

TAXONOMIC STUDY OF THE ORDER ULOTRICHALES (CHLOROPHYTA) FROM NORTH-EASTERN AREAS OF PAKISTAN

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Abstract

Thirteen species belonging to the genera *Binuclearia*, *Geminella*, *Heterothrichopsis*, *Ulothrix* and *Uronema* were collected from various freshwater habitats in Gujranwala, Jauharabad, Kasur, Lahore, Pasrur, Sheikhpura and Sialkot districts of the Punjab; Bahrain, Kalam and Utrod river in Swat (NWFP) and Neelum Valley of Azad Kashmir during March 2003-July 2005. They were taxonomically determined and have been described for the first time from these areas.

Introduction

Ulothrix, the typical genus of the order Ulotrichales was reported for the first time from Pakistan by Shameel (1963) and reaffirmed by Faridi (1971). Later on, a detailed taxonomic study of this genus was made from Swat (Shameel, 1978, 1984) and other areas of Pakistan (Faridi *et al.*, 1982). No investigation was ever made on the other genera of this order. A detailed taxonomic study was, therefore, carried out on all the genera of the order Ulotrichales collected from NWFP and the Punjab Province of Pakistan and certain areas of Azad Kashmir, which is presented herein.

Materials and Methods

Collections were made from various freshwater habitats in Gujranwala, Jauharabad, Kasur, Lahore, Pasrur, Sheikhpura and Sialkot districts of the Punjab; Bahrain, Kalam and Utrod River in Swat (NWFP) and Neelum Valley of Azad Kashmir during March 2003-July 2005. The collected material was taxonomically investigated as described earlier (Zarina *et al.*, 2005). Specimens were identified with the help of authentic literature (West, 1904; Heering, 1914; Tiffany & Britton, 1952; Mattox & Bold; Prescott, 1962; Ramanathan, 1964; Pankow, 1971; Abbott & Hollenberg, 1976; Shameel, 1978; Faridi *et al.*, 1982). The voucher specimens are kept in the Phycology & Phycochemistry Lab., MAH Qadri Biological Research Centre, University of Karachi, where the research work was carried out.

Results

Thirteen species of 5 genera belonging to the phylum Chlorophyta, class Ulvophyceae, order Ulotrichales, family Ulotrichaceae (*vide* Shameel, 2001) have been identified. Their taxonomic enumerations are given below:

Family Ulotrichaceae

It includes all the unbranched filamentous genera, in which the cells are uninucleate having a single girdle shaped chloroplast with the cell-wall not composed of overlapping H-pieces. Almost all of them are known to produce bi- or quadriflagellate zoospores. Sexual reproduction is known only in few genera, and in all cases it is isogamous with a union of biflagellate gametes. The present collection included the following 5 genera, which may be distinguished as follows:

1. Filaments in sheath, cells cylindrical *Geminella*
 Filaments without sheath, cells not cylindrical 2
2. Filaments not attached by holdfast *Heterothrichopsis*
 Filaments attached by a holdfast 3
3. Apical cell pointed *Uronema*
 Apical cell not pointed 4
4. Protoplast in one section *Ulothrix*
 Protoplast in two sections *Binuclearia*

Binuclearia Wittrock 1887: 4

It contains simple filamentous forms, consisting of simple cells united in linear series. There is no broad gelatinous sheath. When young the filaments are attached by a mucilaginous disc, the basal cell is not specialized but the terminal cell has a cellulose cap, other cells are cylindrical. Cell-wall is thick, lamellated; the transverse septa are stratified. The protoplast is concentrated in two small portions separated from each other. Each protoplast contains a nucleus and a laminate, girdle shaped chloroplast, shiny; volutin granules are present at the end of the protoplast. Chloroplast has one marginal pyrenoid, food reserves are starch and volutin. The transverse septa are thick and stratified in older cells, separating the protoplast. Vegetative reproduction is by fragmentation, asexual reproduction is by thick-walled akinetes or quadriflagellate zoospores formed singly in each cell. Only following species were collected:

1. *B. tectorum* (Kützing) Bererex ex Wichmann 1937 (Ramanathan, 1964: 60)

Basionym: *Gloetila tectorum* Kützing.

