



Floristic Assortment of Planktonic and Epipsammic Diatoms from Eastern India with new reports.

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Abstract:

Floristic diversity of planktonic and epipsammic diatoms from Gangetic West Bengal and Chandipur respectively have been carried out for one year and a total of fifty diatom taxa have been documented in the present communication. Gangetic West Bengal harbored mostly planktonic diatoms among which centric forms predominated whereas, Chandipur is a repository of pinnate epipsammic diatoms flora. Among the recorded diatom taxa *Coscinodiscopsis jonesiana*, *Thalassiosira fryxelliae*, *Thalassiosira punctigera*, *Thalassiosira anguste-lineata*, *Thalassiosira visurgis*, *Thalassiosira pacifica*, *Lithodesmium undulatum*, *Nitzschia pungens* var. *atlantica*, *Gyrosigma acuminatum*, *Pleurosigma frenguellanum* and *Chaetoceros danicus* recorded for the first time from gangetic West Bengal. Eighteen different epipsammic diatom species from Chandipur of Balasore district, Orissa have also been reported for the first time.

Keywords: Plankton. Epipsammic diatoms.

Introduction:

Diatoms are ubiquitously distributed in almost every aquatic ecosystem with variable temperature, pH and in brackish water to hyper saline environments. In marine environment they contribute almost 40% of the total carbon fixed and serve as a chief source of zooplankton food in the marine food chain (Nelson et al., 1995; Mann, 1999). At the end of the growing season diatom bloom gets settled down at the bottom of the rivers, lakes or oceans thereby controlling the nutrient as well as biogeochemical cycle of the ecosystem. A floristic study on diatom diversity is always an important line of research for corroboration of population diversity in one hand and to get a better preview of a particular ecosystem on the other. The East coast of India harbors mainly West Bengal and Orissa coast. Several workers have extensively studied and documented diatom flora of Orissa. Swain et al. (1994) reported and published 59 algal species from two temple tanks of Puri of which 8 taxa belong to Bacillariophytes. Jena et al. (2006) documented for the first time 78 diatom taxa from various parts of Orissa. Mohanty and Adhikary (2013) reported 30 species of diatoms from Chilika lagoon. Recently Bhakta et al. (2016) assorted total of 50 algal species from different hot springs of Orissa of which 12 species belong to division Bacillariophyta. The lower part of Gangetic West Bengal mainly encompasses Hooghly- Matla, Bhagirathi- Hooghly estuaries and coastal West Bengal which nourishes a diversified planktonic algal flora as relevant from several literatures (Choudhury and Pal, 2008, 2010, 2011, 2012a, b; Mandal and Sarkar, 2015; Sekh and Sarkar, 2016). Other studies highlighted on the cell volume estimation and diversity of Phytoplanktons from different parts of Indian Sundarbans (Mitra et. al., 2014; Choudhury and Bhadury, 2014). The present study deals with the assortment of diatom flora from lower part of Gangetic West Bengal and Chandipur region of Balasore district, Orissa. Though extensive work had been carried out from these two states but Chandipur region remained unexplored and no such prominent reports are available on the diatom assemblages in Chandipur. From the lower part of Gangetic West Bengal also morphological documentation of diatom population diversity is rare. In the present investigation Chandipur and Raidighi region of Orissa and West Bengal respectively have been surveyed for one year (2016-2017) and recorded a total of 50 diatom taxa and detailed taxonomic enumeration have been done. The SEM studies performed for some of the new reports and dominant taxa from the study area.

Materials and Methods:

Diatom samplings were carried out for one year and a total of 50 samples have been recorded from Gangetic West Bengal and Orissa. The study site includes Mani river near Raidighi bridge (21°59'41.5"N and 88°26'42.3"E) and

Chandipur area of Balasore district, Orissa (21°43'99" N and 87°01'49" E). Planktonic diatoms were sampled using phytoplankton net of mesh size 20µm, through which approximately 50 L of water had been passed and the final volume was brought to 50ml and stored in polythene sampling bottles. As for epipsammic diatoms the surface of the substratum had been scrapped with a very fine scalpel and stored in 50ml falcon tube. The samples were then brought to the laboratory. The turbid soup procured both from the water sample and after washing off the brownish layer on the sand particles, the samples were segregated into two fractions. One fraction was subjected to centrifugation at 10000rpm for 15 minutes. The pellet thus obtained was fixed with 4% formalin for taxonomic enumeration. The other fraction was treated to acid hydrolysis as per protocol of Hassle (1978) with slight modifications. Acid hydrolysis was required to digest the organic casing of the diatom frustules and to get a better preview of the intricate ornamentation under scanning electron microscope (SEM).

Photomicrographs were taken under light microscope (Carl- Zeiss Axiostar) using digital camera (Canon T2-T2 1, 6x SLR 426115). Taxonomic enumeration of diatoms was done using suitable monographs viz. Cupp, 1943; Subhramanyan, 1946; Das and Adhikary, 2014; Round et. al. 1990; Husted, 1930 and verified from Algaebase, a listing of the world's algae (<http://www.algaebase.org>).

For SEM identification the samples were first acid hydrolyzed followed by washing with distilled water and centrifugation at 12000rpm for 10 minutes. The washing step was repeated four times in order to neutralize the diatom frustules and remove excess acid (Hassle, 1978). Finally the frustules were dissolved in 75% ethanol to avoid bacterial contamination till further analysis. Before SEM analysis a drop of the sample was taken on an ethanol wiped glass cover slip (Blue Star) and dried at room temperature at sterile condition. The glass cover slip was then placed on carbon tape and put in Quorum (Q 150 TES) platinum coater to coat the samples with platinum (6nm). Photographs have been taken with the use of Carl Zeiss EVO 18 (EDS 8100) microscope with Zeiss Inca Penta FETX 3 (Oxford instruments) attachment.

