

## TAXONOMIC STUDY OF BACILLARIOPHYTA FROM KALLAR KAHAR LAKE CHAKWAL, PUNJAB, PAKISTAN

MUBASHRAH MUNIR<sup>1</sup>, RAHMATULLAH QURESHI<sup>1,2</sup> MUHAMMAD ARSHAD<sup>1</sup>,  
ABDUL KHALIQ CHAUDHRY<sup>2</sup> AND M.K. LAGHARI<sup>3</sup>

<sup>1</sup>Department of Botany, Pir Mehr Ali Arid Agriculture University, Murree Road Rawalpindi, Pakistan.

<sup>2</sup>Department of Forestry & Range Management, Pir Mehr Ali Arid Agriculture University,  
Murree Road Rawalpindi, Pakistan, <sup>3</sup>Pakistan Museum of Natural History, Islamabad, Pakistan

\*Corresponding author: rahmatullahq@yahoo.com

### Abstract

The present paper reports taxonomic enumeration of Bacillariophyta, a diatomic group from Kallar Kahar Lake, Salt Range, Pakistan. A total of 35 species distributed in two orders, 7 families and 15 genera have been reported for the first time from the study area. Of them, 16 species viz., *Cyclotella gamma*, *Cymbella minuta* var. *silesiaca*, *Gomphonema clavatum*, *Gomphonema gracile*, *Gomphonema affine*, *Mastogloia elliptica*, *Mastogloia smithii* var. *smithii*, *Navicula symmetrica*, *Navicula schroeteri*, *Navicula kotschyi*, *Navicula veneta*, *Navicula duerrenbergiana*, *Navicula pseudolanceolata* var. *denselineolata*, *Navicula cryptotenella*, *Fragilaria famelica*, *Fragilaria microcephala* are new record from Pakistan. Besides, 6 species namely *Achnanthes minutissima*, *Cymbella laevis* var. *laevis*, *Gomphonema angustatum*, *Gyrosigma spencerii*, *Navicula gregaria*, *Campylodiscus bicostatus* are documented as addition to the Punjab Province, Pakistan.

### Introduction

The Kallar Kahar Lake is declared as Game Reserve located in North Central part of Pakistan (Scot, 1986; Rais *et al.*, 2011). The main source of water is freshwater springs appear from the base of hills around the lake and rain water. However, this water turns brackish due to accumulation of salts from catchment hilly areas. Even, since last few years the change in the rain fall pattern posed serious effects on water level of the lake. Moreover the spring water was used to irrigate the *Eriobotrya japonica*, a natural orchard growing on nearby mountains towards the south-west, south and south eastern sides of lake. This activity along with high evapotranspiration further reduces average water depth during summer.

A few studies were carried out reporting diatomic flora of Indo-Pak subcontinent. Carter (1926) added 49 species in the existing diatomic floral record, followed by Abdul-Majeed (1935) reporting 62 species of diatoms from Lahore District. Sarim & Khan (1960) accomplished detailed work on diatom algal flora of Peshawar Valley of Pakistan. After that, a few species of diatoms were described from Punjab, N.W.F.P (presently Khyber Pakhtunkhwa) and Azad Kashmir (Masud-ul-Hasan & Zeb-un-Nisa, 1986; Masud-ul-Hasan & Batool, 1987; Masud-ul-Hasan & Yunus, 1989; Leghari *et al.*, 2004). Moreover, diatoms of Gujarnwala, Kasur, Lahore, Sheikhpura, Sargodah, Attock, Multan, Lahore and Khyber Pakhtunkhwa were described (Tariq-Ali *et al.*, 2006a, b, c, d; 2007, 2008a, b; Shahnaz *et al.*, 2010; Ghazala *et al.*, 2011). Since no work has been reported earlier on the algal flora from Kallar Kahar Lake; therefore, there was worthwhile to record the algal flora of the study area and this paper reports diversity of pennate and centric diatoms from the study area.

### Key to orders

- 1a. Ornamentation about a central point; raphe or pseudoraphe none; cells immobile, often with spine-like, mammillate or long horn-like projection ..... order Biddulphiales
- 1b. Ornamentation bilateral with respect to a median longitudinal line, not radiating from a central point; pseudoraphe or raphe present; cells with raphe mobile ..... order Bacillariales

### Materials and Methods

Algal samples were collected from lake with the help of phytoplankton net, knife, glass slides and crushing epiphytic algae in plastic bags containing water. The samples were transferred to collection bottles and immediately preserved with 4% formalin. One drop from each sample was taken with the help of small pipette and was placed on the glass slide. A cover slip was kept on the slide and observed under the research quality Leica DMLB microscope®. The objectives 10x, 20x, 40x and 100x were used for the enlargement of image of the specimen. Various forms of algae were identified using floristic literature (Hustedt, 1930; Tiffany & Britton, 1971; Patrick & Reimer, 1966; Krammer & Lange-Bertalot, 1997; Hofmann *et al.*, 2011).

### Results and Discussion

Taxonomic evaluation of the collected material indicated the presence of 35 species of diatoms belonging to 15 genera of the class Bacillariophyceae. 16 species viz., *Cyclotella gamma*, *Cymbella minuta* var. *silesiaca*, *Gomphonema clavatum*, *Gomphonema gracile*, *Gomphonema affine*, *Mastogloia elliptica*, *Mastogloia smithii* var. *smithii*, *Navicula symmetrica*, *Navicula schroeteri*, *Navicula kotschyi*, *Navicula veneta*, *Navicula duerrenbergiana*, *Navicula pseudolanceolata* var. *denselineolata*, *Navicula cryptotenella*, *Fragilaria famelica*, *Fragilaria microcephala* were recorded as new to Pakistan. Besides, 6 species such as *Achnanthes minutissima*, *Cymbella laevis* var. *laevis*, *Gomphonema angustatum*, *Gyrosigma spencerii*, *Navicula gregaria*, *Campylodiscus bicostatus* were found addition to the Punjab Province, Pakistan. All species were systematically arranged according to the classification proposed by Shameel (2001). Their taxonomic descriptions are as follows:

**Order Biddulphiales: (Centric)****Family: Coscinodiscaceae****1. *Cyclotella* Kutzing 1834****Key to species**

- 1a. Striae straight ..... 1. *C. meneghiniana*  
 1b. Striae Undulating ..... 2. *C. gamma*

**1. *C. meneghiniana* Kutzing 1844**, Krammer and Lange-Bertalot, 1997, Fig. 1

**Synonym:** *Surirella melosiroides* Meneghini; *Cyclotella operculata*  $\beta$  *rectangula* Kutzing 1849; *Cyclotella rectangular* Brebisson ex Rabenhorst 1853; *Cyclotella zingiana* Thwaites 1848; *Cyclotella meneghiniana* var. *vogesiaca* Grunow in Van Heurck 1882; *Cyclotella meneghiniana* var. *binotata* Grunow in Van Heurck 1882; *Cyclotella meneghiniana* var. *plana* Fricke 1900; *Cyclotella meneghiniana* fo. *plana* (Fricke) Hustedt 1928; *Cyclotella laevisissima* van Goor 1920; *Cyclotella meneghiniana* var. *laevisissima* (van Goor) Hustedt 1928.

