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Neogene Diatoms from Saga Prefecture, Kiushiu Island, Nippon

By

B. V. SKVORTZOV

(Harbin, Manchoukuo)

With Plates IX–XI

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The sample of the remarkable deposit of diatomite, upon which the observations have been made, was forwarded to me some time ago by Prof. TAMIJI KAWAMURA of the Zoological Institute, College of Science, Kyoto Imperial University. The sample consists of pieces of whitish color. The following general features may be pointed out in connection with this deposit.

1) Its diatoms are all of fresh-water origin, except only one marine species—*Melosira Sol.*

2) In external appearance it exhibits a great degree of uniformity. Large *Epithemia*, small *Stephanodiscus*, *Fragilaria*, *Amphora*, small frustules of *Cymbella* and large *Didymosphenia* and *Pinnularia* predominate. Not unfrequent were large *Synedra*, *Melosira*, *Amphipleura*, *Gomphonema*, *Diploneis*, *Stauroneis*, *Navicula* and *Pinnularia*.

3) *Pinnularia lignitica*, known from Nippon fossil in lignit and *Melosira undulata* reported as fossil in Europe were found in Saga deposits.

4) As to the similarity of Saga diatom flora to the recent one of Nippon lakes, the following fossil species from Saga are found in Biwa, Aoki, Kizaki and Ikeda Lakes. They are: *Melosira undulata*, *Stephanodiscus astraea*, different species of *Fragilaria*, *Rhoicosphenia curvata*, *Caloneis Silicula*, *Diploneis ovalis*, *Diploneis Smithii* var. *nipponica*, *Navicula cuspidata*, *Pinnularia microstauron*, *Pinnularia lignitica*, *Pinnularia Hartleyana*, *Amphora ovalis*, *Cymbella sinuata*, *Cymbella prostrata*, *Cymbella cistula*, *Gomphonema augur* var. *Gautieri*, *Gomphonema intricatum*, *Gomphonema vastum* var., *Epithemia*

cistula var. *lunaris*, *Epithemia sorex*, *Rhopalodia gibba*, *Hantzschia amphioxys* and *Surirella robusta* var. *splendida*. Some endemical Nipponic diatoms have been also recognised in Saga deposits. They are—*Diploneis Smithii* var. *nipponica*, *Pinnularia lignitica*, *Pinnularia cucumis*, *Gomphonema lingulatum* and *Gomphonema vastum* var.

5) The occurrence in Saga deposits of some tropical species and at the same time the forms of northern or arctic habitat are remarkable. Such extraordinary mixture was also observed recently in large Nippon Lakes and this gives some idea up to the climate of Neogene time. *Melosira undulata*, a distinct species, widely distributed now in tropical countries, is fairly common in Saga deposits. *Pinnularia Hustedtii*, recently described from Canton River, China, is also common in preparations; *Pinnularia Hartleyana*, known from Liberia, Africa and from Demerara River, South America, was not unfrequent in the above gatherings.

The most remarkable was the discovery in Saga deposits of large diatoms known as *Didymosphenia geminata* var. *curvata*, a form up to date endemical to Baikal Lake of Siberia. It is interesting to note, that *Didymosphenia geminata*, with its varieties, occurs only in Northern part of Eurasia and in mountainous highland of Central Asia. In Nippon this diatom was reported by me from Biwa Lake. An another variety of this algae—*D. g.* var. *curvirostrata*, described by T. BRUN and I. TEMPÈRE from Sendai and Yedo in marine deposits, is not similar with var. *curvata* and is a distinct variety.

6) Although not characterised by many new species, several interesting and novel varieties occur in Saga deposits, and various curious points of structure in connection with forms already well known are clearly brought out. Among the new forms can be named—*Achnanthes Yabe*, *Navicula Yabe*, *Pinnularia sagensis* and *Surirella vermifera*. The diatoms found in Saga deposits are here enumerated.

Melosira varians C. A. AG.

Melosira varians C. A. AG., Fr. HUSTEDT, Bacillar. (1930) 85-86, fig. 41.

Valve cylindrical, hyaline with narrow pseudosulcus. Rare. Reported from Aoki, Kizaki and Biwa Lakes.

Melosira undulata (EHR.) KUTZ.

Melosira undulata (EHR.) KUTZ., A. SCHMIDT, Atlas Diatom. (1893) taf. 180, figs. 1-14, 16-19, 21.

Frustule cylindrical with thick membrane. Valve circular, strongly marked with closely set radiating, punctate striae. Com-

mon. A tropical diatom, known as fossil in Europe. Reported in Aoki, Biwa and Ikeda Lakes.

Melosira sol (EHR.) KUTZ. Plate IX, fig. 6.

Melosira sol (EHR.) KUTZ., A. SCHMIDT, Atlas Diatom. (1893) taf. 179, fig. 21; Fr. HUSTEDT, Die Kieselalgen (1927) Lief. 1, 270-272, fig. 115d.

Frustule cylindrical with a pseudosulcus, forming a robust band. Valve circular, the surface of which is separated into two areas; the outer areas, forming a band one-third the radius in width, strongly marked with closely set radiating costae. The inner areas almost hyaline. Diameter 0.102 to 0.11 mm. Striae 6 to 7 in 0.01 mm. Not common. A marine diatom.

Stephanodiscus astraea (EHR.) GRUN. var. **spinulosa** GRUN. Plate IX. fig. 1.

Stephanodiscus astraea (EHR.) GRUN. var. *spinulosa* GRUN., A. SCHMIDT, Atlas Diatom. (1901) taf. 226, fig. 7.

Frustule undulate with spines at the ends. Valve circular, covered with radiating rows of beads. In the center beading of the secondary rows leave narrow vacant lines. Near the margin one rows of fine spines. Diameter 0.027 to 0.03 mm. Rows of beads 6 to 7, puncta 18 in 0.01 mm. Uncommon. The type is known from Aoki and Kizaki Lakes.

Stephanodiscus astraea (EHR.) GRUN. var. **minutula** (KUTZ.) GRUN. Plate IX, figs. 2, 3.

Stephanodiscus astraea (EHR.) GRUN. var. *minutula* (KUTZ.) GRUN., A. SCHMIDT, Atlas Diatom. (1901) pl. 226, figs. 16, 17.

Valve circular, minute. The central area punctate with irregular dots. Diameter 0.0068 to 0.012 mm. Uncommon.

Stephanodiscus astraea (EHR.) GRUN. var. **intermedia** FRICKE. Plate IX, fig. 4.

Stephanodiscus astraea (EHR.) GRUN. var. *intermedia* FRICKE, A. SCHMIDT, Atlas Diatom. (1901) pl. 225, fig. 38.

Frustule constricted in the middle part and arcuate from the margins. Valve circular, strongly marked with closely set radiating puncta. Diameter 0.018 mm. Striae 6 in 0.01 mm. Uncommon.

