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TAXONOMIC STUDY ON VOLVOCOPHYCEAE SHAMEEL FROM CERTAIN AREAS OF THE PUNJAB

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Abstract

Eight species of green microalgae belonging to the genera *Chlorella*, *Chlorococcum*, *Eudorina*, *Gonium*, *Oocystis*, *Pandorina* and *Volvox* were collected from various freshwater habitats of Lahore, Pasrur and Sialkot districts of the Punjab Province of Pakistan during July 2003 and December 2004. They were microscopically examined and are taxonomically described for the first time from these areas. Although they occurred in all the seasons of the year but were found to grow mostly in summer and winter. The species *Chlorococcum arenosum*, *Eudorina elegans*, *Gonium formossum* and *Volvox aureus* are being reported for the first time from Pakistan.

Introduction

Only a few studies were conducted on the taxonomy of freshwater Volvocophyta Shameel from Punjab Province of Pakistan (Masud-ul-Hasan & Batool, 1987; Masud-ul-Hasan & Yunus, 1989; Shahida *et al.*, 2006; Shahnaz *et al.*, 2007). Therefore, a large survey was made to explore the occurrence of green microalgae in various districts of the Punjab. In this connection, species of the family Mesotaeniaceae (Desmidiophyceae Shameel) were investigated (Waqar-ul-Haq *et al.*, 2007). This is a continuation of this investigation, where species of the class Volvocophyceae have been taxonomically described from this area.

Materials and Methods

Algal material was collected from moist soil, fountain water, rice fields, standing rain water, stagnant water ponds, road-side ponds and other freshwater reservoirs in the area of Lahore, Pasrur and Sialkot districts of the Province of Punjab (Pakistan) during July 2003 and December 2004. It was preserved and brought to the laboratory at Karachi for microscopic study. The methods used for collection, preservation and microscopic examination of the material and preparation of its drawings were the same as described earlier (Waqar-ul-Haq *et al.*, 2007). The specimens were identified with the help of authentic literature (Børgesen, 1901; West, 1904; Wasylik, 1961; Prescott, 1962; Hirano, 1964; Fjerdingstad, 1965; Prescott & Vinyard, 1965; Duthie & Ostrofsky, 1975; Nizamuddin & Gerloff, 1982; Wehr & Sheath, 2003; John *et al.*, 2005). The voucher specimens of the material are deposited in the Phycology & Phycochemistry lab. (Room No. 18), M.A.H. Qadri Biological Research Centre, University of Karachi, where microscopic work was conducted.

Results and Discussion

Eight species of green microalgae belonging to 7 genera, 4 families, 3 orders of the class Volvocophyceae Shameel 2001: 235 and phylum Volvocophyta Shameel 2001: 235 have been identified and taxonomically described. They have been systematically arranged according to the newly proposed classification (Shameel, 2001). Taxonomic enumeration of the relevant taxa is given below.

Order Volvocales

Unicellular or colonial algae; vegetative cells flagellated and motile. Details of other characters are given below in the family description.

Family Volvocaceae

Motile colonial genera in which the cells lie in a hollow sphere and not in superimposed tiers, the number of cells in a colony is definite, a multiple of four, and there is no increase in number of cells after the juvenile phase of development. In asexual reproduction, all or certain specific cells divide simultaneously to form daughter colonies. Sexual reproduction is iso-, aniso- or oogamous. The following four genera of this family were collected, which may be distinguished as follows:

