Diatom Flora of Western Uttar Pradesh, India.

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Abstract

The present paper deals with 57 Diatoms flora including 21 genera from different aquatic habitats of Western Uttar Pradesh, i.e. Saharanpur, Meerut and Ghaziabad districts. The 21 genera (with no. of taxa in parenthesis) are represented by Aulacoseira G.H.K. Thwaites (13), Synedra Ehrenberg (3), Fragilaria (Lyngbe) Rabenhorst (2), Diatom De Candolle (1), Eunotia Ehrenberg (2), Cocconeis (Ehr.) Grunow (3), Achnanthes Bory (2), Anomoeoneis Pfitzer (1), Navicula Bory (9), Cricula A. Grunow (1), Gyrosigma Hassall (1), Diplotilei Ehrenberg (1), Gomphonema Agardh (8), Cymbella Agardh (5), Amphora Ehrenberg (1), Epithemia Brebisson (1), Rhopalodia Mueller (2), Nitzschia Hassall (10), Hantzschia Grunow (1), Cymatopleura Smith (1), Surirella Turpin (2). All these forms have been first time reported from study area.

Keywords: Diatom, Ghaziabad, Meerut, Saharanpur, Uttar Pradesh, India.

Introduction


Diatoms from different parts of Uttar Pradesh have been reported by Singh (1961, 1962, 1963) Prasad and Singh (1996), Sussela and Dwivedi (2002), Misra et al. (2005, 2006, 2007, 2008, 2009). Misra et al. (2008) have some work from Yamuna River Saharanpur. However some work has been done but all these taxa are first time reported from study area.

Materials and Method

Algal samples were collected by Random Sampling Technique from different geographical localities of Western Uttar Pradesh during June 2005 to February 2009. Generally epiphytic forms were collected by squeezing submerged plants and planktonic forms with the help of planktonic mesh net (size 0.5 mm) in the plastic bottles (250 ml). All these collections were fixed in 3-4% formalin and studied after cleaning the frustules by acid treatment, immediately in the field and the collection number and date, localities name were also marked. Slides of diatoms were prepared as per procedure of Patrick and Reimer (1966). A drop of D.P.X was put on the dried and cleaned diatom materials and circular coverslips were placed. Detailed studies were made by examining specimens under a Nikon Labophot–II microscope, attached in oil emersion.

Study Area Description:

Geographically Saharanpur district is surrounded by Shivalik hills in the North by Dehradun and West by Haridwar districts of Uttarakhand state, Northeast and Yamuna river forms the boundary in the West, which separates its from Karnal and Yamunanagar district of Haryana and on South by Muzaffarnagar district of Uttar Pradesh. The district is rectangular in shape and lies between 29°34′45″-30°31′30″N latitudes and 77°09′-78°14′45″E longitude. The geographical area of the district 3860 sq. km. Saharanpur has a tropical climate because of the proximity of the Himalayan region across this Northern district. It is a sub-humid region, especially in the Upper Ganga plain area. Saharanpur records an average temperature of the 23.3°C during the course of the year. June is the hottest month and January is the coldest.

Meerut district falls in Western Uttar Pradesh located 72km Northeast of New Delhi. Meerut district is bounded by Muzaffarnagar district in North; Baghpat district in West, Jyotibaphuleynagar and Bijnor in East; district Ghaziabad in South. Meerut is located between 28°9′8″N latitude and 77°0′7″E longitude. Total area of this district is 2590 sq. k.,. The total area of the agro forestry in the district Meerut is 21324 hectare. The average annual rainfall of 665mm.

Ghaziabad lies in Western Uttar Pradesh adjacent to capital of India. The district is surrounded by the Baghpat and Meerut districts in the North, Gautam Budh Nagar (NOIDA) in the South; Bulandshahr and Jyotibaphuleynagar districts the East, Delhi in the West. District Ghaziabad is located between 22°24′N latitude and 77°25′E longitude. Total area of this district is 1966.9 sq. k.,. The average annual rainfall of 732mm. Agro-climatic region and zone is Western plain Zone in Upper Gangatic region.
Fig. 2: Map of District Sharanpur, Showing Algal Localities.
Fig. 3: Map of District Meerut, Showing Algal Localities.
Results and Discussion


Subclass: Coscinodiscophyceae

Order: Melosirales

Family: Melosiraceae

Genus: Aulacoseira G.H.K. Thwaites 1848

Cells linked tightly to form long state, curved or even coiled filaments, Plastids disoides. A common fresh water, planktonic genus previously placed in Melosira C.A. Agardh. Valves circular. Valve face/ mantle plain or with scattered poroids, which are often restricted with periphery. Valve mantle deep making a right angle to the planar valve face from which it is sharply differentiated; with vertical or curved rows of areolae. Mantle edge plain. Valve face / mantle junction provided with spines, which are expanded at their apices and fit with the spines of adjacent cells to form a linkage breakable only by damaging the spines.
1. *Aulacoseira granulata* (Ehr.) Simonson

(Pl. 1, Fig. 1)

Round, F.E., Crawford R.M. and Mann, D.G. (1990) (Pg.170, Fig.b)

Frustules 7µm in diameter, semi cells 7µm high; number of rows of punctae 10 in 10µm; number of in a row 12 in 10µm in diameter.

Collection Number and Date: 12ME/UP and 6 June 2005.

Locality: Budhi Ganga River, Hastinapur, Meerut.

