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Taxonomic studies of pennate diatoms from Tehsil Landikotal, District Khyber, Khyber Pakhtunkhwa, Pakistan

Muhammad Irfan[1,2], Haroon Khan[3], Muhammad Faiz[3], Rashid Khan[3], Habib Ahmad[4], Naveesa Younis Sheikh[5], Sahib Khan[6], Nabeela[1], Mohammad Kamil[1], Muhammad Ilyas[2], Saif Ullah[1,7], Muhammad Ishaq[8]

[1]Department of Botany, Abdulwalikhan, University Mardan, Pakistan

[2]Department of Botany, University of Swabi- Swabi, Pakistan

[3]Department of Botany, Hazara University Mansehra, Pakistan

[4]Department of Botany, Islamia College, University, Peshawar, Pakistan

[5]Department of Botany, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan

[6]Department of Botany, Kohat University of science and technology, Kohat, Pakistan

[7]Department of Botany, Government Degree College, Lahor, Swabi, Pakistan

[8]Department of Botany, University of Peshawar, Pakistan

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Abstract

The taxonomic study of tehsil Landikotal district Khyber, Khyber Pakhtunkhwa, Pakistan was conducted in order to find out the diversity of Pinnate Diatoms in fresh water lakes. The area having mountains, found natural water streams which flows throughout the year and are best reservoir of diatoms flora. Diatoms samples was collected from fresh water streams, cleaned and preserved in 4% formalin and identified with flora of Pakistan. A total of 17 taxa having 12 genera and 8 families were reported from the study area. Algal species such as *Cymbella brehmii, Cymbella ventricosa, Cymbella prostrata, Epithemia zebra, Synedra tenera, Synedra ulna, Fragilaria construn, Gamphonema constrictum* var *Capitatum, Gamphonema ventricosum, Gamphonema olivaceum, Nitzchia commutate Nitzchia palea, Navicula tascula, Diploneis elliptica, Diatomma anceps, pinnularia gibba* and *Achnanths gibbrula*. Cymbellaceae, Fragilariaceae, Gamphonemataceae and Naviculaceae are the largest families having three taxa each while Nitzchiaceae is the second largest family having two taxa followed by Achananthaceae, Diatomaceae and Rhopalodiaceae having one taxa each reported from the studied area. Keys at generic and specie level were presented. Based on our findings it is concluded that this area need more research to determine the diatoms flora.

* **Corresponding Author:** Muhammad Irfan ✉ Mirfan310@yahoo.com

Introduction

Tehsil Landikotal district Khyber, Khyber Pakhtunkhwa, Pakistan having richest diversity of pinnate diatoms in its water bodies. It is also a neglected field and very little research work has been done in this important field. So that's why the concerned area was selected for research work.

It is located at 34° 64 N 71° 84 E and lies in the Khyber Pass in district Khyber, Khyber Pakhtunkhwa, Pakistan. It is the headquarter of district Khyber and is on the way across the mountains to the district Peshawar. Tehsil Landikotal consists of four major territories, Tirah, Khyber, Landikotal and Shalmans. The Shalmans include Loi Shalman and Kam Shalman. The climatic condition is extreme and temperature is cold to severe cold in winter and warm to blistering hot in summer. The hottest months are from May to August, where as the coldest months are from November to January. Winter rain is brought by westerly winds while the summer rain is related with the monsoon. The average rainfall annually is about 400 mm. such rainfall contributes to increase the flow of natural stream among the mountain throughout the year.

The water of these streams is the mixture of different mineral due to continuous flow of water from the hill outskirt and it is not used for drinking purpose (Anon, 1998). Previously the similar study were conducted from Kallar kahar lake district Chakwal (Laghari *et al.,*2009) diatoms have been reported from identified material of ponds, puddles, stream, ditches (Abdul-Majeed, 1935; Sarim and Khan 1960; Tariq *et al.,*2006; Husna *et al.,*2007; Kubra and Laghari, 1986 from sindh province, Laghari 2008). Only few studies have been conducted on lakes diatoms flora from Pakistan (Munir *et al.,*2012).

