Pak. J. Bot., 39(5): 1797-1805, 2007.

OCCURRENCE OF THE FAMILY PINNULARIACEAE (BACILLARIOPHYTA) IN VARIOUS DISTRICTS OF THE PUNJAB, PAKISTAN

SYED TARIQ-ALI[1], A. ZARINA[1], MASUD-UL-HASAN[2] AND MUSTAFA SHAMEEL[3]

[1]Department of Botany, Federal Urdu University of Arts, Sciences & Technology, Gulshan-e-Iqbal Campus Karachi, Karachi 75300;
[2]Department of Botany, Govt. College University, Kachehri Road, Lahore-54000;
[3]Department of Botany, University of Karachi, Karachi-75270, Pakistan.

Abstract

Eleven species of 6 diatomaceous genera such as *Amphora, Caloneis, Gyrosigma, Mastogloia, Neidium* and *Stauroneis* belonging to the family Pinnulariaceae of the order Bacillriales, class Bacillariophyceae were collected from Gujranwala, Kasur, Lahore, Sialkot districts of the Punjab Province of Pakistan during January-December 2004. They were taxonomically determined and have been described for the first time from their area of collection. *Calonies lanceolata, C. silicula* and *Stauroneis minor* are being reported for the first time from Pakistan.

Introduction

A survey for the collection of diatoms from various districts of the north-eastern areas of Pakistan was started in March 2003. Some of the collected genera such as *Cymbella* C. A. Agardh, *Navicula* Bory *emend*. Cleve and *Nitzchia* Hassall were taxonomically determined and described (Tariq-Ali *et al.*, 2006a, b, c). In this connection a detailed taxonomic study of the genus *Pinnularia* (Ehrenberg) Ehrenberg belonging to the family Pinnulariaceae was also carried out (Tariq-Ali *et al.*, 2006d). In the meantime 6 more genera of this family were collected and investigated. The present paper is a continuation of this investigation.

Materials and Methods

The water samples were collected from various freshwater habitats at Gujranwala, Kasur, Lahore and Sialkot districts of the Punjab Province during January and December 2004. The diatoms were picked up with the help of a dropper from the samples, carefully washed, preserved in plastic bottles containing 3 % formalin and brought to the laboratory. For investigation, the specimens were mounted in 10 % glycerine and examined under stereo-microscope as described earlier (Tariq-Ali *et al.*, 2006c, d). Identification of the specimens down to the species level was carried out with the help of authenthic literature (Cleve, 1894, 1895; West, 1904; Østrup, 1908; Hustedt, 1930; Kolbe & Krieger, 1942; Salim & Khan, 1960; Giffen, 1963, 1966; Hirano, 1964; Starmach, 1964; Fijerdingstad, 1965; Foerster & Schlichting Jr., 1965; Gerloff & Lüdemann, 1966; Schoemann, 1969; Cholnoky, 1970; Biswas, 1975; Nizamuddin, 1984). Drawings were made with the help of camera lucida. The voucher specimens are kept in the Phycology & Phycochemistry Lab. (Room No. 18), MAH Qadri Biological Research Centre, University of Karachi, where this study was conducted.

Results and Discussion

On the basis of their morphological and cytological characteristics, the following 11 species belonging to 6 different genera of the family Pinnulariaceae (order Bacillariales, class Bacillariophyceae, phylum Bacillariophyta; *fide* Shameel (2001). were identified and taxonomically described.

Family Pinnulariaceae

Frustules solitary and free-floating; girdle linear, rectangular or broadly elliptical; valve linear or lanceolate, sublunate; raphe straight, arcuate, with central and polar nodules; striae transverse, punctate, parallel or radiate; chromatophores two or more with pyrenoids. The following 7 genera of this family have been collected, which may be distinguished as follows:

1. Frustules asymmetrical ……..…….. *Amphora*
   Frustules symmetrical ..…… 2
2. Lateral valve-marking strongly oblique, forming a stauros ….…….. *Stauroneis*
   Lateral valve-marking otherwise ..……..... 3
3. Valve gibbous in the middle ……. *Pinnularia*
   Valve not gibbous in the middle …….…… 4
4. Valve convex ……... 5
   Valve linear …….…….. 6
5. Striae crossed by one or more longitudinal lines ...……..... *Caloneis*
   Striae in two sets crossing one another at right angles …… *Gyrosigma*
6. Valvocopulae with partecta present …….. *Mastogloia*
   No such structures present ……..……..... *Neidium*

The genus *Pinnularia* (Ehrenberg) Ehrenberg along with its 8 species *viz*., *P. appendiculata* (C. A. Agardh) Cleve, *P. gibba* Ehrenberg, *P. gracilens* J. Frenguelli, *P. karelica* Cleve, *P. major* (Kützing) Cleve, *P. nobilis* Ehrenberg, *P. stauroptera* (Grunow) Rabenhorst and *P. sudetica* (Hilse) Hilse has already been described previously (Tariq-Ali *et al.*, 2006d). The other genera and their species are being described below.