Class: Fragilariophyceae

Order: Fragilariales

Family: Fragilariaceae

Genus: *Synedra* Ehrenberg 1830

Cells narrow and much elongated, solitary or in tufted, fan shaped or radiating colonies, free floating or epiphytic, sessile or stalked; valves linear to lanceolate, straight or sometimes curved, with poles attenuated or not, often capitates; transverse striation lateral to a conspicuous narrow pseudoraphae; central area may or may not be present, in girdle view elongate with truncate ends and striated; chromatophores two large plates, each usually with three or more pyrenoids.

1. *Synedra dorsiventralis* Mueller

(Pl.1, Fig. 2)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.236, Pl.63, Fig.712)

Cells 44µm long, 8µm broad, striae 15 in 10µm in diameter. Cells solitary; valves irregularly elliptic with narrowed but broadly obtuse ends (sometimes nearly rostrate); transverse striations coarse, rarely somewhat radial; pseudoraphae narrow, linear; central area conspicuous, usually excentric.

Collection Number and Date: 15SP/UP and 31 March 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

2. *S. ulna* (Nitz.) Ehr. var. *amphirhynchus* (Ehr.) Grunow

(Pl. 1, Fig. 3)

Gandhi, H. P. (1967) (Pg.269, Pl.3, Fig.64)

Cells 95µm long, broad 5µm, striae 11 in 10µm in diameter. Frustules very elongated, in the girdle view linear with widened end; valves linear lanceolate with abruptly constricted, large capitate ends. Pseudoraphe narrow, linear. Central area moderate, reaching the sides.

Collection Number and Date: 7GB/UP and 8 June 2005.

Locality: Upper Ganga Canal, Dehraajal Bairaj, Dhawana Ghaziabad.

3. *S. ulna* (Nitz.) Ehr. var. *subequalis* (Grunow) Van Heurck

(Pl. 1, Fig. 4)

Gandhi, H. P. (1999) (Pg.235, Pl.8, Fig.304)

Valves 150µm long, 7µm broad, striae 11 in 10µm in diameter.

Collection Number and Date: 2GB/UP and 7June 2005.

Locality: Railway line side Pond Muradnagar, Ghaziabad.

Genus: *Fragilaria* (Lyngbe) Rabenhorst 1864

Cells rectangular in girdle view, with one or two (sometimes none) intercalary band, without septa and costae, united into free-floating or sessile colonies; mostly zig-zag chains, sometime flat, stellate colonies; valve linear to fusiform, bilaterally symmetric, usually attenuated at the poles, sometime capitate, often mediately inflated (rarely constricted), transverse striae usually fine sometime coarse, pseudoraphe narrow and indistinct or broad and prominent, chromatophores numerous small discoid bodies, or one to four laminate plates without pyrenoids. Auxospores formed singly within the cell.

1. *Fragilaria capucina* Desmaziers

(Pl.1, Fig. 5)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.234, Pl.62, Fig.698)

Cells 33µm long, 4µm broad, striae 16 in10µm in diameter. Cells united into long chains; valves linear, with pseudoraphé and rectangular to elliptical central area; transverse striations fine.

Collection Number and Date: 15SP/UP and 31 March 2007.
Locality: East Yamuna Canal, Klausia, Saharanpur.

2. *F. intermedia* (Grunow) Grunow

(Pl. 1, Fig.6)

Husted, F. (1959) (Pg.152, Fig.6)

Cells 95µm long, 6µm broad, striae 9 in 10µm in diameter.

Collection Number and Date: 17SP/UP and 1 April 2007.

Locality: Kali River, Saapla, Saharanpur.

**Genus: Diatoma De Candolle 1805**

Cells rectangular tabular in girdle view, united at the corners into free floating or sessile, zigzag to linear chains, with one or two intercalary bands, with several transverse septa appearing as transverse costae; valves lanceolate to linear, bilaterally symmetric, with transverse, finely punctate striations between the costae; pseudoraphae narrow, without median expansion; chromatophores numerous, ellipsoid. Auxospores formed singly within the cells.

1. *Diatoma vulgaris* Bory

(Pl. 1, Fig. 7)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.230, Pl.61, Fig.686)

Cells 48µm long, 11µm broad, striae 7 in 10µm in diameter. Cells united into zig-zag colonies, with rounded corners and several delicate intercalary bands; valves elliptic-lanceolate, narrowly slightly, towards the rounded poles, with very narrow pseudoraphae; costae 6-8 in 10 µm in diameter.

Collection Number and Date: 15SP/UP and 31 March 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

**Class: Bacillariophyceae**

**Subclass: Eunotiophyceae**

**Order: Eunotiales**

**Family: Eunotiaceae**

**Genus: Eunotia Ehrenberg 1837**

Cells rectangular to linear to tabular in girdle view, both girdles and valves strongly ornamented, usually with intercalary bonds, free-floating or epiphytic; solitary or united valve to valve into chains; valves arcuate with similar pole but dissimilar margins; concave side regular, convex side inflated only at the poles or regular or undulate, sometimes nearly straight; raphe very short, extending from the fairly evident polar nodule diagonally to the concave margin, no central nodule; neither costae or septa present; intercalary bands usually present; transverse striations or punctuation present; two somewhat laminate chromatophores; without pyrenoids. Auxospore single from the conjugation of two cells.