Materials and method

Algal Sampling

Samples of pinnate diatoms were collected from fresh water lakes of various site of tehsil Landikotal district Khyber, Khyber Pakhtunkhwa, Pakistan. Diatoms samples were collected in plastic bottles, cleaned with diluted sulphuric acid, mounted on slides (Stevenson *et al.,* 2009). And preserved in 4% formalin. Microscopic identification of algal samples was conducted by using the leica DLMB microscope at 100 x magnifications (Kramer and Lange-Bartalot, 1997; Siver and Hamilton, 2011) and flora of Pakistan.

Results and discussion

A total of 17 taxa having 12 genera and 5 families were identified and reported from the study area. The taxonomic description of all species is given as follows.

Family Cymbellaceae

Key to Genera

1a. Cell in girdle view having parallel sides.....1.*Cymbella*

Cymbella

Cell solitary and free floating with parallel side in girdle view, no intercalary band; asymmetric, lunate nearly elliptic, rhombic valves, or some dorsally convex and ventrally concave; axial field wide or narrow with central area without dots; raphe curved, single expanded plate chromatophore.

Key to species

1a. Raphe slightly arched ventrally, distal raphe ends ventrally hooked.... .....*Cymbella Brehmii*

1b. Ventral margin slightly con.....*Cymbella ventricosa*

1c. Rahe nearly median .....*Cymbella*

prostata

Cymbella brehmii Hustedt (1912): Fig.1.

Taxonomic description

Valves darso-ventral or ventrally convex, axial area narrow. central area shortens. Raphe filiform or slightly arched ventrally, proximal raphe ends dorsally deflected; distal ends ventrally deflected. Striate slightly radiate imprecisely scatter. Somewhat variable in number. Ca 11 -13 in 10µ (dorsal central –

occasionally ventral central) becoming .ca 16 in 12µ toward the ends the dorsal striate are generally less numerous (12-15 in 10 µ than the ventral striate (14-16 in 10µ) puncta 21-24 in 10µ.lenght,10-15µ breadth,4-6µ.

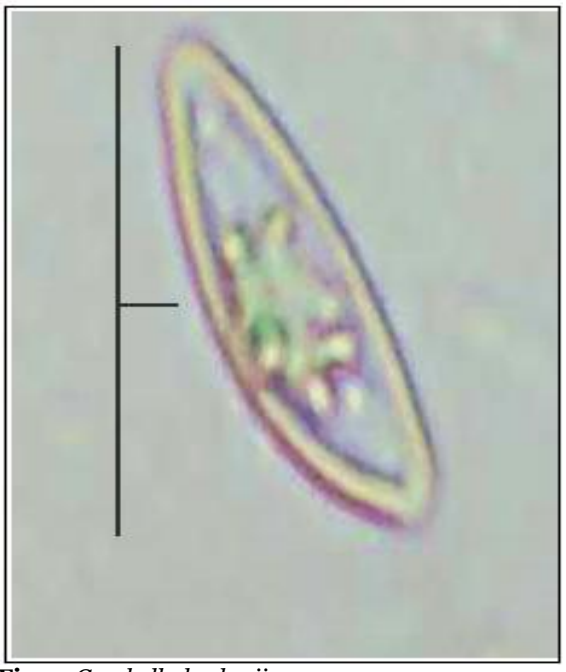

Fig. 1. *Cymbella brehmii.*

Distribution

Europe, North America.

*Cymbella ventricosa (*kuetzing) C. A. Agardh (1830): Fig.2.