Fragilaria pinnata EHR.

Fragilaria pinnata EHR., Fr. HUSTEDT, Bacillar. (1930) 142, fig. 141.

Valve ovate, attenuate at the ends. Length, 0.009 mm; breadth,

0.003. Striae radiate, 11 to 12 in 0.01 mm. Common. Reported from Kizaki Lake.

Fragilaria construens (EHR.) GRUN.

Fragilaria construens (EHR.) GRUN., Fr. HUSTEDT, Bacillar. (1930) 140, fig. 135.

Valve rhomboidal-lanceolate with apiculate ends. Length, 0.01 mm; breadth, 0.005. Striae radiate. Common. Known from Kizaki Lake.

Fragilaria construens (EHR.) GRUN. var. **venter** (EHR.) GRUN.

Fragilaria construens (EHR.) GRUN. var. *venter* (EHR.) GRUN., Fr. HUSTEDT, Bacillar. (1930) 141, fig. 138.

Valve elliptical-lanceolate with subacute ends. Length, 0.013 mm; breadth, 0.0045. Pseudoraphe narrow and lanceolate. Common. Known from Ikeda Lake.

Synedra Ulna (NITZSCH.) EHR. var. **biceps** (KUTZ.)

Synedra Ulna (NITZSCH.) EHR. var. *biceps* (KUTZ.), Fr. HUSTEDT, Bacillar. (1930) 154, fig. 166.

Valve long linear or sublinear, gradually attenuate towards the capitate ends. Length, 0.21 mm; breadth, 0.005. Very common. Known from Kizaki Lake.

Synedra rumpens KUTZ. var. **fragilarioides** GRUN.

Synedra rumpens KUTZ. var. *fragilarioides* GRUN., Fr. HUSTEDT, Bacillar. (1930) 156, fig. 176.

Valve linear-lanceolate, undulate in the middle part and apiculate at the ends. Length, 0.045 mm; breadth, 0.0034. Striae 9 to 10 in 0.01 mm. Uncommon. Reported from Biwa Lake.

Eunotia arcus EHR.

Eunotia arcus EHR., Fr. HUSTEDT, Bacillar. (1930) 175, fig. 216.

Valve boat-shaped with arcuate dorsal and constricted ventral margins. Length, 0.025 mm; breadth, 0.005. Rare.

Cocconeis placentula (EHR.) var. **lineata** (EHR.) CLEVE.

Cocconeis placentula (EHR.) var. *lineata* (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 190, fig. 262.

Valve elliptical, covered with fine longitudinal undulating bands of puncta. Length, 0.039 mm; breadth, 0.02. Uncommon. Reported from Kizaki and Biwa Lakes.

Cocconeis placentula (EHR.) var. **euglypta** (EHR.) CLEVE.

Cocconeis placentula (EHR.) var. *euglypta* (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 190, fig. 261.

Differs from var. *lineata* in its more robust longitudinal undulating bands of puncta. Length, 0.017 mm; breadth, 0.0085. Uncommon. Known from Biwa and Ikeda Lakes.

Achnanthes Yabe sp. nov. Plate IX, fig. 18.

Valve rectangular-elliptical with short rostrate ends. Length, 0.013 mm; breadth, 0.0068. Upper valve with narrow linear axial and central areas, lower valve with a broad, quadrate central area. Striae radiate, 18 in 0.01 mm. A species related to *Achnanthes exigua* GRUN. Uncommon. Named in honor of Prof. Dr. H. YABE, Sendai.

Rhoicosphenia curvata (KUTZ.) GRUN.

Rhoicosphenia curvata (KUTZ.) GRUN., Fr. HUSTEDT, Bacillar. (1930) 211, fig. 311.

Frustule lunate. Valve clavate and lanceolate. Length, 0.025 mm; breadth, 0.005. Reported from Kizaki, Biwa, Ikeda and Aoki Lakes.

Amphipleura Lindheimeri GRUN. Plate X, fig. 1.

Amphipleura Lindheimeri GRUN., Fr. HUSTEDT, Bacillar. (1930) 218, fig. 322.

Valve fusiform, acute. Length, 0.183 mm; breadth, 0.025. Transverse striae 30, longitudinal 22 in 0.01 mm. Common. Known from fresh-water of America.

Gyrosigma acuminatum (KUTZ.) RABH. Plate XI, fig. 8.

Gyrosigma acuminatum (KUTZ.) RABH., Fr. HUSTEDT, Bacillar. (1930) 222-223, fig. 329.

Valve sigmoid-lanceolate, attenuate towards the subacute ends. Length, 0.149 mm; breadth, 0.02. Longitudinal and transverse striae 18 in 0.01 mm. Uncommon. Known from Kizaki, Biwa and Ikeda Lakes.

Caloneis silicula (EHR.) CLEVE.

Caloneis silicula (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 237, fig. 362.

Valve linear-elliptical, slightly triundulate. Length, 0.061 mm; breadth, 0.013. Central area a rectangular stauros. Common. Known from Ikeda Lake.

Caloneis silicula (EHR.) CLEVE var. **truncatula** GRUN.

Caloneis silicula (EHR.) CLEVE var. *truncatula* GRUN., Fr. HUSTEDT, Bacillar. (1930) 238, fig. 364.

Valve linear-elliptical with broad rounded ends. Length, 0.034 mm; breadth, 0.0095. Striae 18 in 0.01 mm. Central area orbicular. Common.

Caloneis bacillum (GRUN.) MERESCH. var. **lancettula** (SCHULTZ.) HUST.

Caloneis bacillum (GRUN.) MERESCH. var. *lancettula* (SCHULTZ.) HUST., Fr. HUSTEDT, Bacillar. (1930) 236, fig. 361.

Valve lanceolate with subacute ends. Length, 0.035 mm; breadth, 0.0068. Striae radiate, 18 in 0.01 mm. Central area a broad rectangular stauros. Uncommon. Known from Aoki and Biwa Lakes.

Neidium iridis (EHR.) CLEVE.

Neidium iridis (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 245, fig. 379.

Valve linear-lanceolate with subacute ends. Length, 0.113 mm; breadth, 0.018. Central area orbicular. Common. Reported from Aoki and Biwa Lakes.

Neidium affine (EHR.) CLEVE var. **amphirhynchus** (EHR.) CLEVE.

Neidium affine (EHR.) CLEVE var. *amphirhynchus* (EHR.) CLEVE, Fr. HUSTEDT, (1930) 243, fig. 377.

Valve fusiform with broad, subacute or rostrate ends. Length, 0.051 mm; breadth, 0.014. Uncommon. Known from Ikeda Lake.

Neidium dubium (EHR.) CLEVE.

Neidium dubium (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 246, fig. 384a.

