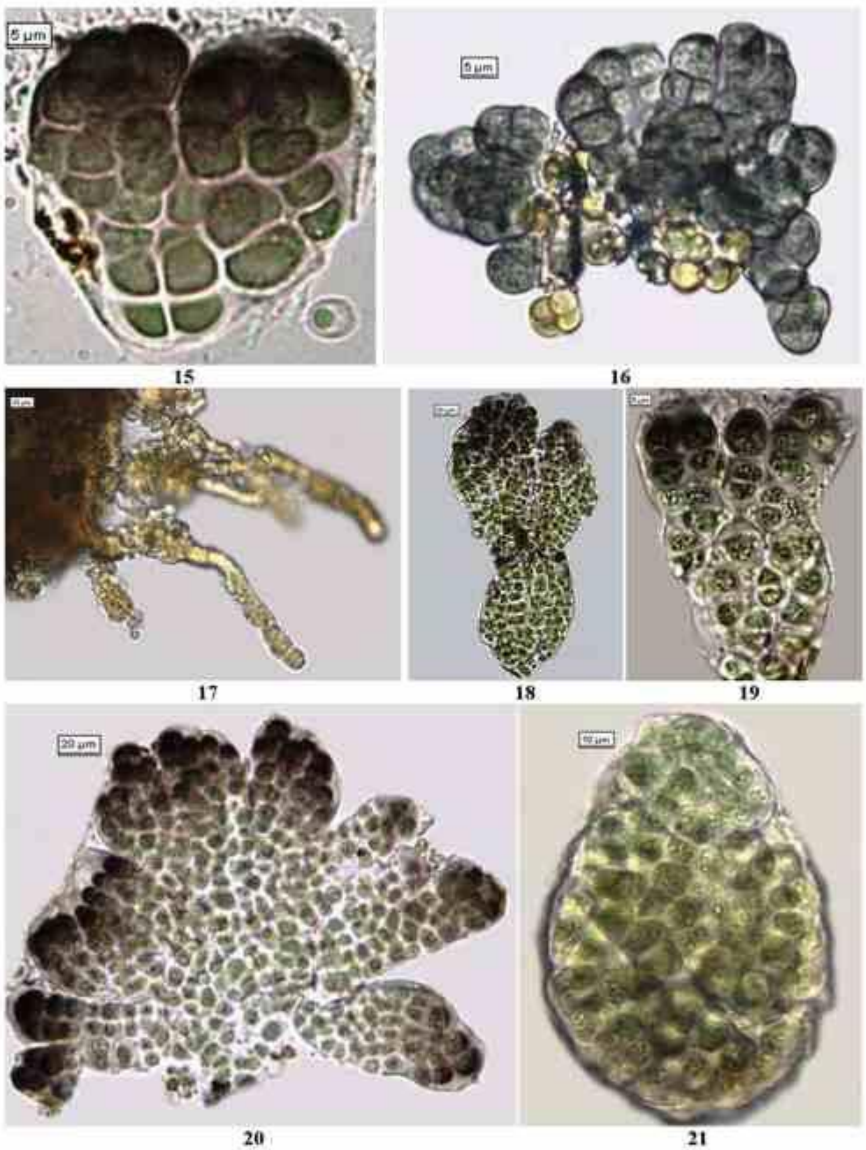

Plate 2. ***Pleurocapsa aurantiaca* Geitler.** Figs. 15&16: Showing young thalli**.** Fig. 17: Showing pseudo-filamentous appendages. Figs. 18&19: Cell packets with individual cell envelopes**.** Fig. 20: A mature fan shaped thallus. Fig. 21: A single packet of mature cells

Stage 4. On the advent another favourable condition during rains (July-August), all spindle like bodies containing primary baeocytes formed in stage-3 become bright blue-green and divide simultaneously by multiple fission and produce numerous (more than a hundred) small secondary baeocytes (1.5µm in diameter) and remain inside much elongated spindle-like clusters (**Fig. 14**). Gradually as the sheath of clusters get gelatinized baeocytes are liberated from one end or from all the sides. The entire stratum on side walls of the pond give a kaleidoscopic view in showing colonies of all stages of growth known to occur in different season in various colours and in different patches. There are certain patches where all cells are dead and colourless. This is also due to the fact that in pond there are many microhabitats occurring in patches due to availability and change of water level condition, light and shades by other macrophytes as well as burrowing by aquatic insects. The process of drying and wetting alternately throughout the years. In summer season also the watering of pond creats favourable condition for some time and that induces many changes in stratum of organisms.