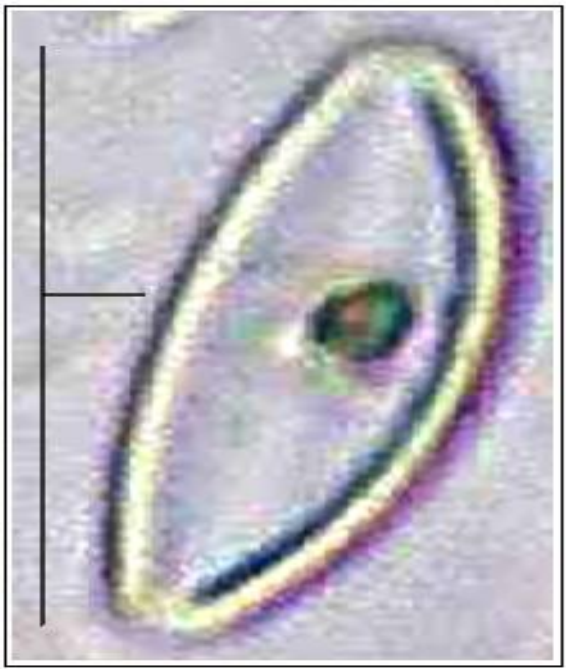

Fig. 2. *Cymbella ventricosa.*

Taxonomic description

Cells 5- 12 x10-40 µ; Valves usually semi elliptic, convex dorsally, ventrally slightly to straight convex, poles sharply rounded; raphe immediately, near ventral side without the poles; axial area thin, slightly expand at medially isolated dot absent; transversely striation 13-19 in 10 µ, radiate generally scatter about 38 in 10µ.

Distribution

Europe, North America, Asia.

Cymbella prostrata Berkeley (1832) : Fig.3.

Fig. 3. *Cymbella prostrate.*

Taxonomic description

Cell 10-30 x 22-98 µ; valves asymmetric, convex dorsally, semi elliptic, ventrally straight with presence of medial expansion, poles generally round; raphe in a straight line with polar deviation; axial part narrow or linear; central area minute, isolated dot absent; transverse striation 8-11-10µ parallel to radiate with crossline about 22 in 10µ.

Distribution

Britain. France. Germany. Mongolia, Iran, Iraq Family Rhopalodiaceae.

Key to genera

1a. Cell in girdle view having rectangular sides..... *Epithemia*

Epithemia

Valves cuneate elevate, lanceolate, or nearly straight with one pole capitate or broader then central and polar nodules. Strictly transverse striation. Or radial, central extending to margine.

Key to species

Cells girdle view is rectungular ..... *Epithemia zebra*

Epithemia zebra

(Ehrenberg) Brebisson (1838) : Fig.4.

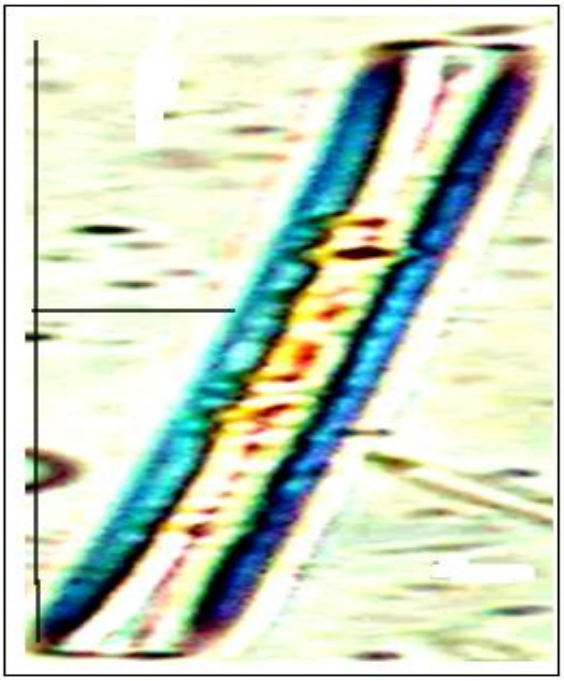

Fig. 4. *Epithemia zebra.*

Taxonomic description

Cell size is from 6-13 x25-145µ.valves are lanceolate, curved gently with nearly parallel side. Gradually reduced to rounded poles. crostata radial, 3-5 in 10. alternating with 4-8 rows of striation.

Distribution

Asia

Family Fragilariaceae

Key to genera

1. Valves with pseudoraphes .....*Synedra*

2. Valves with true raphes ..... *Fragilaria*

Synedra Ehrenberg (1830): Fig. 4.

Taxonomic description

Cells narrow and elongated, solitary or in tufted, fan-shaped or radiating colonies, free-floating or epiphytic stalked or sessile; valves linear, straight or sometime curved with reduced end or not, striation transverse, pseudo raphes; central area smooth.

Key to species

1a. Transverse striate less than 20 in 10 µ or more than 20 in 10 µ..... *Synedra tenere*

1b. Diameter of valves at poles more than 3µ..... *Synedra ulna*

Synedra tenere Cleve-Euler (1953) : Fig.5.