Results and Discussion:

From the present survey a total of 50 diatom taxa were recorded from two different sites of eastern India for the first time. Raidighi of gangetic West Bengal had the maximum variety of planktonic diatoms with a report of over 30 species among which centric diatoms dominated over pennate ones. There were 6 different species of *Thalassiosira* followed by 4 species of *Coscinodiscus*, 3 species of *Skeletonema*, 2 species each of *Rhizosolenia*, *Odontella*. Among them diatom taxa like *Coscinodiscopsis jonesiana*, *Thalassiosira fryxelliae*, *Thalassiosira punctigera*, *Thalassiosira anguste-lineata*, *Thalassiosira visurgis*, *Thalassiosira pacifica*, *Lithodesmium undulatum*, *Nitzschia pungens* var. *atlantica*, *Gyrosigma acuminatum*, *Pleurosigma frenguellianum* and *Chaetoceros danicus* would be reported for the first time from gangetic West Bengal. Chandipur of Balasore district, Orissa harboured 18 different epipsammic diatom species and would also be reported first time from that site. Systematic enumeration of Bacillariophytes had been based on Round et al. (1990) and Medlin and Kaczmarska (2004). Taxonomic enumerations of the recorded taxa are as follows:

PHYLUM: BACILLARIOPHYTA
CLASS: COSCINODISCOPHYCEAE
ORDER: COSCINODISCALES
FAMILY: COSCINODISCACEAE

Coscinodiscus radiatus Ehrenberg (Fig. 1g; 4c)

(Cupp, 1943, pp.56, fig.20; Chowdhury and Pal, 2008, pp.32, fig. 1 E; Sar et al. 2010, pp.9, fig. 45-50)

Cells flat, coin-shaped discs, valves flat, 50-60µm in diameter; valve surface with coarse areolae, without rosette or central area, areolae nearly same size on whole valve.

SEM observation: Central area with conspicuous rosette, larger areolae, surrounded by less developed hyaline area, areolar pattern radial, spiraling decussate arcs, macrorimoportulae larger than microrimoportulae, slightly wider at top than at base (fig. 4c)

Occurrence: Planktonic

Coscinodiscus perforatus Ehrenberg (Fig. 4a)

(Sar et al. 2010, pp.6, fig. 25-32)

Frustule valve circular, flat, 80µm in diameter, valve mantle abruptly sloped, shallow, one to three rows of areolae, areolar pattern radial, secondary forming spiraling decussate arcs; central rosette commonly ordered around a hyaline, irregular, central area.

Occurrence: Planktonic

Coscinodiscus centralis Ehrenberg (Fig. 1d; 4d)

(Subhramanyan, 1946, pp. 98, fig. 49, 55, 58-59; Lee et al., 2015, pp. 579, fig. 4f-g)

Cells disc-shaped; valves convex, 70-196µm in diameter; valve areolated with clear rosette; chamber openings clear; both radial and secondary spiral systems of areolae present; valve edge narrow and striated.

Occurrence: Planktonic

Coscinodiscopsis jonesiana Sar and Sunesen (Fig. 1c; 4b)

[Homotypic Synonym: *Coscinodiscus jonesianus* (Greville) Ostenfeld]

(Sar and Sunesen, 2008, pp. 404, fig. 4-9; 10-14)

Cells solitary; valve convex, flat or slightly depressed in the centre, circular outline, diameters ranging from 75-226µm.

SEM observation: Central rosette of areolae with eccentric location of the foramina, visible as a hyaline area internally, cribrum with complex pattern of perforations.

Occurrence: Planktonic

FAMILY: HEMIDISCACEAE

Actinocyclus normanii Hustedt (Fig. 1a)

(Vidaković et al., 2016, pp. 203, fig. 1A-G)

Valves circular; one valve concave and other convex in the middle, diameter ranges from 15.8–50µm; valves with patterns of radiating parallel rows of areolae; species can occur as single cells or as colonies.

Occurrence: Planktonic

FAMILY: AULACODISCACEAE

Aulacodiscus johnsonii var. *amherstia* Sims and Holmes (Fig. 1b)

(Chowdhury and Pal, 2008, pp. 35, fig. 1H)

Cells discoid; valves with a circular outline, flat with six conical processes symmetrically arranged near margin, areolated; intercalary bands present; chromatophores small, numerous; cells 50-60µm in diameter.

