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TAXONOMIC STUDIES OF THE CLASS ZYGNEMOPHYCEAE SHAMEEL FROM NORTH-EASTERN AREAS OF PAKISTAN

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Abstract

Five species of the algal genera, *Hallasia* Rosenvinge and *Mougeotia* C. A. Agardh have been collected from various freshwater habitats of Kasur, Lahore, Sargodha and Sialkot districts of Punjab Province of Pakistan and Neelum Valley of Azad Kashmir during March and October 2004 and taxonomically investigated. Although, all the species have been described for the first time from their area of collection, most of them are first reports from Pakistan. They were mostly found in spring.

Introduction

Constitution of the phylum Chlorophyta is undergoing rapid changes with the advancement of knowledge. Recently a new classification of algae has been proposed, in which the unicellular and colonial green algae were separated from Chlorophyta and placed under a new phylum Volvocophyta (Shameel, 2001). According to the new concept the filamentous genera of the phylum Chlorophyta showing peculiarities either in the form of cell-division by cap-cell formation or in sexual reproduction by conjugation have been placed under the class Zygnemophyceae (Shameel, 2006). A large survey was started in 2003 to collect algae from various freshwater habitats of the unexplored north-eastern areas of Pakistan and Azad Kashmir, which are difficult to reach. From this collection, several species belonging to the class Zygnemophyceae have been taxonomically described for the first time (Zarina *et al.*, 2006a, b; 2007a, b). The present investigation is a continuation of these studies, which presents a taxonomic description of five species for the first time from their area of collection.

Materials and Methods

Collections were made from Kasur, Lahore, Sargodha and Sialkot districts of Punjab Province of Pakistan and Neelum Valley of Azad Kashmir during March and October 2004. The specimens were obtained by hand-picking from various freshwater habitats like fountain water, running water channels, stagnant ponds and road-side puddles. They were preserved in glass bottles containing 5 % formalin and brought to the laboratory at Karachi, where they were stained in iodine solution and examined in 10 % glycerin mounts under microscope (Zeiss, Germany). Their drawings were made with the help of camera lucida as described earlier (Zarina *et al.*, 2005). The material was taxonomically determined with the help of authentic literature (West, 1904; Czurda, 1932; Rao, 1937; Transeau, 1951; Randhawa, 1959; Prescott, 1962; John *et al.*, 2005). The voucher specimens are kept in the Phycology & Phycochemistry Lab., (Room No. 18), MAH Qadri Biological Research Centre, University of Karachi, where this research work was carried out.

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Results and Discussion

On the basis of their morphological and cytological characteristics, the following 5 genera were identified which may be distinguished as follows:

1. Chloroplasts ribbon like ..... *Spirogyra*
   Chloroplasts otherwise 2
2. Chloroplasts many, 2-7 ..... *Hallasia*
   Chloroplast only 1 or 2 3
3. Chloroplast one, axial plate ..... *Mougeotia*
   Chloroplasts two, stellate 4
4. Zygospores mostly spherical ..... *Zygnema*
   Zygospores quadrate ..... *Zygnemopsis*

The genera, *Spirogyra* Link along with its 42 species, *Zygnema* C. A. Agardh with its 10 species and *Zygnemopsis* with its 6 species have already been described previously (Zarina *et al*., 2006b, 2007b, 2008). The other 2 genera and their species are being described below.

Hallasia Rosenvinge 1924: 212

Unbranched filaments, cells longer than broad, stellate chloroplasts up to 7, aplanospores ellipsoid. Its following species was collected:

1. *H. reticulata* Rosenvinge 1924: 209

References: Transeau, 1951: 61; Randhawa, 1959: 186.
Morphological characters: Unbranched filaments.
Cytological features: Vegetative cells 18-20 μm broad and 35-100 μm long (Fig. 1a), 2-7 stellate chloroplasts in each cell.
Reproductive structures: Reproduction by aplanospores only, aplanospores ellipsoid up to 35 μm in diameter and 60 μm long (Fig. 1b); median spore-wall yellow, scrobiculate or irregularly reticulate; sporogenous cells longer than broad, length up to 240 μm.
Locality: Lahore District: Minar-e-Pakistan (21-3-2004).
Geographical distribution: Previously reported from Denmark: Copenhagen.
Remarks: Specimens were collected from fountain of the historical place at the beginning of spring in free-floating state. It was found in vegetative condition as well as in reproductive state. It is being reported for the first time from Pakistan.