1. *Eunotia alpine* (Naeg.) Hustedt

(Pl. 1, Fig. 8)

Prasad, B. N. and Srivastava, M. N. (1992) (Pg.176, Pl.26, Fig.7)

Cells 30µm long, 4µm broad, striae 19 in10µm in diameter. Valves small linear, slightly arcuate, gradually tapering from the middle towards the acutely rounded ends, dorsal side convex slightly recurved at the apices, ventral side concave, terminal nodules distinct, raphe not well developed; striae fine, lineate, parallel.

Collection Number and Date: 12ME/UP and 1 April 2007.

Locality: Budhi Ganga River, Hastinapur, Meerut.

2. *E. tschirchiana* Grunow

(Pl.1, Fig. 9)

Husted, F. (1938) (Pg.173, Tafel.12, Figs.23-29)

Valves 38µm long, 8µm broad and striae 9 in10µm in diameter.

Collection Number and Date: 22SP/UP and 16 February 2009.

Locality: Yamuna River, Sarsawa, Saharanpur.

**Subclass: Bacillariophycidae**

**Order: Achnanthales**

**Family: Cocconeidaceae**

**Genus: Cocconeis (Ehr.) Grunow 1868**

Cells transversely curved in girdle view, solitary, epiphytic upon submerged aquatics, especially upon slow growing filamentous algae; septa incomplete, intercalary band absent; valves elliptic, epivalve with axial pseudoraphae, hypeovalve with median raphe, straight or sigmoid with
central and polar nodules with transverse striae or punctate rows. Chromatophore single, laminate usually with one or two pyrenoids and adjoining the epivalve. Auxospores single from two conjugate cells or formed parthenogenetically from a single gamete.

1. *Cocconeis pediculus* Ehrenberg

(Pl. 1, Fig.10)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.241, Pl.64, Fig.733)

Cells 21µm long, 18µm broad, striae 18 in 10µm in diameter. Cells curved; valves broadly elliptic; hypovalve with radially arranged transverse striae, with round punctae, 18-20 in 10µm, raphe thread like, straight with small rounded central area; epivalve with striations 15 in 10µm crossed by irregularly longitudinal rows of larger punctae, with narrow linear pseudoraphe scarcely medianly widened.

Collection Number and Date: 15SP/UP and 1 April 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

2. *C. placentula* Ehrenberg

(Pl.1, Fig.11)

Prasad, B. N. and Srivastava, M. N. (1992) (Pg.198, Pl.27, Fig.6)

Cells 21µm long, 11µm broad, striae 19 in 10µm. Valves small elliptical, valve with raphe not seen, rapheless valves bears distinctly punctuate, radially arranged striae; pseudoraphae distinct, narrow and linear.

Collection Number and Date: 5SP/UP and 1 June 2005.

Locality: Dhobighat, Paundhoi River, Saharanpur.

3. *C. placentula* (Ehr.) var. *lineata* (Ehr.) Cleve

(Pl. 1, Fig.12)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.241, Pl.64, Fig.736)

Cells 26 µm long, 16µm broad, striae 12 in 10µm in diameter. Striae in both transverse and longitudinal series, with isolated punctae and hyaline areas appearing towards margins, auxospore parthenogenetic.

Collection Number and Date: 15SP/UP and 1 April 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

Order: Achnanthales

Family: Achnanthaceae

Genus: *Achnanthes* Bory 1822

Cells somewhat rectangular and longitudinally bent or curved in girdle view, generally attached by gelatinous stalks, or sessile and united into bundles at the valves, rarely into filaments, sometimes free floating, solitary, valves generally linear-lanceolate or somewhat elliptic; hypovalve usually concave, with raphe, a distinct central nodule, rather inconspicuous polar nodules, central area sometimes transversely widened into a stauros; epivalve generally convex, with a pseudoraphe; transverse striations, often somewhat radiate, and in some species prominent costa; chromatophores one, two, or numerous and discoid. Two auxospores formed from two cells by the conjugation of two pairs of gametes.

1. *Achnanthes exigua* Grunow

(Pl. 2, Fig. 1)

Krammer, K. and Lange-Bertalot (1988) (Pg.733, Pl.3, Fig.n)

Cells 26µm long 6µm broad, striae 9 in 10µm in diameter.

Collection Number and Date: 17SP/UP and 1 April 2007.

Locality: Kali River, Saapla, Saharanpur.

2. *A. nodosa* Cleve

(Pl.2, Fig. 2)

Husted, F. (1959) (Pg.407, Fig.861)

Cells 21µm long, 11µm broad, striae 10 in 10µm in diameter.

Collection Number and Date: 17SP/UP and 1 April 2007.

Locality: Kali River, Saapla, Saharanpur.

Order: Naviculales

Family: Anomoeoneisceae

Genus: *Anomoeoneis* Pfitzer 1871

Valves solitary, free floating, rhomboidal, elliptical with obtuse usually protracted rostrate or capitate apices, in some species abruptly constricted in the middle, symmetrical longitudinally or transversely; in girdle view somewhat rectangular axial area narrow; linear, median;
central area broad, rounded lyriform or transversely dilated, symmetrical, sometimes asymmetrical, unilaterally; raphe thin, median straight or slightly undulate with distinct central and polar nodules, in some species central nodule slightly bent in same direction or in opposite directions, terminal fissures usually curved forming hook-like structures; striae fine, usually punctuate sometimes lineate arranged transversely and crossed by longitudinal zig-zag hyaline spaces; intercalary band absent; chromatophore single, laminate located longitudinally.