**References:** Sarim, 2005:135; Leghari *et al.*, 2007:33.

**General characters:** Cells diameter 12.9  $\mu$ m; radial striae 8 /10  $\mu$ m; smooth central area or radially punctate and with large isolated punctae; broad outer zone.

**Distribution:** Britain, Iceland, Florida, Iran, Israel and Azad Kashmir, Pakistan: Bara River.

**2. *C. gamma* Skvortsov 1963**, Krammer and Lange-Bertalot, 1997, Fig. 2

**General characters:** Cells diameter 31.9  $\mu$ m; radial striae 9/ 10  $\mu$ m; striae show undulation.

**Distribution:** Europe.

**Order: Bacillariales (Pennate)****Key to the families**

- 1a. Single chromatophore:  
 2a. Valves symmetric in both axes or only longitudinally ..... 1. Surirelliaceae  
 2b. Valves asymmetric in both axes:  
 3a. Solitary or free floating, or attached, sessile or within gelatinous tubes .....2. Cymbellaceae  
 3b. Rarely solitary, usually epiphytic or sessile:  
 4a. Valve rectangular .....3. Epithemiaceae  
 4b. Valve straight, lanceolate or club shaped, with one pole broader than the other or capitate .....4. Gomphonemaceae  
 1b. Two or numerous chromatophores:  
 5a. Dissimilar valves, convex epivalve and usually concave hypovalve.....5. Achnantheaceae  
 5b. Valves generally symmetric in both axes:  
 6a. Monoraphid.....6. Fragilariaceae  
 6b. Biraphid.....7. Naviculaceae

**Family: Achnantheaceae****Key to the genera**

- 1a. Cells somewhat rectangular and longitudinal bent or curved in girdle view, valves generally linear-lanceolate ..... 1. *Achnanthes*  
 1b. Cells solitary, epiphytic transversely curved in girdle view, valves generally Elliptic ..... 2. *Cocconeis*

**2. *Achnanthes* Bory 1822**

**1. *A. minutissima* (Kutz.) Cleve, 1833:578**, Tiffany & Britton (1971), Fig. 3

**Synonym:** *Achnanthes minutissima* (Kutz.)1833:578

**References:** Leghari *et al.*, 1999:167; Leghari *et al.*, 2001:634; Leghari *et al.*, 2004:5; Zaman & Hussain, 2006:81; Leghari *et al.*, 2006:99; Leghari *et al.*, 2006:175; Leghari *et al.*, 2006:133; Leghari *et al.*, 2009:160.

**General characters:** Cells 2-4  $\mu$ m in width and 5-40  $\mu$ m in length.; valves linear-elliptic, slightly narrowed to rounded poles.; transverse striations 33-35 in 10  $\mu$ m; hypovalve with delicate thread like raphe, central area

small; epivalve with very narrow pseudo raphe, central area absent.

**Distribution:** USA, Pakistan: Sanghar, Islamabad, Kunhar River, Kurang River, Sindh (Bakar Lake) and Peshawar.

**3. *Cocconeis* Ehrenberg 1835; Grunow 1868**

**1. *C. placentula* Ehrenberg 1838: 194**, Patrick and Reimer (1966), Fig. 4

**Homotypic synonyms:** *Cocconeis pediculus* var. *placentula* (Ehrenberg) Grunow 1867, *Cocconeis communis* var. *placentula* (Ehrenberg) O.Kirchner 1878,

*Cocconeis communis* f. *placentula* (Ehrenberg) Chmielewski 1885.

**References:** Hirano, 1964:186; Leghari *et al.*, 2001:634; Marshall & Burchardt, 2004:275; Leghari *et al.*, 2004:5 Zaman & Hussain, 2006:81; Leghari *et al.*, 2006:99; Leghari *et al.*, 2006:133; Ashraf *et al.*, 2008:53; Tariq-Ali, 2008:120.

**General characters:** Flat or slightly curved cells, 10-37 µm in length and 15-56 µm in breadth; valves elliptic, striae transverse, more or less radial, 23-25- µm/10 µm; hypovalve have straight raphe and inter-marginal hyaline ring, central area round, small; epivalve with linear pseudoraphe.

**Distribution:** Britain, Denmark, Finland, Germany, Iceland, Netherlands, Romania, Spain, Sweden, Turkey, Canary Islands, United States of America, Pakistan (Lahore, Islamabad, Peshawar, Kunhar River), Azad Kashmir.

#### Family: Cymbellaceae

#### Key to the genera

- 1a. 1a. intercalary band absent,, axial field wide or narrow, near the concave side of valve ..... 1. *Amphora*  
1b. 1b. intercalary band present, axial field strongly excentric, near the ventral margin ..... 2. *Cymbella*

#### 5. *Amphora* Ehrenberg 1840

**1. *A. coffeaeformis* Agardh. 1844: 108**, Hustedt (1930), Fig. 6

**Basionym:** *Frustulia coffeaeformis* C. A. Agardh 1827.

**Synonymy:** *Amphora aponina* Kützing 1844.

**References:** Hustedt, 1930: 345; 349; Starmach, 1964: 426; Gerloff & Ludemann, 1966: 108; Schoeman, 1969: 37; Nizamuddin, 1984: 20; Daudpota & Leghari, 1993:

#### Family: Epithemiaceae

#### 4. *Epithema* Brebisson 1838

**1. *E. adnata* (Kützing) Brebisson 1838** Krammer & Lange-Bertalot, 1997, Fig. 5

**Synonym:** *Epithemia zebra* (Ehrenberg) Kützing 1844; *Frustulia adnata* Kützing 1838; *Eunotia zebra* (Ehrenberg 1838) Ehrenberg 1838; *Epithemia kurzeana* Rabenhorst Alg. Sachsens 1848-1860.

**References:** Leghari, & Akhtar, 2006: 99

**General characters:** Cells length 51.4 µm, diameter 9.3µm; striae 14/10 µm; dorsal side convex, ventral side concave; ends capitate; constricted below the poles; costae present.

**Distribution:** Pakistan (Kurang River, Tarbela Dam).

122; Leghari *et al.*, 1999:161; Leghari & Sultana, 1993: 15; Jahangir *et al.*, 2000: 1967; Leghari & Leghari, 2002: 183, Leghari *et al.*, 2007: 33; Tariq-Ali, 2007: 1799; Aliya *et al.*, 2009:868.

