

Freshwater diatom flora in the bottom sediments of Lake Biwa (South Basin): *Navicula sensu lato*

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Abstract Bottom sediments were collected at 10 sampling sites in the South Basin of Lake Biwa from May, 2000 to January, 2001. Eighty-one taxa including two new taxa, were found. The list in this study covers most of the epilithic flora described by Watanabe & Houki (1988) and Tuji (1995), and several species that were not found in the epilithic flora. These species may live on the bottom sediment. The high biodiversity in this study is likely a result of mixing living diatom communities with live and/or dead diatoms transported from other habitats.

Key words: *N. subtropicatrix* sp. nov., *Navicula pseudobrasiliiana* sp. nov., *Navicula alisoviana* comb. et stat. nov., *Diademsis contenta* var. *parallela* comb. nov., *Sellaphora perventralis* comb. nov., *Diademsis confervacea* var. *nipponica* comb. et stat. nov., *Placoneis neglecta* (Krasske) comb. nov., sediment, clay.

Introduction

The diatom flora of Lake Biwa has been studied by several diatomists. Skvortzov (=Skvortzov) (1936b) described 59 new taxa using one bottom sediment clay sample. Negoro studied phytoplankton and fossil diatoms (Negoro, 1958, 1960). Mori (1974) studied a long sediment core (197.2 m long) and examined the diatom succession in Lake Biwa. Watanabe and Houki (1988) examined the epilithic diatom flora and reported 164 taxa. Tuji (1995) discussed the relationship between the epilithic diatom flora and environmental factors. Tuji & Kociolek (2000) and Tuji (2002) described the endemic planktonic diatoms of Lake Biwa. Tuji & Houki (2001) wrote a monograph for centric diatoms of Lake Biwa. Tuji *et al.* (2002) discussed the relationship between epiphytic diatom flora and environmental conditions.

In this study, I described the *Navicula*-sensu lato flora from the bottom sediments of the South Basin of Lake Biwa. Similar floras for other genera are in preparation. Recently the endemism of diatom floras throughout the world has been widely discussed by many diatomists (Edlund &

Jahn, 2001). Lake Biwa is an ancient lake and the largest lake in Japan. The diatom flora of Lake Biwa should be very important for understanding the biogeography of Japanese and East Asian diatoms.

The taxonomy and classification of freshwater diatoms is changing very rapidly. Photographs of many type specimens have been published (Simonsen, 1987; Krammer & Lange-Bertalot, 1986) and we are beginning to understand the variation of species in greater detail. We now understand that small differences in populations among study areas are potentially significant at the species-level; as a result, many new taxa have been described (Metzeltin & Lange-Bertalot, 1998). In this study, the *Navicula*-sensu lato flora of Lake Biwa has been re-examined with new material and in light of these recent changes in diatom systematics and taxonomy.

Materials and Methods

Bottom sediments were collected at 10 sampling sites in the South Basin of Lake Biwa from May, 2000 to January, 2001. Sediment samples (Material TNS-AL-54381m—TNS-AL-54470m

in TNS) were oxidized with H₂O₂ and mounted onto glass slides with Pleurax (Slide TNS-AL-54381—TNS-AL-54470 in TNS) and observed using a Zeiss Axiophot. Photographs were taken using a Nikon DXM-1200 and printed after image processing.

Results & Discussion

I found 81 taxa including two new taxa. Since the relative abundances of *Navicula* sensu lato taxa were generally low, many taxa were found. Only one individual was seen in many taxa making it difficult to study some species in detail. Furthermore, many taxa were observed as only broken frustules. Taxa only observed with broken frustules were omitted from this paper. These taxa were likely transported from other habitats after death.

It is difficult to compare the flora in this study to the flora of other studies (Watanabe & Houki, 1988; Tuji, 1995) directly, because the names of many taxa have been changed. Using published figures of Watanabe & Houki (1988), the list in this study covers most members of the epilithic flora. Several common species in this study, such as *Navicula alisoviana* (Skvortzov) comb. et stat. nov., *Geissleria paludosa* (Hustedt) Lange-Bertalot & Metzeltin, *Navicula perventralis* Hustedt and *Navicula kizakensis* Skv., were not found in the epilithic flora. These species are probably epipelagic and live on the bottom sediment. The high biodiversity in this study is likely the result of a mixture of living diatoms and diatoms that have been transported living and/or dead from other habitats and areas.

List of diatom taxa observed in this study

Aneumastus tusculus (Ehrenb.) D.G.Mann & Stickle in Round, Crawford & Mann, Diatoms. 663. 1990.

Basionym: *Navicula tuscula* Ehrenb., Ber. Bekanntm. Verh. Königl. Preuss. Akad. Wiss. Berlin 1840: 215. (Pl. 10, Fig. 4)

Cavinula cocconeiformis (W.Greg. ex Grev.) D.G.Mann & Stickle in Round, Crawford & Mann, Diatoms: 665. 1990.

Basionym: *Navicula cocconeiformis* W.Greg. ex Grev., Ann. Mag. Nat. Hist. ser 2, 15: 256, pl. IX: f. 6. 1855. (Pl. 8, Figs. 1–2)

Cavinula pseudoscutiformis (Hust.) D.G.Mann & Stickle in Round, Crawford & Mann, Diatoms: 665. 1990.

Basionym: *Navicula pseudoscutiformis* Hust. in Pascher, Süsw. 10(2): 291, f. 495. 1930. (Pl. 8, Figs. 5–6)

Craticula ambigua (Ehrenb.) D.G.Mann in Round, Crawford & Mann, Diatoms. 666. 1990.

Basionym: *Navicula ambigua* Ehrenb., Abh. K. Akad. Wiss. Berlin, Physik. Kl. 1841: 417, pl. II: f. II.9. 1843. (Pl. 10, Fig. 6)

Craticula cuspidata (Kütz.) D.G.Mann in Round, Crawford & Mann, Diatoms. 666. 1990.

Basionym: *Frustulia cuspidata* Kütz., Linnaea. 8: 549. pl. 14. f. 26. 1833. (Pl. 10, Fig. 7)

Diadesmis confervacea Kütz., Kies. Bacill. Diat. 109. 1844.

Syn. *Navicula confervacea* (Kütz.) Grunow, Van Heurck, Syn. Diat. Belg. expl. pl. XIV: f. 36. 1880. (Pl. 9, Figs. 1–3)

Diadesmis confervacea var. *nipponica* comb. et. stat. nov.

Basionym: *Navicula confervacea* f. *nipponica* Skvortzov, Philippine J. Sc. 61: 34. pl. 2. f. 7. pl. 4. f. 23. 1936. (Pl. 9, Fig. 4)

Diadesmis contenta (Grunow) D.G.Mann in Round, Crawford & Mann, Diatoms. 666. 1990.

Basionym: *Navicula contenta* Grunow, in Van Heurck, Syn. Diat. Belg. 109. 1885. (Pl. 8, Fig. 46)

Diadesmis contenta var. *parallela* comb. nov.

Basionym: *Navicula contenta* var. *parallela* J.B.Petersen, Dansk Bot. Ark. 5(9): 15, f. 2. 1928 (Pl. 8, Fig. 45)

Information available for this taxon is minimal because it is so small. I identified this taxon using Patrick & Reimer (1966). This taxon should belong to the genus *Diadesmis*, and is thus proposed for transfer.

Diadesmis contenta var. ***biceps*** (Grunow) P.B.Ham., in Hamilton, Poulin, Charles & Angell, *Diat. Res.* **7**: 30. *tab.* 4. 1992.

Basionym: *Navicula trinodis* var. *biceps* Grunow, in Van Heurck, *Syn. Diat. Belg. expl. pl. XIV: f. 31B*. 1880. (Pl. 8, Figs. 47–48)

Eolimna minima (Grunow) Lange-Bert., *Biblioth. Diatomol.* **38**: 153. 1998.

Basionym: *Navicula minima* Grunow, Van Heurck, *Syn. Diat. Belg. expl. pl. XIV: f. 15*. 1880. (Pl. 8, Figs. 10–12)

Geissleria paludosa (Hust.) Lange-Bert. & Metzeltin, *Iconogr. Diat.* **2**: 67. 1996.

Basionym: *Navicula lagerstedtii* var. *palustris* Hust. in A. Schmidt Atlas, *pl. 400. f. 27–29*. 1934. (Pl. 8, Figs. 33–35)

Hippodonta capitata (Ehrenb.) Lange-Bert., Metzeltin & Witk., *Iconogr. Diat.* **4**: 254. 1996.

Basionym: *Navicula capitata* Ehrenb., *Ber. K. Akad. Wiss. Berlin* 1856: 53. *Infusionsthierchen*, 185, *pl. XIII, f. XX* 1838. (Pl. 8, Figs. 24–25)

Hippodonta linearis (Østrup) Lange-Bert., Metzeltin & Witk., *Iconogr. Diat.* **4**: 261. 1996.

Basionym: *Navicula hungarica* var. *linearis* Østrup, *Danske Diat. Reitzel. København.* **79**, *pl. 2, f. 53*. 1910. (Pl. 8, Fig. 27)

Hippodonta luneburgensis (Grunow) Lange-Bert., Metzeltin & Witk., *Iconogr. Diat.* **4**: 262. 1996.