Morphological characters: Filaments uniseriate, unbranched, with cylindrical cells (Fig. 1).

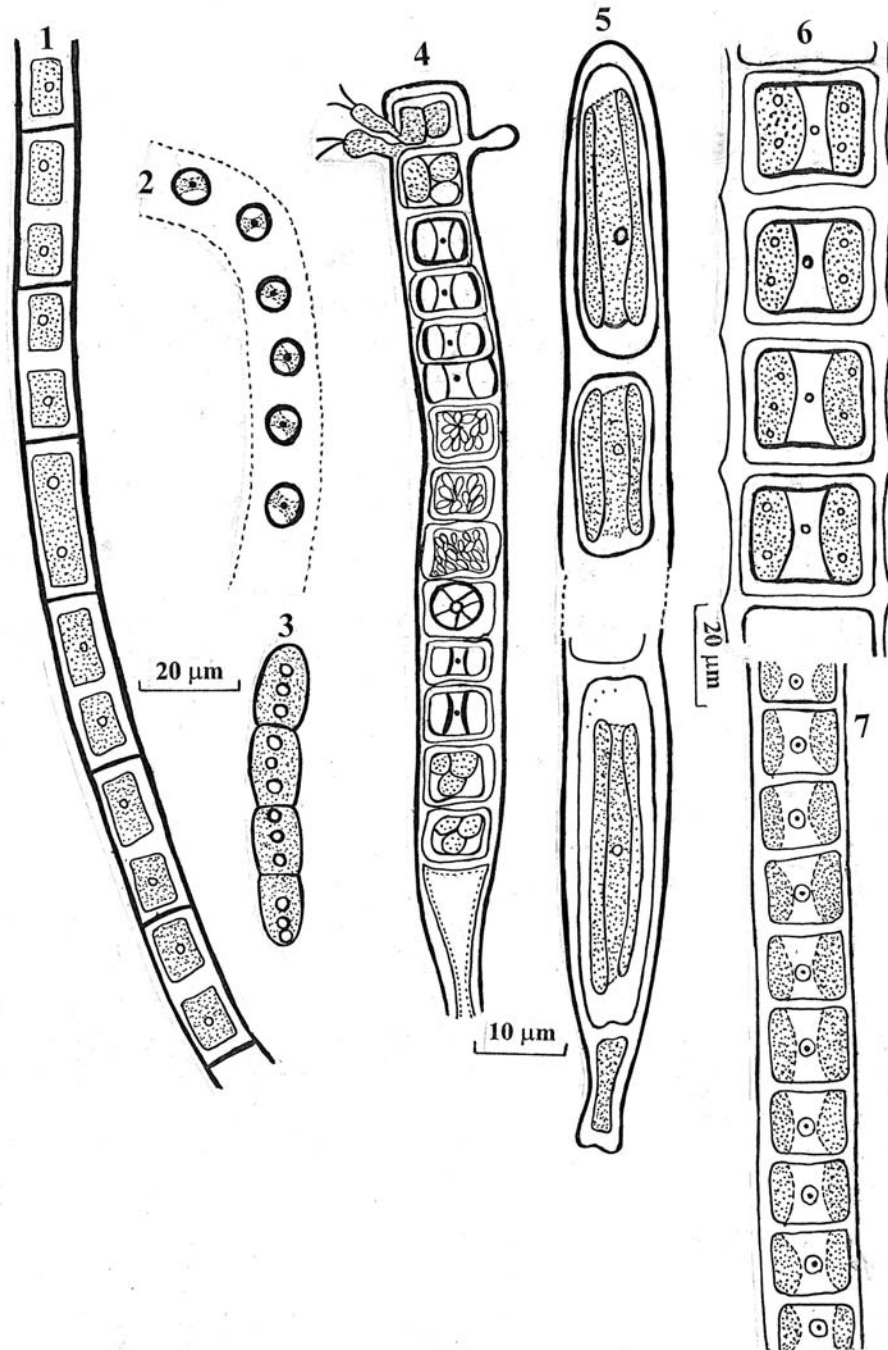
Cytological features: Cells 11-12 µm broad, 23-24 µm long; chloroplast parietal, plate like, with a conspicuous pyrenoid.