**General characters:** Cells length 20-50µm, 10-18µm breadth,

**Distribution:** Azad Kashmir, Pakistan (Karachi, Thatta, Kasur and Pandoki).

#### 6. *Cymbella* C.A. Agardh

#### Key to the species

- 1a. Cells length 20-70µm, breadth 7-16µm ..... 1. *C. affinis*  
1b. Cells length less than 20µm, breadth 5-12µm:  
2a. Striae 11-13 in 10µm ..... 2. *C. minuta*  
2b. Striae 12 in 10µm or more:  
3a. Raphe broad –lateral ..... 3. *Cymbella laevis*  
3b. Raphe excentric ..... 4. *Cymbella tumida*

**1. *C. affinis* Kutz. 1844: 80**, Hustedt (1930), Fig. 7

**References:** Ostrup, 1908: 266; Starmach, 1964: 448; Hirano, 1964:197; Hirano, 1966: 29; Nizamuddin, 1984: 44; Masud-ul-Hasan & Zeb-un-Nisa, 1986: 244; Masud-ul-Hasan & Yunus, 1989: 122; Tariq-Ali, 2006:162.

**General characters:** Length 20-70µm, breadth 7-16µm; valves asymmetric, semilanceolate to semielliptic, convex dorsally, concave to straight ventrally; poles rostrate or rounded; raphe excentric; axial area narrow, slightly medianly widened, with ventral median striae ending in an isolated dot; striae 9-12 in 10µm, radiate.

**Distribution:** Azad Kashmir: Chenari, Pakistan: Quetta, Lahore, Attock, Afghanistan, Libya, Poland, Faeroes (Denmark).

**2. *C. minuta* var. *Silesiaca* ( Bleisch ex Rabh.) Reim. comb. nov., 1864: 1802**, Patrick and Reimer (1966), Fig. 8

**Synonym:** *Cymbella ventricosa* var. *Silesiaca* ( Bleisch ex Rabh.) Cl.-Eul *et al.*, 1955: 124.

**General characters:** Cell length 18-40µm, breadth 7-9µm; striae 11-13 in 10µm; valves strongly dorsi-ventral; axial area narrow, linear, ventrally displaced and almost parallel to the ventral margin.

**Distribution:** USA

**3. *C. laevis* Naeg. ex Kutz. var. *laevis* 1849:58**, Patrick and Reimer (1966), Fig. 9

**References:** Leghari *et al.*, 2001:634; Ashraf *et al.*, 2008:182.

**General characters:** Cell length 20-35 µm, breadth 6-10 µm; striae 12 in 10µm, radiate; valves moderately to strongly dorsi-ventral, poles bluntly rounded, axial area linear, raphe broad –lateral.

**Distribution:** USA, Azad Kashmir, Pakistan: Kunhar River.

**4. *C. tumida* (Brebisson) Van. Heurck 1880**, Hustedt (1930), Fig. 10

**Synonym:** *Cocconema tumidum* Breb. ex Kutz., 1849: 60, *Cymbella stomatophora* Grun., *Cymbella tumida* (Breb. ex Kutz.) V. H.1880.

**References:** Sarim & Khan, 1960: 89; Starmach, 1964: 453; Hirano, 1964:201; Leghari *et al.*, 1999:167; Jahangir *et al.*, 2000: 1967; Leghari *et al.*, 2003: 711; Leghari *et al.*, 2006: 175; Tariq-Ali,2006:166; Leghari *et al.*, 2009:160.

**General characters:** Cells breadth 15-23  $\mu\text{m}$ , length 40-105  $\mu\text{m}$ ; valve asymmetric and curved, broadly naviculoid, with rostrate poles, convex dorsal sides and straight or slightly convex ventral sides; transverse striations 8-10 in 10  $\mu\text{m}$  radial, punctate.

**Distribution:** Lahore, Peshawar, Attock, Quetta, Islamabad, and Thatta (Pakistan).

#### Family: Gomphonemaceae

#### 7. *Gomphonema* Agardh 1824

##### Key to the species

- 1a. Valve spindle shape .....1. *G. clavatum*  
 1b. Valve linear-lanceolate .....2. *G. gracile*  
 2a. Axial area linear .....3. *G. affine*  
 2b. Axial area narrow.....4. *G. angustatum*

**1. *G. clavatum* Ehrenberg 1832**, Krammer & Lange-Bertalot, 1997, Fig. 11

**Synonym:** *Gomphonema longiceps* Ehrenberg; *Gomphonema mustela* Ehrenberg 1954; *Gomphonema montanum* Schumann 1867; *Gomphonema subclanvatum* (Grunow) Grunow in Van Heurck 1885; *Gomphonema commutatum* in Van Heurck 1880

**General characters:** Length of cell 42.7  $\mu\text{m}$ , diameter 9.2  $\mu\text{m}$ ; striae 10 /10  $\mu\text{m}$ , radiate, punctate; valve spindle shape; axial area linear, central area variable.

**Distribution:** South America, Europe, Australia and New Zealand, Asia (Iran).

**Distribution:** America, Europe, Australia and New Zealand, Asia (Singapore and China).

**3. *G. affine* Kutzing 1844**, Krammer & Lange-Bertalot, 1997, Fig. 13

**Synonym:** *Gomphonema lanceolatum* sensu Hustedt (*et al.*) non Ehrenberg1843 nec Agardh1830; *Gomphonema magnificum* Gandhi 1960

**General characters:** Length of cell 33.3  $\mu\text{m}$ , diameter 8  $\mu\text{m}$ ; striae 11 /10  $\mu\text{m}$ , radial; axial area linear.

**Distribution:** South America, Europe, Australia and New Zealand and Asia (Turkey).

**2. *G. gracile* Ehrenberg 1838**, Krammer & Lange-Bertalot, 1997, Fig. 12

**Synonym:** *Gomphonema lanceolatum* Ehrenberg 1841; *Gomphonema grunowii* Patrick 1975

**General characters:** Length of cell 46.3  $\mu\text{m}$ , diameter 8.3  $\mu\text{m}$ ; striae 11 /10  $\mu\text{m}$  in the middle part and 13 /10  $\mu\text{m}$  towards the ends; valve linear-lanceolate with blunt round ends; axial area broad, central area with a dot toward one side.

**4. *G. angustatum* C.Agardh 1831: 33**, Sabater *et al.*, 1990, Fig. 14

**References:** Zaman & Hussain 2006: 81.

**General characters:** Length of cell 24.4  $\mu\text{m}$ , diameter 6.6  $\mu\text{m}$ ; striae 10 /10  $\mu\text{m}$ , radial; nearly symmetrical, with round, constricted ends; central area broad, axial area narrow.