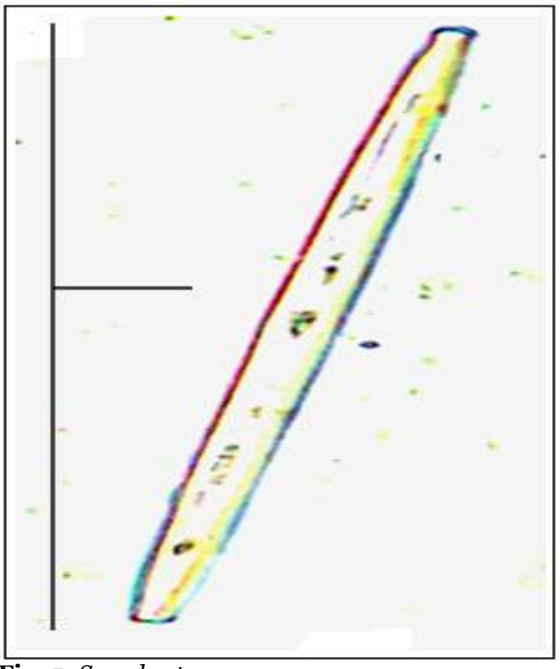

Fig. 5. *Synedra tenere.*

Taxonomic description

Cell 2-4 x 30-120 µ, solitary; valves lanceolate narrowly, hardly capitates; transversely striation 18-22 in 10 µ; pseudoraphe narrow, central area generally missing.

Distribution

North America

Synedra ulna Ehrenberg (1830) : Fig.6.

Fig. 6. *Synedra ulna.*

Taxonomic description

Valves linear to lanceolate, progressively tapperd toward the terminal, having broad rounded poles; transverse striations 8-12 (mostly 10) in 10 µ finely punctuate; narrowly linear pseudoraphe, with central area differing, often missing. Cell 5-9 x50-350µ.

Distribution

Asia, America, Europe, Australia. Africa

Fragilaria

Key to species

1c. Redial striation 14-17 in 10 µ.....3.*Fragilaria construens*

*Fragilaria construens (*Ehrenberg1862) : Fig.7.

Taxonomic description

Valves greatly extended maidenly almost cruciform, with lances-like pseudoraphe; striations transverse 14-17 in 10 µ, slightly redial. Cell 5-12 x7-25 µ, integrated into rather long compact chain.

Distribution

North and south America, Africa, Europe, South West Asia.

Family Gamphonemataceae

Key to genera

1.Valve margin not so adjoined. Girdle view symmetric or asymmetric..... *Gamphonema*

Fig. 7. *Fragilaria construens.*

Gamphonema

Cell usually epiphytic on the end of dichotomously branched gelatinous stalks. Sometime sessile and solitary and free-floating transverse asymmetric in both girdle and valve views, cuneate in girdle view. girdle smooth without intercalary bands or septa.

Key to species

1a. Median striation alternately long ..... *Gamphonema constrictum*

1b. Striation frequently lacking..... *Gamphonema ventricosum*

1c. Central area without such dot.....*Gamphonema olivaceum*

Gamphonema constrictum var *Capitatum* Ehrenberg (1838): Fig.8.

Taxonomic description

Valves are clavate, constricted below the broad round apical poles, with reduces basal poles. narrow axial area. central have broad area. and irregularly demarcated with a dot on side. striation transverse, radial. or punctate, alternately long and short in the middle of the valves. cell usually 8-15x30-65µ.

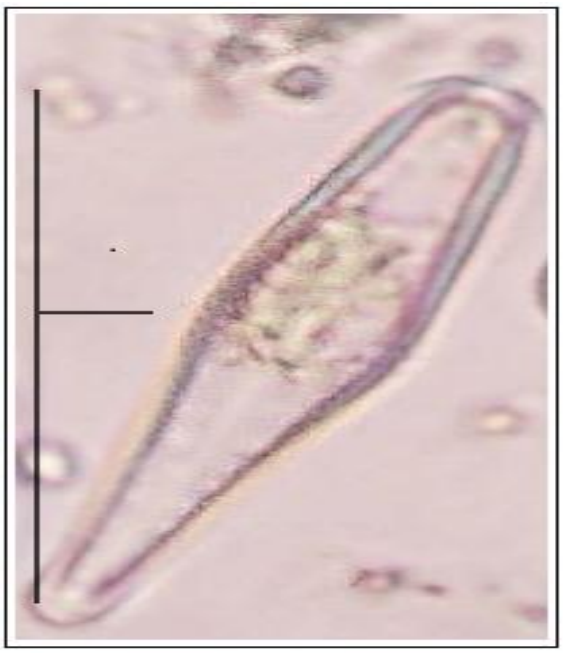

Fig. 8. *Gamphonema constrictum* var *Capitatum*.