Occurrence: Planktonic

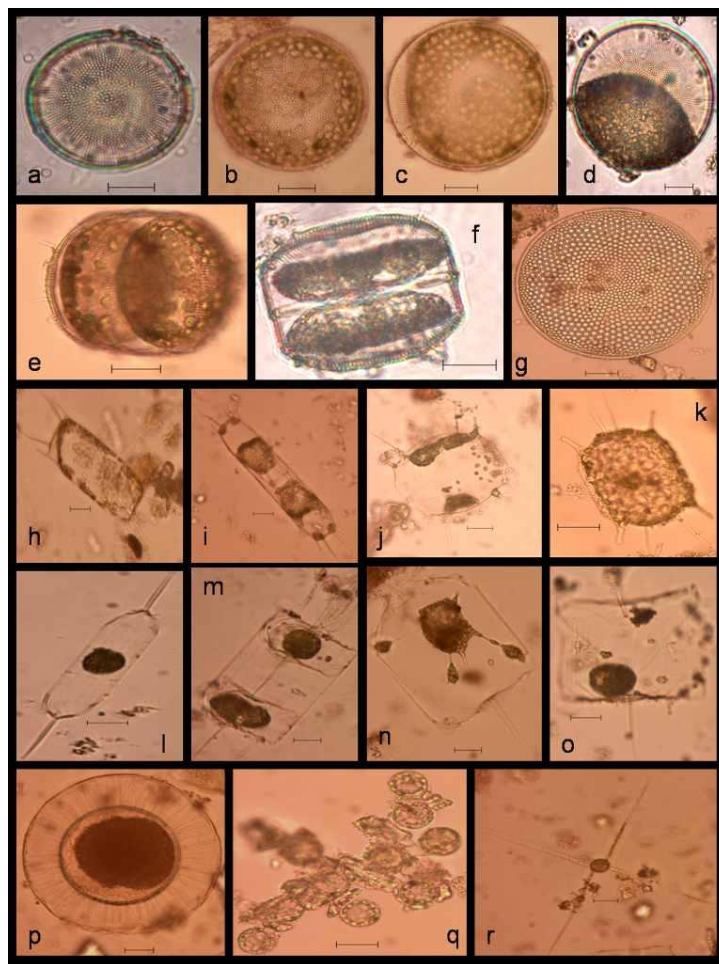


Fig.1. a) *Actinocyclus normanii*, b) *Aulacodiscus johnsonii* var. *amherstia*, c) *Coscinodiscopsis jonesiana*, d) *Coscinodiscus centralis*, e-f) *Thalassiosira punctigera*, g) *Coscinodiscus radiatus*, h-i) *Trieres chinensis*, j) *Cerataulus heteroceros*, k) *Trieres mobiliensis*, l-m) *Ditylum brightwellii*, n-o) *Lithodesmium undulatum*, p) *Planktoniella sol*, q) *Thalassiosira fryxelliae*, r) *Chaetoceros danicus*. (Scale bar- 10µm)

ORDER: RHIZOLENIALES
FAMILY: RHIZOLENIACEAE

Rhizolenia setigera Brightwell (Fig. 2m)

(Cupp, 1943, pp. 88, fig. 49; Yun and Lee, 2010, pp. 180, fig. 5)

Cells rod like, 4-20µm in diameter; valves conical only slightly oblique; apical process cylindrical, thickened for some distance from base, solid at base or with a fine canal in the center with a very long, fine, straight spine; cell wall weakly siliceous.

Occurrence: Planktonic

Rhizolenia setigera f. *pungens* Brunel (Fig. 2n)

[Homotypic Synonym: *Rhizolenia pungens* Cleve-Euler]

(Yun et al., 2011, pp. 144, fig. 1; Sunesen and Sar, 2007, pp. 7, fig. 35-47)

Cells solitary or in pairs, cylindrical, bilaterally symmetrical, circular in cross-section, and 3.8-16.7µm in diameter; valve sharply sub-conical, elongated, with a tapering needle-shaped process, almost straight, 25-97.5µm in length.

Occurrence: Planktonic

CLASS: MEDIOPHYCEAE

ORDER: THALASSIOSIRALES

FAMILY: THALASSIOSIRACEAE

Thalassiosira decipiens Jørgensen (Fig. 4e)

(Hoppenrath et al., 2007, pp. 277, fig. 16-18; Lehmkuhl, et al. pp.321, fig. 46-54)

Cells 10–32.0µm in diameter, heterovalvate with eccentric, relatively coarse hexagonal areolae, valve face covered by minute siliceous granules, one tiny central strutted process on one valve, one prominent labiates process between two marginal strutted processes.

Occurrence: Planktonic

Thalassiosira visurgis Hustedt (Fig. 4g)

(Li et al., 2013, pp. 104, fig. 128)

Valve face flat, 10-18.0µm in diameter; areolae arranged in linear or eccentric lines, one fultoportula present on the center, close to a large areola; valve margin characterized by a ring of fultoportulae, two rimoportulae with long external tubes located almost on opposite sides, each taking the place of a fultoportula.

Occurrence- Planktonic

Thalassiosira pacifica Gran and Angst (Fig. 4f)

(Li et al., 2013, pp. 101, fig. 103-104)

Valve diameter 12-26µm, valve face flat; areolae organized into linear; one fultoportula present at the valve center, valve margin characterized by a ring of regularly spaced marginal fultoportulae, a rimoportulae replaces a fultoportula.

Occurrence- Planktonic

Thalassiosira angustilineata Fryxell and Hasle (Fig. 2i)

(Sunesen et al., 2009, pp. 72, fig. 5A-C)

Cells collected in colonies by several mucilaginous tracts, distribution pattern of reinforced processes, a complete marginal ring; diameter 6-40µm.

Occurrence: Planktonic

Thalassiosira punctigera Hasle (Fig. 1e, f; 4h)

(Hasle, 1983, pp. 605, fig. 40; Gomez and Souissi, 2010, pp. 1427, fig. 4G-I)

Cells in girdle view box shaped; chloroplasts many, small, rounded discs; cells 40-186µm in diameter; varying number of large tubular occluded process.

Occurrence: Planktonic

Thalassiosira fryxelliae Sunesen & Sar (Fig. 1q)

(Sunesen et al., 2009, pp. 73, fig. 6A-C)

Cells embedded in a mass Jelly, variable annealing pattern, linear, sub linear, eccentric or irregular; marginal lipid process included in the tube reinforced process ring; cells 10-23µm in diameter.