**Distribution:** Arctic, North America, Europe, Australia and New Zealand and Asia: Iran, China, Singapore, Pakistan: Peshawar.

#### Family: Naviculaceae

##### Key to the genera

- 1a. Raphe sigmoid ..... 1. *Gyrosigma*  
 1b. Raphe not sigmoid:  
 2a. Valve with internal septa present, each with a central oval chamber..... 2. *Mastogloia*  
 2b. Valve without intercalary bands, poles capitate, rounded or rostrate.....3. *Navicula*  
 3a. Two longitudinal incised chromatophores.....4. *Neidium*  
 3b. Single laminate chromatophores with irregular margin.....5. *Rhopalodia*

#### 8. *Gyrosigma* Hassall 1845; emend. Cleve 1894

**1. *G. spencerii* (Quekett) Griffith & Henfrey 1856**, Krammer & Lange-Bertalot, 1997), Fig. 15

**Synonym:** *Navicula spencerii* Quekett 1848; *Pleurosigma kutzingii* Grunow 1860; *Pleurosigma*

*spencerii* var. *kutzingii* (Grunow) Grunow 1880; *Gyrosigma kutzingii* (Grunow) Cleve 1894

**References:** Zaman & Hussain 2006: 81; Ashraf *et al.*, 2008:182.

**General characters:** Cells length 120  $\mu\text{m}$ , diameter 13.9  $\mu\text{m}$ ; striae 24/10  $\mu\text{m}$ .

**Distribution:** Azad Kashmir, Pakistan: Peshawar.

### 9. *Mastogloia* Thwaites ex W. Smith 1856

#### Key to varieties

- 1a. Striae 16 /10  $\mu\text{m}$ , radial .....1. *M. elliptica*  
 1b. Striae 18 /10  $\mu\text{m}$ , parallel.....2. *M. smithii*

**1. *M. elliptica* (Aghardh) Cleve 1993**, Krammer & Lange-Bertalot, 1997, Fig. 16

**Synonym:** *Frustulia elliptica* Aghardh 1824

**General characters:** Length of cell 40.2  $\mu\text{m}$ , diameter 10.3  $\mu\text{m}$ ; striae 16 /10  $\mu\text{m}$ , radial, punctate; valve elliptic to linear lanceolate, with round poles.

**Distribution:** Europe, Australia New Zealand.

**2. *M. smithii* var. *smithii* Thwaites ex W. Smith 1856**, Krammer & Lange-Bertalot, 1997, Fig. 17

**General characters:** Length of cell 25.1  $\mu\text{m}$ , diameter 8.5  $\mu\text{m}$ ; striae 18 /10  $\mu\text{m}$ , transverse, punctate; valve broadly elliptic-lanceolate, with protracted broad round poles; axial area linear, central area round; rectangular chambers 8 in 10  $\mu\text{m}$ .

**Distribution:** Europe, Australia New Zealand.

### 10. *Navicula* Bory 1822; Emend. Cleve 1894

#### Key to the species

- 1a. Striae strongly radiate:  
 2a. Valve linear-lanceolate:  
 3a. Striae more than 13 in 10  $\mu\text{m}$ ..... 1. *N. symmetrica*  
 3b. Striae less than 13 in 10  $\mu\text{m}$ .....2. *N. schroeteri*  
 2b. Valve elliptic-lanceolate to lanceolate elliptic or lanceolate:  
 4a. Axial area linear.....3. *N. Kotschyi*  
 4b. Axial area narrow:  
 5a. Valve with acute ends.....4. *N. radiosa*  
 5b. Valves with protracted ends:  
 6a. Lineolae very distinct.....5. *N. gregaria*  
 6b. Lineolae not very distinct.....6. *N. veneta*  
 1b. Striae parallel at ends or radiate throughout:  
 7a. Slightly broad valves.....7. *N. duerrenbergiana*  
 7b. Broad valves:  
 8a. Cell length more than 27  $\mu\text{m}$ .....8. *N. pseudolanceolata*  
 8b. Cell length less than 27  $\mu\text{m}$ :  
 9a. Cells with rostrate ends.....9. *N. salinarum*  
 9b. Cells with rounded ends.....10. *N. cryptotenella*

**1. *N. symmetrica* Patrick 1944**, Lange-Bertalot, 2001, Fig.18

**General characters:** Length of cells 30  $\mu\text{m}$ , diameter 6.8  $\mu\text{m}$ ; striae 15/10  $\mu\text{m}$  strongly radiate; dense, coarse lineolae; linear-lanceolate valve with rounded ends; narrow axial area, central area vary in shape.

**Distribution:** Cosmopolitan, America, Australia and New Zealand.

**2. *N. schroeteri* Meister 1932**, Lange-Bertalot, 2001, Pl. 38, P., Fig.19

**Synonym:** *Navicula simulata* Manguin 1942; *Navicula symmetrica* Patrick 1944; *Navicula symmetrica* var. *escambia* Patrick 1959

**General characters:** Length of cells 33.6  $\mu\text{m}$ , diameter 8  $\mu\text{m}$ ; striae 13/10  $\mu\text{m}$ , strongly radiate, lineolae coarse; linear-lanceolate valve with rounded ends; narrow axial area, central area vary in shape rounded, elliptic and rectangular.

**Distribution:** Cosmopolitan, Europe, America, Australia and New Zealand.

**3. *N. kotschyi* Grunow 1860**, Krammer & Lange-Bertalot, 1997, Fig. 20

**Synonym:** *Navicula kotschyana* Grunow in Van Heurck 1880; *Navicula grimmei* Krasske in Hustedt 1930

**General characters:** Length of cells 21.1  $\mu\text{m}$ , diameter 6.3  $\mu\text{m}$ ; striae 18/10  $\mu\text{m}$ , radiate; Valve elliptic-lanceolate to lanceolate elliptic; axial area linear, central area rectangular.

**Distribution:** Europe

**4. *N. radiosa* Kutzing 1844**, Krammer & Lange-Bertalot, 1997, Fig. 21

**References:** Zaman & Hussain 2006: 81; Tariq-Ali *et al.*, 2006a:439; Leghari *et al.*, 2009: 161; Husna *et al.*, 2007:58.

**General characters:** Length of cells 61.8  $\mu\text{m}$ , diameter 9.6  $\mu\text{m}$ ; striae 10/10  $\mu\text{m}$ , convergent towards the ends and strongly radiate throughout; Valves narrow lanceolate, narrow or acute ends; axial area narrow, central part not symmetrical.