Reproductive structures: Reproduction by akinetes, quadriflagellate zoospores.

Locality: Lahore District: Dinanath (1-8-2004).

Geographical distribution: Previously recorded from India: Himalayas (Randhawa, 1948), Chennai (Iyengar, 1960).

Habitat: The collection was made from rice fields, where it occurred in freefloating state in massive quantity.



Figs. 1-7. Species of the Ulotrichales: 1. *Binuclearia tectorum*, 2. *Geminella ordinata*, 3. *Heterotrithopsis viridis*, 4. *Ulothrix aequalis*, 5. *U. cylindrica*, 6. *U. flacca*, 7. *U. moniliformis*.

***Geminella* Turpin 1828: 329 emend. Lagerheim 1883**

It comprises of uniseriate filaments, mostly free floating, rarely sessile. The filaments are enclosed by a mucilaginous envelope varying in its relative width, but always hyaline and homogenous. The cells are cylindrical, ellipsoidal or oblong, mostly separated by mucilage and scarcely adherent to each other. They contain a laminate chloroplast, partially filling the cell, pyrenoid may or may not be present. Reproduction is by fragmentation, aplanospores, akinetes, and sometimes swimmers are produced. Only following species could be collected:

2. *G. ordinata* (W. et G. S. West) Heering 1914: 14
(Prescott, 1962:101; Ramanathan, 1964: 65)

Basionym: *Hormospora ordinata* W. et West G. S. West.

Morphological characters: Unbranched filamentous algae, surrounded by a mucilaginous sheath (Fig. 2).

Cytological features: Cells arranged in a row with equidistant intervening spaces, inside a gelatinous sheath; cells 4-6 μm broad and 7-9 μm long; chloroplast parietal, laminate and have one pyrenoid.

Reproductive structures: Reproduction by fragmentation, aplanospores, akinetes.

Locality: Sheikhpura District: Sattarwala (15-5-2004).

Geographical distribution: Previously reported from Europe, Asia, America and South-Africa.

Habitat: The collections were obtained from stagnant water ponds.

***Heterothrichopsis* Iyengar et Kanthamma 1941: 105**

It includes unbranched filamentous forms made up of a few cells, placed in a row. Each cell contains a single nucleus and one or 2-4 parietal plate-like chloroplasts with one or more pyrenoids in each. In very young cell there is only one chloroplast, but as the cells become older the number of chloroplast increases to 2, 4 or 8. The cell-wall is thin and uniform, reproduction is by fragmentation. Asexual reproduction takes place by aplanospores, no zygospore or gamete has been observed. In the present collection only following species could be collected:

3. *H. viridis* Iyengar et Kanthamma 1941: 105
(Ramanathan, 1964: 97)

Synonym: *Ulotrichopsis viridis* Iyengar et Kanthama 1940: 167.

Morphological characters: Filaments unbranched and 4-celled (Fig. 3).

Cytological features: Cells 6-8 μm broad and 14-16 μm long; chloroplasts 2-4 with a pyrenoid in each.

Reproductive structures: Reproduction by aplanospores.

Locality: Sheikhpura District: Aliwala (30-8-2004).

Geographical distribution: Previously known from India.

Habitat: The specimens were collected from stagnant water channels.