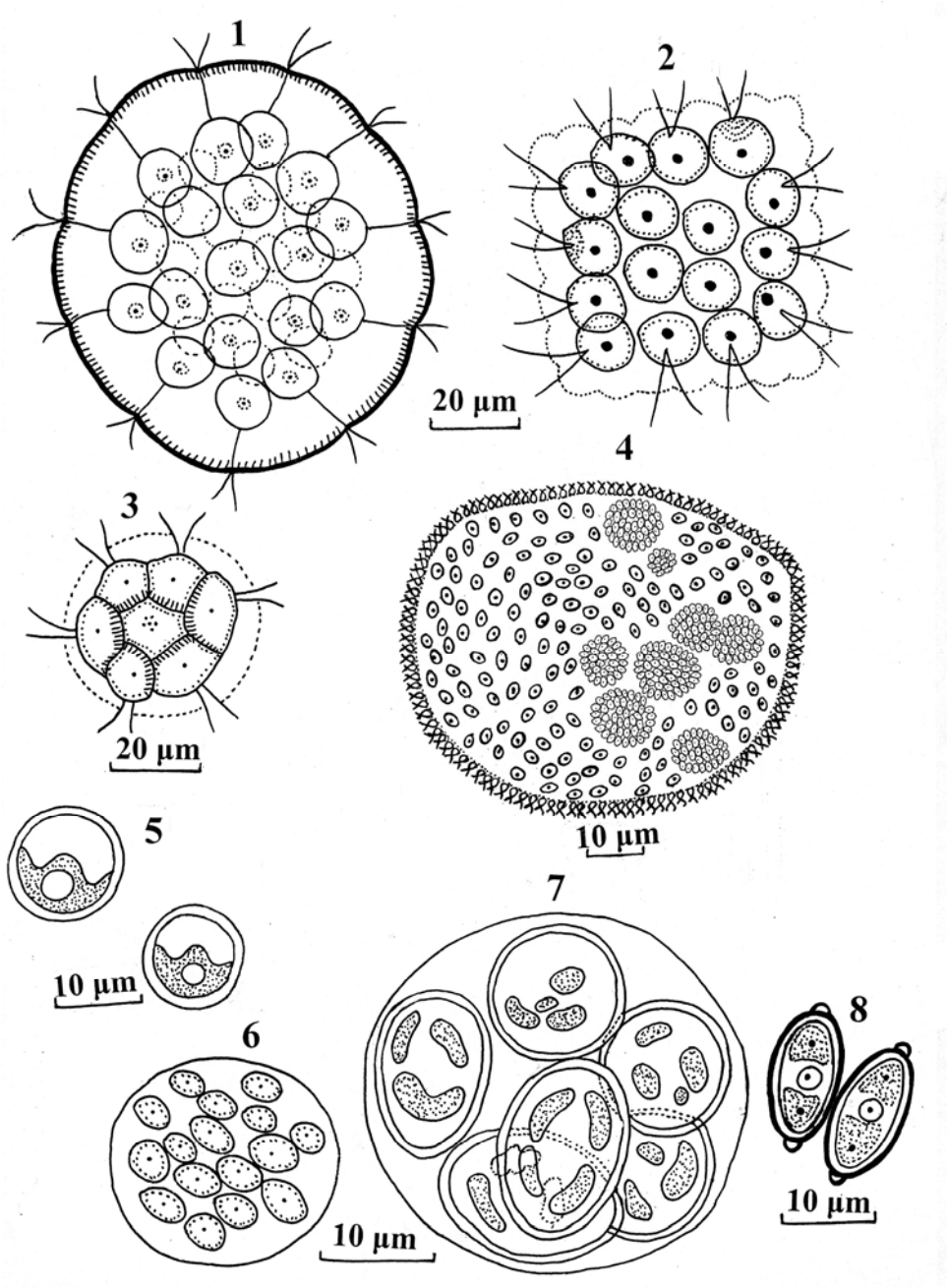
1. Colony large, more than 500 celled ……..……... *Volvox*
   Colony small, less than 100 celled ...……..……..… 2
2. Coenobium oval shaped, more than 32 celled ...……..… *Eudorina*
   Coenobium otherwise up to 32 celled ……...…… 3
3. Colony quadrangular ..……..…….. *Gonium*
   Colony ovate or obovoid ..……. *Pandorina*

Eudorina Ehrenberg 1832: 78

Spherical or oval-shaped colonies, composed of motile cells within a gelatinous envelop. The number of cells varies from 16-64 and arranged in tiers. Only following species was present in the collection.