Basionym: *Navicula hungarica* var. *luneburgensis* Grunow in Mojsisovics & Neumayr, *Beitr. Paläontol. österr.-Ung.* **2**: 156, *pl. XXX. f. 43, 44*. 1882. (Pl. 8, Fig. 26)

Hippodonta subcostulata (Hust.) Lange-Bert., Metzeltin & Witk., *Iconogr. Diat.* **4**: 264. 1996.

Basionym: *Navicula subcostulata* Hust., *Abh. Wiss. Ges. Bremen Jg.* **8/9**: 386, *f. 13*. 1934. (Pl. 8, Fig. 28)

Luticola mutica (Kütz.) D.G.Mann in Round, Crawford & Mann, *Diatoms*. 670. 1990.

Basionym: *Navicula mutica* Kützing, *Bacillarien*: 93. *pl. 3. f. XXXII*. 1844. (Pl. 9, Fig. 11)

Luticola nipponica comb. et stat. nov.

Basionym: *Navicula mutica* var. *nipponica* Skvortzov, *Philippine J. Sc.* **61**: 270. *pl. 4. f. 10*. 1936.

Synonym: *Luticola muticoides* (Hustedt) D.G. Mann in Round, Crawford, & Mann, *Diatoms*. 671. 1990.

Synonym: *Navicula muticoides* Hustedt, *Explor. Parc Natl. Albert, Mission H. Damas* **8**: 82. 1949. (Pl. 9, Fig. 10)

Luticola peguana (Grunow) D.G.Mann in Round, Crawford & Mann, *Diatoms*: 671. 1990.

Basionym: *Navicula mutica* var. *peguana* Grunow in Cleve & Möller, *Diatoms*. 188. 1879.

Syn. *Navicula goeppertiana* var. *peguana* (Grunow) Lange-Bert. in Krammer & Lange-Bertalot, *Biblioth. Diatomol.* **9**: 72. 1985. (Pl. 9, Figs. 8–9)

Luticola cf. ***goeppertiana*** (Pl. 9, Fig. 12)

Mayamaea atomus var. ***permitis*** (Hust.) Lange-Bert., *Arch. Protistenk.* **148**: 72. 1997.

Basionym: *Navicula permitis* Hust., *Arch. Hydrobiol.* **40**: 919. *pl. XLI. f. 8, 9*. 1945. (Pl. 8, Fig. 19–21)

Navicula alisoviana comb. et stat. nov.

Basionym: *Navicula viridula* var. *alisoviana* Skvortzov, *Mem. South. Ussuri Branch State Russian Geogr. Soc.* **22. pl. 4, f. 22**. (Pl. 1, Figs. 8–9)

Skvortzov (1936a) identified this taxon as *Cymbella hybrida*. The form found in the present material is very similar to the description and figures of *N. viridula* var. *linearis* by Krammer & Lange-Bertalot (1997). However, *N. alisoviana* has strongly rostrate valve apices and it differs from the original description, holotype and paratype specimens of *N. viridula* var. *linearis* (Simonsen 1987).

Navicula capitatoradiata H.Germain, *Fl. Diat.* 188. 1981.

Basionym: *Navicula cryptocephala* var. *intermedia* Grunow, in Van Heurck, *Syn. Diat. Belgique. pl. VIII. f. 10*. 1880. (Pl. 4, Fig. 4)

Navicula cari Ehrenb., *Ber. K. Akad. Wiss. Berlin.* **83**. 1836. (Pl. 2, Fig. 9)

Individuals in this study agree the photograph of isotype presented by Lange-Bertalot (2001).

Navicula cryptocephala Kütz., *Bacillarien.* **95**, *pl. 3, f. XX, XXVI*. 1844.

The form found in the present material agrees

very closely with the lectotype designated by Cox (1995). (Pl. 2, Figs. 1–6)

Navicula cryptotenella Lange-Bert. in Kramm. & Lange-Bert. Biblioth. Diatomol. **9**: 62, pl. 18, f. 22, 23, pl. 19, f. 1–10, pl. 27, f. 1. 1985.

(Pl. 2, Fig. 18)

Lake Biwa material agrees with the holotype designated by Krammer & Lange-Bertalot (1985). Several reports from Japan (Watanabe & Houki, 1988) include the specimens having wider breadth (pl. 7, f. 18–20) compare to this taxon. I suggest that other reports from Japan represent a different taxon than *N. cryptotenella*.

Navicula delicatilineolata nom. nud.

(Pl. 7, Figs. 1–5)

The description of this taxon is now in press by Mayama (2003) as *Navicula delicatilineolata* Mayama et H.Kobayasi. My observations agree with their description and figure (personal communication).

Navicula diversipunctata Hust., Ber. Deutsch. Bot. Ges. **61**: 275. pl. VIII. f. 5. 1944.

(Pl. 10, Fig. 3)

Navicula erifuga Lange-Bert. in Krammer & Lange-Bertalot, Biblioth. Diatomol. **9**: 69. 1985.

Basionym: *Navicula leptocephala* Bréb. ex Grunow in Van Heurck, Syn. Diat. Belg.: expl. pl. 7 f. 16. 1880. non Rabenhorst 1853: 39, f. 669.

(Pl. 7, Figs. 16–17)

Navicula exilioides nom. nud.

(Pl. 7, Figs. 13–15)

The description of this taxon is now in press by Mayama (2003) as *Navicula exilioides* Mayama et H.Kobayasi. My observations agree with their description and figures (personal communication).

Navicula gastum f. *nipponica* Skvortzov, Philippine J. Sc. **61**: 274, pl. 8: f. 8. 1936.

(Pl. 3, Figs. 4–5)

Resembles *N. salinarum* var. *nipponica* Skvortzov (1936a) and *N. menisculus*. This taxon is very rare and I could not study it in detail.

Navicula glomus J.R.Carter in Carter & Bailey-Watts, Nova Hedwigia. **33**: 578, pl. 13, f. 17. 1981. (Pl. 8, Fig. 43)

Navicula gregaria Donkin, Quart. J. Micr. Sc., ser. 2, **1**: 10, pl. I, f. 9. 1861. (Pl. 2, Figs. 10–11)

The form found in the present material agrees very closely with the lectotype designated by Patrick (see Cox, 1995).

Navicula gysingensis Foged, Bot. Not. **1952**: 167, pl. II, f. 7. 1952. (Pl. 8, Fig. 44)

Navicula hasta var. *gracilis* Skvortzov, Philippine J. Sc. **61**: 275, pl. 7: f. 9. 1936.

(Pl. 3, Fig. 1)

This taxon was described by Skvortzov (1936b) from L. Biwa. Resembles *N. hasta* var. *punctata* Boyer, but differs by not having the character of mid-valve striae distinctly punctae and reaching the median line.

Navicula hintzii Lange-Bert., Biblioth. Diatomol. **27**: 114. pl. 61. f. 15–18. 1993.

Syn. *Navicula hintzii* Lange-Bert. in Krammer & Lange-Bertalot in H. Ettl *et al.* (eds.), Süswasserfl. Mitteleuropa **2(4)**: pl. 63: f. 9–12. 1991. (nom. illigit). (Pl. 7, Figs. 6–8)

Resembles *N. cataracta-rheni* and is identified using the shape of valves and filiform raphe with very distinct central raphe endings. More examination using a SEM is needed for identification of this taxon.

Navicula kizakensis Skvortzov, Philipp. J. Sc. **61**: 39, pl. 16. f. 12. pl. 3. 1936.

Resembles *N. schadei* Krasske, differs by its weakly capitate apices. (Pl. 8, Figs. 39–42)

Navicula laterostrata Hust., Int. Rev. Hydrobiol. u. Hydrogr. **13**: 357, f. 4. 1925. (Pl. 6, Figs. 1–3)

Though having finer striae than noted by Simonsen (1987), other characters agree with the type.

Navicula leptostriata E.G.Jørg., Biologisk. Skrift. **5**: 59, pl. 2, f. 25. 1948. (Pl. 2, Fig. 21)

Navicula lundii E.Reichardt, Ber. Bayer. Bot. Ges. **56**: 180. 1985.

Basionym: *Navicula cryptocephala* f. *terrestris* J.W.G.Lund, New Phytol. **45**: 86, f. 9H-9W. 1946. (Pl. 2, Figs. 12–13)

The variation of this taxon presented by Lange-Bertalot (2001), is very broad. The individuals in this study have relatively narrow valves.

Navicula menisculus Schum., Schr. K. Phys.-
Ökon. Ges. Königsberg. 8: 56, *pl. II, f. 33*. 1867.

(Pl. 3, Fig 3)

Navicula microdigitoradiata Lange-Bert., Biblioth. Diatomol. **27**: 122. 1993.

Basionym: *Navicula cincta* f. *minuta* Van
Heurck, Syn. Diat. Belgique. 82. 1885.

Syn. *Navicula microdigitoradiata* Lange-Bert.
in Krammer & Lange-Bertalot in Ettl *et al.*
(eds.), Süswasserfl. Mitteleuropa **2(4)**: expl. *pl.*
59. f. 23, 24. 1991. (nom. illigit), non *N. cincta*
var. *minuta* Skvortzov, Philippine J. Sc. **64**: 445,
pl. 1, f. 17. 1938. (Pl. 2, Figs. 14–17)

Navicula nipponica (Skvortzov) Lange-Bert.,
Biblioth. Diatomol. **27**: 126. 1993.