Mougeotia C. A. Agardh 1824: 35

Filaments unbranched, consisting of cylindrical cells; cells many time longer than broad, with plane end walls; chloroplast a flat axial plate with the nucleus apposed to the cell-wall, where two chloroplasts occur in each cell the nucleus situated in between the chloroplasts; pyrenoids arranged in one or many rows; reproduction by zygospores, while in some by aplanospores; conjugation largely scalariform, rarely lateral and isogamous; conjugation canal bulges and gametangia cut off by one or two walls; zygospores

spheroid, ovoid, ellipsoid, doliform or quadrato-ovoid. The following four species were collected, which may be distinguished as follows:

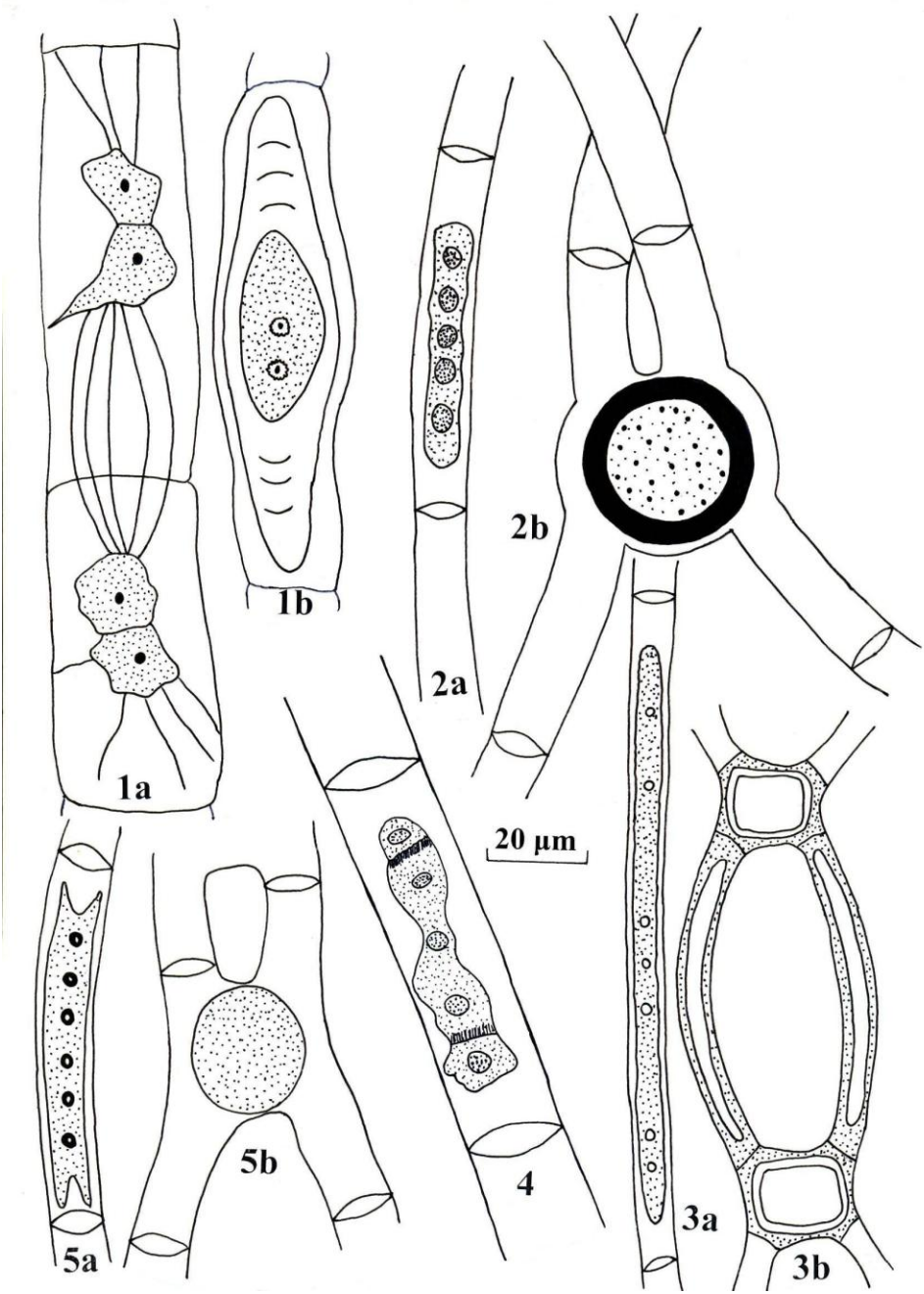
1. Vegetative cells more than 22 µm broad ..…… *M. genuflexa (4)*
   Vegetative cells up to 22 µm broad ...……. 2
2. Vegetative cells more than 120 µm long …….…… *M. elegantula (3)*
   Vegetative cells up to 120 µm long .……... 3
3. Zygospores globose ……..…….. *M. calcarea (2)*
   Zygospores ovoid to sub-globose ...……... *M. sphaerocarpa (5)*