***Amphora* Ehrenberg 1840 *ex* Kützing 1844: 11**

Frustules asymmetrical, solitary and free floating; girdle broadly elliptical with tunicate ends; valve sublunate; dorsal side convex, ventral side concave; end acute or obtuse; raphe arcuate, near the ventral valve face; striae punctate, radiate, delicate; chromatophores split up into many granules. The following two species have been collected, which may be distinguished as follows:

1. Valve convex ..…… *A. coffeaeformis (1)*
   Valve lunate ..……..… *A. ovalis (2)*

1. *A. coffeaeformis* (C. A. Agardh 1827) Kützing 1844: 108

References: Hustedt, 1930: 345; Kolbe & Krieger, 1942: 349; Starmach, 1964: 426; Gerloff & Lüdemann, 1966: 108; Schoeman, 1969: 37; Nizamuddin, 1984: 20; Daudpota & Leghari, 1993: 122; Leghari & Sultana, 1993: 15; Jahangir *et al*., 2000: 1967; Leghari & Leghari, 2002: 183.
Basionym: *Frustulia coffeaeformis* C. A. Agardh 1827.
Synonymy: *Amphora aponina* Kützing 1844.
General characters: Frustules elliptic lanceolate; valve convex on the dorsal side and nearly straight on the ventral side; length 26-30 µm and breadth 8-10 µm (Fig. 1).
Cytological features: Chromatophores split up into many granules.
Locality: Kasur District: Pandoki (22-12-2004).
Geographical distribution: Poland, Libya, South Africa, Kurdistan.
Remarks: The specimens were collected during winter from village Pandoki. Sexual reproduction was not observed. The material was obtained in vegetative form.

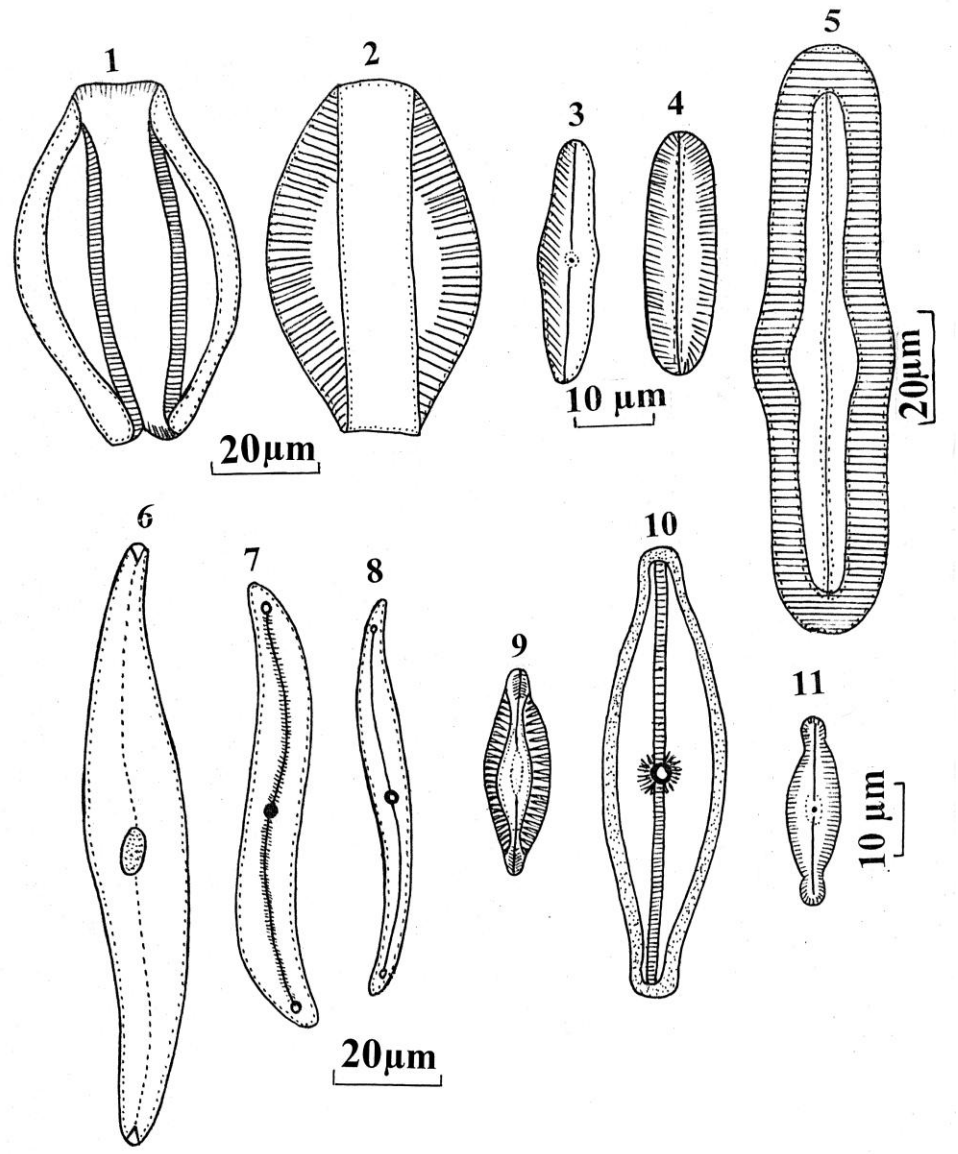
2. *A. ovalis* (Kützing 1844) Kützing 1844: 107