Basionym: *Navicula radiosa* f. *nipponica*
Skvortzov, Philipp. J. Sc. **61**: 273, *pl. 2. f. 2. pl. 3.*
f. 20. 1936. (Pl. 4, Figs. 1–3)

Described by Skvortzov (1936b) from Lake
Biwa. Common in Lake Biwa (Tuji, 1995). Re-
sembles *N. oppugunata*, but differs by cuneate
ends and circular central area.

Navicula parablis M.H.Hohn & Hellerman,
Trans. Amer. Micr. Soc. **82**: 307. *pl. III. f. 17*.
1963. (Pl. 7, Figs. 9–12)

Navicula peregrina (Ehrenb.) Kütz., Bacillarien.
97. 1844.

Basionym: *Pinnularia peregrina* C.G. Ehrenb.
1843, Abh. K. Akad. Wiss. Berlin, Physik. Kl.
451, *pl. I, f. I. 5, 6, pl. II, f. IV. 1, pl. II, f. VI. 22*.

(Pl. 3, Fig. 8)

Navicula pseudobrasiliana sp. nov.

(Pl. 6, Figs. 9–12)

Valvae angustae ellipticae, apicibus late rotun-
datis, 27–38 μm longae, 8–9 μm latae. Striae
tranapicales modice radiantes in media parte val-
vae, parallelae ad apices, 16–19 in 10 μm , paulo
densiores versua apices. A *N. brasiliiana* differt
striae parallelae ad apices.

Narrow, elliptic valves with broadly rounded
apices, 27–38 μm long, 8–9 μm broad. Striae
gently radiate to parallel near apices, 16–19 in
10 μm , somewhat denser towards the apices. Re-
sembles *N. brasiliiana*, differs from it by parallel
striae near the apices.

Holotype: Slide TNS-AL-54458 in TNS,

shown in f. 9.

Type Material: TNS-AL-54458m in TNS.

Type Locality: Lake Biwa, Japan.

This taxon is also similar to *N. jakovlevicii*
Hust.; however, it differs from *N. jakovlevicii* be-
cause the raphe is not curved near apices in *N.*
pseudobrasiliana.

Navicula pseudolanceolata Lange-Bert., Cryp-
togamie Algologie. **1**: 32, *pl. II, f. 1–8*. 1980.

(Pl. 5, Figs. 5–7)

The form found in the present materials agrees
very closely with the holotype and lectotype des-
ignated by Lange-Bertalot (1980).

Navicula radiosa Kütz., Bacillarien, 91, *pl. 4. f.*
XXIII. 1844. (Pl. 4, Fig. 6)

Navicula reinhardtii (Grunow) Grunow, Van
Heurck, Syn. Diat. Belg. expl. *pl. VII: f. 5*. 1880.

Basionym: *Stauroneis reinhardti*, Gek. Algen.
Verhandlungen der kaiserlich königlichen zoolo-
gisch botanischen Gesellschaft in Wien. **10**: 566.
pl. 6. f. 19. 1860. (Pl. 10, Fig. 5)

The forms found in the present material agree
very closely with the original figure and descrip-
tion.

Navicula rhynchocephala Kütz., Bacillarien
145, *pl. 30, f. 35*. 1844. (Pl. 3, Fig. 9)

Resembles *N. peregrina*. Differs from it by
having strongly curved striae pattern in the cen-
tral area.

Navicula rostellata Kütz., Bacillarien. 95. *pl. 3.*
f. LXV. 1844.

Syn. *Navicula viridula* var. *rostellata* (Kütz.)
Cleve 1895. (Pl. 1, Figs. 2–4)

Navicula rotunda Hust., Arch. Hydrobiol. **40**:
916, *pl. XLI, f. 29*. 1945.

non *Navicula rotunda* G. W. Andrews 1966.

(Pl. 8, Figs. 13–18)

Navicula salinarum Grunow, K. Svenska Vet.
Akad. Handl., ser. 4. **17**: 33, *pl. II, f. 34*. 1880.

(Pl. 5, Fig. 1)

Navicula schroeteri F.Meister, Kies. Asien 38. *f.*
100. 1932. (Pl. 5, Fig. 16)

Navicula seibigiana Lange-Bert., Biblioth. Di-
atomol. **27**: 137, *pl. 44: f. 6–15*. 1993.

(Pl. 8, Figs. 29–30)

Navicula semenoides Hust., Arch. Hydrobiol. **18**: 163, pl. V, f. 8. 1927. (Pl. 8, Fig. 4)

Navicula seminuloides Hust., Arch. Hydrobiol. suppl. **15**: 239, pl. XVII, f. 29–31. 1937.

(Pl. 8, Fig. 31)

Navicula seminuloides var. *sumatrensis* Hust., Arch. Hydrobiol. suppl. **15**: 239, pl. XVII, f. 32–33. 1937. (Pl. 8, Fig. 32)

Navicula submuralis Hust., Arch. Hydrobiol. **40**: 918, pl. XLI, f. 37. 1945. (Pl. 8, Figs. 22–23)

Navicula subrhynchocephala Hust., Arch. Hydrobiol. Suppl. **14**, 156, f. 11. 1935.

(Pl. 5, Figs. 2–4)

Navicula subtrophicatrix sp. nov.

(Pl. 5, Figs. 8–15)

Valvae anguste lanceolate, apicibus angustis rostratis, 22–31 μm longae, 5–9 μm latae. Striae, 10–13 in 10 μm , paulo densiores versus apices, punctae 20–25 in 10 μm . Differt a *N. trophicatrix* proprie magnitudine semper minore.

Narrow, lanceolate valves with narrow, rostrate apices, 22–31 μm long, 5–6 μm broad. Striae radiate throughout, 10–13 in 10 μm , more coarse in central area. 20–25 punctae in 10 μm . Resembles *N. trophicatrix*, differs from it by smaller valves.

Holotype: Slide TNS-AL-54438 in TNS, shown in pl. 5, f. 12.

Type Material: TNS-AL-54438m in TNS.

Type Locality: Lake Biwa, Japan.

Navicula thoroddseni Foged, Biblioth. Phyc. **15**: 83, pl. XVII, f. 5, 7–10. 1974. (Pl. 8, Fig. 3)

Navicula undulata Skvortzov, Philippine J. Sc. **61**: 275, pl. 4, f. 2, pl. 7, f. 6. 1936. (Pl. 3, Fig. 2)

The taxon was described by Skvortzov (1936b) from L. Biwa. Differs from *N. hasta* var. *gracilis* by its lanceolate and undulate valve form. Common in L. Biwa.

Navicula vandamii Schoeman & R.E.M. Archibald, Nova Hedwigia. **44**: 482. 1987.

Basionym: *Navicula acephala* Schoeman, Diat. Lesotho. 107, pl. 5, f. 152, 153. 1973. non Heribaud 1903. (Pl. 2, Fig. 19)

Lake Biwa material agrees with the original drawing. Because I found only one individual, it was not possible to examine this taxon in detail.

Navicula venerabilis M.H.Hohn & Hellerman, Trans. Amer. Micr. Soc. **82**: 313, pl. III, f. 1. 1963. (Pl. 4, Fig. 5)

Though having more narrow valve ends than Lange-Bertalot (2001), I found only one individual and could not examine this species in detail.

Navicula venezuelensis Hust., Gessner & Vareschi, Ergeb. Deutsch. Limnol. Venezue la Exped. 1952. **1**: 115, f. 33–36. 1956.

Syn. *Navicula cariocincta* Lange-Bert. in Nevo & Wasser. 271, pl. 23, f. 203–207. 2000.

(Pl. 3, Figs. 6–7)

Resembles *N. recens*. Differs from it by narrower valves. Hustedt (1956) described this taxon from the assemblage on *Potamogeton*. This taxon may be an epiphytic species. The form found in the present material agrees very closely with the lectotype designated by Simonsen (1987).

Navicula virgata Hust., Kies. Deutschl., Öst. Schw. **7(3–4)**: 743, f. 1720. 1966.

(Pl. 10, Figs. 1–2)

The form found in the present material agrees very closely with the lectotype designated by Simonsen (1987).

Navicula viridula (Kütz.) Ehrenb., Ber. K. Akad. Wiss. Berlin 53. 1836.

Basionym: *Frustulia viridula* Kütz., Linnaea, **8**: 23, pl. 13, f. 12. 1833. (Pl. 1, Fig. 1)

Krammer & Lange-Bertalot (1997) showed the lectotype of this taxon (pl. 37, f. 1). My observations are comparable to the lectotype.

Navicula viridula var. *rostrata* Skvortzov, Philippine J. Sci. **66**: 56, pl. 1, f. 17. 1938.

(Pl. 1, Figs. 5–7)

Lake Biwa specimens are closely allied to the above taxon. Differs from it by having smaller central area and cuneate apices.

Navicula wildii Lange-Bert., Biblioth. Diatomol. **27**: 141, pl. 46, f. 9–13. 1993. (Pl. 2, Fig. 20)

Navicula yuraensis Negoro & Gotoh ex Gotoh, Diatom. **9**: 33. 1994.