2. *M. calcarea* (Cleve) Wittrock 1872: 40

Basionym: *Sphaerospermum calcarea* Cleve 1868.
References: West, 1904: 121; Czurda, 1932: 63; Rao, 1937: 285; Transeau, 1951: 90; Randhawa, 1959: 123; Prescott, 1962: 300; John *et al.*, 2005: 484.
Morphological characters: Filaments 13-14 µm broad.
Cytological features: Vegetative cells 57-109 µm long; chloroplasts with 4-5 pyrenoids in a single row (Fig. 2a); cells elongating and becoming geniculate before spore formation.
Reproductive structures: Conjugation scalariform; zygospores globose, 28-29 µm in diameter, formed in the conjugating tube and extending in both gametangia (Fig. 2b); spore wall smooth, colorless; aplanospores not observed.
Locality: Sargodha District: Sargodha (12-4-2004).
Geographical distribution: Previously reported from India, Brazil, Greenland, Canada and U.S.A.: Michigan.
Remarks: Specimens were collected near Sargodha City during spring. They were found in free-floating condition, in vegetative as well as reproductive states. This species is also being reported for the first time from Pakistan.

3. *M. elegantula* Wittrock 1872: 40

References: West, 1904: 121; Czurda, 1932: 88; Transeau, 1951: 108; Randhawa, 1959: 156; Prescott, 1962: 301; Biswas, 1975: 572; Masud-ul-Hasan, 1978: 81; Masud-ul-Hasan & Yunus, 1989: 112; John *et al.*, 2005: 484.
Morphological characters: Filaments very slender, becoming geniculate in conjugation.
Cytological features: Vegetative cells 4-6 µm broad and 140-143 µm long (Fig. 3a); chloroplast with 4-8 pyrenoids in a row.
Reproductive structures: Conjugating cells geniculate; conjugation scalariform, dividing both gametangia; zygospores quadrate, 16-18 µm broad and 16-18 µm long, with rounded corner (Fig. 3b); spore-wall hyaline and smooth.
Locality: Sialkot District: Head Marala (7-7-2004).
Geographical distribution: U. S. A., Europe, China, India and Pakistan.
Remarks: The collection work was carried out during summer. The specimens were found in stagnant water channels, in mixed and attached condition with submerged grasses. They occurred in vegetative as well as reproductive stages. The temperature, locality and pH of water were favourable for their growth.



Figs. 1-5. Species of Zygnemophyceae from Pakistan: 1. *Hallasia reticulata*: 1a. vegetative cell, 1b. aplanospore formation; 2. *Mougeotia calcarea*: 2a. vegetative cell, 2b. zygospore formation; 3. *M. elegantula*: 3a. vegetative cell, 3b; scalariform conjugation; 4. *M. genuflexa*: vegetative cell, 5. *M. sphaerocarpa*: 5a. vegetative cell, 5b. zygospore formation.

4. *M. genuflexa* (Dillwyn) C.A. Agardh 1824: 83

Basionym: *Conferva genuflexa* Dillwyn.
References: West, 1904: 122; Czurda, 1932: 94; Transeau, 1951: 94; Randhawa, 1959: 132; Prescott, 1962: 301; John *et al.*, 2005: 487.
Morphological characters: Filaments slender.
Cytological features: Vegetative cells 33-53 μm broad and 84-86 μm long (Fig. 4), often geniculate and attached to other similar cells, forming extensive nets; sometimes with rhizoidal branches.
Reproductive structures: Conjugation stage was not found in the present material.
Locality: Lahore District: Mari Village (29-10-2004).
Geographical distribution: Europe, China (Kiangni), Manchuria, Morocco.
Remarks: The collection was made in the autumn season from a village, which was totally a cultivated area. During this season rich growth of algae occurred as compared to other seasons, as heavy rainfall took place. This species was found in free-floating state in stagnant water pools. It is being reported for the first time from Pakistan.

5. *M. sphaerocarpa* Wolle 1887: 227

References: Czurda, 1932: 68; Rao, 1937: 287; Transeau, 1951: 92; Randhawa, 1959: 129; Prescott, 1962: 305.
Morphological characters: Unbranched filaments.
Cytological features: Vegetative cells 18-22 μm broad and 60-120 μm long (Fig. 5a); chloroplast plate like; pyrenoids 4-7 in a regular row.
Reproductive structures: Conjugation scalariform; zygospores formed in greatly enlarged conjugating tube and extending somewhat into both gametangia; zygospores ovoid to sub-globose, 38-40 μm broad and 44-46 μm long (Fig. 5b).
Localities: Kasur District: Kot Mela Ram (8-10-2004); Azad Kashmir: Neelum Valley (6-4-2004).
Geographical distribution: U.S.A., China, India.
Remarks: Specimens were collected from two different places in different seasons. During autumn it occurred in massive quantity in planktonic form. It was raining heavily during this time and many stagnant ponds were formed which provided favourable condition for its growth, as compared to those found during spring. This species is also being reported for the first time from Pakistan.

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