1. Anomoeoneis sphaerophora Pfitzer

(Pl.2, Fig.3)

Prasad, B. N. and Srivastava, M. N. (1992) (Pg.176, Pl.26, Fig.7)

Valves 52µm long, 18µm broad, striae 14 in 10µm in diameter. Frustules solitary long, in girdle view, more or less rectangular, in valve view, subelliptical to elliptical lanceolate with convex margins and narrowly, produced slightly capitately rounded ends; axial area narrow, linear, central area large, asymmetrical, unilaterally widend, raphe thin, straight with distinct central nodules and hook shaped terminal fissures; striae dense, coarsely punctuate, interrupted by hyaline longitudinal zig-zag spaces, slightly radial throughout the valves.

Collection Number and Date: 3ME/UP and 2 June 2005.
Locality: Nagla Pond, Nagla road, Meerut.

Family: Naviculaceae

Genus: Navicula Bory 1822; emend Cleve 1894

Cells generally solitary and free-floating, sometimes aggregated into irregularly radiating clusters, rectangular in girdle view smooth, with smooth girdles and without intercalary bands; valves elongate, usually attenuated towards capitates, rounded or rostrate poles; axial field narrow with distinct, straight raphe and polar and central expansions, nodules small; transverse striations, sometimes somewhat medially radial; two laminate chromatophores varely four to eight, in frequently with one or more pyrenoids. Auxosporas formed in the pair by the fusion of two gametes from each of two approximated cells.

1. Navicula anglica Ralfs

(Pl. 2, Fig. 4)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.262, Pl.67, Fig.764)

Cells 31 µm long, 11 µm broad, striae 12 in 10µm in diameter. Valves elliptic with short rostrate and slightly capitately ends; transverse striations radial, short end or either side rounded central area.

Collection Number and Date: 27SP/UP and 16 February 2009.
Locality: Paper mill Pond, Saharanpur.

2. N. accommodata Hustedt

(Pl. 2, Fig.5)

Husted, F. (1959) (Pg.64, Fig.1208c)

Valves 16µm long, 5µm broad, striae 15 in 10µm in diameter.

Collection Number and Date: 17SP/UP and 16 February 2009.
Locality: Kali River, Saapla, Saharanpur.

3. N. chandolensis Gandhi var. capitatta Gandhi

(Pl.2, Fig.6)

Gandhi, H. P. (1999) (Pg.165, Pl. IV, Fig.123)

Valves 40µm long, 8µm broad, striae 16 in 10µm in diameter.

Collection Number and Date: 12ME/UP and 1 April 2007.
Locality: Budhi Ganga River, Hastinapur, Meerut.

4. N. feuerborni Hustedt

(Pl.2, Fig. 7)

Husted, F. (1938) (Pg.269, Pl.14, Figs.9-10)

Valves 31µm long, 8µm broad, striae 15 in 10µm in diameter.

Collection Number and Date: 17SP/UP and 16 February 2009.
Locality: Kali River, Saapla, Saharanpur.

5. N. grimmei Krasske

(Pl.2, Fig. 8)

Husted, F. (1938) (Pg.236, Pl.17, Fig.14)
Valves 43µm long, 15µm broad, striae 12 in 10µm in diameter.

Collection Number and Date: 22SP/UP and 16 February 2009.

Locality: Yamuna River, Sarsawa, Saharanpur.

6. *N. gottlandica* Grunow

(Pl. 2, Fig. 9)

Gandhi, H. P. (1956) (Pg.405, Pl. I, Fig.5)

Valves 57µm long, 12µm broad, striae 12 in 10µm in diameter. Valves broadly lanceolate with narrowed produced acute rounded ends. Raphe thin and straight, axial area narrow, linear, central area small, radial in the middle and convergent at the ends, lineate.

Collection Number and Date: 15SP/UP and 1 April 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

7. *N. parventralis* Hustedt

(Pl.2, Fig.11)

Husted, F. (1938) (Pg.241, Pl.17, Fig.50)

Valves 23µm long, 10µm broad, striae 13 in 10µm in diameter.

Collection Number and Date: 25SP/UP and 16 February 2009.

Locality: Nakud Pond, Nakud, Saharanpur.

8. *N. radiosa* Kuetzing

(Pl.2, Fig.12)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.255, Pl.67, Fig.780)

Valves 62µm long, 10µm broad, striae 13 in 10µm in diameter.

Collection Number and Date: 15SP/UP and 1 April 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

9. *N. viridula* Kütz. var. *chandolensis* Gandhi

(Pl.2, Fig.13)

Prasad, B. N. and Singh, Y. P. (1996) (Pg.145, Pl.27, Fig.1)

Valves 70µm long, 13µm broad, striae 10 in10µm in diameter.

Collection Number and Date: 12ME/UP and 1 April 2007.

Locality: Budhi Ganga River, Hastinapur, Meerut.

Genus: *Craticula* A. Grunow 1868

Cells solitary, naviculoid, usually lying in valve view. Two elongate, simple plate-like plastids per cell, lying one against each side of the girdle. One to several pyrenoids per plastid; pyrenoids not long rods as *Navicula* Bory. The Valves are lanceolate, with narrow rostrate or capitulate poles. Striae of normal valves more or less strictly parallel. Uniseriate and consisting of small round or elliptical poroides occluded by hymens at their internal apertures.


(Pl.2, Fig.10)

Round, F.E., Crawford R.M. and Mann, D.G. (1990) (Pg.594, Fig.h)

Valves 62µm long, 16µm broad, striae 13 in 10µm in diameter. Valves long, lanceolate with distinctly constricted highly produced rounded ends; Raphe thin and straight, median with distinct closely placed central nodules; Axial area narrow, linear, central are moderately broad; striae fine, lineate parallel through the valve.