1. *E. elegans* C. G. Ehrenberg 1831 *ex* Ralfs 1832: 78

Synonymy: *Eudorina stagnale* Wolle, *E. pluricocca* G. M. Smith.
References: Børgesen, 1901: 238; West, 1904: 195; Wasylik, 1961: 268; Prescott, 1962: 76; Hirano, 1964: 209; Fjerdingstad, 1965: 536; Prescott & Vinyard, 1965: 444; Duthie & Ostrofsky, 1975: 254; Nizamuddin & Gerloff, 1982: 130; Wehr & Sheath, 2003: 23; John *et al.*, 2005: 317.
General characters: Colonies spherical or oval; cells spherical or pyriform; chloroplast cup-shaped, massive; each cell bi-flagellated, flagella equal in length; diameter of colonies from 91-105 µm; cells 11-21 µm in diameter (Fig. 1).
Localities: Lahore District: Ali Liaquat Town Village (19-7-2003), Lakho Dahr (11-12-2004), Handos Village (19-12-2004), fountain of Zoological Garden (4-8-2004); Pasrur District: Bakhatpur Village (5-3-2004).



Figs. 1-6. Species of Volvocophyceae: 1. *Eudorina elegans*, 2. *Gonium formossum*, 3. *Pandorina morum*, 4. *Volvox aureus*, 5. *Chlorococcum arenosum*, 6. *Chlorella vulgaris*, 7. *Oocystis borgei*, 8. *O. marssonii*.

Geographical distribution: U.S.A., Alaska, North America, England, Denmark, Poland, Libya and Afghanistan.
Remarks: The species was found to occur in two districts of the Punjab during spring, summer and winter. It was collected in large quantity and is being reported for the first time from Pakistan.

***Gonium* O. F. Müller 1773: 60 *emend.* Prescott *in* Prescott, Silva *et* Wade 1949: 84**

A free swimming, plate like, quadrangular colony of 4-32, ovate, ovoid, pyriform or bilobed cells, so arranged within a gelatinous envelop that a rectangle of 4-8 central cells is enclosed by a peripheral series of 12-24 individuals. The long axis of the central cells is at right angles to the plane of colony, but axis of the peripheral cells is radial to the center of the colony. Cells inter-connected by fine protoplasmic processes, individual envelope adjoined by stout processes with those of neighbouring, cells, so that oval or quadrangular interstices are formed in the colonial mucilage. Flagella 2, attached in the narrow, anterior end, just above 2 contractile vacuoles. Chloroplast a parietal cup with 1 or 2 pyrenoids; pigment-spot usually large and conspicuous, lying laterally at the anterior end. Sexual reproduction by the division of the vegetative cells into 4-16-(32) isogametes which fuse in pairs, the quardriflagellate zygote becoming a thick-walled resting spore. Only following species was collected:

2. *G. formossum* Pascher 1927: 418

References: Prescott, 1962: 74; Wehr & Sheath, 2003: 244.
General characters: Colonies flat, quadrangular; cells pyriform or ovoid, smaller end outward; chloroplast cup-shaped with pyrenoid; eye-spot present, two flagella equal; diameter of cell 10.5-11.2 µm; colony margin is undulate, rather straight; cell length 10-12 µm, width 7-10 µm (Fig. 2).
Locality: Lahore District: Lakho Dahr (19-2 & 11-12-2004).
Geographical distribution: Previously reported from U.S.A., North America.
Remarks: The specimens were collected during winter. They were found in free-floating state. This species is being reported for the first time from Pakistan.

***Pandorina* Bory de Saint-Vincent 1824: 521**

Colony ovate or obovoid; composed of 8-16-(32) globose or pyriform cells, compactly arranged and enclosed by a common gelatinous envelop; cells with the broad anterior end directed outward; chloroplast a parietal cup with 1 basal pyrenoid; pigment-spot anterior and lateral; flagella 2, arising from the anterior end of the cell and diverging widely after emerging from the colonial envelop; the colony swimming in a rolling or tumbling fashion; vegetative reproduction by simultaneous division of each cell in the colony to form many colonies; sexual reproduction by isogametes, formed in groups of 8 or 16, by the partition of some or all of the cells of the colony. Only following species was found in the present collection.