**Distribution:** America, Australia and New Zealand Asia, Iran, China, Pakistan: Peshawar, Lahore.

**5. *N. gregaria* Donkin 1861**, Krammer & Lange-Bertalot, 1997, Fig. 22

**Synonym:** *Navicula cryptocephala* Kutzing pro parte; *Navicula gregalis* Cholnoky 1963; *Navicula phyllepta* Kutzing sensu Brockmann und sensu Hendey

**References:** Zaman & Hussain 2006: 81.

**General characters:** Length of cells 38 µm, diameter 8 µm; striae 14/10 µm, weakly radiate, strongly convergent, lineolae very distinct. Lanceolate to elliptic-lanceolate valves, protracted ends; narrow and linear axial area, wide central area.

**Distribution:** Very common in South America, Europe and Asia: Iran and Pakistan: Peshawar.

**6. *N. veneta* Kutzing 1844**, Krammer & Lange-Bertalot, *Naviculaceae*, 1997, Fig. 23

**General characters:** Length of cells 18.9 µm, diameter 5.5µm; striae 15/10 µm, weakly radiate, convergent, lineolae not distinct. Lanceolate or rhombic-lanceolate valves, ends protracted; linear and narrow axial and small central area.

**Distribution:** Cosmopolitan and pollution tolerant.

**7. *N. duerrenbergiana* Hustedt in Schmidt et al., 1934**, Lange-Bertalot, 2001, Fig. 24

**Synonym:** *Navicula stundlii* Hustedt 1959

**General characters:** Length of cells 34.2 µm, diameter 4.6 µm; striae 17/10 µm, more or less radiate, parallel at the ends; Valves linear lanceolate, slightly broad in the middle; axial area narrow.

**Distribution:** Europe

**8. *N. pseudolanceolata* var. *denselineolata* Lange-Bertalot 1985**, Krammer & Lange-Bertalot, 1997, Fig. 25

**General characters:** Length of cells 27.6 µm, diameter 5.7 µm; striae 14/10 µm, parallel at ends and radiate throughout the valve. Valves lanceolate or rhombic lanceolate; small central area, axial area narrow.

**Distribution:** Europe

**9. *N. salinarum* Grunow in Cleve Grunow 1880**, Krammer & Lange-Bertalot, 1997, Fig. 26

**References:** Hussain et al., 1984:83; Kubra & Leghari, 2008:28.

**General characters:** Length of cells 21.6 µm, diameter 6.6 µm; striae 19/10 µm, strongly radiate, parallel and convergent. Valves broad, lanceolate with rostrate ends; axial area narrow, central part large and circular.

**Distribution:** Pakistan: Quetta, Kamalia, Sharaqpur.

**10. *N. cryptotenella* Lange-Bertalot 1985**, Krammer & Lange-Bertalot, 1997, Fig. 27

**Synonym:** *Navicula tenella* Brebisson ex Kutzing 1849 sensu Grunow 1880; *Navicula radiosa* var. *tenella* (Brebisson ex Kutzing) Van Heurck 1845;

**General characters:** Length of cells 22.2 µm, diameter 6 µm; striae 15/10 µm, parallel convergent. Lanceolate valves with rounded ends, broad in the middle narrow towards ends; raphe filiform; axial portion narrow.

**Distribution:** Europe, Australia, America, New Zealand and Asia: Taiwan.

## 11. *Neidium* Pfitzer 1871

**1. *N. dubium* (Ehrenberg) Cleve 1894**, Hofmann et al., 2011, Fig. 28

**Reference:** Suphan and Peerapornpisal, 2009:44.

**Basionym:** *Navicula dubium* Ehrenberg

**General characters:** Valve linear, linear-elliptic; slightly convex, cuneate, with more or less pointed ends; striae 21/10µm, length 56µm, breadth 14.9µm.

**Distribution:** Europe, North America, Australia and Asia: China & Thailand.

## 12. *Rhopalodia* O. Muller 1895

**1. *R. gibba* (Ehrenberg) O. Mull. 1895: 65**, Hustedt (1930), Fig. 29

**Basionym:** *Navicula gibba* Ehrenberg 1830.

**Homotypic Synonyms:** *Navicula gibba* Ehrenberg 1830, *Pinnularia gibba* (Ehrenberg) Ehrenberg 1843, *Frustulia gibba* (Ehrenberg) Jenner 1845, *Epithemia ventricosa* var. *gibba* (Ehrenberg) J. Schumann 1869, *Cystopleura gibba* (Ehrenberg) Kuntze 1891, *Schizonema gibbum* (Ehrenberg) Kuntze 1898.

**Heterotypic Synonyms:** *Navicula gibba* Ehrenberg 1832, *Eumotia gibba* (Ehrenberg) Ehrenberg 1843.

**References:** Mehwish & Aliya 2005: 122; Tariq-Ali, 2008: 846; Aliya et al., 2009: 868.

**General characters:** Cells in girdle view broadly linear with median inflation and broadly rounded poles, breadth 18-30 µm and length 35-300µm; costae 6-8 in 10 µm alternating with 2-3 rows of striations, 12-14 µm in 10 µm.

**Distribution:** Belgium, Britain, Iceland, Romania, Spain, Turkey (Europe), USA, Brazil, Pakistan (Islamabad, Sialkot), China, New South Wales, Northern Territory, Queensland, Tasmania, Victoria, Western Australia, Hawaiian Islands.

## Family Fragilariaceae

### Key to the genera

- 1a. Valve fusiform ..... 1. *F. famelica*
- 1b. Valve linear to linear-lanceolate..... 2. *F. ulna*
- 2a. Valve length 49.2 µm ..... 3. *F. tenera*
- 2b. Valve length 12.5 µm ..... 4. *F. microcephala*