References: Cleve, 1895: 104; Østrup, 1908: 275; Hustedt, 1930: 293; Kolbe & Krieger, 1942: 349; Salim & Khan, 1960: 47; Hirano, 1964: 196; Starmach, 1964: 422; Fjerdingstad, 1965: 568; Foerster & Schlichting Jr., 1965: 490; Gerloff & Lüdemann, 1966: 107; Giffen, 1966: 253; Cholnoky, 1970: 7; Nizamuddin, 1984: 23; Sultana *et al*., 1991:70; Leghari & Sultana, 1993: 15; Jahangir *et al*., 2000: 1967; Leghari & Leghari, 2002: 183; Leghari *et al*., 2002: 78, 2004: 41, 2005a: 156.
Basionym: *Amphora affinis* Kützing 1844.
Synonymy: *Amphora lybica* Ehrenberg, *Navicula amphora* Ehrenberg 1832.
General characters: Frustules solitary, gridle elliptical with tunicate apices; valve lunate; raphe curved; straie finely punctate, row of short straie near the ventral surface; length 20-30 µm and breadth 12-17 µm; striae 9-12 within 10 µm (Fig. 2).
Cytological features: Chromatophores split up into many granules.
Locality: Kasur District: Pandoki (22-12-2004).
Geographical distribution: India, Afghanistan, Libya, South Africa, Ontario (Canada), Poland, Faeröes (Denmark).
Remarks: These specimens were also collected during winter from village Pandoki, mixed with *A. coffeaeformis* (Agardh) Kützing. This material was also obtained in the vegetative form only.

Caloneis Cleve 1891 *in* Cleve *et* Grove 1894: 46

Valve convex, linear or lanceolate in general outline; with transverse, smooth or finely punctate striae, crossed by one or more longitudinal lines; endochrome of two chromatophores lying one on each valve entire in some species deeply cleft in others. The following three species were collected, which may be distinguished as follows:

1. Valve more than 36 µm long ..…… *C. lanceolata (3)*
   Valve less than 36 µm long .....……. 2
2. Valve linear with rounded ends ……..…….... *C. lepidiformis (4)*
   Valve linear with sub-cuneate ends ..……...……..… *C. silicula (5)*



Figs. 1-11. Algal species of the family Pinnulariaceae from Punjab: 1. *Amphora coffeaeformis*, 2. *A. ovalis*, 3. *Caloneis lanceolata*, 4. *C. lepidiformis*, 5. *C. silicula*, 6. *Gyrosigma acuminatum*, 7. *G. scalproides*, 8. *G. tenuissimum*, 9. *Mastogloia smithii*, 10. *Neidium affine*, 11. *Stauroneis minor*.