Valve broad linear with subrostrate ends. Length, 0.037 mm; breadth, 0.013. Striae 18 in 0.01 mm. Uncommon. Reported from Kizaki and Ikeda Lakes.

Diploneis ovalis (HILSE) CLEVE.

Diploneis ovalis (HILSE) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 249, fig. 390.

Valve elliptical with broad ends. Length, 0.034 mm; breadth, 0.014. Transverse rows of alveoli radiate at the ends. Central area orbicular. Common. Reported from Aoki, Kizaki, Biwa and Ikeda Lakes.

Diploneis Smithii (BREB.) CLEVE var. **nipponica** SKV.

Diploneis Smithii (BREB.) CLEVE var. *nipponica* SKVORTZOV, Diatom. Kizaki Lake (1936), pl. 2, figs. 1, 9.

Valve elliptical with broad ends. Length, 0.057 mm; breadth, 0.034. Central nodule quadrate. Costae with double rows of alveoli, forming oblique lines, 6 to 6½ in 0.01 mm. Common. Reported from Kizaki and Biwa Lakes.

Stauroneis phoenicenteron EHR.

Stauroneis phoenicenteron EHR., Fr. HUSTEDT, Bacillar. (1930) 255, fig. 404.

Valve lanceolate with subacute ends. Length, 0.155 mm; breadth, 0.042. Central area a rectangular stauros. Striae radiate, punctate, 18 in 0.01 mm. Uncommon. Reported from Aoki, Kizaki and Biwa Lakes.

Stauroneis anceps EHR.

Stauroneis anceps EHR., Fr. HUSTEDT, Bacillar. (1930) 256, fig. 405.

Valve elliptical-lanceolate with subcapitate ends. Length, 0.051 mm; breadth, 0.012. Striae radiate, fine, about 24 in 0.01 mm. Uncommon. Reported from Kizaki and Ikeda Lakes.

Navicula cuspidata KUTZ.

Navicula cuspidata KUTZ., Fr. HUSTEDT, Bacillar. (1930) 268, fig. 433.

Valve lanceolate, attenuate towards the ends. Length, 0.136 mm; breadth, 0.037. Transverse striae parallel, about 15 in 0.01 mm. Common. Reported from Aoki and Kizaki Lakes.

Navicula americana EHR.

Navicula americana EHR., Fr: HUSTEDT, Bacillar. (1930) 280, fig. 469.

Valve linear with broad rounded ends. Length, 0.08 mm; breadth, 0.021. Striae radiate, marginal about 15 in 0.01 mm. Rare. Known from Kizaki Lake.

Navicula bacillum EHR.

Navicula bacillum EHR., Fr. HUSTEDT, Bacillar. (1930) 280, fig. 465.

Valve linear with slightly gibbous margin and broad rounded ends. Length, 0.039 mm; breadth, 0.009. Striae radiate, 12 (middle), 18 (end) in 0.01 mm. Median line in a thick siliceous rib. Uncommon.

Navicula cryptocephala KUTZ. var. **exilis** (KUTZ.) GRUN.

Navicula cryptocephala KUTZ. var. *exilis* (KUTZ.) GRUN., VAN HEURCK, Synopsis (1880-1885) 85, pl. 8, figs. 3, 4; pl. 14, fig. 34.

Valve lanceolate with attenuate, subacute ends. Length, 0.018 mm; breadth, 0.004. Striae radiate, 18 in 0.01 mm. Uncommon. Known from Kizaki Lake.

Navicula menisculus SCHUM. Plate IX, fig. 13.

Navicula menisculus SCHUMANN, Fr. HUSTEDT, Bacillar. (1930) 301, fig. 517.

Valve elliptical-lanceolate with subacute ends. Length, 0.034 mm; breadth, 0.013. Striae radiate, not lineate, not divergent at the ends, 10 in 0.01 mm. Uncommon. Reported from Biwa Lake.

Navicula Reinhardtii GRUN. Plate X, fig. 6.

Navicula Reinhardtii GRUN., Fr. HUSTEDT, Bacillar. (1930) 301, fig. 519.

Valve elliptical with slightly attenuate, abruptly obtuse ends. Length, 0.042 mm; breadth, 0.013. Striae robust, radiate, striolate, 6 in 0.01 mm. Common. Reported from Biwa Lake.

Navicula Reinhardtii GRUN. var. **gracilior** GRUN. Plate XI, fig. 7.

Navicula Reinhardtii GRUN. var. *gracilior* GRUN., VAN HEURCK, Synopsis (1880–1885) 87.

Valve more narrow, almost linear-lanceolate. Length, 0.068 mm; breadth, 0.014. Striae 7 in 0.01 mm. Uncommon.

Navicula Yabe sp. nov. Plate X, fig. 7; Plate XI, fig. 5.

Valve linear-lanceolate, gibbous in the middle, gradually attenuate towards subcapitate ends. Length, 0.085 to 0.096 mm; breadth, 0.017 to 0.018. Striae radiate, robust, fine lineolate, 5 to 6 in 0.01 mm. Axial area linear, narrow; central area orbicular. Median line filiform with distinct central pores. Terminal fissures comma-shaped. Common. A species related to *Navicula Reinhardtii* GRUN. Named in honor of Prof. Dr. H. YABE, Sendai.

Navicula dicephala (EHR.) W. SMITH. Plate X, fig. 5.

Navicula dicephala (EHR.) W. SMITH, Fr. HUSTEDT, Bacillar. (1930) 302, fig. 526.

Valve rectangular linear-lanceolate with rostrate ends. Length, 0.037 mm; breadth, 0.011. Striae radiate and curved, 12 in 0.01 mm, not lineolate. Not unfrequent. Reported from Aoki and Kizaki Lakes.

Navicula placentula (EHR.) GRUN. Plate X, fig. 10.

Navicula placentula (EHR.) GRUN., Fr. HUSTEDT, Bacillar. (1930) 303, fig. 532.

Valve elliptical-lanceolate with broad, subacute ends. Length, 0.074 mm; breadth, 0.027. Striae radiate, 7 in 0.01 mm. Central area orbicular. Uncommon. Known from Biwa Lake.

Navicula gastrum EHR. Plate X, fig. 17.

Navicula gastrum EHR., Fr. HUSTEDT, Bacillar. (1930) 305, fig. 537.

Valve broad elliptical-lanceolate with rostrate ends. Length, 0.03 mm; breadth, 0.014. Striae radiate, in the middle alternately longer and shorter, about 11 in 0.01 mm. Uncommon. Known from Ikeda Lake.

Navicula hasta PANT. var. **fossilis** var. nov. Plate X, fig. 4.

Valve lanceolate, gradually tapering from the middle to the subacute ends. Length, 0.102 mm; breadth, 0.017. Striae radiate, not lineate, 6 in 0.01 mm. Differs from the type in its not lineate striae. Uncommon.