***Ulothrix* Kützing 1833: 517**

It is made up of simple unbranched filaments of undefined length, special holdfast cells may be found at the base of filaments. Growth of filament diffused by cell division (holdfast does not divide). Chloroplast is single, girdle shaped, parietal band, partly or fully encircling the protoplast, pyrenoid one or more in each cell. A small nucleus is present, generally placed internally to the chloroplast. Vegetative multiplication is by fragmentation, asexual reproduction is by zoospores of two types *i.e.*, biflagellated microzoospores and quadriflagellated macrozoospores, which are formed in all cells except basal cells. Sexual reproduction is by isogamy. The following six species of this genus were collected, which may be distinguished as follows:

1. Each cell contains one pyrenoid 2
Each cell contains more than one pyrenoids 3
2. Cell-wall thick, without mucilage *U. aequalis*
Cell-wall thin and somewhat mucilaginous *U. tenerrima*
3. Cells contain 6 pyrenoids *U. flacca*
Cells contain less than 6 pyrenoids 4
4. Cells more than 11 μm in breadth *U. tenuissima*
Cells less than 11 μm in breadth 5
5. Cells 7-8 μm in breadth *U. cylindrica*
Cells 9-11 μm in breadth *U. moniliformis*

4. *U. aequalis* Kützing 1845: 197

(Heering, 1914: 35; Prescott, 1962: 96; Ramanathan, 1964: 36; Shameel, 1978: 380;
Faridi *et al.*, 1982: 182)

Morphological characters: Filament very long, composed of cylindrical cells (Fig. 4).

Cytological features: Cells cylindrical, 15-17 μm broad; cell-wall somewhat thickened; chloroplast broad, girdle shaped, covering more than half the wall surface; containing one pyrenoid.

Reproductive structures: Asexual reproduction by quadriflagellated macrozoospores and aplanospores, biflagellated or quadriflagellated microzoospores also present.

Locality: Lahore District: fountain of zoo (3-8-2003).

Geographical distribution: Previously reported from Europe, America, New Zealand and Asia.

Habitat: It was collected from fountain of zoo, where the temperature was 37.2 °C and pH about 7.5.

5. *U. cylindrica* Prescott 1944: 349

(Prescott, 1962: 96; Ramanathan, 1964: 36)

Morphological characters: Filaments unbranched, long, curved and lightly entangled (Fig. 5).

Cytological features: Cells elongate, cylindrical, 7-8 μm in width and 25-26 μm long; cell-wall thin and not constricted at joints; chloroplast a broad band nearly equal to the cell in length and covering $\frac{3}{4}$ of the wall circumference; pyrenoids 2-5.

Reproductive structures: Reproduction by fragmentation and zoospores.

Locality: Pasroor District: Mutaik-Raypootan Village (4-3-2003).

Geographical distribution: America, India (Ramanathan, 1964).

Habitat: It was collected from standing water.

6. *U. flacca* (Dillwyn) Thuret in Le Jolis 1863: 56
(Ramanathan, 1964: 43; Abbott & Hollenberg, 1976: 55)

Basionym: *Conferva flacca* Dillwyn 1805 [1802-1809].

Morphological characters: Filament bright to dark-green, entangled often in large skeins (Fig. 6).

Cytological features: Cells are cylindrical, 34-35 μm in diameter; each cell with six pyrenoids.

Reproductive structures: Reproduction by fragmentation and zoospores.

Locality: N.W.F.P.: Swat, Bahrain and Kalam (12-8-2003).

Type locality: Swansea, Glamorgan, Wales.

Geographical distribution: Previously reported from, Europe, Asia, Australia, New Zealand, America.

Habitat: Collected from slow running water.

7. *U. moniliformis* Kützing 1849
(Ramanathan, 1964: 40)

Morphological characters: Filaments light or yellow-green, clearly constricted at the cross walls (Fig.7).

Cytological features: Cells 9-11 μm broad and 12-14 μm long (cells 6-9 μm in diameter). Chloroplast on one side of the cell, rarely forming a girdle, usually with one or two but sometimes more pyrenoids.

Reproductive structures: Reproduction by akinets or by quadrifagellate zoospores.

Localities: Kasur District: 23 km away from Kasur (15-6-2005), Sheikhpura District: near Sheikhanwala (30-8-2003).

Geographical distribution: Cosmopolitan in distribution: previously reported from USA, Europe, Africa, India, New Zealand.

Habitat: The specimens were collected from roadside puddles.