3. *C. lanceolata* Østrup

Reference: Hirano, 1964: 189.
General characters: Valve length 36-42 µm and breadth 6-8 µm; costae 14 within 12 µm (Fig. 3).

Cytological features: Two chromatophores lying one in each valve.
Locality: Gujranwala District: Harrar (11-12-2004).
Geographical distribution: Europe, Afghanistan.
Remarks: The specimens were collected during winter from roadside ponds near Harrar. Sexual reproduction was not observed and the material was obtained in vegetative form. This species is being reported for the first time from Pakistan.

4. *C. lepidiformis*

Reference: Husna *et al.,* 2007: 58.
General characters: Valve linear with rounded ends; length 10 μm and breadth 4 μm; raphe straight and hair like; central pores moderately separate, axial, very narrow, linear, no central area; striae slightly radiate, about 30 within 10 μm; crossed by a longitudinal line near the margin (Fig. 4).
Cytological features: Two chromatophores lying one in each valve.
Locality: Lahore District: Shalimar Garden (28-6-2004).
Geographical distribution: Pakistan.
Remarks: The material was obtained during summer from fountain water of Shalimar Garden. Sexual reproduction was not observed in them. The specimens were collected in the vegetative form only.

5. *C. silicula* (Ehrenberg) Cleve 1894

References: Cleve, 1894: 51; Østrup, 1908: 261; Hustedt, 1930: 236; Kolbe & Krieger, 1942: 344; Salim & Khan, 1960: 26; Hirano, 1964: 189; Starmach, 1964: 408; Schoeman, 1969: 38; Cholnoky, 1970: 10; Biswas, 1975: 574; Husna *et al.*, 2007: 58.
Synonymy: *Caloneis ventricosa* (Ehrenberg) F. Meister 1912
General characters: Valve linear, gibbous in the middle, with broad sub-cuneate ends; axial area narrow, central area rounded; longitudinal line marginal; striae parallel or nearly so, 10 to 18 within 10 μm (Fig. 5).
Cytological features: Two chromatophores lying one in each valve.
Locality: Lahore District: Shalimar Garden (24-4-2004).
Geographical distribution: Kurdistan, Afghanistan, France, Poland, Faeröes (Denmark), South Africa, USA.
Remarks: The specimens were collected during spring from fountain of Shalimar Garden. Sexual reproduction was not observed. The material was obtained in vegetative form. This species is being reported for the first time from Pakistan.

Gyrosigma* Hassall 1845: 435, *nom. cons.

Frustules solitary and free-floating, lanceolate; girdle straight and linear, oblong; valve convex, sigmoid, gradually attenuated towards acute or broadly rounded poles; striae in two delicate sets crossing one another at right angles; median line (raphe) with curvature; central and polar nodules present; chromatophores two or more, elongated with irregular outline and lie on opposite sides of the girdle. Its following three species were present in the collected material, which may be distinguished as follows:

1. Valves more than 100 µm long ...……..... *G. acuminatum (6)*
   Valves less than 100 µm long ..…… 2
2. End of valves rounded ..……..……... *G. scalproides (7)*
   End of valves acute ..…… *G. tenuissimum (8)*

6. *G. acuminatum* (Kützing) Rabenhorst 1853: 47

References: Østrup, 1908: 262; Kolbe & Krieger, 1942: 344; Salim & Khan, 1960: 38; Hirano, 1964: 189; Starmach, 1964: 412; Foerster & Schlichting Jr., 1965: 491; Nizamuddin, 1984: 60; Masud-ul-Hasan & Yunus, 1989: 121; Daudpota & Leghari, 1993: 122; Leghari & Leghari, 2002: 183; Shahida *et al*., 2006: 180.
General characters: Frustules solitary, valve slightly sigmoid, gradually tapering from the middle towards obtuse ends; flexure considerable, striae not distinct; median line and central nodules clear; length 120-138 µm, breadth in the middle 15-19 µm and at the ends 4-6 µm (Fig. 6).
Cytological features: Chromatophores two or more, elongated with irregular outline.
Localities: Kasur District: Kasur (22-12-2004); Gujranwala District: Chandala, Kamonkey (10-12-2004).
Geographical distribution: Afghanistan, Kurdistan, India, Libya, Ontario (Canada), Poland, Faeröes (Denmark).
Remarks: The material was obtained from stagnant pond of Kasur and from a road side puddle of Chandala, Kamonkey during winter season. Sexual reproduction was not observed in them. The specimens were collected in vegetative form only.