Syn. *Navicula yuraensis* Negoro & Gotoh, Acta Phytotax. et Geobot. **34**: 91, f. 1 a–c. 1983.

(Pl. 6, Figs. 13–15)

Navicula rostellata var. *biwaensis* Skvortzov, Philipp. J. Sc. **61**: 272, pl. f. 14. 1936.

(Pl. 2, Figs. 7–8)

Oestrupia bicontracta (Østrup) Lange-Bert. & Krammer, *Naviculaceae*, 108. 1985.Basionym: *Navicula bicontracta* Østrup, *Bot. Tidsskr.* **25**: 32. *pl. I, f. 7*. 1903. (Pl. 9, Fig. 7)***Placoneis clementis*** (Grunow) E.J.Cox, *Diat. Res.* **2**: 155. 1987.Basionym: *Navicula clementis* Grunow, *Beitr. Paläont. Österr.-Ung.* **2**: 144. *pl. XXX, f. 52*. 1882. (Pl. 9, Fig. 16)***Placoneis elginensis*** (W.Greg.) E.J.Cox, *Diat. Res.* **2**: 155. 1987.Basionym: *Pinnularia elginensis* W.Greg., *Quart. J. Micr. Sc.* **4**: 9. *pl. I, f. 38*. 1856.

(Pl. 9, Fig. 17)

Placoneis neglecta (Krasske) comb. nov.Basionym: *Navicula neglecta* Krasske, *Bot. Arch.* **27**: 354. *f. 5*. 1929. (Pl. 9, Fig. 13–15)***Sellaphora bacillum*** (Ehrenb.) D.G.Mann, *Brit. Phycol. J.* **24**: 2. 1989.Basionym: *Navicula bacillum* Ehrenb., *Abh. K. Akad. Wiss. Berlin, Physik. Kl.* 1838: 130. 1839. (Pl. 9, Fig. 6)***Sellaphora laevissima*** (Kütz.) D.G.Mann *D.G.Mann, Brit. Phycol. J.* **24**: 2. 1989.Basionym: *Navicula laevissima* Kütz., *Bacillarien*. 96. *pl. 21, f. XIV*. 1844.

(Pl. 6, Fig. 8, Pl. 9, Fig. 5 ?)

Sellaphora perventralis comb. nov.Basionym: *Navicula perventralis* Hust., *Arch. Hydrobiol. suppl.* **15**: 241, *pl. XVII, f. 49, 50*. 1937.Syn. *Sellaphora verecundiae* Lange-Bert. 1994. (Pl. 8, Figs. 36–38)The lectotype of this taxon was designated by Simonsen (1987). My observations on Lake Biwa material agree it. *Sellaphora verecundiae* Lange-Bertalot should be a synonym of this taxon. This taxon should belong within the genus *Sellaphora*, and is thus proposed for transfer.***Sellaphora pupula*** (Kütz.) Mereschk. *Ann. Mag. Nat. Hist. Ser.* **7**: 9: 187. 1902Basionym: *Navicula pupula* Kütz., *Bacillarien*, 93. *pl. 30, f. 40*. 1844. (Pl. 6, Figs. 4–7)***Sellaphora seminulum*** (Grunow) D.G.Mann, *Brit. Phycol. J.* **24**: 2. 1989.Basionym: *Navicula seminulum* Grunow, *Verh. K.-K. Zool.-Bot. Ges. Wien* **10**: 552. *pl. 2, f. 2*. 1860.

(Pl. 8, Figs. 7–9)

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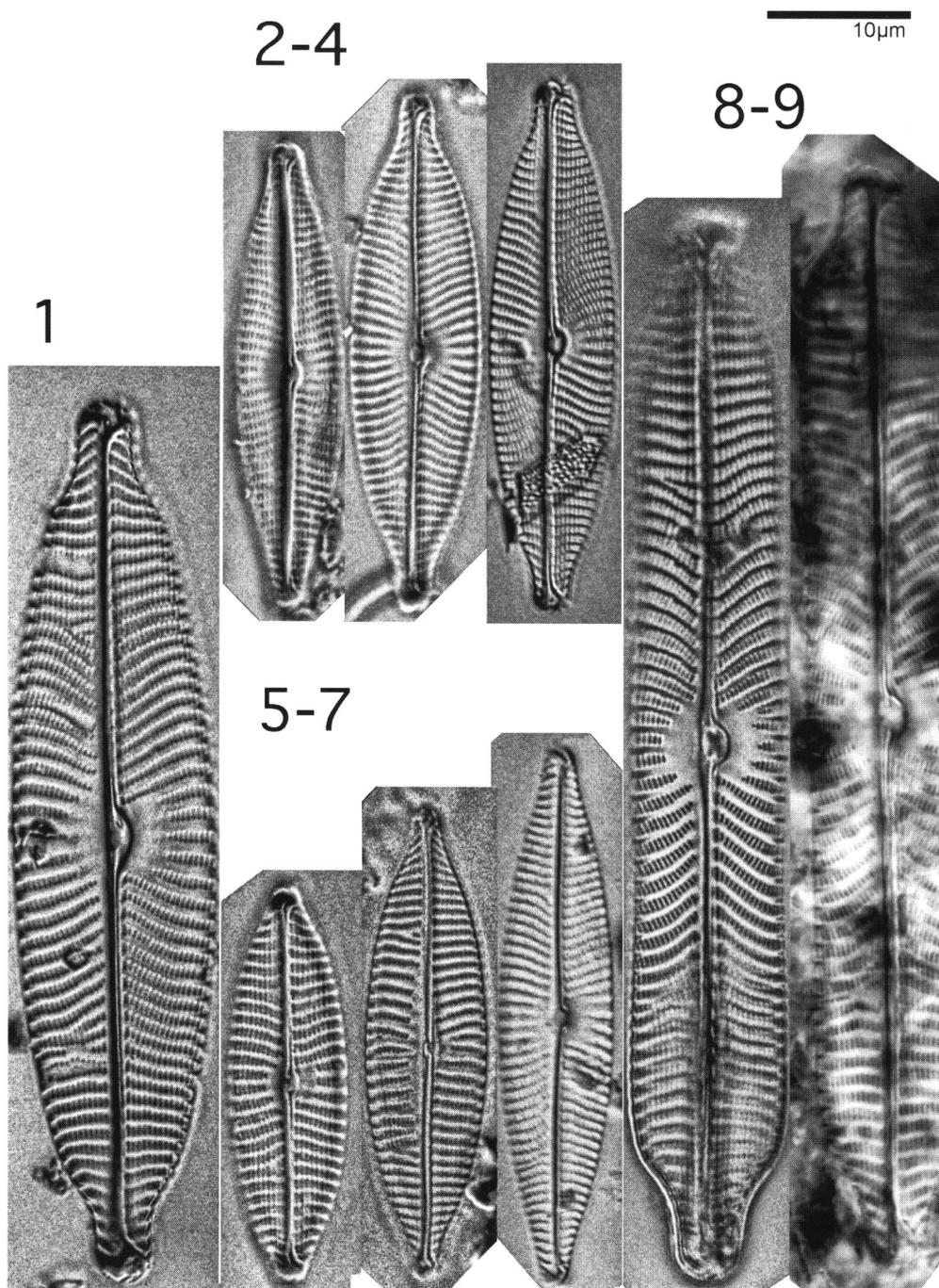


Plate 1. ($\times 2000$). 1. *Navicula viridula* (Kütz.) Ehrenb., 2-4. *Navicula rostellata* Kütz., 5-7. *Navicula viridula* var. *rostrata* Skvortzov, 8-9. *Navicula alisoviana* comb. nov.