Collection Number and Date: 22SP/UP and 16 February 2009.

Locality: Yamuna River, Sarsawa, Saharanpur.

Genus: *Gyrosigma* Hassall 1845; emend, Cleve 1894

Cells solitary free floating, sometimes in gelatinous tubes, elliptic-lanceolate in girdle view, intercalary bands, sometimes narrowly so, rarely with nearly straight sides to broadly rounded poles; raphe sigmoid; with small central, and polar nodules; axial area narrow with small usually rounded central area; transverse striations crossing longitudinal striations at right angles; two chromatophores regularly or irregularly shaped plates, generally with several pyrenoids.

1. *Gyrosigma scalpoides* (Rabenhurst) Cleve

(Pl. 2, Fig. 14)
Valves 50µm long, 10µm broad, Valves lanceolate, sigmoid, and gradually attenuated to rounded poles, transverse striations usually perpendicular to the middle line, sometimes medianly radial 22-24 in 10µm.

Collection Number and Date: 15SP/UP and 1 April 2007.

Locality: East Yamuna Canal, Klausia, Saharanpur.

**Family: Pinnulariaceae**

**Genus: Diploneis Ehrenberg 1844**

Cells solitary, rectangular in girdle view; valve usually elliptic, sometimes linear or with a median constriction; central nodules transversely quadrate, prolonged towards the poles into horn which enclose the straight raphe; longitudinal furrow on each side of horns and central nodules transverse costae or rows of punctuate, sometimes somewhat radial, often crossed by longitudinal costae or rows of punctae, chromatophores two, longitudinal incised or not.

1. *Diploneis puella* (Schumann) Cleve

(Pl.2, Fig. 15)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.249, Pl.65, Fig.752)

Cells 15µm long, 8µm broad, striae 16 in 10µm in diameter. Valves elliptic, central area large and four sided; horn evident, furrow very narrow; transverse costae delicate, somewhat radial 16 in 10µm, with in terminate spaces very finely punctuate; longitudinal costae indistinct.

Collection Number and Date: 27SP/UP and 16 February 2009.

Locality: Paper mill Pond, Saharanpur.

**Order: Cymbellales**

**Family: Gomphonemaceae**

**Genus: Gomphonema Agardh 1824**

Valves rarely solitary, usually in fan shaped colonies, attached to dichotomously branched gelatinous stalk, sometime sessile, free floating asymmetrical transversely, intercalary bands and costae absent, in valve view cuneate clavate, lanceolate or nearly straight with one pole usually broader than the other, axile area usually narrow, straight, sometimes broad and lanceolate, central area broad, elliptical unilateral or centric with an asymmetrical placed dots, raphe thin, median with central and polar nodules, striae fine or coarse, lineate or punctate parallel slightly radial sometimes convergent towards poles chromatophores usually single with single pyrenoids.

1. *Gomphonema acuminatum* Ehrenberg

(Pl.3, Fig. 1)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.272, Pl.72, Fig.830)

Cells 72µm long, 10µm broad, striae 10 in 10µm in diameter. Valves generally cuneate, expanded near the apex and less so medially, with a broad flat apex acutely topped and with a deep sub-apical constriction; central area large with an isolated dots; transverse striations somewhat radial.

Collection Number and Date: 5SP/UP and 3 June 2005.

Locality: Yamuna River, Sarsawa, Saharanpur.

2. *G. constrictum* Ehrenberg

(Pl.3, Fig. 2)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.271, Pl.72, Fig.839)

Cells 36µm long, 11µm broad, striae 11 in 10µm in diameter. Valves clavate, constricted below the broad rounded apical pole, with attenuated basal pole; axial area narrow; central area broad and irregularly defined, with a dot on one sides; transverse striation, radial, evidently punctuate, alternately long and short in the middle of the valve.

Collection Number and Date: 7GB/UP and 8 June 2005.

Locality: Upper Ganga Canal, Dehrajal Bairaj and Dhawana, Ghaziabad.

3. *G. constrictum* var. *capitatum* f. *turgidum* (Ehr.) Mayer

(Pl.3, Fig.3)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.271, Pl.72, Fig.841)

Cells 30µm long, 10µm broad, striae 12 in 10µm in diameter.
Collection Number and Date: 15SP/UP and 1 April 2007.
Locality: East Yamuna Canal, Klausia, Saharanpur.

4. *G. intermedium* Hustedt

(Pl.3, Fig.4)

Hustedt, F. (1938) (Pg.120, Pl.117, Fig.256)

Valves 60µm long, 12µm broad, striae 11 in 10µm in diameter.

Collection Number and Date: 5SP/UP and 3 June 2005.
Locality: Yamuna River, Sarsawa, Saharanpur.

5. *G. parvulum* (Kuetz) var. *exilissima* Grunow

(Pl.3, Fig.5)

Gandhi, H.P. (1959 a) (Pg.119, Pl. IV, Fig.77)

Valves 31µm long, 7µm broad and striae 13 in 10µm in diameter. Valves broadly lanceolate-clavate with apex clearly constricted and produced beak like striae radial in shape.

Collection Number and Date: 10SP/UP and 1 April 2007.
Locality: Budhi Yamuna River, Ambala road, Suaakhedi, Saharanpur.