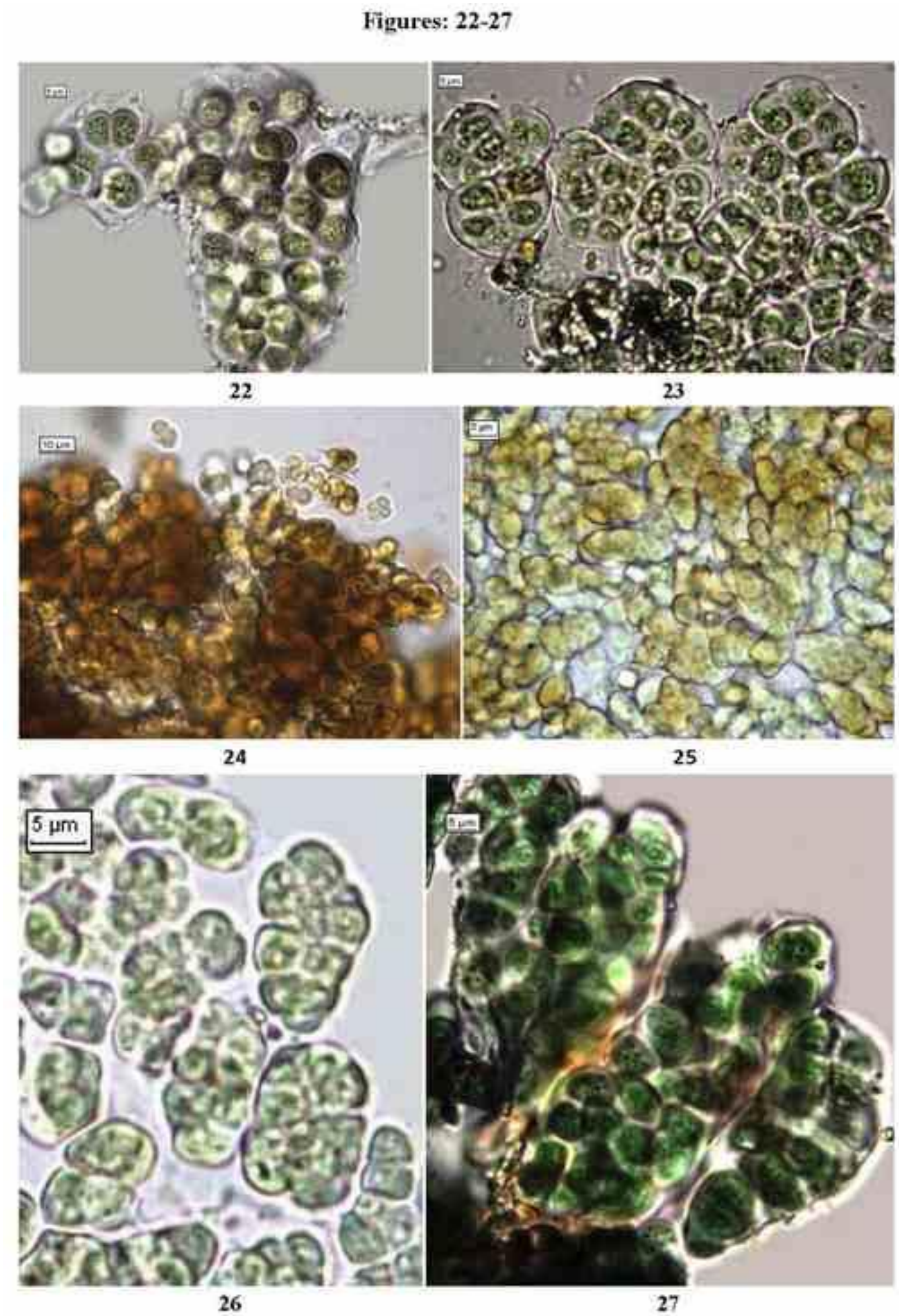

Plate 3. ***Pleurocapsa aurantiaca*** **Geitler.** Figs. 22-24: Showing formation and liberation of cell packets**.** Figs. 25-27: Showing packets of primary baeocytes in different magnification

Taxonomic status

This organism belongs to Hyellaceae and not to Hydrococcaceae because it produces baeocytes. In Hyellaceae it is comparable to *Pleurocapsa* and not to *Hyella* as it is not pseudo-heterotrichous. In the present organism pseudofilamentous structures are extremely rare and they are not chalk borring. Waterbury and Stanier (1978) made intensive study of several strains in culture isolated from marine habitats and suggested two types, one corresponds to *Hyella* and the other to *Pleurocapsa* but they did not define their strains taxonomically. Desikachary (1959) did not include any species of *Pleurocapsa*, but describe one species each of *Hyella* and *Scopulonema*. However, Tiwari et al, 2007 included three species of *Pleurocapsa*, three of *Hyella* and one of *Scopulonema*. In *Pleurocapsa*, only four species are reported from fresh water habitats and many others are known from marine habitats (Komarek & Anagnostidis 1998). Among fresh water species of *Pleurocapsa*, it is closure to *P. aurantiaca* Geitler which also grows in submerged condition and form flat covering on stony substrates. This species has been reported earlier from Alps and western Carpathians, Europe by Geitler (1932) and it may be a new record from India. More interesting point about the present taxon is its ability to perennate generation after generation with increase in number of baeocytes from four to more than a hundred by multiple fission.

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