Occurrence: Planktonic

Planktoniella sol Schütt (Fig. 1p)

(Cupp, 1943, pp. 63, fig. 27)

Valves nearly flat with structure like that in *Coscinodiscus excentricus*; cells disk-shaped, central disk varies in diameter 25-81µm, entire cell from 60-165µm; one valve of cell provided with wings.

Occurrence: Planktonic

FAMILY: SKELETONEMATACEAE

Skeletonema costatum Cleve (Fig. 2j)

(Castillo et al., 1995, pp. 109, fig. 17-22)

Cells joined in long chains of 6-24 cells, with varying spaces between sibling cells; each cell has 1 or 2 chloroplasts; valves are flat or slightly convex; cells 2-15µm in diameter; space between sibling cells 2-11.5µm.

Occurrence: Planktonic

Skeletonema tropicum Cleve (Fig. 2k)

(Castillo et al., 1995, pp. 110, fig. 23; Sarno et al., 2005, pp. 166, fig. 9; Jung et al., 2009, pp. 202, fig. 4)

Cells 5-18µm in diameter, pervalvar axes 3-9µm, rarely exceeding twice the cell diameter; a colony was straightly connected with 10-52 cells, and 2-4 chloroplasts were seen in each cell.

Occurrence: Planktonic

Skeletonema marinoi Sarno and Zingone (Fig. 2l)

(Jung et al., 2009, pp. 197, fig. 2; Sarno et al., 2005, pp. 160, fig. 5)

Cells 3.5-10µm in diameter; the pervalvar axes 8-18µm; a colony was straightly connected with 16-33 cells, each cell contained one or two chloroplasts; valve face slightly convex; mantle vertical.

Occurrence: Planktonic

ORDER: LITHODESMIALES

FAMILY: LITHODESMIACEAE

Ditylum brightwellii Grunow (Fig. 1l, m; 5a, d)

(Lee, 2015, pp. 72-73, fig. 60; Subhramanyan, 1946, pp. 147, fig. 263, 264; Cupp, 1943, pp. 148, fig. 107-A,B)

Cells prism-shaped, with strongly rounded angles to nearly cylindrical, usually 3-5 times as long as broad; valves 20-80µm in diameter, valves triangular to circular with a central hollow process, marginal ridge present by small parallel ribs; chloroplasts small and numerous granules.

Occurrence: Planktonic

Lithodesmium undulatum Ehrenberg (Fig. 1n, o)

(Lee, 2015, pp. 78-79, fig. 66A; Subhramanyan, 1946, pp. 149, fig. 270)

Frustules weakly siliceous, cells solitary by the valve border, cells rectangular in the girdle view; valve 50µm and pervalvar axis 30-45µm, valve margin undulate; chloroplasts numerous and small rounded bodies.

Occurrence- Planktonic

ORDER: EUPODISCALES
FAMILY: EUPODISCACEAE

Cerataulus heteroceros Sims and Witkowski (Fig. 1j; 5b)

[Homotypic Synonym: *Biddulphia heteroceros* Grunow]

(Rath and Addhikary, 2005, pp. 72, pl. 10, fig. 55; Subhramanyan, 1946, pp. 149, fig. 270)

Cells box-shaped without a sharp constriction between valve and girdle zone in girdle view, horns from each pole of apical axis well developed; two strong spines on each valve a short distance from the horn; valve 50µm in diameter.

Occurrence: Planktonic

Trieres mobiliensis Ashworth & Theriot (Fig. 1k; 5c)

[Homotypic Synonym: *Odontella mobiliensis* Grunow]

(Subhramanyan, 1946, pp. 155, fig. 287; Lee, 2015, pp. 88-89, fig. 74)

Cells elliptical-lanceolate in valve view, single; valve and girdle zone not clearly demarcated; thin walled; valve horns slender and directed outwards, two long straight spines on each valve placed equally apart from the horns; valve 30µm in diameter.

SEM observation: External tube of rimoportula long, and the end lanceolate, position of rimoportula oblique with apical axis in the valve view.

Occurrence: Planktonic

Trieres chinensis Ashworth and Theriot (Fig. 1h, i)

[Homotypic Synonym: *Odontella chinensis* (Greville) Grunow]

(Subhramanyan, 1946, pp. 154, fig. 281; Gomez and Souissi, 2010, pp. 1428, fig. 4A-C)

Cells large, weakly silicified, cylindrical, elliptical-lanceolate in valve view, pervalvar axis elongated; apical axis 50-100-196µm; girdle band not clearly demarcated; two thin horns at the corners of the valve and near each other a long thin spine.

Occurrence: Planktonic

ORDER: CHAETOCEROTALES
FAMILY: CHAETOCEROTACEAE

Chaetoceros danicus Cleve (Fig. 1r; 4i)

(Cupp, 1943, pp. 109, fig. 65; Sunesen et al., 2009, pp. 81, fig. 18A-D; Lee et al., 2013, pp. 8, fig. 11,12)

Cells usually living singly, with very small or no aperture; apical axis of cells 5–29µm; valves elliptical to circular, with a flat to convex face; setae arising near edge of valve outside apical plane.