Navicula variostriata KRASSKE var. **fossilis** var. nov. Plate IX, fig. 11.

Valve linear-elliptical with broad rounded ends. Length, 0.03 mm; breadth, 0.01. Axial area narrow, somewhat dilated towards the middle. Central area a fascia, widened and truncate outwards. Striae radiate, shortened around the central area, 18 to 20 in 0.01 mm. Differs from the type in its different shape of central area. Uncommon. The type is known from Europe.

Pinnularia microstauron (EHR.) CLEVE.

Pinnularia microstauron (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1920) 320, fig. 582.

Valve linear-lanceolate with parallel margins and subrostrate ends. Length, 0.059 mm; breadth, 0.01. Striae radiate, 11 in 0.01 mm. Central area a broad fascia. Common. Reported from Aoki, Kizaki and Ikeda Lakes.

Pinnularia gibba EHR. fo. **subundulata** MAYER.

Pinnularia gibba EHR. fo. *subundulata* MAYER, Fr. HUSTEDT, Bacillar. (1930) 327, fig. 601.

Valve linear-lanceolate, slightly triundulate with subcapitate ends. Length, 0.057 mm; breadth, 0.01. Striae radiate, 9 in 0.01 mm. Common. Reported from Kizaki and Ikeda Lakes.

Pinnularia Saga sp. nov. Plate X, fig. 12.

Valve linear-lanceolate with slightly triundulate margins. Length, 0.102 to 0.113 mm; breadth, 0.014 to 0.015. Striae robust, radiate, 6 to 8 in 0.01 mm. Axial area broad, somewhat dilated in the middle to an elliptical space on one side to a transverse fascia. Median line filiform with distinct central poles and comma-shaped terminal fissures. Common. A species related to *Pinnularia gibba* EHR.

Pinnularia Saga var. **isostauron** var. nov. Plate X, fig. 13.

Differs from the type in its irregularly stauros, larger and broader on one side of the valve than on the other. Length, 0.113 mm; breadth, 0.015. Striae radiate, 6 to 7 in 0.01 mm. Common.

Pinnularia Saga var. **undulata** var. nov. Plate X, fig. 15.

Differs from the type in its undulate valves and capitate ends. Length, 0.102 mm; breadth, 0.017. Stauros on one side of the valve only. Uncommon.

Pinnularia acrosphaeria BREB.

Pinnularia acrosphaeria BREB., Fr. HUSTEDT, Bacillar. (1930) 330, fig. 610.

Valve linear with capitate ends. Length, 0.059 mm; breadth, 0.01. Striae almost parallel, 9 in 0.01 mm. Axial area broad irregular punctate. Median line filiform with comma-shaped fissures. Uncommon. Reported from Biwa Lake.

Pinnularia major (KUTZ.) CLEVE var. **linearis** CLEVE.

Pinnularia major (KUTZ.) CLEVE var. *linearis* CLEVE, PANTOSEK, Fossile Bacillar. Ungarns (1904) 3, pl. 7, fig. 113.

Valve linear with parallel margins and broad ends. Length, 0.187 mm; breadth, 0.032. Striae radiate, divergent in the middle and convergent at the ends, 7 in 0.01 mm. Axial area broad, linear. Central area orbicular. Known as recent and fossil in Europe and America. Common. Reported from Kizaki and Biwa Lakes.

Pinnularia lignitica CLEVE. Plate X, fig. 14.

Pinnularia lignitica CLEVE, A. SCHMIDT, Atlas Diatom. (1914) pl. 313, fig. 7.

Valve lanceolate-elliptical with attenuate and broad subacute ends. Length, 0.074 mm; breadth, 0.02. Striae divergent in the middle, convergent at the ends, 8 to 9 in 0.01 mm with distinct bands. Axial and central area lanceolate. Common. Reported from Nipponic lignit as fossil and as recent from Kizaki and Ikeda Lakes.

Pinnularia Hustedti MEISTER. Plate IX, fig. 7.

Pinnularia Hustedti MEISTER, Seltene und neue Kieselalgen. Berichte d. Schweiz. Bot. Gesellschaft. (1934) Band 44, 102, fig. 82.

Valve linear-lanceolate, gibbous in the middle and with capitate ends. Length, 0.272 mm; breadth, 0.027. Striae divergent in the middle and convergent at the ends, 9 in 0.01 mm with distinct bands. Uncommon. Known from Canton River, China and from Kizaki Lake, Nippon.

Pinnularia major (KUTZ.) CLEVE var. **sagensis** var. nov. Plate X, fig. 18.

Valve almost linear with slightly gibbous in the middle. Length, 0.23 mm; breadth, 0.02. Axial area linear, narrow. Central area suborbicular. Striae radiate, 10 to 11 in 0.01 mm with indistinct bands. Differs from the type in its longer and narrower valves and subcapitate ends. Uncommon.

Pinnularia cucumis SKV.

Pinnularia cucumis SKVORTZOV, Diatom. Biwa Lake (1936), pl. 8, fig. 3.

Valve broad-linear, almost rectangular with broad rounded ends. Length, 0.129 mm; breadth, 0.025. Striae 7 to 8 in 0.01 mm. Reported only from Biwa Lake.

Pinnularia Hartleyana GREVILLE. Plate XI, fig. 6.

Pinnularia Hartleyana GREVILLE, Description of new and rare Diatoms. (1865) T. M. S. Vol. 13, pl. 6, fig. 30.

Valve linear-lanceolate, triundulate with subrostrate ends. Length, 0.127 mm; breadth, 0.018. Striae divergent at the middle, convergent at the ends, 7 to 8 in 0.01 mm, forming in the middle a short rectangular stauros. Longitudinal bands distinct. Uncommon. Reported from Aoki and Kizaki Lakes, and common in the tropics.

Pinnularia viridis (NITZSCH.) EHR.

Pinnularia viridis (NITZSCH.) EHR., Fr. HUSTEDT, Bacillar. (1930) 334-335, fig. 617a.

Valve linear with obtuse ends. Length, 0.095 mm; breadth, 0.017. Common. Reported from Aoki Lake.

Amphora ovalis KUTZ.

Amphora ovalis KUTZ., Fr. HUSTEDT, Bacillar. (1930) 342, fig. 628.

Frustule elliptical. Length, 0.029 mm; breadth, 0.017. Valve lunate with a biarcuate median line. Common. Known from Biwa and Ikeda Lakes.

Amphora ovalis KUTZ. var. **libyca** (EHR.) CLEVE.

Amphora libyca EHR., A. SCHMIDT, Atlas Diatom. (1875) pl. 26, fig. 105.

Differs from the type in having a distinct central area, uniting with a blank band across the striae. Length, 0.042 mm; breadth, 0.01. Uncommon. Reported from Kizaki, Biwa and Ikeda Lakes.