8. *U. tenerrima* (Kützing) Kützing 1843
(Heering, 1914: 32; Tiffany & Britton, 1952: 26; Prescott, 1962: 96; Ramanathan, 1964: 37; Pankow, 1971: 76; Shameel, 1978: 382; Faridi *et al.*, 1982: 186)

Basionym: *Conferva tenerrima* Kützing 1833.

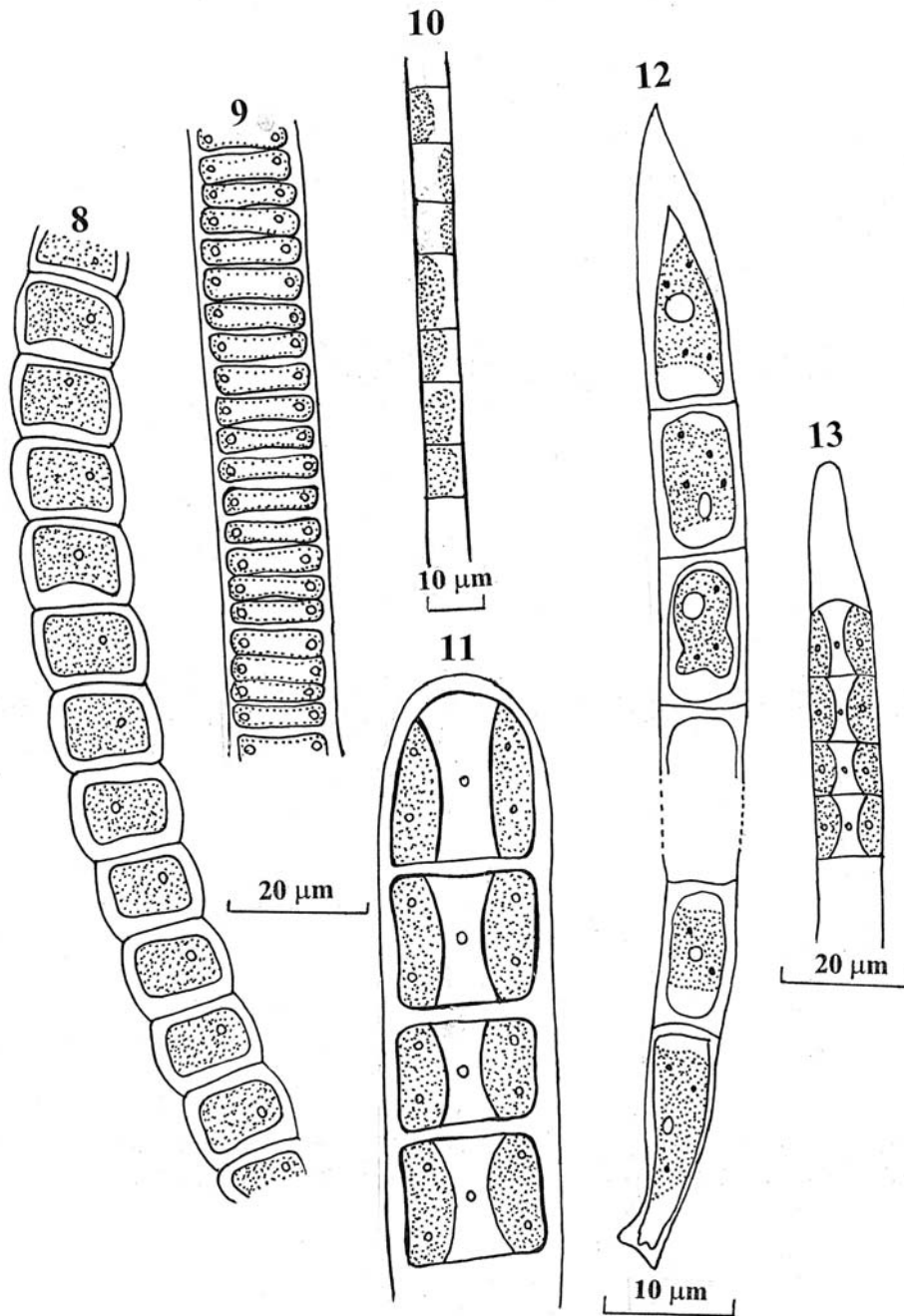
Morphological characters: Filaments attached or free floating, mucilaginous (Fig. 8).