7. *G. scalproides* (Rabenhorst) Cleve

References: Kolbe & Krieger, 1942: 344; Salim & Khan, 1960: 38; Starmach, 1964: 416; Masud-ul-Hasan & Yunus, 1989: 121; Jahangir *et al*., 2000: 1967; Leghari & Leghari, 2002: 183; Leghari *et al*., 2005: 170; Leghari *et al*., 2004: 42; Shahida *et al.*, 2006: 180.
General characters: Frustules solitary, valve sigmoid, linear; ends rounded, a little oblique, median line nearly straight; central nodule large and conspicuous; valves 54-70 µm in length and 11 µm in breadth (Fig. 7).
Cytological features: Chromatophores two or more, elongated with irregular outline.
Locality: Gujranwala District: Chak Pello, Kamonkey (11-12-2004).
Geographical distribution: Kurdistan, Poland.
Remarks: The specimens were collected during winter from a roadside pond of Chak Pello, Kamonkey. Sexual reproduction was not observed. The material was obtained in vegetative form only.

8. *G. tenuissimum* (W. Smith 1853) Griffith *et* Henfreyh 1856

References: Salim & Khan, 1960: 39; Giffen, 1963: 232, 1966: 262.
Basionym: *Pleurosigma tenuissimum* W. Smith 1853.
General characters: Frustules solitary; valve sigmoid, linear, lanceolate, very narrow; apices acute, striae not visible; length 81-83 µm and breadth 5-7 µm (Fig. 8).

Cytological features: Chromatophores two or more, elongated with irregular outline.
Localities: Lahore District: Shalimar Garden (23-1-2004); Jhang District: Riwaz Bridge, Chund (25-1-2004).
Geographical distribution: South Africa, Pakistan.
Remarks: The material was obtained during winter season from Shalimar Garden and from riverside puddles near Riwaz Bridge, Chund. Sexual reproduction was not observed in them. The material was obtained in vegetative form.

***Mastogloia* Thwaites *ex* W. Smith 1856: 63**

Frustules biraphid, symmetrical to the apical and tarnsapical axes, elliptical to lanceolate in outline; apices rounded to capitate; valvocopulae with partecta or chambers; raphe straight, striae distinctly punctuate; axial area narrow, central area slightly expanded. This genus is distinguishable by the valvocopulae having partecta. The present collection included the following species only.

9. *M. smithii* Thwaites *ex* W. Smith 1856: 65

References: West, 1904: 297; Østrup, 1908: 276; Kolbe & Krieger, 1942: 344; Hirano, 1964: 188; Starmach, 1964: 258; Nizamuddin, 1984: 68; Daudpota & Leghari, 1993: 122; Leghari & Sultana, 1993: 16; Leghari *et al*., 1995: 12.
General characters: Valves 33-40 μm in length and 10.8-12.0 μm in breadth (Fig. 9).
Cytological features: Chromatophores two with pyrenoids.
Locality: Kasur District: Kahna Now (23-12-2004).
Geographical distribution: Afghanistan, Kurdistan, Libya, Poland, Faeröes (Denmark).
Remarks: The specimens were collected during winter from village Kahna Now. Sexual reproduction was not observed, and the material was obtained in vegetative form only.

***Neidium* Pfitzer 1871**

Valve linear or lanceolate; medium fissures turned in opposite direction, terminal fissures appearing bifurcate; striae transverse, usually oblique, finely punctate, crossed by one or several longitudinal blank lines; chromatophores two, lying on the girdle side, in cell-division each forming a partially divided pair; a large pyrenoid may be found in the middle of each chromatophore. Only following species of this genus was collected.

10. *N. affine* (Ehrenberg 1843) Pfitzer 1871

References: Østrup, 1908: 261, Starmach, 1964: 390; Schoeman, 1969: 58; Biswas, 1975: 581; Husna *et al.*, 2007: 60.
Basionym: *Navicula affinis* Ehrenberg 1843.
General characters: Striae 14 within 10 μm; puncta oblique in the middle, convergent at the ends, 15 within 10 μm; length 238 μm (Fig. 10).
Cytological features: Chromatophores two, lying on the girdle side; a large pyrenoid found in the middle of each chromatophore.
Locality: Lahore District: Shalimar Garden (29-8-2004).
Geographical distribution: USA, South Africa, Poland, Faeröes (Denmark).