Cymbella Ehrenbergii KUTZ.

Cymbella Ehrenbergii KUTZ., Fr. HUSTEDT, Bacillar. (1930) 356, fig. 656.

Valve slightly asymmetrical, rhombical-lanceolate with subacute ends. Length 0.093 mm; breadth, 0.034. Striae radiate, punctate, 9 in 0.01 mm. Central area orbiculate. Common. Reported from Aoki and Kizaki Lakes.

Cymbella heteropleura EHR.

Cymbella heteropleura EHR., A. SCHMIDT, Atlas Diatom. (1875) pl. 9, figs. 4, 5.

Valve slightly asymmetrical, lanceolate with subrostrate ends. Length, 0.102 mm; breadth, 0.03. Striae radiate, punctate, 9 to 10 in 0.01 mm. Uncommon. A diatom of arctic and northern regions. Reported from Aoki Lake.

Cymbella sinuata GREG.

Cymbella sinuata GREG., Fr. HUSTEDT, Bacillar. (1930) 361, fig. 668a, b.

Valve slightly asymmetrical, linear, on one side triundulate. Length, 0.023 mm; breadth, 0.0068. Striae robust, 8 in 0.01 mm. Rare. Reported from Aoki, Kizaki and Biwa Lakes.

Cymbella turgida (GREG.) CLEVE. Plate X, fig. 2.

Cymbella turgida (GREG.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 358, fig. 660.

Valve asymmetrical, lunate, slightly centrally gibbous ventral, and arcuate at dorsal margins. Length, 0.064 mm; breadth, 0.017. Striae radiate, robust, lineate, $4\frac{1}{2}$ (ventral), 6 (dorsal) in 0.01 mm. Common. Known in tropics and reported from Aoki and Kizaki Lakes.

Cymbella prostrata (BERKELEY) CLEVE. Plate IX, fig. 16; Plate X, fig. 16.

Cymbella prostrata (BERKELEY) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 357, fig. 659; *Eucyonema prostratum* RALFS in A. SCHMIDT, Atlas Diatom. (1875) pl. 10, figs. 64-69.

Valve asymmetrical, subelliptical with arcuate dorsal and slightly arcuate at ventral margins or lunate with curvate ends. Length, 0.02 to 0.037 mm; breadth, 0.0085 to 0.01. Striae radiate, lineate, 7 to 12 in 0.01 mm. Uncommon. Known from fresh and slightly brackish water. Reported as fossil from Italy and recent in Aoki, Kizaki, Biwa and Ikeda Lakes.

Cymbella leptoceros (EHR.?) GRUN.

Cymbella leptoceros (EHR.?) GRUN., Fr. HUSTEDT, Bacillar. (1930) 353, fig. 645.

Valve asymmetrical, gibbous in the middle, attenuate towards the ends. Length, 0.034 mm; breadth, 0.01. Striae robust, lineate, 9 in 0.01 mm. Median line slightly arcuate, gibbous in the middle part. Rare. Reported from Aoki and Ikeda Lakes.

Cymbella lanceolata (EHR.) VAN HEURCK. Plate XI, fig. 2.

Cymbella lanceolata (EHR.) VAN HEURCK, Fr. HUSTEDT, Bacillar. (1930) 364, fig. 679.

Valve asymmetrical, lunate with elongate ends. Length, 0.178 to 0.235 mm; breadth, 0.034 to 0.047. Striae radiate, punctate, 6 to 9 in 0.01 mm. Some species are larger than the type from Europe. Common.

Cymbella lanceolata EHR. var. **cornuta** EHR. Plate XI, fig. 1.

Cymbella lanceolata EHR. var. *cornuta* EHRENBERG, Microgeologie (1856) pl. 15, A. fig. 94.

Differs from the type in its more elongate, not so undulate valves.

Length, 0.144 mm; breadth, 0.022. Striae 10 (ventral), 9 (dorsal) in 0.01 mm. Uncommon. Known as fossil and recent.

Cymbella cistula (HEMPRICH.) GRUN.

Cymbella cistula (HEMPRICH) GRUN., Fr. HUSTEDT, Bacillar. (1930) 363, fig. 676a.

Valve asymmetrical with arcuate margins and attenuate, subacute ends. Length, 0.93 mm; breadth, 0.02. Striae radiate, 8 in 0.01 mm with three puncta, ending the median striae of the ventral margin. Uncommon. Reported from Aoki, Kizaki, Biwa and Ikeda Lakes.

Cymbella aspera (EHR.) CLEVE.

Cymbella aspera (EHR.) CLEVE, Fr. HUSTEDT, Bacillar. (1930) 365, fig. 680.

Valve asymmetrical, sublanceolate with long, subacute ends. Length, 0.17 mm; breadth, 0.034. Striae robust, punctate, 7 in 0.01 mm. Rare. Known from Ikeda Lake.

Didymosphenia geminata (LYNGBYE) M. SCHMIDT var. **curvata** SKV. and MEYER. Plate IX, figs. 5, 9, 10.

Didymosphenia geminata (LYNGBYE) M. SCHMIDT var. *curvata* SKV. and MEYER, A contribution to the Diatoms of Baikal Lake (1928) 31, pl. 3, fig. 137.

Valve asymmetrical, clavate and curvate. Middle part gibbous, gradually attenuate to the truncate apex. Basis elongate. Length, 0.119 to 0.127 mm; breadth, 0.032 to 0.035. Striae robust, radiate and punctate. Large specimens seldom have some puncta, forming partly, compact striae. Middle striae alternately longer and shorter, but some forms have striae of regular size. Near the central nobule is a segment row of 3 to 4 puncta. Median line filiform, arcuate with large distinct comma-shaped fissures. Common in Saga deposits and known in Baikal Lake of Siberia. The Saga forms of *Didymosphenia geminata* differs from *G. g.* var. *curvirostra* TEMPÈRE and BRUN* in its not capitate ends. The last variety was discovered as fossil from fresh-water deposits of Sendai and Yedo.

Didymosphenia geminata (LYNGB.) M. SCHMIDT var. **sibirica** GRUN. fo. **elongata** SKV. and MEYER. Plate X, fig. 3.

Didymosphenia geminata (LYNGB.) M. SCHMIDT var. *sibirica* GRUN. fo. *elongata* SKV. and MEYER, A contribution to the Diatoms of Baikal Lake (1928) 31, pl. 2, fig. 130.

Differs from var. *curvata* in its straight, not curved valves. Length, 0.153 mm; breadth, 0.037. Costae 7 in 0.01 mm. Uncommon. Known from Baikal Lake.

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* J. BRUN et J. A. TEMPÈRE, Diatomées Fossiles du Japon, espèces marines et nouvelles des calcaires argileux de Sendai et de Yedo. Geneve. 1889.

Gomphonema acuminatum EHR.