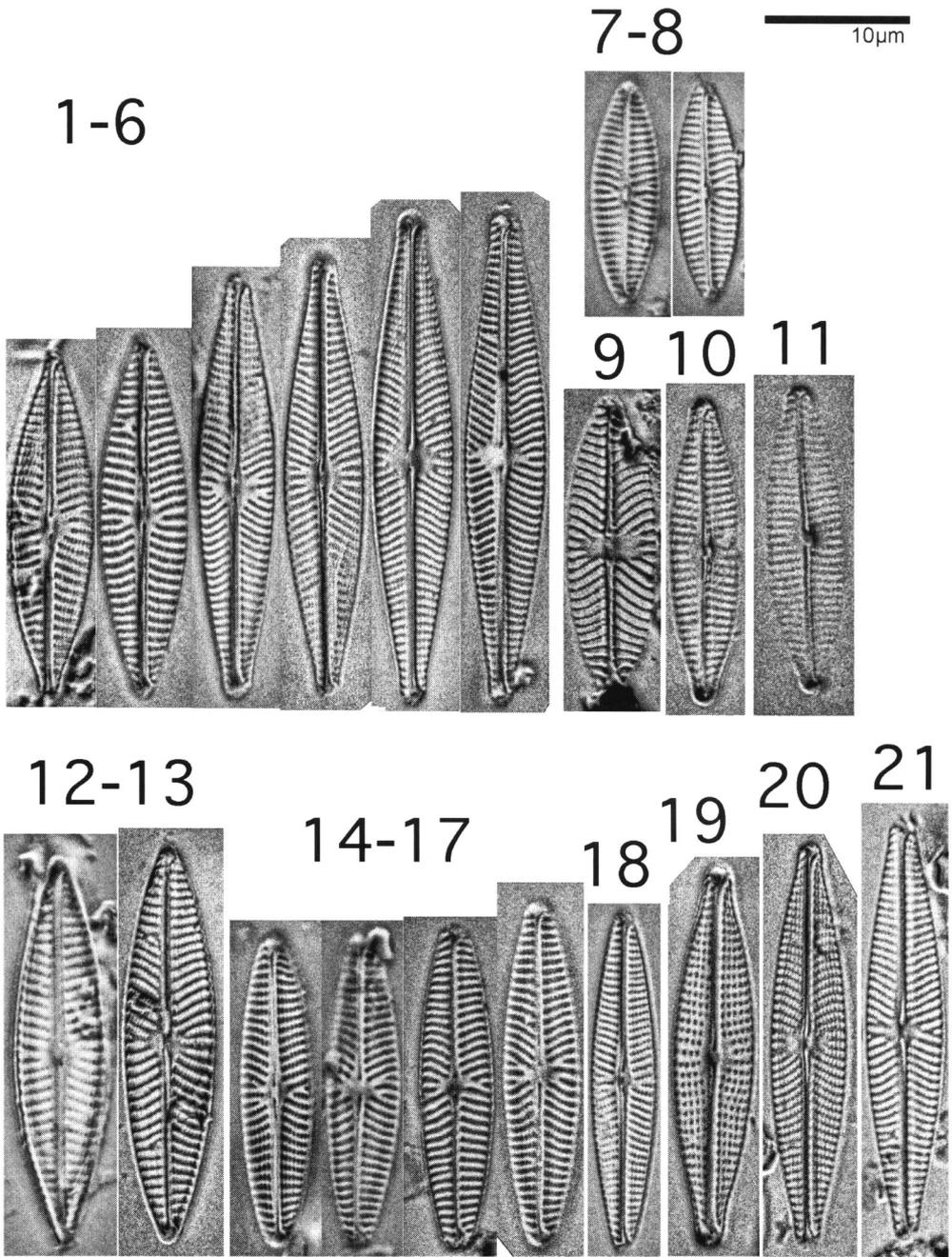


Plate 2. (×2000). 1-6. *Navicula cryptocephala* Kütz., 7-8. *Navicula rostellata* var. *biwaensis* Skvortzov, 9. *Navicula cari* Ehrenb., 10-11. *Navicula gregaria* Donkin, 12-13. *Navicula lundii* E.Reichardt, 14-17. *Navicula microdigitoradiata* Lange-Bert., 18. *Navicula cryptotenella* Lange-Bert., 19. *Navicula vandamii* Schoeman & R.E.M.Archibald, 20. *Navicula wildii* Lange-Bert., 21. *Navicula leptostriata* E.G.Jørg.

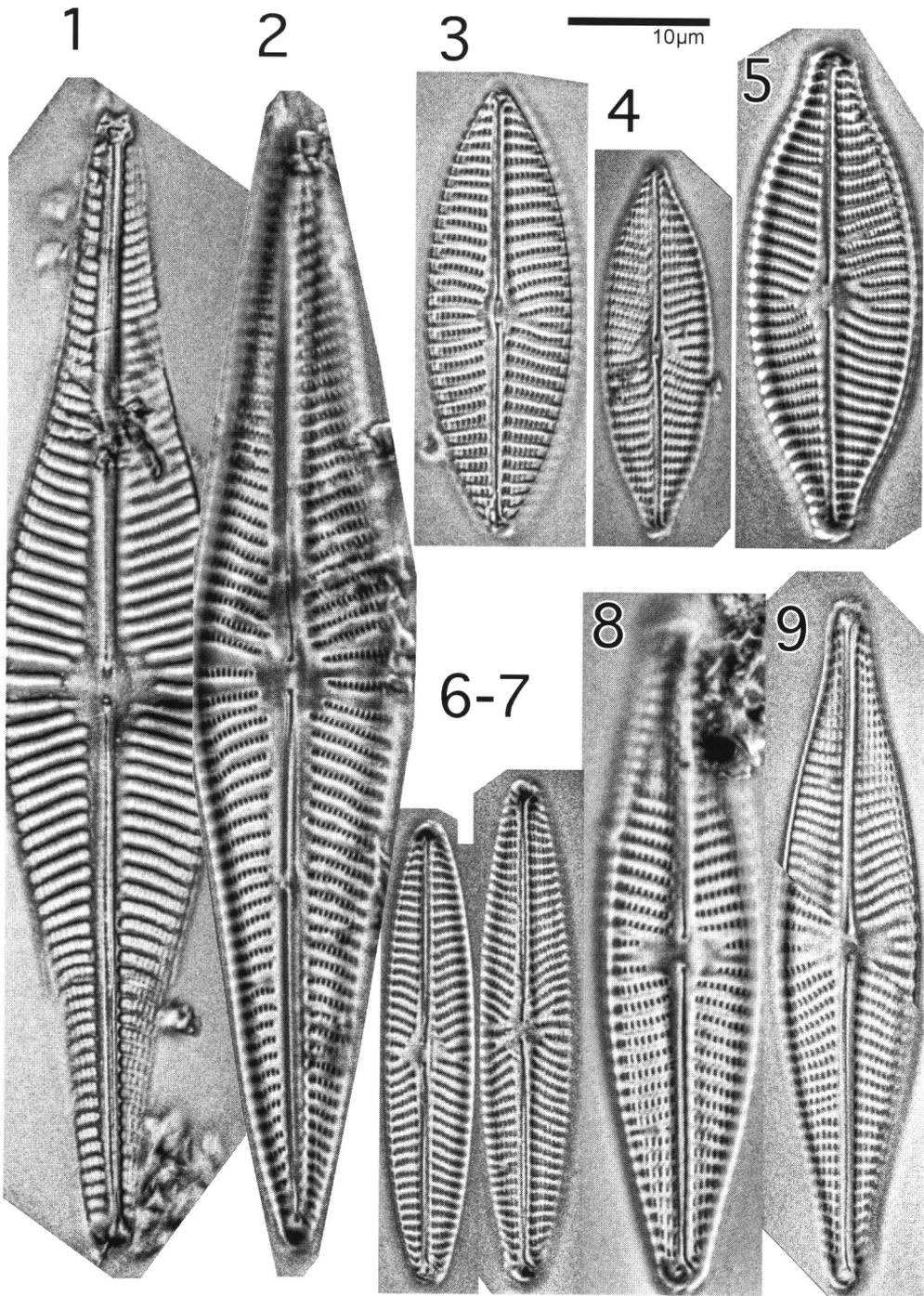


Plate 3. ($\times 2000$). 1. *Navicula hasta* var. *gracilis* Skvortzov, 2. *Navicula undulata* Skvortzov, 3. *Navicula meniscus* Schum., 4-5. *Navicula gastum* f. *nipponica* Skvortzov, 6-7. *Navicula venezuelensis* Hust., 8. *Navicula peregrina* (Ehrenb.) Kütz., 9. *Navicula rhynchocephala* Kütz.

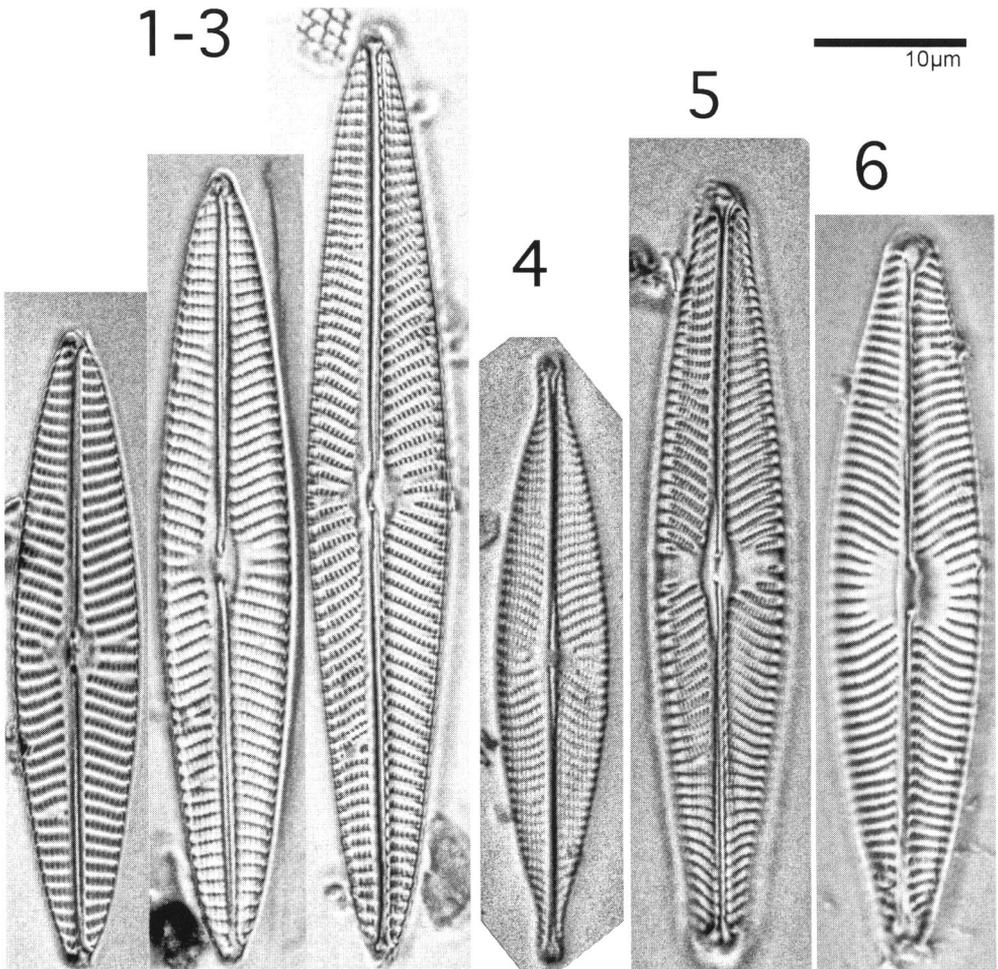


Plate 4. ($\times 2000$). 1-3. *Navicula nipponica* (Skvortzov) Lange-Bert., 4. *Navicula capitatoradiata* H.Germain, 5. *Navicula venerabilis* M.H.Hohn & Hellerman, 6. *Navicula radiosa* Kütz.