Remarks: The material was obtained during summer from the fountain water of Shalimar Garden. Sexual reproduction was not observed in them. The material was obtained in vegetative form only.

***Stauroneis* Ehrenberg 1843: 422**

Lateral valve marking strongly oblique, interrupted in the mid region by an undecorated area over the central nodule which extends to the margins of the valve (forming a stauros). Only following species of this genus was found in the present collection.

11. *S. minor* (E. V. Østrup) A. Cleve-Euler

Reference: Hirano, 1964: 188.
General characters: Length of cell 39-40 μm and breadth 10.2-10.5 μm; central area a distinct stauros; striae distinctly punctate (Fig. 11).
Cytological features: Chromatophores long.
Locality: Lahore District: Manawan (18-9-2004).
Geographical distribution: Afghanistan.
Remarks: The specimens were collected during autumn from a pond in Manawan. Sexual reproduction was not observed, and the material was obtained in vegetative form. This species is being reported for the first time from Pakistan.

References

Biswas, S. 1975. Freshwater algae of new Borough Warren Dune Area. *Nova Hedw.*, 24: 561-589.
Cholnoky, B.J. 1970. Hydrobiologische Untersuchungen in Transvaal-III. Die Fishteiche von Marble Hall. *Bot. Mar.*, 13: 5-44.
Cleve, P.T. 1894. Synopsis of the naviculoid diatoms-I. *Kongl. Svensk. Vet.-Akad. Handl.*, 26: 1-194.
Cleve, P.T. 1895. Synopsis of the naviculoid diatoms-II. *Kongl. Svensk Vet.- Akad. Handl.*, 27: 1-129.
Daudpota, N. and M.K. Leghari. 1993. Some diatoms from Kinjhar Lake (Sindh) Pakistan. *Biologia*, 39: 121-126.
Fjerdingstad, E. 1965. Taxonomy and saprobic valency of benthic phytomicro-organisms. *Int. Rev. ges. Hydrobiol.*, 50: 475-604.
Foerster, J.W. and H.E. Schlichting Jr. 1965. Phycoperiphyton in an oligotrophic lake. *Trans. Amer. Microscop. Soc.*, 84:
Gerloff, J. and D. Lüdemann. 1966. *Leitfaden der Trink- und Brauch-wasserbiologie*. 2nd ed., Gustav Fischer Verlag, Stuttgart, 360 pp.
Giffen, M.H. 1963. Contribution to the diatom flora of South Africa. I. Diatoms of the estuaries of the eastern Cape Province. *Hydrobiol.*, 21:201-265.
Giffen, M.H. 1966. Contribution to the diatom flora of South Africa. III. Diatoms of the marine littoral regions at Kidd's Beach near east London, Cape Province, South Africa. *Nova Hedw.*, 13: 245-292+5 pls.
Hirano, M. 1964. Freshwater algae of Afgahanistan. *In*: *Plants of West Pakistan and Afghanistan*. (Ed.): S. Kitamura, Kyoto Univ., Japan, p. 167-245.
Husna, R., A. Zarina, Masud-ul-Hasan and M. Shameel. 2007. Taxonomic study of some diatoms from Lahore, Pakistan. *Int. J. Phycol. Phycochem.*, 3: 55-64.
Hustedt, F. 1930. Bacillariophyta. In: *Süßwasserflora*. (Ed.): A. Pascher. 10: 1-466.

Jahangir, T.M., M.Y. Khuhawar, S.M. Leghari, W.A. Balouch, A.A. Leghari and A. Leghari. 2000. Some studies on water quality and biological life at Kinjhar and Haleji lakes of district Thatta, Sindh, Pakistan. *Pak. J. Biol. Sci.*, 3: 1965-1972.

Kolbe, R.W. and W. Krieger. 1942. Süßwasseralgen aus Mesopotanien und Kurdistan. *Ber. Deutsch. Bot. Gesel.*, 60: 336-355 + pl 1.

Leghari, M.K. and M.Y. Leghari. 2002. Comparative ecological study of phytoplankton of Bakar and Phoosna lakes-Pakistan. *Pak. J. Sci. Ind. Res.*, 45: 182-190.

Leghari, M.K. and K. Sultana. 1993. A list of diatoms of Malka Parbat: Kaghan, Pakistan. *In*: *Cryptogamic Flora of Pakistan*. (Eds.): T. Nakaike & S. Malik. Vol. 2, Nat. Sci. Museum, Tokyo. p. 13-18.