Distribution

Europe, Africa, North America, Asia.

Gamphonema ventricosum W.Gregory (1856): Fig.9.

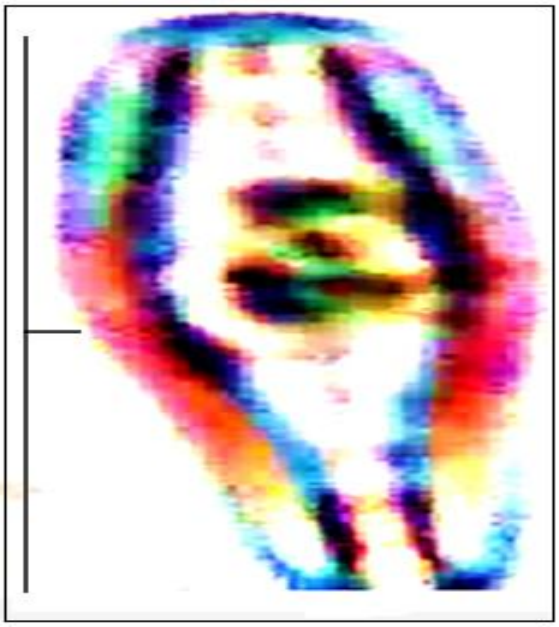

Fig. 9. *Gamphonema olivaceum*.

Taxonomic description

Valve broadest in middle of the valve, narrowed toward the broadly rounded apex; strongly narrowed to the slightly swollen basis. Axial are one-fourth to one-third the breadth of the valve central area large, transverse, rounded; a distinct punctum on one side of the central nodule Raphe narrow, terminal nodules distinct. Striea radiate, almost parallel at the apex and not strongly radiate at the basis. striae, 11-13in 10µ length,30-55, breadth,9=11µ.

Distribution

Europe, Atlantic Islands, North America, Asia.

Gamphonema olivaceum Brébisson (1838) : Fig.10.

Fig. 10. *Gamphonema Ventricosam*.

Taxonomic description

Valves clavate to ovoid, apex round and base transversely round; Axial are linear and narrow; the central area crosswise widened without dot; raphe instantly oblique striation 10-14 in 10µ radial and unclearly punctuate, Cells 5-10 x15-40µ.

Distribution

North America

Family Nitzschiaceae

Key to genera

1a. Cells rhombi in cross-section, Valves with transverse costae ..... Nitzschia

Nitzschia

Cells solitary and free- floating or densely clustered in simple or unbranched gelatinous tubules, elongated rectangular, or sigmoid in girdle view, with somewhat attenuated poles, rhombi in cross-section. Valves

longitudinally. Asymmetric, very variable in shape. straight, sigmoid, linear.

Key to species

1a. Valves medially constricted.....1. *Nitzschia commutate*

1b. Valves not medially constricted.....2 *Nitzchia Palea*

Nitzchia commutate Grunow (1880) : Fig.11.

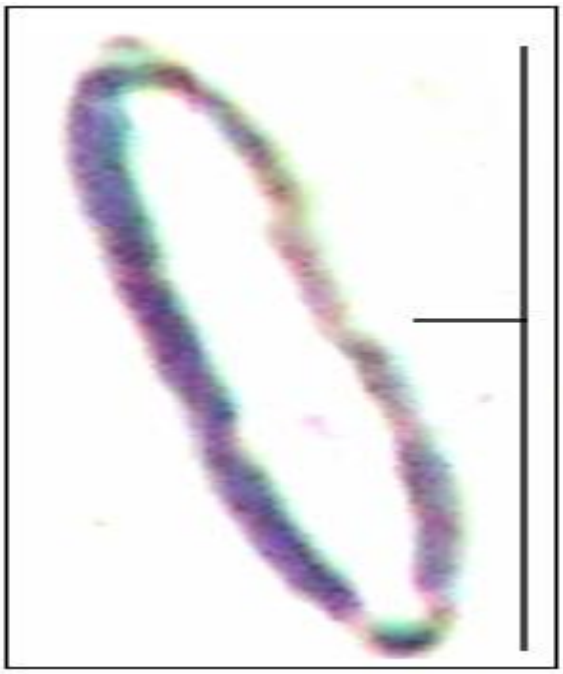

Fig. 11. *Nitzchia commutate.*

Taxonomic description

Cells are 6-13x45-75 µ in girdle view broadly linear, somewhat constricted, with rounded poles; valves linear with concave sides and cuneate, acute ends striation 15-25µ faintly or keel punctate.