Gomphonema acuminatum EHR., Fr. HUSTEDT, Bacillar. (1930) 370, fig. 683.

Valve clavate, biconstricted with apiculate apex. Length, 0.035 mm; breadth, 0.008. Uncommon. Reported from Kizaki Lake.

Gomphonema augur EHR. Plate X, fig. 11.

Gomphonema augur EHR., Fr. HUSTEDT, Bacillar. (1930) 372, fig. 688.

Valve clavate with truncate and apiculate apex. Length, 0.051 mm; breadth, 0.013. Isolated puncta distinct. Common. Known from Kizaki Lake.

Gomphonema augur EHR. var. **Gautieri** VAN HEURCK. Plate XI, fig. 8; Plate XI, fig. 9.

Gomphonema augur EHR. var. *Gautieri* VAN HEURCK, A. SCHMIDT, Atlas Diatom. (1902) pl. 240, fig. 17.

Valve clavate, slightly biconstricted with apiculate apex. Basis in some specimens very long. Length, 0.085 mm; breadth, 0.015. Striae 9 in 0.01 mm. Fr. FRICKE has figured the long form of this diatom in the Atlas of Dr. A. SCHMIDT from lignit of Nippon. Common. Reported from Aoki, Kizaki, Biwa and Ikeda Lakes.

Gomphonema sphaerophorum EHR.

Gomphonema sphaerophorum EHR., VAN HEURCK, Synopsis (1880-1885) pl. 23. fig. 30.

Valve lanceolate with subtruncate and usually constricted apex. Length, 0.039 mm; breadth, 0.0068. Striae 8 to 9 in 0.01 mm. Isolated puncta distinct. Rare.

Gomphonema constrictum EHR.

Gomphonema constrictum EHR., Fr. HUSTEDT, Bacillar. (1930) 377, fig. 714.

Valve clavate and constricted with broad capitate apex. Length, 0.048 mm; breadth, 0.01. Isolated puncta distinct. Uncommon. Known from Aoki Lake.

Gomphonema intricatum KUTZ.

Gomphonema intricatum KUTZ., Fr. HUSTEDT, Bacillar. (1930) 375, fig. 697.

Valve linear-clavate with elongate apex and basis. Length, 0.045 mm; breadth, 0.0068. Striae 8 in 0.01 mm. Isolated puncta distinct. Common. Reported from Kizaki, Biwa and Ikeda Lakes.

Gomphonema lingulatum HUST. Plate IX, fig. 15.

Gomphonema lingulatum HUSTEDT, Bacillar. aus dem Aokikosee in Japan 166-167, taf. 5, fig. 5.

Valve clavate with broad, truncate apex and narrow basis. Length, 0.017 mm; breadth, 0.0076. Striae marginal. No isolated

puncta. Uncommon. Reported from Aoki, Kizaki and Biwa Lakes.

Gomphonema vastum HUST. var. **fossilis** var. nov. Plate IX, fig. 12; Plate X, fig. 8.

Valve lanceolate-clavate with long, subacute ends. Length, 0.042 to 0.044 mm; breadth, 0.007 to 0.0085. Striae marginal, 14 to 15 in 0.01 mm. Isolated puncta distinct. Differs from var. *elongata* SKV. from Biwa Lake in its acuminate ends and coarser striae. The type is known from Aoki and Kizaki Lakes.

Gomphonema vastum HUST. var. **capitata** var. nov. Plate X, fig. 9.

Differs from the type in its capitate apex. Length, 0.042 mm; breadth, 0.0068. Striae 11 to 12 in 0.01 mm. Isolated punta distinct. Uncommon.

Gomphonema olivaceum (LYNGB.) KUTZ. var. **calcarea** CLEVE. Plate IX, fig. 14.

Gomphonema olivaceum (LYNGB.) KUTZ. var. *calcarea* CLEVE, A. SCHMIDT, Atlas Diatom. (1902) pl. 233, figs. 20, 21.

Valve lanceolate-clavate with attenuate, subacute ends. Length, 0.039 mm; breadth, 0.008. Striae 9 to 10 in 0.01 mm. No isolated puncta. Rare. Known from fresh-water on moist limestone rocks in Gothland.

Epithemia turgida (EHR.) KUTZ.

Epithemia turgida (EHR.) KUTZ., A. SCHMIDT, Atlas Diatom. (1904) pl. 250, figs. 1-3.

Valve lunate, attenuate towards subcapitate ends. Length, 0.119 mm; breadth, 0.017. Costae 3 in 0.01 mm. Common. Known from Aoki and Biwa Lakes.

Epithemia Hyndmanni W. SMITH.

Epithemia Hyndmanni W. SMITH, A. SCHMIDT, Atlas Diatom. (1904) pl. 249, figs. 1-10.

Valve more robust than of *Epithemia turgida*, more lunate and arcuate. Ends not capitate. Length, 0.105 mm; breadth, 0.02. Common. Reported from Biwa Lake.

Epithemia cistula RALFS var. **lunaris** GRUN. Plate IX, fig. 17.

Epithemia cistula RALFS var. *lunaris* GRUNOW, Beitrage zur Kenntniss der Fossilen Diatom. Österreich-Ungarns (1882) 137, 138, taf. 19, figs. 1, 2.

Valve strongly arcuate, lunate with attenuate subacute ends. Length, 0.042 mm; breadth, 0.012. Striae 12 in 0.01 mm. Fossil in Europe, recent in South China, Aoki and Kizaki Lakes in Nippon.

Epithemia zebra (EHR.) KUTZ. var. **saxonica** (KUTZ.) GRUN.

Epithemia zebra (EHR.) KUTZ. var. *saxonica* (KUTZ.) GRUN., A. SCHMIDT, Atlas Diatom. (1904) pl. 252, figs. 12-14.

Valve moderately curvate with slightly recurved ends. Length, 0.045 to 0.049 mm; breadth, 0.01. Costae 3 to 4, striae 12 in 0.01 mm. Common. Reported from Kizaki and Biwa Lakes.

Epithemia sorex KURZ.

Epithemia sorex KURZ., Fr. HUSTEDT, Bacillar. (1930) 388, fig. 736.

Valve arcuate with capitate ends. Length, 0.034 mm; breadth, 0.012. Common. Reported from Aoki, Kizaki, Biwa and Ikeda Lakes.

Rhopalodia gibba (EHR.) O. MULL.

Rhopalodia gibba (EHR.) O. MULL., Fr. HUSTEDT, Bacillar. (1930) 390, fig. 740.

Valve linear-lanceolate, reflexed at the dorsal margin. Length, 0.068 mm; breadth, 0.0085. Common. Known from Aoki, Kizaki, Biwa and Ikeda Lakes.

Rhopalodia gibberula (EHR.) O. MULL.