Occurrence: Planktonic

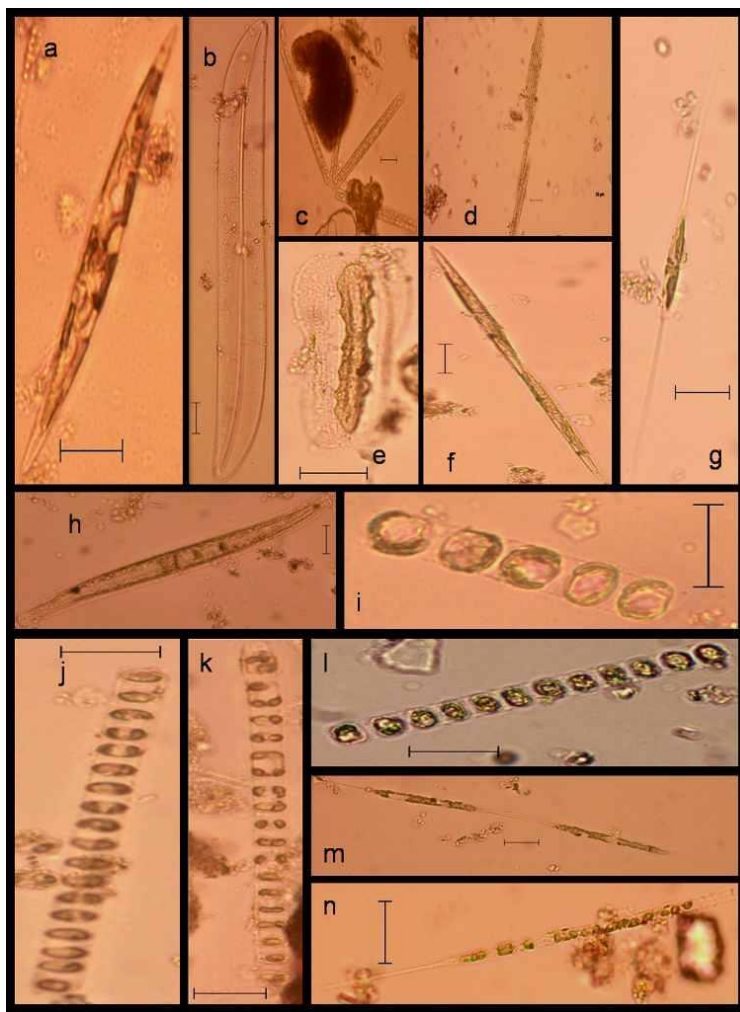


Fig.2: a) *Pleurosigma frenguellianum*, b) *Gyrosigma acuminatum*, c) *Thalassionema frauenfeldii*, d) *Bacillaria paxillifera*, e) *Amphiprora gigantea* var. *sulcata*, f) *Nitzschia pungens* var. *atlantica*, g) *Nitzschia longissima*, h) *Nitzschia sigma*, i) *Thalassiosira angustelineata*, j) *Skeletonema costatum*, k) *Skeletonema tropicum*, l) *Skeletonema marinoi*, m) *Rhizosolenia setigera*, n) *Rhizosolenia setigera* f. *pungens*. (Scale bar- 10µm)

CLASS: BACILLARIOPHYCEAE
ORDER: THALASSIONEMATALES
FAMILY: THALASSIONEMATACEAE

Thalassionema frauenfeldii Tempère and Peragallo (Fig. 2c; 5e)

(Cupp, 1943, pp. 184, fig. 135; Sar et al., 2007, pp. 64, fig. 2)

Cells united by their ends into fan-shaped, stellate or zigzag colonies; valve outline linear, slightly inflated in the middle, narrower towards the head-pole than towards the footpole; cells 70-210µm in diameter.

Occurrence: Planktonic

ORDER: BACILLARIALES
FAMILY: BACILLARIACEAE

Bacillaria paxillifera T.Marsson (Fig. 2d)

[Heterotypic Synonym: *Nitzschia paradoxa* Grunow; *Bacillaria paradoxa* Gmelin]

(Cupp, 1943, pp. 206, fig. 159; Hustedt, 1930, pp. 396, fig. 755-756)

Cells united into movable colonies, cells sliding one another; valve linear-lanceolate with produced ends, valve 70-115µm in length and 4-6µm in width; chromatophores small and numerous.

Occurrence: Planktonic

Hantzschia amphioxys Grunow (Fig. 3n)

(Mohanty and Adhikary, 2013, pp. 617, fig. pl. 3, fig. 15; Santos et al., 2012, pp. 765, fig. 4k)

Valves 20–29.3µm in length and 4–6µm in breadth of the central parts; valves linear to linear-lanceolate, apices subcapitate; dorsal margin straight to slightly convex in valve view.

Occurrence: Epipsammic

Nitzschia pungens var. *atlantica* Cleve (Fig. 2f)

(Cupp, 1943, pp. 202, fig. 156)

Valves linear-lanceolate, acute; cells united into stiff chains by the overlapping tips of the cells; chains motile; valves 60-162µm in length and 3-4.8µm in width; chromatophores two plates in each cell, lying along the cell wall under normal condition.

Occurrence: Planktonic

Nitzschia longissima Ralfs (Fig. 2g)

(Cupp, 1943, pp. 201, fig. 154)

Valves linear-lanceolate; ends extended into very long horns; valves 90-250µm in length; chromatophores two, in center only, not in hairlike ends.

Occurrence: Planktonic

Nitzschia sigma W.Smith (Fig. 2h)

(Hustedt, 1930, pp. 420, fig. 813; Mohammad-Noor et al., 2013, pp. 34, fig. 5e)

Valve may be distinctly sigmoid or linear-lanceolate in middle, with ends curved in opposite directions; apices small and capitate; cell 70-200µm in length and 5-13µm in width.

Occurrence: Planktonic

Nitzschia bilobata var. *minor* Grunow (Fig. 3q)

(Cupp, 1943, pp. 200, fig. 152)

Valves linear-lanceolate, constricted in middle, apiculate at ends (in valve view); cells broad, oblong, truncate, constricted in middle; valve 18-70µm in length and 5-7µm in width.