6. *G. spheroporum* Ehrenberg

(Pl.3, Fig.6)

Tiffany, L. H. and Britton, M. E. (1952) (Pg. 272, Pl. 72, Fig. 847)

Valves 40µm long, 9µm broad, striae 9 in 10µm in diameter. Valves elliptic-clavate, sharply narrowing towards a rounded slightly capitates basal pole and with a much knob-like apical pole; axial area narrow; linear, central area small, with a dot at one side; transverse striations; more or less clearly punctuate, slightly radial.

Collection Number and Date: 7GB/UP and 8 June 2005.
Locality: Upper Ganga Canal, Dehrajhal Bairaj and Dhawana, Ghaziabad.

7. *G. subventricosum* Hustedt

(Pl.3, Fig.7)

Prasad, B. N. and Singh, Y. P. (1996) (Pg.156, Pl.28, Fig.4)

Valves 44µm long, 12µm broad, striae 11 in 10µm in diameter.

Collection Number and Date: 12ME/UP and 1 April 2007.
Locality: Budhi Ganga River, Hastinapur, Meerut.

8. *G. truncatum* Ehrenberg

(Pl.3, Fig. 8)

Krammer, K. and Lange-Bertalot, H. (1988) (Pg. 369, Fig. 159:17)

Valves 46µm long, 12µm broad, striae 11 in 10µm in diameter.

Collection Number and Date: 1SP/UP and 2 June 2005.
Locality: Nakud Pond, Nakud, Saharanpur.

Family: Cymbellaceae

Genus: *Cymbella* Agardh 1830

Cells solitary, free-floating or attached at the ends of gelatinous stalk or confined in branched gelatinous tubes, with parallel sides in girdle view and smooth girdles without intercalary bands; valve asymmetric (sometimes only slightly so) lunate or nearly elliptic or rhombic or naviculoid, dorsally convex, ventrally concave, straight or somewhat convex; axial field wide or narrow, nearer the ventral margins, with central area with or without dots; raphe curved with well defined nodules; transverse striations radiate, sometimes cross-lined; chromatophore a single expanded plate. Auxospore formed in pairs between conjugating cells.

1. *Cymbella affinis* Kutzing

(Pl. 3, Fig. 9)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.279, Pl.73, Fig.856)

Valves 40µm long, 10µm broad, striae 10 in 10µm in diameter. Valves quite asymmetric, semi-lanceolate to semi-elliptic, convex dorsally, concave to straight ventrally, with rostrate, rounded poles; raphe excentric; undulate towards the central nodules; axial area narrow, slightly medianly widened, with ventral median striae ending in isolated dots; transverse striations radiate with cross lined.

Collection Number and Date: 12ME/UP and 1 April 2007.
Locality: Budhi Ganga River, Hastinapur, Meerut.
2. *C. cymbiformis* (Kuetzing) Brebisson

(Pl.3, Fig.10)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.278, Pl.74, Fig.873)

Valves 50μm long, 10μm broad, striae 8 in 10μm in diameter. Valves naviculoid, strongly curved, dorsally convex, ventrally near straight, with slight median expansion; raphe excentric; broad; axial area narrow, somewhat medianly widened; transverse striations radiate.

Collection Number and Date: 5SP/UP and 3 June 2005.

Locality: Yamuna River, Sarsawa, Saharanpur.

3. *C. lacustris* (Agardh) Cleve

(Pl.3, Fig.11)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.276, Pl.74, Fig.867)

Valves 35μm long, 11μm broad, striae 10 in 10μm in diameter. Valves linear-lanceolate, scarely asymmetric, with broadly rounded poles; axial area linear, more or less medianly expanded, raphe only slightly excentric and curved; transverse striations cross-lined somewhat radiate in the centre, convergents towards the ends and scattered at the poles.

Collection Number and Date: 18SP/UP and 15 February 2009.

Locality: Devikund, Deoband, Saharanpur.

4. *C. turgida* (Greg.) Cleve

(Pl. 3, Fig.12)

Prasad, B. N. and Singh, Y. P. (1996) (Pg.153, Pl.28, Fig.13)

Valves 50μm long, 12μm broad, striae 9 in10μm in diameter.

Collection Number and Date: 7GB/UP and 8 June 2005.

Locality: Upper Ganga Canal, Dehrajhal bairaj, Dhawana, Ghaziabad.

5. *C. ventricosa* Kuetzing

(Pl.3, Fig.13)

Prasad, B. N. and Srivastava, M. N. (1992) (Pg.275, Pl.34, Fig.7)

Valves 30μm long, 8μm broad, striae 10 in 10μm in diameter. Valves elliptical-lanceolate, asymmetrical with dorsal and ventral margins convex; ends constricted on the dorsal side, produced and rounded; raphe thick, excentric, undulate with central nodules bent ventrally, terminal fissures turned dorsally; axial area linear narrow, gradually widening towards center; central area broad elliptical with two isolated punctae on the dorsal side; striae course lineate, radial becoming close towards the ends.

Collection Number and Date: 7GB/UP and 8 June 2005.

Locality: Upper Ganga Canal, Dehrajhal bairaj, Dhawana, Ghaziabad.

**Order: Thalassiophysales**

**Family: Catenulaceae**

**Genus: Amphora Ehrenberg 1840**

Frustules biraphid, asymmetrical to the apical axis, symmetrical to trans apical axis. Valve mantle on dorsal margins, making the valve arched and not entirely in focus at one focal plane, raphe not central, eccentric to strongly eccentric, straight, arched or slightly sigmoid; striae on dorsal margins usually crossed by hyaline areas, striae on ventral margin short, sometimes difficult to see, depending on the position of the valve. Stigmata lacking terminal nodules in distinct.