Distribution

North America.

Nitzchia palea var *Tennirostris* W.Smith (1856): Fig.12.

Taxonomic description

Cell 2.5-5.0x 20-65µ; valves linear to linear-lanceolate with cuneate poles; striation 35-40 in 10µ; keel punctae 10-15 in 10µ.

Distribution

North America.

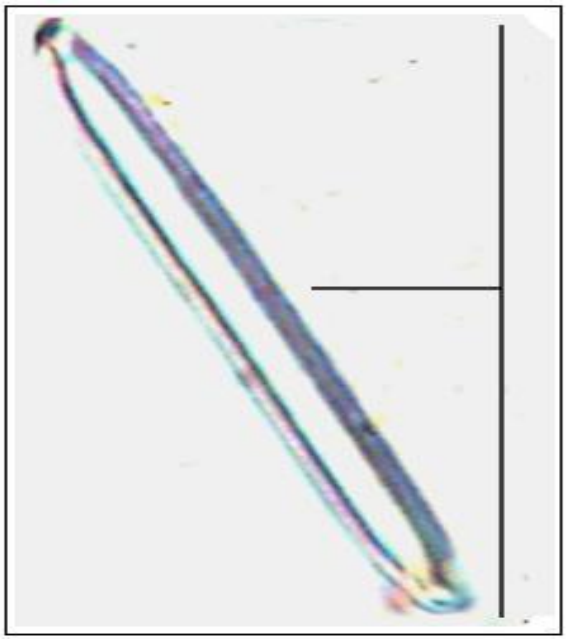

Fig. 12. *Nitzchia palea*var, *Tennirostris.*

Family Naviculaceae

Key to genera

1a. Valves with transverse striate or row of punctate..... *Navicula*

1b. Central nodule prolonged into horn or not so prolonged .....*Diploneis*

1c. Valves with transverse costae.....*Pinnularia*

Navicula

Taxonomic description

Cell generally solitary and free floating, sometime aggregated into irregularly radiating clusters, rectangular in girdle view with smooth girdle and without intercalary bands; valves elongate, usually attenuated toward capitate, rounded or rostrate poles. Auxo spores formed the fusion of two gametes from each of two of two approximated cells.

Key to species

1a. Valves with a row of punctate..... *Navicula scula*

Naviculata scula Ehrenberg (Grunow) Cleve (1894) : Fig.13.

Taxonomic description

Valves elliptic with rostrate-capitate ends, linear and narrow axial area; transverse radial, interrupted by longitudinal hyalines. cell size 8-20x 10-60µ.

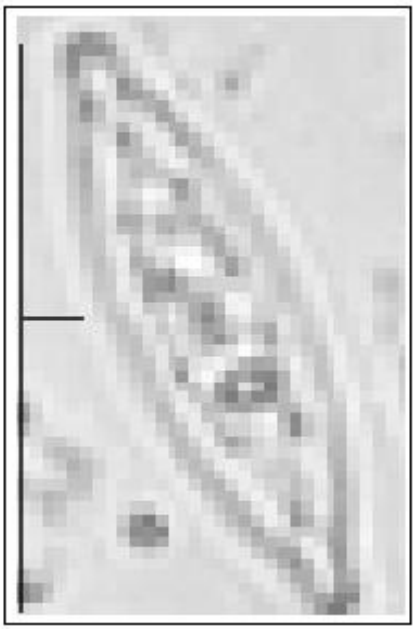

Fig. 13. *Navicula tascula.*

Distribution

Europe, North America.

Diploneis

Axial field narrow with distinct straight raphe and polar band central fusion of two expansion, nodules small. transverse striation, sometime somewhat medially radial. Two laminate chromatophores rarely four to eight infrequently with one or more pyrenoids.