Leghari, M.K., K. Sultana and M. Haga. 1995. Diatoms from unexplored Diamer face of Nanga Parbat Part I. *Biologia*, 41: 11-12.

Leghari, M.K., M.Y. Leghari and M. Shah. 2002. Ecological study of algal flora of Korang Nalla of Rawal Dam, Islamabad. *Biologia*, 48: 65-80.

Leghari, M.K., M.Y. Leghari and S.M. Leghari. 2004. Water chemistry and its relation with algae of Rawal Dam, Islamabad and Wah Garden, district Attock. *Sindh Univ. Res. J.*, (Sci. Ser.), 36: 29-48.

Leghari, S.M., M.Y. Khuhawar, T.M. Jahangir and A. Abdullah. 2005a. Limnological study of Pir Bukhari (Karsaz) and Manghopir warm springs, Karachi, Sindh, Pakistan. *Int. J. Phycol. Phycochem.*, 1: 151-158.

Leghari, S.M., M.Y. Khuhawar, T.M. Jahangir and A. Leghari. 2005b. Some studies on Toung natural springs of Thana Bula Khan, district Dadu, Sindh, Pakistan. *Int. J. Phycol. Phycochem.*, 1: 167-172.

Masud-ul-Hasan and A. Yunus. 1989. An addition to the algal flora of Lahore. *Biologia*, 35: 99-131.

Nizamuddin, M. 1984. *Diatoms of Libya*. Dept. of Botany, Univ. Al-Fateh, Tripoli, 144 pp.

Østrup, E. 1908. Freshwater diatoms. *In*: *Botany of the Faeröes Based Upon Danish Investigations.* (Ed.): E. Warming, Gyldendalske Boghandel, Nordisk Forlag, Copenhagen p. 260-290.

Salim, K.M. and M.H. Khan. 1960. *The Diatomales: The Fresh Water Diatoms of Peshawar Valley*. Dept. of Botany, Peshawar Univ., Peshawar, 66 pp +11 pls.

Schoeman, F.R. 1969. Diatoms from the Orange Free State (South Africa) and Lesotho. N0. 2, *Revist. Biol.*, 7: 35-74.

Shahida, B., A. Zarina, Masud-ul-Hasan and M. Shameel. 2006. Taxonomic study of some Volvocophyta Shameel and Bacillariophyta from Rabwah and Sargodha, Pakistan. *Int. J. Phycol. Phycochem.*, 2: 173-182.

Shameel, M. 2001. An approach to the classification of algae in the new millennium. *Pak. J. Mar. Biol.*, 7: 233-250.

Starmach, K. 1964. *Flora Slodkowodna Polski*, 6. *Chrysophyta, II. Bacillariophyceae-Okrzemki*. Panstwowe Wydawnictwo Naukowe, 610 pp.

Sultana, K., M.K. Leghari, B. Inam and F. Bano. 1991. Some diatoms of Bogharmung Valley, Dadar-III. *Biologia*, 37: 69-72.

Tariq-Ali, S., A. Zarina, Masud-ul-Hasan and M. Shameel. 2006a. Taxonomic studies on *Cymbella* (Bacillariophyta) from Punjab and Azad Kashmir. *Pak. J. Bot.*, 38: 161-167.

Tariq-Ali, S., A. Zarina, Masud-ul-Hasan and M. Shameel. 2006b. Taxonomic studies of *Navicula* (Bacillariophyta) from certain areas of the Punjab, Pakistan. *Pak. J. Bot.*, 38: 435-441.

Tariq-Ali, S., A. Zarina, Masud-ul-Hasan and M. Shameel. 2006c. Taxonomic studies on *Nitzschia* (Bacillariophyta) from Kasur and Lahore districts of Pakistan. *Proc. Pak. Acad. Sci.*, 43: 151-155.

Tariq-Ali, S., A. Zarina, Masud-ul-Hasan and M. Shameel. 2006d. Diversity of *Pinnularia* (Bacillariophyta) in the north-eastern areas of Pakistan. *Pak. J. Bot.*, 38: 1249-1255.

West, G. S. 1904. *A Treatise on the British Freshwater Algae*. Camb. Univ. Press, Cambridge, 372 pp.

(Received for publication 13 April 2007)