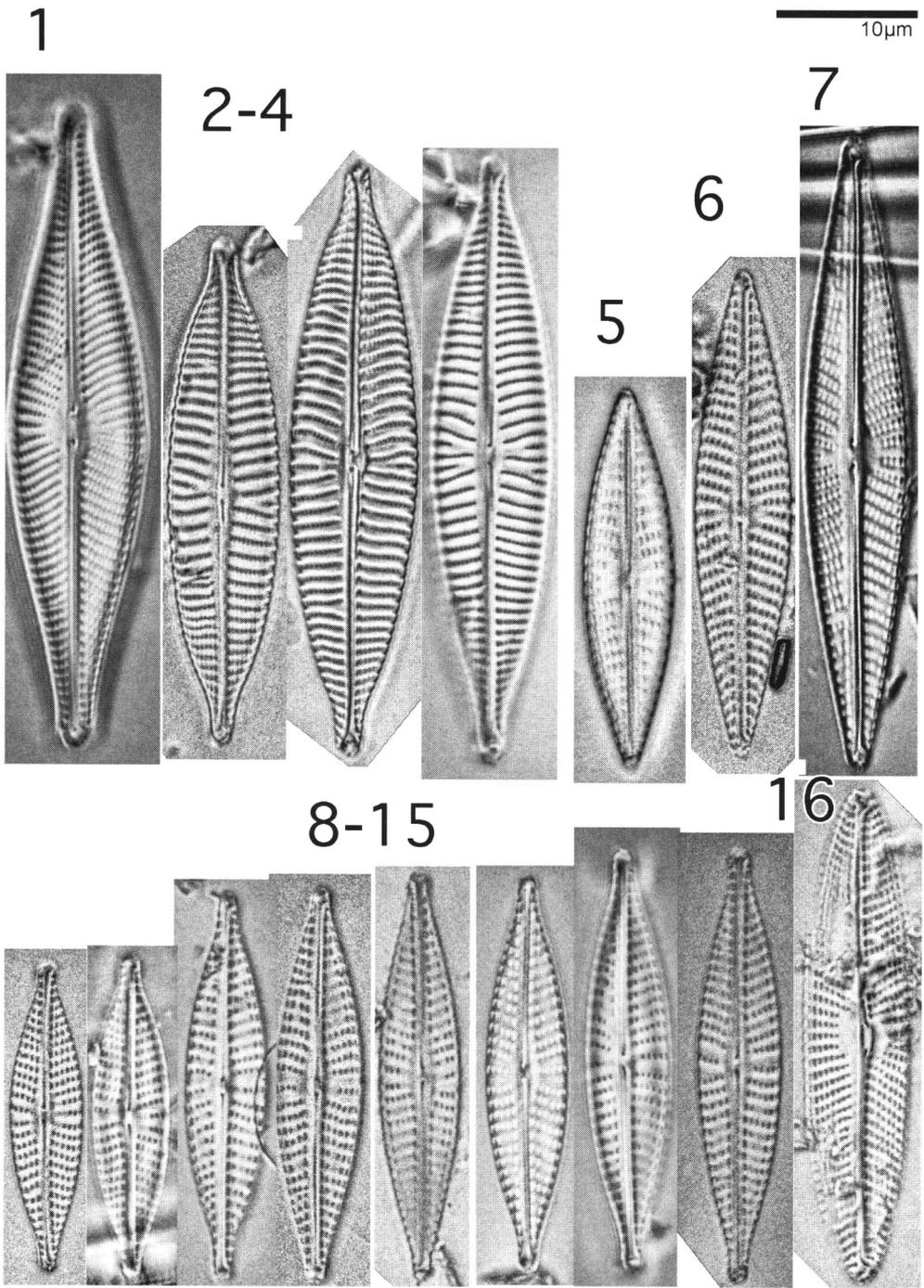


Plate 5. ($\times 2000$). 1. *Navicula salinarum* Grunow, 2-4. *Navicula subrhynchocephala* Hust., 5-7. *Navicula pseudolanceolata* Lange-Bert., 8-15. *Navicula subtropicatrix* sp. nov., 16. *Navicula schroeteri* F.Meister.

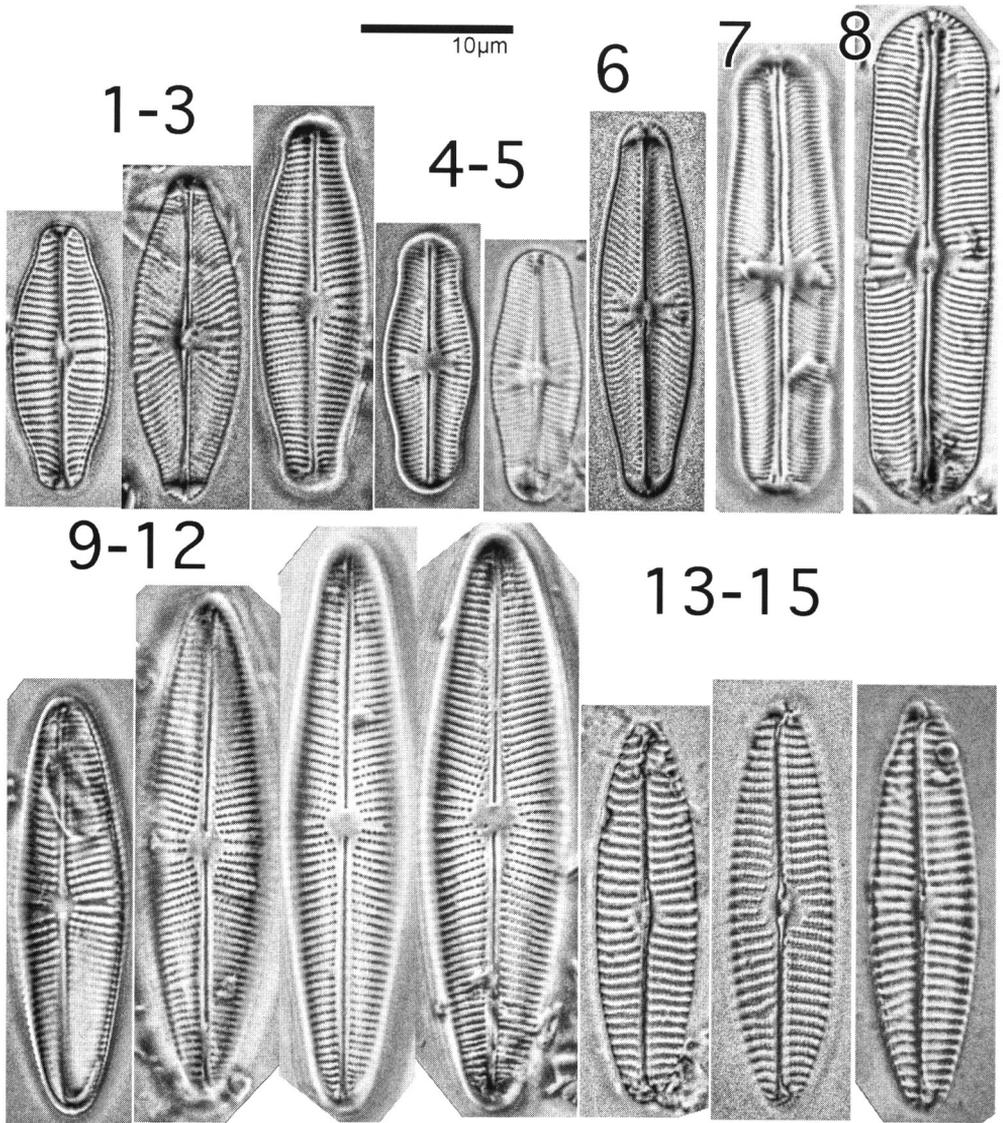


Plate 6. ($\times 2000$). 1-3. *Navicula laterostrata* Hust., 4-7. *Sellaphora pupula* (Kütz.) Mereschk., 8. *Sellaphora laevisissima* (Kütz.) D.G.Mann, 9-12. *Navicula pseudobrasiliana* sp. nov., 13-15. *Navicula yuraensis* Gotoh.