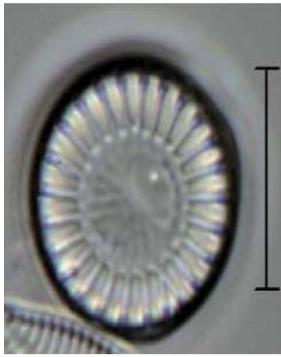


Fig. 1.  
*Cyclotella meneghiniana*

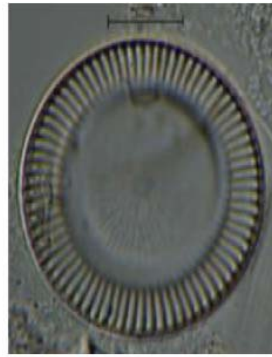


Fig. 2.  
*Cyclotella gamma*

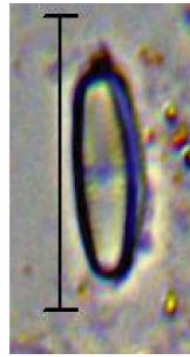


Fig. 3.  
*Achnanthes minutissima*



Fig. 4.  
*Cocconeis placentula*



Fig. 5.  
*Epithemia adnata*



Fig. 6.  
*Amphora coffeaeformis*



Fig. 7.  
*Cymbella affinis*



Fig. 8.  
*Cymbella minuta* var. *Silesiaca*



Fig. 9.  
*Cymbella laevis*



Fig. 10.  
*Cymbella tumida*



Fig. 11.  
*Gomphonema clavatum*

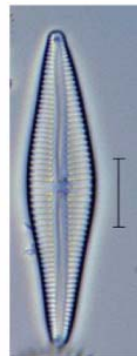


Fig. 12.  
*Gomphonema gracile*

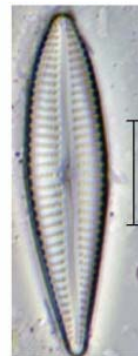


Fig. 13.  
*Gomphonema affine*



Fig. 14.  
*Gomphonema angustatum*

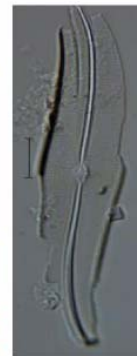


Fig. 15.  
*Gyrosigma spencerii*



Fig. 16.  
*Mastogloia elliptica*

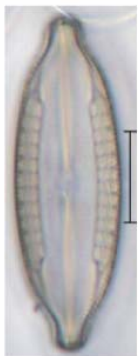


Fig. 17.  
*Mastogloia smithii* var. *smithii*

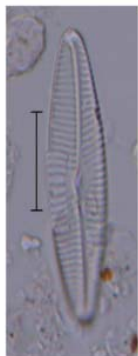


Fig. 18.  
*Navicula symmetrica*

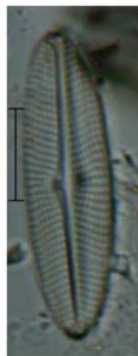


Fig. 19.  
*Navicula schroeteri*

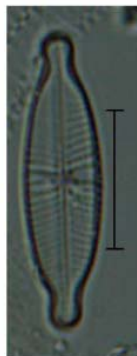


Fig. 20.  
*Navicula kotschyi*

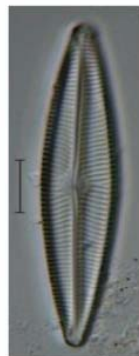


Fig. 21.  
*Navicula radiosa*

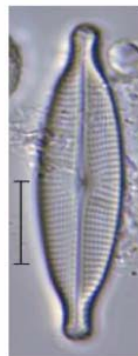


Fig. 22.  
*Navicula gregaria*

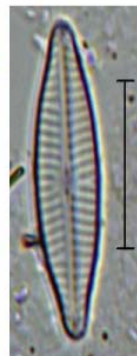


Fig. 23.  
*Navicula veneta*

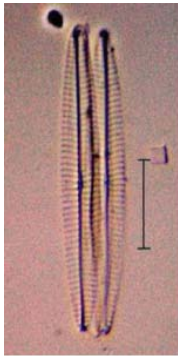


Fig. 24.  
*Navicula duerrenbergiana*

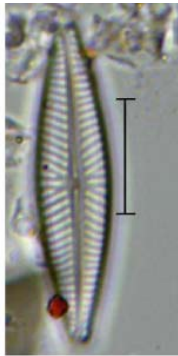


Fig. 25.  
*Navicula pseudolanceolata*

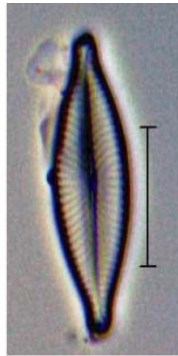


Fig. 26.  
*Navicula salinarum*

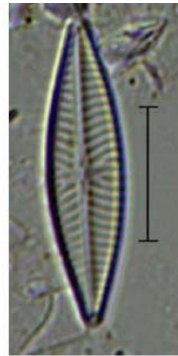


Fig. 27.  
*Navicula cryptotenella*



Fig. 28.  
*Neidium dubium*

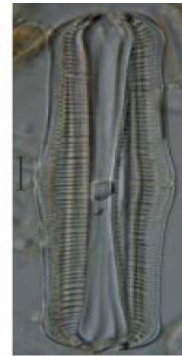


Fig. 29.  
*Rhopalodia gibba*

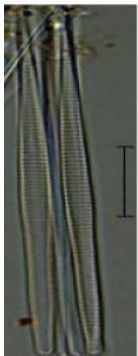


Fig. 30.  
*Fragilaria famelica*



Fig. 31.  
*Fragilaria ulna*



Fig. 32.  
*Fragilaria tenera*



Fig. 33.  
*Fragilaria microcephala*



Fig. 34.  
*Tabularia fasciculata*



Fig. 35.  
*Campylodiscus bicostatus*

### 13. *Fragilaria* Lyngbye 1819; Rabenhorst 1864

#### 1. *F. famelica* (Kutzing) Lange-Bertalot 1980, Krammer & Lange-Bertalot, 1997, Fig. 30

**Basionym:** *Synedra famelica* Kutzing

**General characters:** Valve length 50  $\mu\text{m}$ , diameter 2.8  $\mu\text{m}$ , striae 19/10  $\mu\text{m}$ , transverse; valves fusiform, with slightly constricted, round poles.

**Distribution:** America, Europe.

#### 2. *F. ulna* (Nitzsch) Lange-Bertalot 1980, Krammer and Lange-Bertalot, 1997, Fig. 31

**Basionym:** *Bacillaria ulna* Nitzsch

**Synonym:** *Bacillaria ulna* Nitzsch 1817; *Synedra ulna* (Nitzsch) 1832.

**References:** Tariq-Ali, 2008:132; Ashraf *et al.*, 2008:182; Leghari *et al.* 2006: 37; Leghari *et al.*, 2009: 161; Shahnaz *et al.*, 2010:44; Kubra & Leghari, 2008:28.

**General characters:** Cells length 250  $\mu\text{m}$ , diameter 9.7  $\mu\text{m}$ ; striae 9/10  $\mu\text{m}$ ; valve linear to linear-lanceolate; central area variable, axial area linear.

**Distribution:** Europe, Asia: Turkey, Quetta, Pakistan.

#### 3. *F. tenera* (W. Smith) Lange- Bertalot 1980, Krammer & Lange-Bertalot, 1997, Fig. 32

**Basionym:** *Synedra tenera* W. Smith

**References:** Sarim *et al.*, 2008: 38.

**General characters:** Valve length 49.2  $\mu\text{m}$ , diameter 2  $\mu\text{m}$  Striae 20/10  $\mu\text{m}$ , transverse, near the poles extend from one margin to the other; valves narrowly lanceolate; central area variable, axial area linear.