Rhopalodia gibberula (EHR.) O. MULL., Fr. HUSTEDT, Bacillar. (1930) 391, fig. 742.

Valve lunate with narrow ends reflexed from dorsal side. Length, 0.054 mm; breadth, 0.0085. A brackish water diatom. Reported from Kizaki and Ikeda Lakes.

Hantzschia amphioxys (EHR.) GRUN.

Hantzschia amphioxys (EHR.) GRUN., Fr. HUSTEDT, Bacillar. (1930) 394, fig. 747.

Valve linear-lanceolate with slightly arcuate ventral and constricted dorsal margins. Length, 0.054 mm; breadth, 0.0085. Common. Reported from Aoki, Kizaki, Biwa and Ikeda Lakes.

Nitzschia amphibia GRUN.

Nitzschia amphibia GRUN., Fr. HUSTEDT, Bacillar. (1930) 414, fig. 793.

Valve linear-lanceolate with subacute ends. Length, 0.022 to 0.03 mm; breadth, 0.0038 to 0.006. Costae 7 to 9, striae 18 in 0.01 mm. Common. Known from Aoki and Ikeda Lakes.

Nitzschia sigmoidea (EHR.) W. SMITH.

Nitzschia sigmoidea (EHR.) W. SMITH, Fr. HUSTEDT, Bacillar. (1930) 419, fig. 810.

Valve linear, sigmoid. Length, 0.21 mm; breadth, 0.028. Costae 8 in 0.01 mm. Common only in fragments. Reported from Aoki and Kizaki Lakes.

Cymatopleura elliptica (BREB.) W. SMITH var. **constricta** GRUN. Plate XI, fig. 4.

Cymatopleura elliptica (BREB.) W. SMITH var. *constricta* GRUN., Fr. HUSTEDT, Bacillar. (1930) 428, fig. 826.

Valve linear-elliptical, slightly constricted in the middle. Length, 0.1 mm; breadth, 0.05. Costae 4 in 0.01 mm. Rare. Reported from Biwa Lake.

Surirella robusta EHR. var. **splendida** (EHR.) VAN HEURCK.

Surirella robusta EHR. var. *splendida* (EHR.) VAN HEURCK, Fr. HUSTEDT, Bacillar. (1930) 437, figs. 851–852.

Valve elongate-ovate with one end much broader than the other. Length, 0.122 mm; breadth, 0.034. Costae $1\frac{1}{2}$ in 0.01 mm. Pseudoraphe distinct. Common. Reported from Aoki, Kizaki, Biwa and Ikeda Lakes.

Surirella vermifera sp. nov. Plate XI, fig. 3.

Valve linear, irregularly curved with broad enlarged subcapitate and subacute ends. Length, 0.22 mm; breadth, 0.013. Outer rim distinct. Costae short one-third of the valve breadth. Not common. A distinct species.

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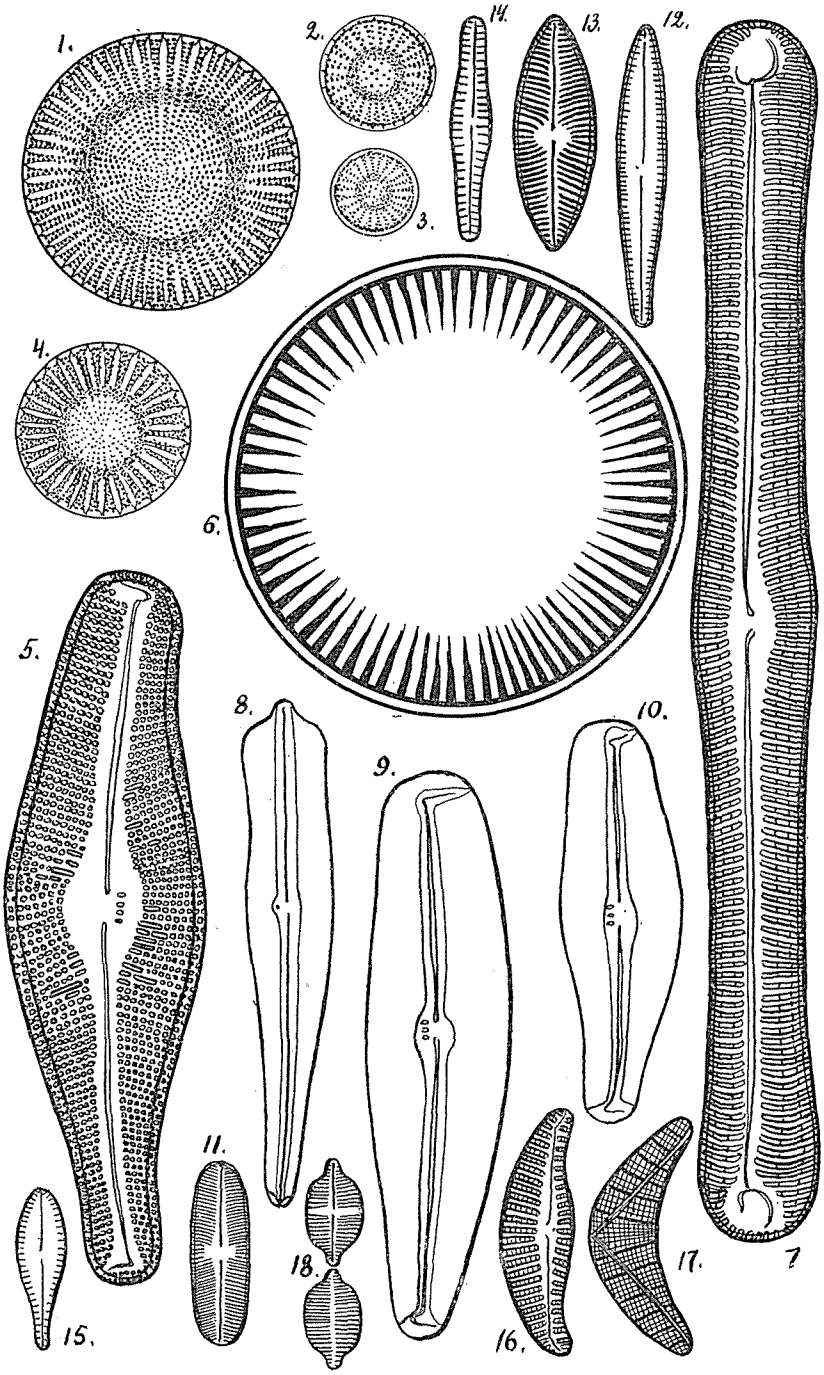
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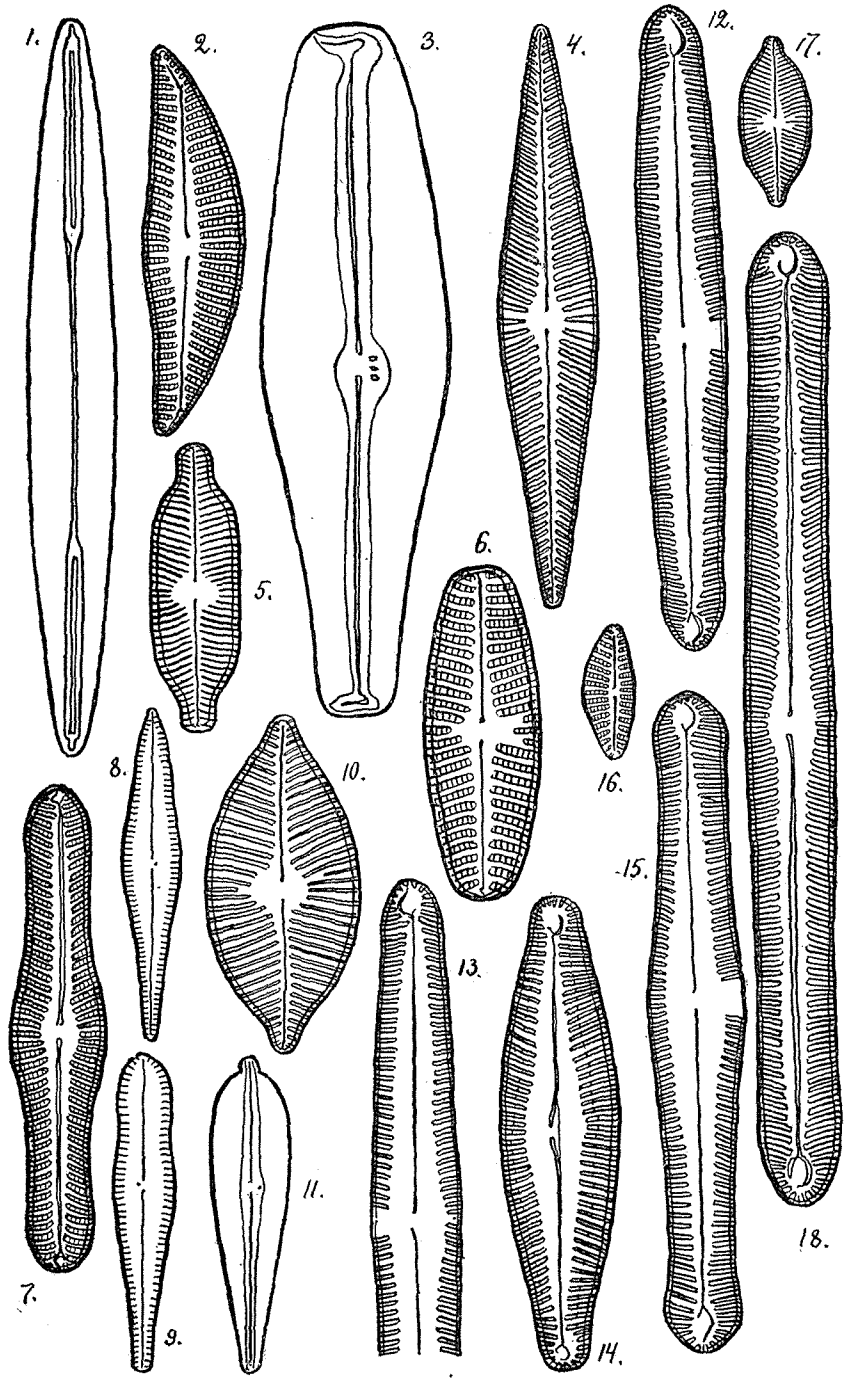
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Illustrations