Key to species

1. Transverse costae 9-15 in 10 µ; longitudinal costae evident.....*Diploneis elliptica*

Diploneis elliptica (kuetzing) Cleve (1894) : Fig.14.

Taxonomic description

Cells 10-30 x20-65 µ valves broadly elliptic with large roundly quadrate central nodule with distinct horns, furrow slender, medianly somewhat widened; transverse costate somewhat redial, 9-13 in 10µ crossed by numerous irregular longitudinal costae, forming areolae 9-14 in 10 µ.

Distribution

Asia.

Europe. North America. Australia.

Fig. 14. *Diploneis elliptica.*

Pinnularia

Usually concave cells, with raphe, a distinct nodule,rather inconspicuous polar nodules, central area sometime transversely widened into a stauros; epivalve generally convex, with a pseudoraphe; transverse striation, often somewhat radiate, and in some species prominent costae; Chromatophores.

Key to species

1a. Valves 7-13 x50 140µ.....1.*Pinnularia gibba*

Pinnularia gibba

Ehrenberg (1843) : Fig.15.

Taxonomic description

Cell 7-13 x50-140 µ; valves linear-lanceolate with lightly convex side diminishing toward broad capitates to cuneate poles with varyingly wide axial area and an elliptically banded central area; transverse striations radial in the middle, parallel toward the poles and convergent at the poles,9-11 in 10µ variable species.

Distribution

Europe, North America. South America, Asia.

Family Achnanthaceae

Key to genera

1. Girdle longitudinally bent or bowed.....*Achnanthes*

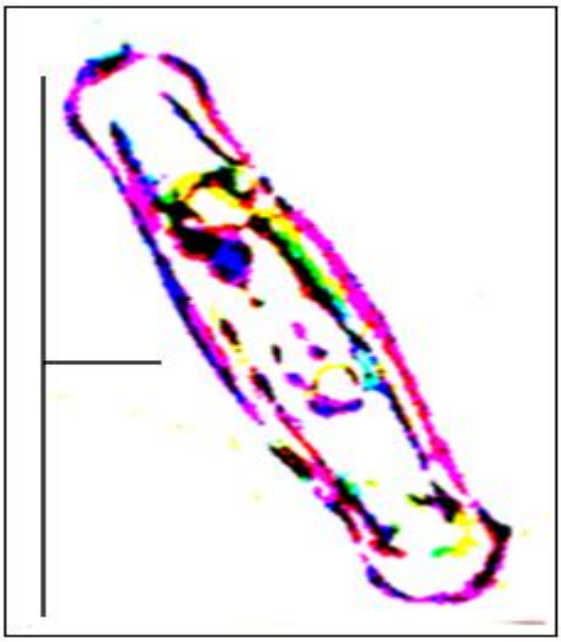

Fig. 15. *Pinnularia gibba.*

Achnanthes

cell somewhat longitudinally- rectangular curbed or bent in girdle view, mainly attached by jellylike stalk, or sessile and joint into bundle at or near valves,not often into filament, sometime complimentary floating, solitary; valves generally linear-lanceolate or somewhat elliptic; hypovalve.

Key to species

valves gradually tapering toward poles.....*Achnanthes minutissima*

Achnanthes mintissima Kützing (1833) : Fig.17.

Taxonomic description

Cell are 4-5 µ x5-45µ in size. Valves linear, elliptic, slightly narrowed to rounded poles, transverse striation 30-35 in 105 µ, hypovalves with delicate thread like raphe, central area small; epivalves with very narrow pseudoraphe.

Distribution

North America, Europe.