1. *Amphora rugosa* Hustedt

(Pl.3, Fig. 14)

Hustedt, F. (1938) (Pg. 415, Tafel.24, Fig. 1)

Valves 30 μm long, 17μm broad, striae 15 in 10μm in diameter.

Collection Number and Date: 22SP/UP and 16 February 2009.

Locality: Yamuna River, Sarsawa, Saharanpur.

**Order: Rhopalodiales**

**Family: Rhopalodiaceae**

**Genus: Epithemia Brebisson 1838**

Cells solitary, usually epiphytic upon submerged equatics, attached at the girdle, rectangular in girdle view, smooth girdles, and intercalary bands; valves slightly to strongly

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curved dorsally convex, ventrally straight to concave, with broadly rounded to the capitates and sometimes recurved poles, axial field near ventral side except for V-shaped median extension towards dorsal side, raphe with polar and central nodules with the inner fissure containing circular pores transverse septa appearing as costae and alternating with two or more rows of punctae; a single chromatophore with irregular projections.

1. *Epithemia sorex* Kuetzing

(Pl.3, Fig. 15)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.281, Pl.75, Fig.881)

Cells 52µm long, 11µm broad, striae 13 in10µm in diameter. Valves ventrally concave, dorsally convex, constricted below the recurved capitates poles costae 6 in 10 µm in diameter.

Collection Number and Date: 12ME/UP and 1 April 2007.

Locality: Upper Ganga Canal, Hastinapur, Meerut.

**Genus: Rhopalodia Mueller 1895**

Cells usually solitary and free floating, girdle faces, girdle linear, nearly elliptic, clave medianly inflated, with broadly rounded to nearly flat poles; valves lunate to sickle-shaped, convex margins, with raphe bearing central and polar nodules; transversely costate with alternating delicate striation; with or without intercalary bands, a single laminate chromatophores with irregular margins. Auxospore formed in the pairs between two generally differently sized cells, elongation of auxospores as in the *Epithemia*.

1. *Rhopalodia brebissonii* Krammer

(Pl.3, Fig. 16)

Krammer, K. and Lang-Bertalot, H. (1988) (Pg.164, Fig. 113:12)

Valves 31µm long, 8µm broad, striae 3 in one fibulae in 10µm in diameter.

Collection Number and Date: 13ME/UP and 1 April 2007.

Locality: Upper Ganga Canal, Hastinapur, Meerut.

2. *R. gibba* (Kuetzing) Mueller

(Pl.4, Fig.1)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.282, Pl.75, Fig.884)

Valves 80µm long, 20µm broad, striae 8 in 10µm in diameter. Valves in girdle view broadly linear with median inflation and broadly rounded poles. Valves very broadly lunate with almost straight ventral sides and recurved acutes poles.

Collection Number and Date: 13ME/UP and 1 April 2007.

Locality: Upper Ganga Canal, Hastinapur, Meerut.

**Order: Bacillariales**

**Family: Bacillariaceae**

**Genus: Nitzschia Hassall 1845**

Cells solitary and free floating or densely clustered in simple or unbranched gelatinous tubes, elongate-rectangular or sigmoid in girdle view; with somewhat attenuated poles, rhombic in cross section; valves longitudinally asymmetric, very variable to shapes; straight, sigmoid linear elliptic, somewhat undulate, medially constricted or not poles acute or rostrate or capitates, often much attenuate; near one margin is a keel with a raphe having small nodules and a row of circular pore (“cranial dots”) opening towards the interior of the cell; transversely striate or punctuate; two chromatophores on the same girdle face. Two auxospores formed by the conjugation of two cells in a somewhat crossed apposition.

1. *Nitzschia amphibia* Grunow

(Pl.4, Fig. 2)

Prasad, B. N. and Srivastava, M. N. (1992) (Pg.285, Pl.36, Fig.16)

Valves 20µm long, 4µm broad, striae 18 in 10µm in diameter. Valves short, linear-lanceolate with slightly constricted produced, sub-rostrate ends, carnial dots big, rounded, median two slightly placed apart; striae coarse, indistinctly punctuate parallel throughout the valve.

Collection Number and Date: 16SP/UP and 1 April 2007.

Locality: Devikund, Deoband, Saharanpur.

2. *N. denticula* Grunow

(Pl.4, Fig. 3)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.286, Pl.77, Fig.902)
Valves 29μm long, 5μm broad, striae 17 in 10μm and keel punctuate 6 in 10μm in diameter. Valves long lanceolate, with acutely rounded poles; transverse striations; keel punctuate appearing costae.

Collection Number and Date: 13ME/UP and 1 April 2007.
Locality: Upper Ganga Canal, Hastinapur, Meerut.

3. N. diducta Hustedt
(Pl.4, Fig. 4)
Prasad, B. N. and Singh, Y. P. (1996) (Pg.157, Pl.30, Fig.2)
Valves 56μm long, 9μm broad, striae 30 in 10μm and carinal dots 9 in 10μm in diameter.
Collection Number and Date: 19GB/UP and 3 April 2007.
Locality: Road side Pond, Delhi bypass road, Hapur, Ghaziabad.

4. N. frustulum var. perpusilla Rabenhorst
(Pl.4, Fig. 5)
Prasad, B. N. and Singh, Y. P. (1996) (Pg.158, Pl.31, Fig. 5)
Valves 44μm long, 4μm broad, striae 17 in 10μm, carinal dots 11 in 10μm in diameter.
Collection Number and Date: 11GB/UP and 3 April 2007.
Locality: Railway line side Ponds, Pilkuha, Ghaziabad.