Cytological features: Cells 8.0-9.5 μm broad and 4.0-5.5 μm long; cell-wall thin, somewhat mucilaginous; chloroplast girdle shaped, encircling more than half the width of the cell, with one pyrenoid.

Reproductive structures: Reproduction by fragmentation and zoospores.

Localities: Gujranwala District: Nandipur (7-12-2003); Jauharabad District:(25-4-2004); Lahore District: Hunjarwala field (16-8-2004), near Wahga Boarder (25-12-2004); Sheikhpura District: Mureedke and Narang Mundi (12-9-2004).

Geographical distribution: Previously reported from Europe, America, New Zealand, Central India (Ramanathan, 1964), Srilanka, Myanmar and also from Lahore (Randhawa, 1948).



Figs. 8-13. Species of the Ulotrichales: 8. *Ulothrix tenerrima*, 9. *U. tenuissima*, 10. *U. variabilis*, 11. *U. zonata*, 12. *Uronema confervicolum*, 13. *U. gigas*.

Habitat: It occurred in canal side ponds and stagnant water pools.

Remarks: It was collected from five different places of the Punjab during spring, summer and winter. Slight morphological changes like size differences were observed in the specimens obtained from different places due to various ecological conditions. The massive growth of this species was found in rice fields.

9. *U. tenussima* Kützing 1833: 517

(Heering, 1914: 32; Prescott, 1962: 97; Ramanathan, 1964: 34; Shameel, 1978: 381; Faridi *et al.*, 1982: 186)

Morphological characters: Filament long, composed of cylindrical cells (Fig. 9).

Cytological features: Cells mostly 16-18 μm in breadth, 3-5 μm in length and 14-30 μm thick; chloroplast a broad band with two or more pyrenoids.

Reproductive structures: Zoospores formed in somewhat swollen cells.

Localities: Lahore District: fountain of zoo (3-8-2004); Sheikhpura District: near Sheikhanwala (28-2-2004); Azad Kashmir: Neelum Valley (15-12-2004).

Geographical distribution: Previously reported from Europe, America, New Zealand, India, Myanmar, Pakistan.

Remarks: The collection work was carried out during beginning to the late summer from three different places. During early summer it was collected from cold water ponds, and in late summer it was obtained from fountain water locality and from road side puddles.

10. *U. variabilis* (Kützing) Kützing 1849: 349

(Tiffany & Britton, 1952: 26; Prescott, 1962: 97; Ramanathan, 1964: 39; Faridi *et al.*, 1981: 156, 1982: 187; Anjum *et al.*, 1982: 108)

Basionym: *Hormidium variabile* Kützing.

Morphological characters: Filaments long, slender and entangled, forming cottony masses rarely with a pointed basal cell (Fig. 10).

Cytological features: Cells 7 μm broad, 10-12 μm longer, cylindrical; chloroplast a parietal folded plate, not filling more than half the circumference of the cell, appearing as a plate covering one side of the cell.

Reproductive structures: Reproductive organs were not observed.

Locality: Lahore District: Punjab University, old campus (16-12-2004).

Geographical distribution: Worldwide: Europe, Africa, America, Asia.

Habitat: Patches of soil with algal growth have been collected, as it occurred on wet soil surface in massive quantity. It was in soil binding habitat.

11. *U. zonata* (Weber et Mohr) Kützing 1833: 251

(Børgesen, 1901: 245; Heering, 1914: 35; Tiffany & Britton, 1952: 26; Prescott, 1962: 97; Ramanathan, 1964: 30; Pankow, 1971: 75; Shameel, 1978: 378; 1984: 275; Faridi *et al.*, 1982: 182)

Basionym: *Conferva zonata* Weber et Mohr 1804.

Synonym: *Ulothrix shameelii* Faridi in Faridi *et al.*, 1982: 184.