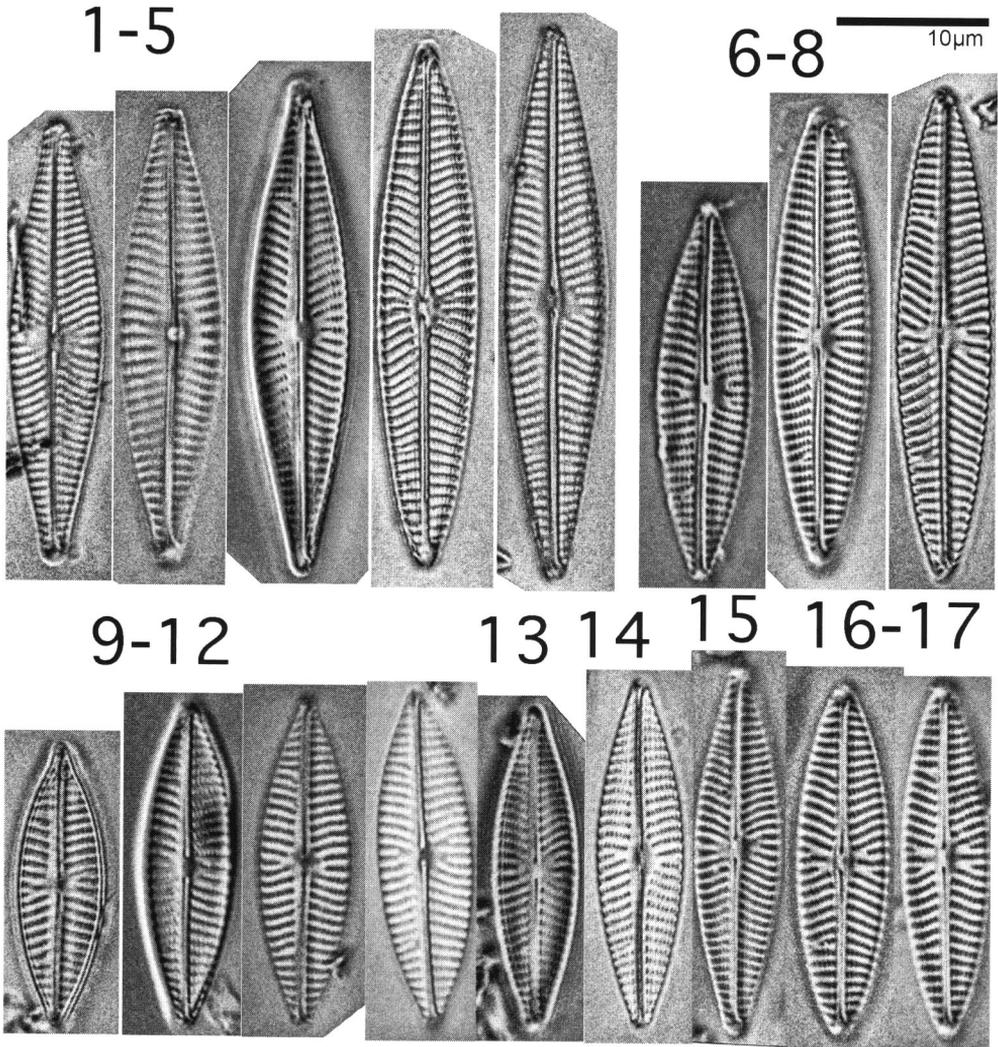


Plate 7. ($\times 2000$). 1-5. *Navicula delicatilineolata*, 6-8. *Navicula hintzii* Lange-Bert., 9-12. *Navicula parablis* M.H.Hohn & Hellerman, 13-15. *Navicula exilioides* nom nud., 16-17. *Navicula erifuga* Lange-Bert.

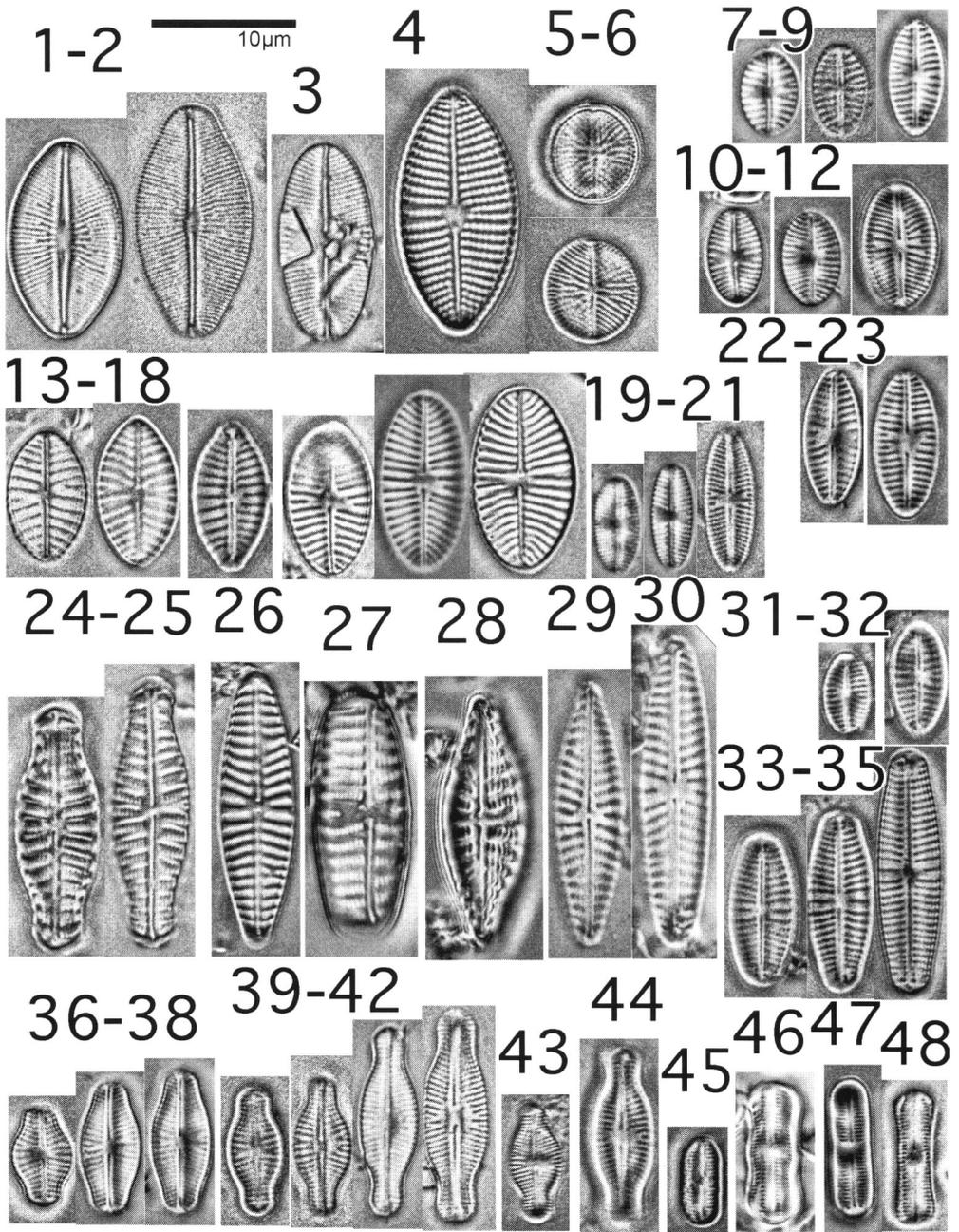


Plate 8. ($\times 2000$). 1–2. *Cavinula cocconeiformis* (W.Greg.) D.G.Mann & Stickle, 3. *Navicula thoroddseni* Foged, 4. *Navicula semenoides* Hust., 5–6. *Cavinula pseudoscutiformis* (Hust.) D.G.Mann & Stickle, 7–9. *Sellaphora seminulum* (Grunow) D.G.Mann, 10–12. *Eolimna minima* (Grunow) Lange-Bert., 13–18. *Navicula rotunda* Hust., 19–21. *Mayamaea atomus* var. *permitis* (Hust.) Lange-Bert., 22–23. *Navicula submuralis* Hust., 24–25. *Hippodonta capitata* (Ehrenb.) Lange-Bert., 26. *Hippodonta luneburgensis* (Grunow) Lange-Bert., 27. *Hippodonta linearis* (Østrup) Lange-Bert., 28. *Hippodonta subcostulata* (Hust.) Lange-Bert., 29–30. *Navicula seibigiana* Lange-Bert. 31. *Navicula seminuloides* Hust., 32. *Navicula seminuloides* var. *sumatrensis* Hust., 33–35. *Geissleria paludosa* (Hust.) Lange-Bert. & Metzeltin, 36–38. *Sellaphora perventralis* comb. nov., 39–42. *Navicula kizakensis* Skvortzov, 43. *Navicula glomus* J.R.Carter, 44. *Navicula gysinensis* Foged, 45. *Diademsis contenta* var. *parallela* comb. nov., 46. *Diademsis contenta* (Grunow) D.G.Mann, 47–48. *Diademsis contenta* var. *biceps* (Grunow) P.B.Ham.