5. N. obtusa var. scalpelliformis Grunow
(Pl.4, Fig. 6)
Prasad, B. N. and Singh, Y.P. (1996) (Pg.159, Pl.31, Fig. 9)
Valves 65μm long, 9μm broad and carinal dots 7 in 10μm in diameter.
Collection Number and Date: 27SP/UP and 1 February 2009.
Locality: Paper mill, Pond, Saharanpur.

6. N. sigma var. regidula Grunow
(Pl.4, Fig.7)
Prasad, B. N. and Singh, Y. P. (1996) (Pg.161, Pl.29, Fig. 12)
Valves 65μm long, 6μm broad and carinal dots 8 in 10μm in diameter.
Collection Number and Date: 27SP/UP and 1 February 2009.
Locality: Paper mill, Pond, Saharanpur.

7. N. sigmoidea (Nitzsch) Smith
(Pl.4, Fig.8)
Tiffany, L. H. and Britton, M. E. (1952) (Pg.286, Pl.77, Fig.902)
Valves 29μm long, 5μm broad, striae 17 in 10μm keel punctuate 6 in 10μm in diameter. Valves long-lanceolate, gradually attenuated towards acutely rounded ends; carinal dots indistinct; striae fine, punctuate parallel throughout the valve.
Collection Number and Date: 27SP/UP and 1 February 2009.
Locality: Paper mill, Pond, Saharanpur.

8. N. sinuata (Smith) Grunow in Cleve and Grunow var. tabellaria (Grunow) in Van Heurek
(Pl.4, Fig.9)
Krammer, K. and Lange-Bertalot, H. (1988) (Pg.52, Fig.39:12)
Valves 24μm long, 7μm broad, striae 7 in 10μm in diameter.
Collection Number and Date: 7GB/UP and 8 June 2005.
Locality: Upper Ganga Canal, Dehrajhal bairaj, Dhawana, Ghaziabad.

9. N. subtilis (Kuetz.) Grunow var. paleacea Grunow
(Pl.4, Fig.10)
Prasad, B. N. and Srivastava, M. N. (1992) (Pg.308, Pl.35, Fig.16)
Valves 30μm long, 4μm broad, striae 17 in 10μm in diameter. Valves small, linear-lanceolate, gradually attenuated towards acutely rounded ends; carinal dots indistinct; striae fine, punctuate parallel throughout the valve.
Collection Number and Date: 7GB/UP and 8 June 2005.
Locality: Upper Ganga Canal, Dehrajhal bairaj, Dhawana, Ghaziabad.
10. *N. towutensis* Hustedt

(Pl.4, Fig.11)

Hustedt, F. (1959) (Pg.139, Fig.339)

Valves 17μm long, 6μm broad, striae 16 in 10μm in diameter.

Collection Number and Date: 27SP/UP and 1 February 2009.

Locality: Paper mill, Pond, Saharanpur.

**Genus: Hantzschia Grunow 1880**

Cells rectangular in cross-section, with keeled margins opposite each other; otherwise as in the genus Nitzschia.

1. *Hantzschia amphioxys* (Ehr.) Grunow

(Pl.4, Fig.12)

Tiffany, L. H. and Britton, M. E. (1952) (Pg.289, Pl.75, Fig.886)

Valves 60μm long, 7μm broad, striae 16 in 10μm, keel punctae 8 in 10μm in diameter.

Collection Number and Date: 27SP/UP and 1 February 2009.

Locality: Paper mill, Pond, Saharanpur.

**Order: Surirellales**

**Family: Surirellaceae**

**Genus: Cymatopleura Smith 1851**

Cells generally solitary and free floating, rectangular, naviculoid, cuneate or sigmoid in girdle view, smooth, valve linear, elliptic or ovate or sometimes spirally twisted, valve faces transversely folded, the fold appearing as costae, along valve margin is a keel, containing a raphe, transverse costae parallel, either long or short and delicate striations across the valve face, interrupted by a median longitudinal pseudo-raphe, chromatophores single, appearing as two laminate plate. A single auxospore formed at the end to end conjugation of two cells.

1. *Cymatopleura solea* (Breb.) Smith

(Pl.4, Fig.13)

Gandhi, H. P. (1959) (Pg.131, Pl. IV, Figs.108-109)

Valves 56μm long and 15μm broad and costae 4 in 10μm, heteropolar, narrowly ovate, wing canal about 3-4 in 10 μm striae fine.

Collection Number and Date: 27SP/UP and 1 February 2009.

Locality: Paper mill, Pond, Saharanpur.

2. *S. subsalsa* Smith

(Pl.4, Fig.15)

Gandhi, H. P. (1959) (Pg.121, Pl. IV, Figs.84-86)

Valves 43μm long and 11μm broad and costae 4 in 10μm in diameter, heteropolar, ovate or ovate-lanceolate with acutely rounded base. Axial field narrow, linear to lanceolate, striae 7 in 10μm.

Collection Number and Date: 27SP/UP and 1 February 2009.

Locality: Paper mill, Pond, Saharanpur.
PLATE-1

Legend

PLATE 2

Legend

PLATE-3

Legend

PLATE-4


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Bibliography


Prasad, B. N. and Singh, Y. 1996. Algal indicator of water pollution, B. Singh and M. P. Singh, Dehradun, India. 263.