Occurrence: Epipsammic

Nitzschia dissipata Rabenhorst (Fig. 5g)

(Morales and Hamilton, 2002, pp. 4, pl. 2, fig. 1-2)

Valve lanceolate to fusiform shape with subrostrate or apiculate ends; raphe in eccentric position; runs to one side of longitudinal axis of valve instead of along valve margins.

SEM observation: Large canopeum with two rows of punctae, each on one side of the raphe fissure; fibulae thick and form distinct clear areas at junction with canal raphe and valve face interior.

Occurrence: Epipsammic

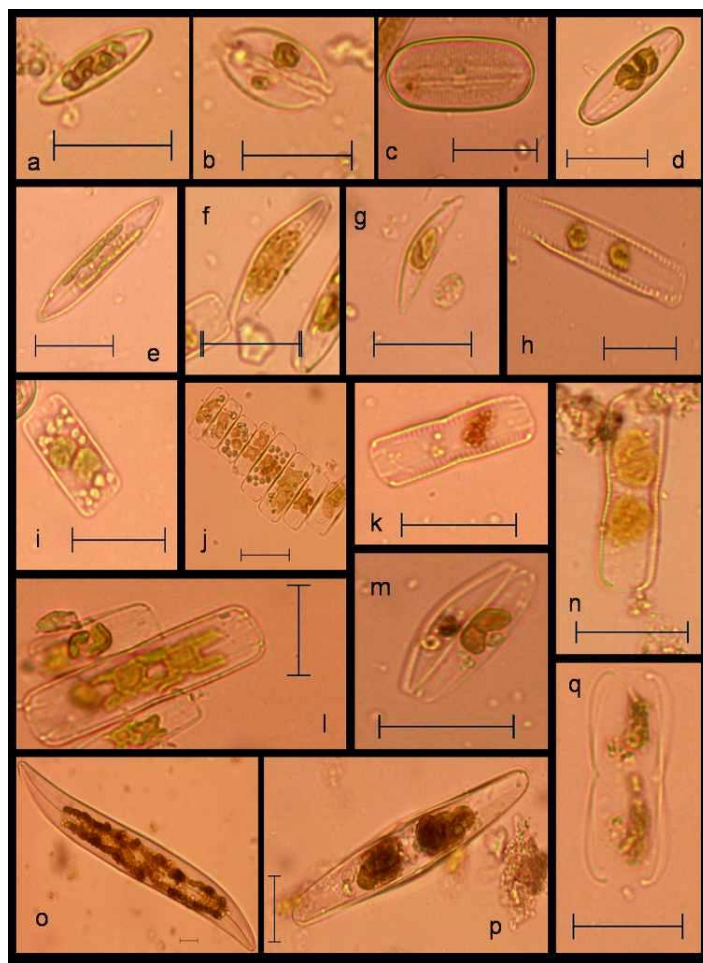


Fig.3. **a)** *Achnantheidium* *alpestre*, **b)** *Halamphora* *subturgida*, **c)** *Diploneis* *obliqua*, **d)** *Sellaphora* *pupula*, **e)** *Frustulia* *vulgaris*, **f)** *Encyonema* *vulgare*, **g)** *Encyonema* *venezolanum*, **h)** *Mastogloia* *smithii*, **i-j)** *Eunotia* *minor*, **k)** *Navicula* *fortis*, **l)** *Cosmioneis* *pusilla*, **m)** *Seminavis* *robusta*, **n)** *Hantzschia* *amphioxys*, **o)** *Pleurosigma* *normanii*, **p)** *Donkinia* *carinata*, **q)** *Nitzschia* *bilobata* var. *minor*. (Scale bar- 10µm)

ORDER: CYMBELLALES
FAMILY: GOMPHONEMATACEAE

Encyonema venezolanum Krammer (Fig. 3g)

(Vouilloud et al., 2010, pp. 51, fig. 16-20)

Cells strongly dorsiventral; valves asymmetric, dorsal margin strongly convex, ventral margin straight slightly tumid at the centre, ends rounded; cells 11-21µm in length and 3-5µm in width.

Occurrence: Epipsammic

Encyonema vulgare Krammer (Fig. 3f)

(Vouilloud et al., 2010, pp. 52, fig. 21-26)

Cells strongly dorsiventral; valves asymmetric, dorsal margin strongly convex, ventral margin slightly tumid at the centre, ends rounded; cells 14-43µm in length and 4-11µm in width.

Occurrence: Epipsammic

ORDER: COCCONEIDALES

FAMILY: ACHNANTHIDIACEAE

Achnantheidium pyrenaicum Kobayasi (Fig. 5i)

[Heterotypic synonym: *Achnanthes biasoletiana* Grunow]

(Joh, 2012, pp. 24, fig. 13)

SEM morphology: Valve elliptical to elliptical-lanceolate, linear-elliptical to linear in outline, with broadly rounded or rostrate ends; raphe valve, axial area narrow linear to slightly lanceolate, central area not distinct; valves 5-35µm in length and 2-6µm in breadth.

Occurrence: Epipsammic

Achnantheidium alpestre Lowe and Kociolek (Fig. 3a; 5j)

(Potapova, 2010. *Achnantheidium alpestre*. In Diatoms of the United States, http://westerndiatoms.colorado.edu/taxa/species/achnantheidium_alpestre)

SEM observation: Valves linear-lanceolate with subrostrate ends; raphe valve concave with linear axial area, widens slightly in middle portion of valve; striae parallel or very slightly radiate throughout both valves; valve 8-20µm in length and 3-4.4µm in width.