**Distribution:** Europe, America, Australia and Pakistan: Tarbela Dam

#### 4. *F. microcephala* Grunow in Cleve & Moller 1878, Fig. 33

**General characters:** Valve length 12.5  $\mu\text{m}$ , diameter 3.5  $\mu\text{m}$ ; striae 15/10  $\mu\text{m}$  and transverse; valve lanceolate, with blunt round ends.

### 14. *Tabularia* Ehrenberg 1839

#### 1. *T. fasciculata* (C. Agardh) D.M. Willaims & Round 1986, Krammer & Lange-Bertalot, 1997, Fig. 34

**Reference:** Ghazala & Shakil, 2010:70.

**Synonym:** *Fragilaria fasciculata* (C. Agardh) Lange-Bertalot 1880

**General characters:** Valve length 33.1  $\mu\text{m}$ , 3.9 diameter  $\mu\text{m}$ , striae 14/10  $\mu\text{m}$ , transverse; cell lanceolate with round poles; axial area lanceolate.

**Distribution:** Europe, Australia, Asia: China, Pakistan (Multan).

**Family:** Surirelliaceae

### 15. *Campylodiscus* Ehrenberg 1840

#### 1. *C. bicostatus* W. Smith in Roper 1854, Krammer & Lange- Bertalot, Fig. 35

**Basionym:** *Cocconeis clypeus* Ehrenberg

**Homotypic Synonym:** *Cocconeis clypeus* Ehrenberg 1838



**Heterotypic Synonym:** *Surirella clypeus* Ehrenberg 1840, *Campylodiscus ovatus* Ralfs 1861

**General characters:** Cells with circular valves, diameter 39.5 µm; striae 15/10 µm; valve face ornamentation appearing in one sector.

**Distribution:** Atlantic Islands, South America.

#### Acknowledgement

The first two authors are thankful to the Higher Education Commission, Islamabad Pakistan for financial support under the HEC Indigenous 5000 Fellowship Program Batch-VI for carrying out this research work.

#### References

- Abdul-Majeed, M. 1935. *Freshwater Algae of the Punjab. I. Bacillariophyta (Diatomeae)*. Punj. Univ. Publ., Lahore, 45 pp.
- Aliya, R., A. Zarina and M. Shameel. 2009. Survey of fresh water Algae from Karachi, Pakistan. *Pak. J. Bot.*, 41(2): 861-870.
- Ashraf, F., M.K.Leghari and G.Murtaza.2008. Seasonal succession of algal species from Hajira and its adjacent areas, District Poonch, Azad Kashmir. *Int.J.Phycol. & Phycochem.*, 4(2): 179-184.
- Ashraf, F., M.K. Leghari and G. Murtaza. 2008. Freshwater Algae from Hajira and its adjacent areas, District Poonch, Azad Kashmir. *Int. J. Phycol. & Phycochem.*, 4(1): 47-56.
- Carter, N. 1926. Freshwater algae from India. *Rec. Bot. Surv. Ind.*, 9: 263-302.
- Cholnoky, B.J. 1970. Hydrobiologische Untersuchungen in Transvaal-III. Die Fishteiche von Marble Hall. *Bot. Mar.*, 13(suppl.): 5-44.
- Daudpota, N. and M.K. Leghari. 1993. Some diatoms from Kinjhar Lake (Sindh), Pakistan. *Biologia*, 39(2): 121-126.
- Ghazala, B. and A. Shakil. 2010. Qualitative analysis of fresh water Bacillariophyta in fish farms at Multan City, Pakistan. *Int. J. Phycol. Phycochem.*, 6(2): 69-72.
- Ghazala, B. and A. Habib. 2011. Distribution of family Fragilariaceae (Bacillariophyta) in the region of Multan, Pakistan. *Pak. J. Bot.*, 43(1): 15-27.
- Gerloff, J. and D. Ludemann. 1966. *Leitfaden der Trink- und Brauch-wasserbiologie*. Gust. Fisch. Verlag, Stuttgart, 360 pp.
- 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(1/2): 245-292+5 pls.
- Hirano, M. 1964. *Freshwater algae of Afghanistan*. Reprint: The Kyoto University scientific expedition to the Karakoram and Hindukush, Vol. III: 167-245.
- Hirano, M. 1966. *Freshwater algae from Northeastern part of Afghanistan*. Reprint: The Kyoto University scientific expedition to the Karakoram and Hindukush, Vol. III: 15-54.
- Hussain, A., M.K. Leghari and M. Munir. 2008. Qualitative and quantitative distribution of algal species from paddy fields of Sharaqpur and Kamalia, Punjab. *Int. J. Phycol. & Phycochem.*, 4(2): 149-158.
- Hofmann, G., M. Werum and H. Lange- Bertalot. Edit: Lange- Bertalot, H. 2011. *Diatomeen in Subwasser-Benthos von Mitteleuropa*. Publisher Gantner Verlag K. G. pp.908
- Husna, R., A. Zarina, Masud-ul- Hasan and M. Shameel. 2007. Taxonomic study of some Diatoms from Lahore, Pakistan. *Int. J. Phycol Phycochem.*, 3(1):55-64.
- Hussain, F. G. Anjum, M. I. Zaidi and M. A. F. Faridi. 1984. Fresh water algae of Hanna Urak Valley Quetta. *P.J. Bot.*, 16(1):81-84.
- Hustedt, F. 1930. *Bacillariophyta (Diatomaei)*. Fisher Verlag Jena. Pp 1-465.
- Jahangir, T.M., Y.M. Khuhawar and S.M.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.
- Kubra, G. and Leghari, M.K. 2008. Ecological study of algal species of rumly streams , Islamabad. *Int .J. Phycol. Phcochem.*, 4(1):19-30.
- Krammer, K. and H. Lange-Bertalot. 1997. *Subwasserflora von Mitteleuropa, Bacillariophyceae: Bacillariaceae, Epithemiaceae, surirellaceae*. vol. 2/2. pp. 611
- Krammer, K. and H. Lange-Bertalot. 1997. *Subwasserflora von Mitteleuropa, Bacillariophyceae: Naviculaceae*. vol. 2/1. pp. 876
- Krammer, K. and H. Lange-Bertalot. 1997. *Subwasserflora von Mitteleuropa, Bacillariophyceae: Centrales, Fragilariaceae and Eunotiaceae*. vol. 2/3, pp 576.
- Krammer, K. and H. Lange-Bertalot. 1997. *Subwasserflora von Mitteleuropa, Bacillariophyceae: Achnantheaceae Kritische Ergänzungen zu Navicula (lineolatae) and Gomphonema*. vol. 2/4, pp 365.
- Leghari, M.K., K. Sultana and T. Bando. 1991. Taxonomic studies of order Naviculales  
Malka Parbat Kaghan (Part I). *Biologia*, 37(1): 9-12.
- Leghari, M.K. and Y.M.Leghari. 1999. Seasonal variation of Phytoplankton in Bakar Lake, District Sanghar, Pakistan. *Pak. J.Pl. Sci.*, 5(2): 159-171.
- Leghari, M.K. and K. Sultana. 1993. A list of diatoms of Malka Parbat: Kaghan, Pakistan. In: Cryptogamic Flora of Pakistan. (Eds.): T. Nakaike and S. Malik. Vol. 2, Nat. Sci. Mus., Tokyo. p. 13-18.
- 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., M.Y. Leghari, M. Shah and S.N. Arbani. 2003. Ecological study of algal flora of Wah Garden, district Attock, Pakistan. *Pak. J. Bot.*, 35: 705-716.
- Leghari, M. K., M.I. Jalalani and A.Z. Khattak. 2004. Ecological study of phytoplankton of Rawal Dam, Islamabad, Pakistan. *Pak. J. Sci.*, 10(1):1-8.
- Leghari, M. K., S. B. Waheed and Y.M. Leghari. 2001. Ecological study of Algal Flora of Kunar river of Pakistan. *Pak. J. Bot.* 33(special issue): 629-639.
- Leghari, M. K., and N. Akhtar. 2006. Algal species recorded from gut contents of fish *Catla Catla* (Hamilton et Buchanan) Ahmad from Kurang river. *Int. J. Phycol. Phcochem.*, 2(2):131-136.
- Leghari, M. K., F. Butt and Shafique-ur-Rehman. 2007. Freshwater algae from Bunkhurma/ Mirpur, Azad Kashmir. *Int. J. Phycol. Phcochem.*, 3(1): 29-36.
- Leghari, M.K. and N. Akhtar. 2006b. Algal species recorded from gut contents of fish *Cyprinus carpio* from Kurang River and its physico-chemical properties. *Int. J. Phycol. Phcochem.*, 2(1): 93-102.
- Leghari, M. K., M.I. Jalalani., M.H. Soomoro and S.N. Arbani. 2009. Composition dynamics of epiphytic algal flora on *Hydrilla verticellata* (Hydrocharitaceae) in Rawal Dam water of Islamabad. *Int. J. Phycol. Phcochem.*, 5(2):155-166.
- Leghari, M.K., K. Sultana and M. Haga. 1995. Diatoms from explored Diaper face of Nanga Parbat Part I. *Biologia*, 41: 11-12.
- Marshall, H.G. and L. Urhardt. 2004. Phytoplankton composition within the tidal freshwater-oligohaline regions of the Rappahannock and Pamunkey rivers in Virginia. *Castanea*, 69(4): 272-283.
- Masud-ul-Hasan and A. Yunus. 1989. An addition to the algal flora of Lahore. *Biologia*, 35: 99-131.