3. *P. morum* (O. F. Müller) Borry de Saint-Vincent 1824: 600

Basionym: *Volvox morum* O. F. Müller.
References: Børgesen, 1901: 238; West, 1904: 194; Wasylik, 1961: 268; Prescott, 1962: 75; Fjerdingstad, 1965: 535; Prescott & Vinyard, 1965: 444; Duthie & Ostrofsky, 1975:

254; Nizamuddin & Gerloff, 1982: 130; Masud-ul-Hasan & Yunus, 1989: 106; John *et al.*, 2005: 320.
General characters: Colonies broadly oval in shape, eight or sixteen celled; cells obovoid to spherical; chloroplast cup-shaped; eye-spot present; two equal flagella, cell length equal to the width; length of colony with mucilage 52-54 µm, without mucilage 41-43 µm; width of colony with mucilage 41-42 µm, without mucilage 34-36 µm (Fig. 3).
Localities: Lahore District: Ali Liaquat Town Chungi (19-7-2004), Handos Village (19-12-2004), Mahmood Booti (13-7-2004).
Geographical distribution: U.S.A. Alaska, England, Denmark, Poland and Libya.
Remarks: It was collected from rice fields and ponds at different places of Lahore during summer and winter, mixed with the species of *Eudorina* and *Volvox*.

***Volvox* Linnaeus 1758: 820**

The colonies are visible to the nacked eye and strongly phototactic. Each colony is composed of numerous (500-50000) vegetative and somatic cells, which are arranged at the periphery of coenobial mucilage. The cells are surrounded by mucilaginous envelopes of their own and interconnected by cytoplasmic connections. The present collection included only following species.

4. *V. aureus* Ehrenberg 1832: 77

Synonymy: *Volvox dioca* Cohn, *V. lismorensis* Playfair, *Janetosphaera aurea* (Ehrenberg) W. Shaw.
References: West, 1904: 197; Prescott, 1962: 78; Fjerdingstad, 1965: 537; Wehr & Sheath, 2003: 242; John *et al.*, 2005: 326.
General characters: The somatic cells have *Chlamydomonas*-like organization. The cells are spherical to sub-spherical, inter connected by cytoplasmic strands. Colony is 518-569 µm broad (Fig. 4).
Locality: Lahore District: Ali Liaquat Town Village (19-7-2004).
Geographical distribution: Previously reported from U.S.A., North America and England.
Remarks: It was collected from stagnant water pond during summer. This species is being reported for the first time from Pakistan.

Order Chlorococcales

Nonmotile unicells or colonies; division of the cells gives rise to zoospores or gametes. Details of other characters are given below in the family description.

Family Chlorococcaceae

The cells vary in shape from spherical to fusiform or spindle shaped. It is characterized by the use of zoospores in asexual reproduction, which escape through a pore in the wall and separate immediately. In some forms arrested zoospores (aplanospores) may also function. The thalli are mostly solitary and free-floating, but may also be gregarious, sedentary and inhabiting moist soil or other subaerial habitats.

The cell-wall may be smooth, chloroplast which may be a parietal or massive cup, or axial and stellate, with one or more pyrenoids. Only following genus was collected:

***Chlorococcum* Meneghini 1842: 24**

Cells spherical, solitary or more often gregarious in amorphous gelatinous clumps or forming films on moist or submerged substrates; cell-wall thin; chloroplast a thin parietal plate, covering the wall or nearly so; pyrenoids one, rarely more than one; reproduction by 8-16 zoospores. Only following species was found in the present collection.

5. *C. arenosum* Archibald *et* Bold 1970

Synonymy: *Chlorococcum ellipsoideum* Deason *et* Bold.
Reference: Archibald & Bold, 1970: 22.
General characters: Cells spherical, 7-9 µm in diameter, solitary or in small clumps; cell-wall close to the cytoplasm smooth, thick in old cells; chloroplast a parietal hollow sphere, ½ to 1/3 of cell cavity; pyrenoids one to few, distinct; uninucleate (Fig. 5).
Locality: Lahore District: Punjab University Old Campus (16-12-2004).
Geographical distribution: U.S.A.: Texas.
Remarks: Collection was made from surface of moist soil during winter. This species is being reported for the first time from Pakistan.