Plate IX

Fig. 1. *Stephanodiscus astraea* (EHR.) GRUN. var. *spinulosa* GRUN.
Figs. 2, 3. . . . . var. *minutula* (KUTZ.) GRUN.
Fig. 4. . . . . var. *intermedia* FRICKE.
5. *Didymosphenia geminata* (LYNGB.) M. SCHMIDT var. *curvata* SKV. and MEYER.
6. *Melosira Sol* (EHR.) KUTZ.
7. *Pinnularia Hustedtii* MEISTER.
8. *Gomphonema augur* EHR. var. *Gautieri* VAN HEURCK.
Figs. 9, 10. *Didymosphenia geminata* (LYNGB.) M. SCHMIDT var. *curvata* SKV. and MEYER.
Fig. 11. *Navicula variostriata* KRASSKE var. *fossilis* var. nov.
12. *Gomphonema vastum* HUST. var. *fossilis* var. nov.
13. *Navicula menisculus* SCHUM.
14. *Gomphonema olivaceum* (LYNGB.) KUTZ. var. *calcarea* CLEVE.
15. *Gomphonema lingulatum* HUST.
16. *Cymbella prostrata* (BERKELEY) CLEVE.
17. *Epithemia cistula* RALFS var. *lunaris* GRUN.
18. *Achnanthes Yabe* sp. nov.

Plate X

Fig. 1. *Amphipleura Lindheimeri* GRUN.
2. *Cymbella turgida* (GREG.) CLEVE.
3. *Didymosphenia geminata* (LYNGB.) M. SCHMIDT var. *sibirica* GRUN. fo. *elongata* SKV. and MEYER.
4. *Navicula hasta* PANT. var. *fossilis* var. nov.
5. *Navicula dicephala* (EHR.) W. SMITH.
6. *Navicula Reinhardtii* GRUN.
7. *Navicula Yabe* sp. nov.
8. *Gomphonema vastum* HUST. var. *fossilis* var. nov.
9. *Gomphonema vastum* HUST. var. *capitata* var. nov.
10. *Navicula placentula* (EHR.) GRUN.
11. *Gomphonema augur* EHR.
12. *Pinnularia Saga* sp. nov.
13. *Pinnularia Saga* var. *isostauron* var. nov.
14. *Pinnularia lignitica* CLEVE.
15. *Pinnularia Saga* var. *undulata* var. nov.
16. *Cymbella prostrata* (BERC.) CLEVE
17. *Navicula gastrum* EHR.
18. *Pinnularia major* (KUTZ.) CLEVE var. *sagensis* var. nov.

Plate XI

Fig. 1. *Cymbella lanceolata* EHR. var. *cornuta* EHR.
2. *Cymbella lanceolata* (EHR.) VAN HEURCK.
3. *Surirella vermifera* sp. nov.
4. *Cymbella elliptica* (BREB.) W. SMITH var. *constricta* GRUN.
5. *Navicula Yabe* sp. nov.
6. *Pinnularia Hartleyana* GREVILLE.
7. *Navicula Reinhardtii* GRUN. var. *gracilior* GRUN.
8. *Gyrosigma acuminatum* (KUTZ.) RABH.
9. *Gomphonema augur* EHR. var. *Gautieri* VAN HEURCK.