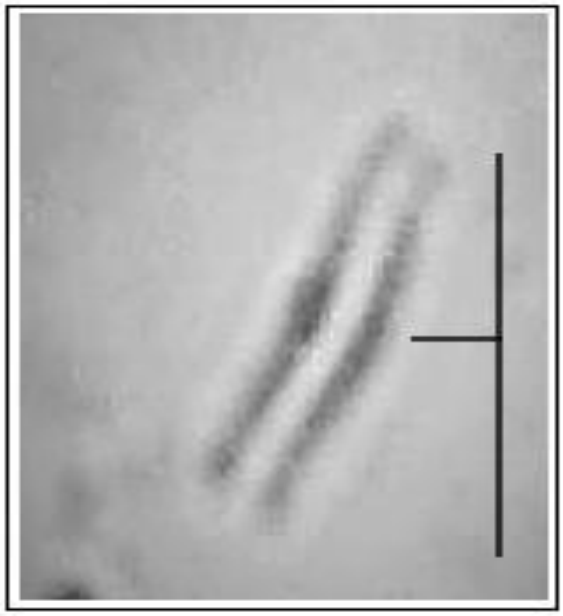

Fig. 16. *Achnanthes mintissima.*

Family Diatomaceae

Key to genera

1.Girdle view rectangular.....*Diatoma*

Diatoma

Cells are rectangular tubular in girdle view, at the corner cell are united.it sometime free floating, zigzag to linear chain, with one or two intercalary bands with several transverse septa appearing. Valves lanceolate to linear, bilaterally, symmetric, finely punctate striation between costae, pseudoraphe narrow, without median expansion,

Key to species

1.Valves Capitate, narrowly linear..... *Diatoma anceps*

Diatomma anceps (Ehrenberg) Kirchner (1878) Fig.17.

Taxonomic description

Valves linearly arranged, capitatenear or at poles, with slight pseudoraphe; costae weak,3-6 in 10 µ striation oblique 18-20 in 10 µ. Cell 4-8 x15-100 µ

united into nearly packed chain, with few or no intercalary bands.

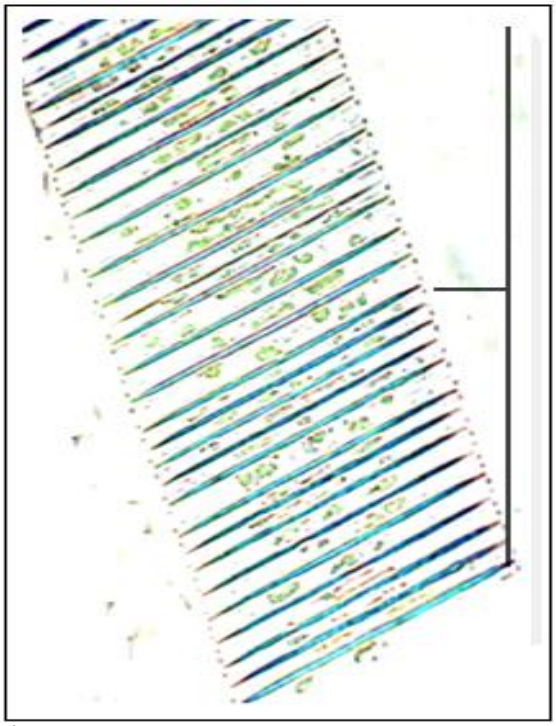

Fig. 17. *Diatoma anceps.*

Distribution

North America, Europe, Asia.

Conclusion

The taxonomic study of tehsil Landikotal district Khyber, Khyber Pakhtunkhwa, Pakistan was conducted in order to find out the diversity of Pinnate Diatoms. A total of 17 taxa having 12 genera and 8 families were reported from the study area. Algal species such as *Cymbella brehmii*, *Cymbella ventricosa, Cymbella prostrata, Epithemia zebra, Synedra tenera, Synedra ulna, Fragilaria construn, Gamphonema constrictum* var *Capitatum, Gamphonema ventricosum, Gamphonema olivaceum, Nitzchia commutate Nitzchia palea, Navicula tascula, Diploneis elliptica, Diatomma anceps, pinnularia gibba* and *Achnanths gibbrula*. Cymbellaceae, Fragilariaceae, Gamphonemataceae and Naviculaceae are the largest families having three taxa each while Nitzchiaceae is the second largest family having two taxa followed by Achananthaceae, Diatomaceae and Rhopalodiaceae having one taxa each reported from the studied area. Keys at generic and specie level were presented. Based on our findings it is concluded that this area need more research to determine the diatoms flora.

Acknowledgement

The authors are really thankful to the inhabitants of tehsil Landikotal, District Khyber, Khyber Pakhtunkhwa, Pakistan.

Author's contribution

MI, HK & MF & RK conducted the experiment and HA, NYS & SK carried out the statistical analysis N, MK & MI designed the experiment and SU & MI structured and wrote the manuscript.

Conflict of interest

The authors declared that they have no conflict of interest.

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