Order Chlorellales

Unicellular or colonial algae; lack the capacity for zoospore formation; only a few produce flagellated gametes; reproduction restricted to nonmotile autospores or autocolonies.

Family Chlorellaceae

Unicellular individuals; cells small and thin walled; parietal chloroplast. In the present collection only following genus was collected:

***Chlorella* M. Beiijerinck 1890: 758**

The cells are small, spherical or ellipsoidal and usually occur as isolated individuals. Chloroplast is parietal and the cells are thin walled; uninucleated when young. Only following species was present in the collection.

6. *C. vulgaris* M. Beiijerinck 1890: 758

Synonymy: *Chlorella candida* Shihira *ex* Krauss 1965, *C. pyrenoidosa* var. *duplex* (Kützing) West.
References: West, 1904: 230; Prescott, 1962: 237; Siddiqui & Faridi, 1964: 64; Fjerdingstad, 1965: 537; Ahmed *et al.*, 1983: 398; John *et al.*, 2005: 336.
General characters: Colony 33-42 µm broad; cells small, spherical and usually occurs as isolated individuals; chloroplast parietal (Fig. 6).

Locality: Lahore District: near Bund Road (28-9-2004).
Geographical distribution: Previously reported from U. S. A., England and Pakistan.
Remarks: Material was collected from roadside pond during autumn.

Family Oocystaceae

The cells lack vegetative multiplication and zoospores formation. Reproduction is solely by autospores, small miniature born inside a reproducing cell. There is tendency for the retention of daughter cells within the mother cell walls. Gelatinization of the mother cell walls may occur, or the cells may be within a gelatinous matrix. Its following genus was collected:

***Oocystis* Nägeli *in* A. Braun 1855: 94**

Cells are oval or elliptic, single or in groups of two to about sixteen retained within the partially gelatinized mother cell-wall. Sometimes successively formed cell generation are included within a single mother cell-wall. The sheath is firm and uniform. Polar thickening occurs on the walls of many species. In the present collection following two species were found, which may be distinguished as follows:

1. Polar thickening present …… *O. marssonii*
   Polar thickening absent ……..……. *O. borgei*

7. *O. borgei* J. Snow 1903: 379

References: Prescott, 1962: 243; Siddiqui & Faridi, 1964: 68; Prescott & Vinyard, 1965: 455; Ahmed *et al.,* 1983: 398; John *et al.,* 2005: 372.
General characters: Colony globose, 33-35 µm in diameter; cells usually occur several in a group, broadly oval in shape; 1-4 chloroplasts with one pyrenoid in each; cells are 12-13 µm broad and 14.0-16.5 µm long (Fig. 7).
Locality: Sialkot District: Ugokay Village (26-5-2004).
Geographical distribution: Previously reported from U.S.A. and Pakistan.
Remarks: It was collected from standing rain water mixed with *Hydrodictyon reticulatum* (Linnaeus) Lagerheim during spring.

8. *O. marssonii* Lemmermann 1898

Synonymy: *Oocystis crassa* var. *marsonii* (Lemmermann) Printz 1913.
References: Siddiqui & Faridi, 1964: 69; Smith & Bold, 1966: 39; John *et al.,* 2005: 374.
General characters: Cells oblong 6-7 µm broad and 11-15 µm long; polar thickening present; 1-2 chloroplast with one pyrenoid in each (Fig. 8).
Localities: Lahore District: fountain of Zoological Garden (4-8-2004); Sialkot District: Darganwali Village (27-5-2004).
Geographical distribution: Previously reported from England and Pakistan.
Remarks: Collection was made from fountain water pond mixed with *Phacus pyrum* (Ehrenberg) Stein and *Euglena minima* Francé during summer and rain water pond during spring.

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