- Masud-ul-Hasan and I. Batool. 1987. A Taxonomic study of same freshwater algae from Attock Sargodha districts. *Biologia*, 33: 345-366.
- Masud-ul-Hasan and Zeb-un-Nisa. 1986. Taxonomic studies of some freshwater algae from Azad Jammu and Kashmir. *Biologia*, 32: 229-256.
- Mehwish, H. and R. Aliya. 2005. Occurrence of freshwater algae at different localities of Karachi University. *Int. J. Phycol. Phycochem.*, 1(2): 117-124.
- Nizamuddin, M. 1984. *Diatoms of Libya*. Dept. of Botany, Univ. Al-Fateh Tripoli, 144 pp.
- Ostrup, E. 1908. Freshwater diatoms. In: *Botany of the Faeroes Based Upon Danish Investigations*. (Ed.): E. Warming, Gyldendalske Boghandel, Nordisk Forlag, Copenhagen p. 260-290.
- Patrick, R. and C.W. Reimer. 1966. The diatoms of the United States exclusive of Alaska and Hawaii: Fragilariaceae, Eunotiaceae, Achnantheaceae, Naviculaceae. 1: 1-688. Philadelphia: Academy of Natural Sciences.
- Rais, M., M. Anwar, T. Mehmood and I. Hussain. 2011. Bird diversity and conservation at Kallar Kahar Lake with special reference to water birds. *P. J. Zool.*, 43(4): 673-681.
- Sarim, K.M. and M.H. Khan. 1960. *The Diatomales: The Fresh Water Diatoms of Peshawar Valley*. Dept. Botany, Peshawar Univ., Peshawar, 66 pp. +11 pls.
- Sarim, K.M. 2005. The fresh water algae of Bara River Peshawar, Pakistan. *Pak. J. Pl. Sci.* 6 (1-2): 133- 136.
- Sarim, K.M. Khair-un-Nisa and N. Afzal. 2008. Some fresh water algae of Tarbela Dam, Pakistan. *Pak. J. Pl. Sci.* 14 (1): 35- 39.
- Schoeman, F.R. 1969. Diatoms from the Orange Free State (South Africa) and Lesotho. *Revist. Biol.*, 7 92): 35-74.
- Scot, D.A., (Ed.). 1986. *A directory of Asian wetlands*. IUCN, Gland, Switzerland and Cambridge, U.K.pp.1181.
- Shahnaz, A. A. Zarina, Masud-ul-Hassan and M. Shameel. 2010. Taxonomic study of diatoms (Bacillariophycota) from Lahore, Pakistan. *Int. J. Phycol. Phcochem.*, 6(1): 41-50.
- Shameel, M. 2001. An approach to the classification of algae in the New Millennium. *Pak. J. Mar. Biol.*, 7(1&2): 233-250.
- 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 on *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.
- Tariq-Ali, S., A. Zarina, Masud-ul-Hasan and M. Shameel. 2007. Occurrence of the family Pinnulariaceae (Bacillariophyta) in various districts of the Punjab, Pakistan. *Pak. J. Bot.*, 39: 1797-1805.
- Tariq-Ali, S., Masud-ul-Hasan and M. Shameel. 2008a. Occurrence of Pennate Diatoms (Bacillariophyta) in the Punjab and N.W.F.P, Pakistan. *Pak. J. Bot.*, 40(2): 841-847.
- Tariq-Ali, S., Masud-ul-Hasan and M. Shameel. 2008b. Taxonomic study on certain Diatoms from Freshwater habitats of North-Eastern areas of Pakistan. *Proc. Pak. Acad. Sci.*, 45(3): 117-123.
- Tiffany, L.H. and M.E. Britton. 1971. *The algae of Illinois*. Hapner. 395 p.
- Zaman, A. and F. Hussain. 2006. Impact of water quality on the algal diversity during winter season in Peshawar valley, Pakistan. *Int. J. Phycol. Phcochem.*, 2(1): 77-86.

(Received for publication 6 July 2011)