Morphological characters: Filament long, stout, variable in diameter, attached in earlier stages, later free with cylindrical cell (Fig. 11).

Cytological features: Cells varying in width and length, length generally smaller than width, cell 27-48 μm broad and 30-53 μm long; chloroplast band shaped, broad, covering

only the median region of the cell and containing more than one pyrenoids, often several; end cell rounded.

Reproductive structures: In the present collection reproductive structures were not seen.

Localities: Gujranwala District: Nandipur (19-2-2004), N.W.F.P.: Swat, Utrod River (19-2-2004); Azad Kashmir: Neelam Valley (15-12-2004).

Geographical distribution: Worldwide occurrence, previously recorded from various parts of India: Mumbai, Assam, Bengal and Pakistan: Swat.

Habitat: Collections were made along the canal side ponds and slow running water of river.

Remarks: Specimens of the present collection differed in the structure of their apical cell and holdfast from *Ulothrix zonata* var. *faridii* (= *Ulothrix shameelii*), which was described earlier from Swat (Shameel, 1978, 1984; Faridi *et al.*, 1982)

***Uronema* Lagerheim 1887: 517**

The characteristic feature of this genus is the terminal cell of the filaments which is often tapering to an acuminate tip. It comprises of simple, unbranched filaments, mostly attached by a narrow basal cell or disc. The following two species of this genus were collected, which may be distinguished as follows:

1. Cells less than 12 μm broad, 1-3 pyrenoids *U. confervicolum*
Cells more than 12 μm broad, 2-3 pyrenoids *U. gigas*

12. *U. confervicolum* Lagerheim 1887: 518

(West, 1904: 80; Mattox & Bold, 1962: 29; Ramanathan, 1964: 50;
Faridi *et al.*, 1982: 183)

Synonym: *Ulothrix confervicola* (Lagerheim) Mattox *et* Bold 1962: 29.

Morphological characters: Filaments many celled, straight, long, attached by a disc formed by basal cell (Fig. 12).

Cytological features: Cells 4-8 μm broad and 5.6-21.0 μm long; basal cell 5-6 μm broad, 15-16 μm long; terminal cell pointed, 15-20 μm long; cells cylindrical; chloroplast extending the full length of the cell, parietal, encircling the protoplast and containing 1-3 pyrenoids.

Reproductive structures: Aplanospores and zoospores not observed.

Locality: Sialkot District: Darganwali Village (25-6-2005).

Geographical distribution: Previously reported from America, Europe, Africa and India (Ramanathan, 1964).

Habitat: It was collected being attached at the margins of puddles mixed with *Microspora tumidula* Hazen.

13. *U. gigas* Vischer 1933

(Ramanathan, 1964: 53)

Morphological characters: Filaments a few mm long, unbranched, constricted at intervals (Fig. 13).

Cytological features: Cells 13-14 μm broad and 10-11 μm long; pyrenoids 2-3 in each cell; terminal cell elongated.

Locality: N.W.F.P.: Swat, Kalam, Utrod River (13-8-2004).

Geographical distribution: Previously reported from Europe: Switzerland.

Habitat: Collection work was carried out from the river side.

Discussion

Taxonomy of the order Ulotrichales is in a chaotic condition. Contrary to the classical view, Forest (1945) amalgamated the genera *Chlorohormidium*, *Stichococcus* and *Uronema* with *Ulothrix*. Mattox & Bold (1962) put *Ulothrix* and *Uronema* together but retained others as separate genera, and this view was later supported by Faridi *et al.*, (1982). In his synoptical study on Ulotrichales, Ramanathan (1964) followed the classical view and maintained all the genera as separate entities. *Chlorohormidium* may be distinguished from other genera by lacking a pronounced holdfast and producing biflagellate zoospores (Fott, 1960) similarly *Stichococcus* is also easily distinguishable from other genera (Faridi *et al.*, 1982). *Uronema* has pointed apical end, while *Ulothrix* possesses an apical cell with prominently broad end. Therefore, in the present investigation the classical view has been followed.

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