Occurrence: Epipsammic

ORDER: EUNOTIALES

FAMILY: EUNOTIACEAE

Eunotia minor Grunow (Fig. 3i-j)

(Taylor et al., 2007, pl. 19)

Striae widely spaced at the centre of the cell which becomes denser towards the apices; cells sometimes occur in chain form; valve 11-60µm in length and 5-8µm in width.

Occurrence: Epipsammic

ORDER: MASTOGLOIALES

FAMILY: MASTOGLOIACEAE

Mastogloia smithii Thwaites ex W. Smith (Fig. 3h)

(Lee et al., 2014, pp. 8, fig. 5-8; Hustedt, 1930, pp. 215, fig. 314)

Cells solitary; valves elliptical-lanceolate with rostrate to subcapitate apices; cell 20–50µm in length and 5–15µm in width.

Occurrence: Epipsammic

ORDER: NAVICULALES

FAMILY: AMPHIPLEURACEAE

Amphiprora gigantea var. *sulcata* Cleve (Fig. 2e)

(Cupp, 1943, pp. 198, fig. 151; Bhattacharya et al., 2011, pp. 102, fig. 38)

Cells strongly constricted; junction lines curved like a bow; cells 60-120µm in length; striae curved; connecting zones with numerous longitudinal divisions.

Occurrence: Planktonic

Frustulia vulgaris De Toni (Fig. 3e)

(Taylor et al., 2007, pl. 43)

Valves elliptic-lanceolate, linear-elliptical to linear-lanceolate; apices broadly rounded or protracted, more or less subcapitate; valve 16-60µm in length and 4-12µm in width.

Occurrence: Epipsammic

FAMILY: COSMIONEIDACEAE

Cosmioneis pusilla Mann and Stickle (Fig. 3l)

(Round et al., 1990, pp. 526, fig. b-c)

Cells solitary, naviculoid, lying in girdle view; two H-shaped plastids present, one against each valve; valve lanceolate or elliptical, with rostrate or strongly capitate poles; cell 26µm in length and 8µm in breadth.

Occurrence: Epipsammic

FAMILY: DIPLONEIDACEAE

Diploneis obliqua Hustedt (Fig. 3c)

(Siqueiros-Beltrones et al., 2017, pp. 28, fig. 7 M-N; López-Fuerte et al., 2010, pp. 33, pl. 19, fig. 7-10)

Cells 18-84.5µm in length and 8-28.5µm in width.

Occurrence: Epipsammic

FAMILY: NAVICULACEAE

Navicula fortis Ralfs ex Pritchard (Fig. 3k)

(Donkin, 1870, pp. 57, pl.viii, fig. 8)

Frustule small, constricted in the middle, angles slightly rounded, extremities truncate; valve broadly lanceolate or lozenge shaped, obtuse; striae reaching to the median line, slightly oblique and connivent; cell 15µm in length.

Occurrence: Epipsammic

Gyrosigma acuminatum Rabenhorst (Fig. 2b)

[Heterotypic Synonym: *Gyrosigma spenceri*_(W.Smith) Griffith and Henfrey]

(Cupp, 1943, pp. 194, fig. 144; Sterrenburg, 1995, pp. 469, fig. 7-16)

Valves sigmoid, lanceolate, with obtuse ends; raphe central; central nodule elliptical; valve 120-237µm in length; mostly brackish and fresh water species.

Occurrence: Planktonic

Seminavis robusta Danielidis and Mann (Fig. 3m; 5h)

(Chepurnov et al., 2002, pp. 1005, fig. 1, 4)

Cells have strongly dorsoventral, semilanceolate (“cymbelloid”) valves, two girdle-appressed chloroplasts; valve 16–60.5µm in length.

SEM observation: Striae uniseriate; raphe straight and closer to the ventral side; axial area wider dorsally than ventrally, slightly expanded at the center

Occurrence: Epipsammic

FAMILY: PLEUROSIGMATACEAE

Pleurosigma frenguellianum Sunesen, Sterrenburg and Sar (Fig. 2a)

(Sar et al., 2014, pp. 5, fig. 25-30)

Cell with one or two ribbon-shaped chloroplasts, sometimes convoluted at valve centre, lying appressed to the girdle towards the poles; valve linear-lanceolate, slightly sigmoid, with acute apices, 90-289µm in length and 7-29µm in width.

Occurrence: Planktonic

Pleurosigma normanii Ralfs (Fig. 3o)

(Das and Adhikary, 2014, pp. 234, pl. 18, fig. 13)

Frustules broadly lanceolate, sigmoid with obtuse end, transverse striae, not clearly visible in fresh material; cell 90-109.5µm in length and 14.3-20µm in width.

Occurrence: Epipsammic

Donkinia carinata Ralfs (Fig. 3p)

[Homotypic Synonym: *Pleurosigma carinatum* Donkin]

(Subhramanyan, 1946, pp. 176, fig. 388)

Valves convex, linear-lanceolate, acute at the ends; valve 50-60µm in length and 8µm in width; raphe on elevated keel.

Occurrence: Epipsammic

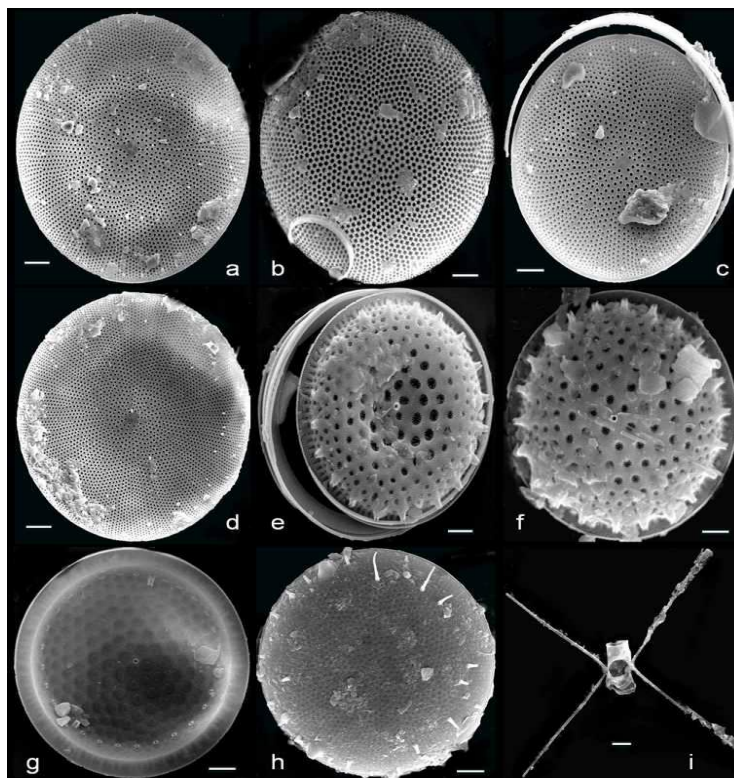


Fig.4(SEM photomicrographs): **a)** *Coscinodiscus perforatus*, **b)** *Coscinodiscopsis jonesiana*, **c)** *Coscinodiscus radiatus*, **d)** *Coscinodiscus centralis*, **e)** *Thalassiosira decipiens*, **f)** *Thalassiosira pacifica*, **g)** *Thalassiosira visurgis*, **h)** *Thalassiosira punctigera*, **i)** *Chaetoceros danicus*. (Scale bar- 3µm)

FAMILY: SELLAPHORACEAE

Sellaphora pupula Mereschkovsky (Fig. 3d)

(Das and Adhikary, pp. 243, pl. 18, fig. 40)

Frustules linear, lanceolate, slightly attenuated apices to rounded end; central area wide, axial area narrow; striation not clear in fresh material; cell 20-25.6µm in length and 5.5-8.2µm in breadth.

Occurrence: Epipsammic

ORDER: THALASSIOPHYSALES

FAMILY: CATENULACEAE

Halamphora suburgida Levkov (Fig. 3b; 5f)

[Homotypic Synonym: *Amphora suburgida* Hustedt]

(Sala et al., 2006, pp. 162, fig. 38-39; 40-51)

Frustule elliptic, gently constricted in middle part with slightly protracted, truncate ends; cell 12–25.2µm in length and 6–11µm in width; valves semi-elliptical with convex ventral margin

SEM observation: Valve vaulted, dorsal side convex with a high mantle, ventral side wide and structureless; raphe with internal proximal ends bent ventrally, terminating under a tongue-like expansion.

Occurrence: Epipsammic

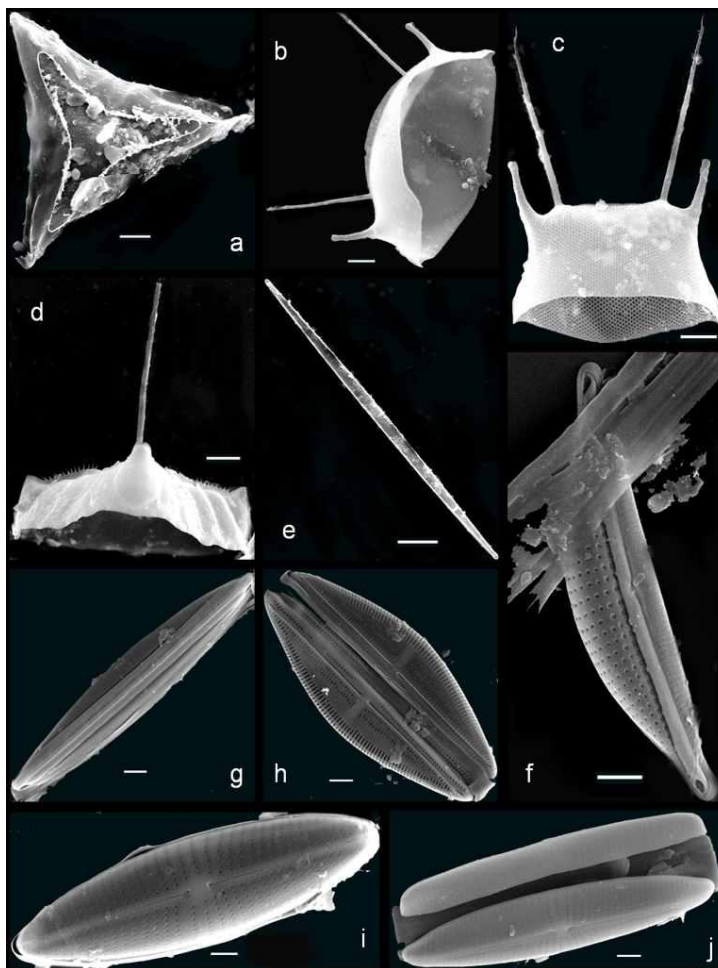


Fig.5(SEM photomicrographs) :a, d) *Ditylum brightwellii*, b) *Cerataulus heteroceros*, c) *Trieres mobiliensis*, e) *Thalassionema frauenfeldii*, f) *Halamphora suburgida*, g) *Nitzschia dissipata*, h) *Seminavis robusta*, i) *Achnanthisdium pyrenaicum*, j) *Achnanthisdium alpestre*. (Scale bar- 3µm)

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