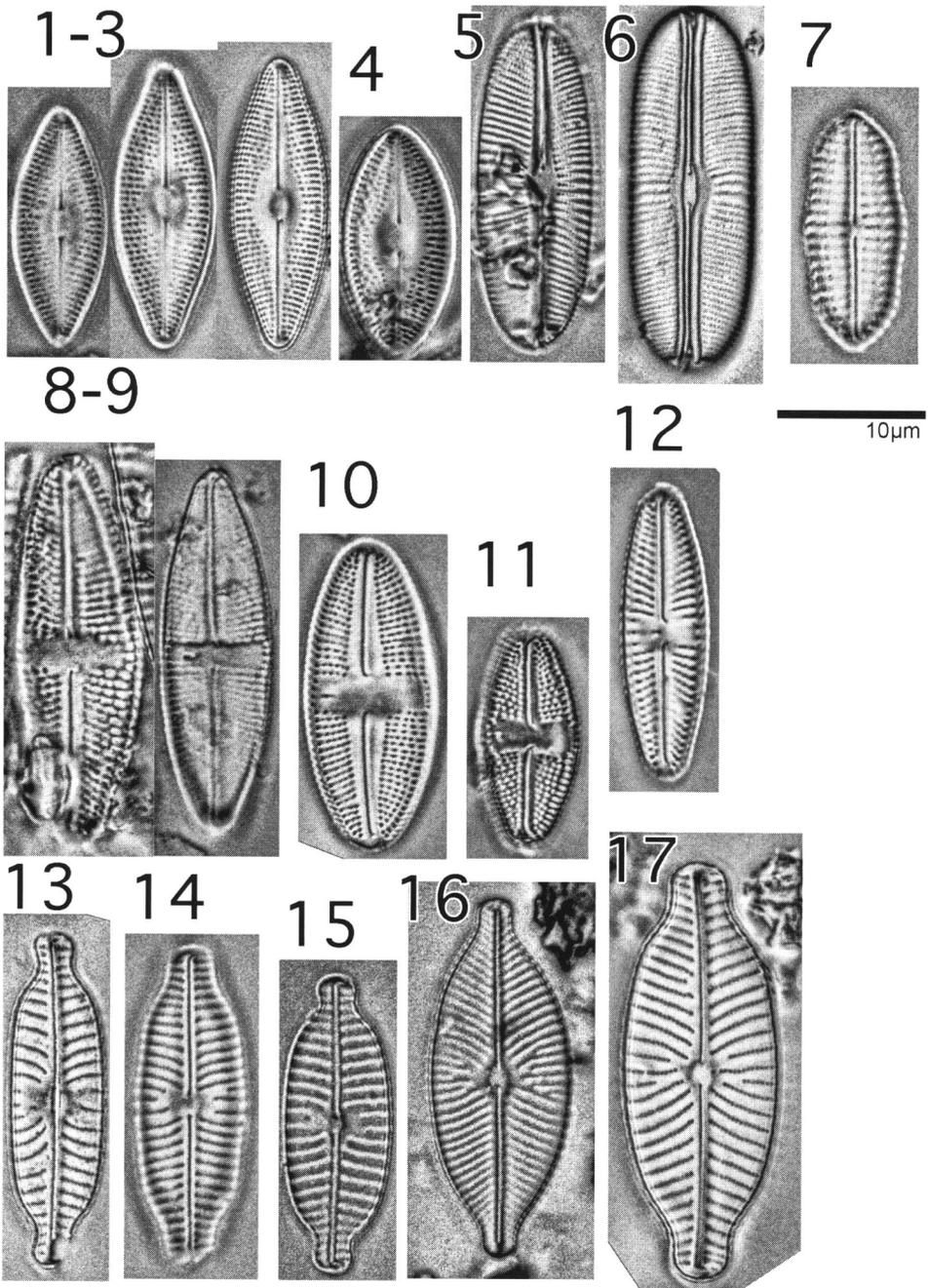


Plate 9. ($\times 2000$). 1-3. *Diademesmis confervacea* Kütz., 4. *Diademesmis confervacea* var. *nipponica* comb. et stat. nov., 5. *Sellaphora laevissima* (Kütz.) D.G.Mann, 6. *Sellaphora bacillum* (Ehrenb.) D.G.Mann, 7. *Oestrupia bicontracta* (Østrup) Lange-Bert. & Krammer, 8-9. *Luticola peguana* (Grunow) D.G.Mann, 10. *Luticola nipponica* comb. et stat. nov., 11. *Luticola mutica* (Kütz.) D.G.Mann, 12. *Luticola* cf. *goeppertiana*, 13-15. *Placoneis neglecta* (Krasske) comb. nov., 16. *Placoneis clementis* (Grunow) E.J.Cox, 17. *Placoneis elginensis* (W.Greg.) E.J.Cox.

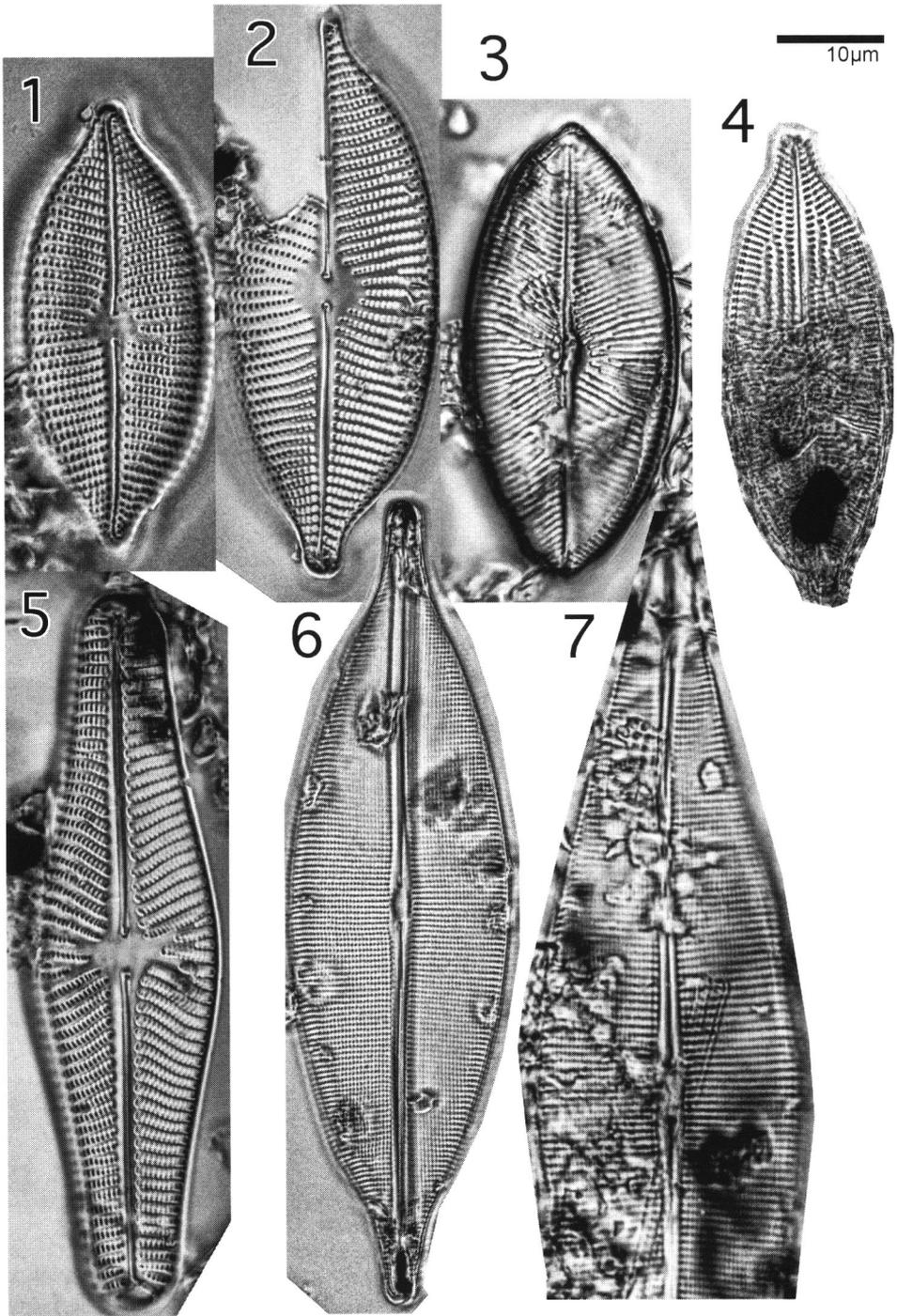


Plate 10. ($\times 1500$). 1–2. *Navicula virgata* Hust., 3. *Navicula diversipunctata* Hust., 4. *Aneumastus tusculus* (Ehrenb.) D.G.Mann & Stickle, 5. *Navicula reinhardtii* (Grunow) Grunow, 6. *Craticula ambigua* (Ehrenb.) D.G.Mann, 7. *Craticula cuspidata* (Kütz.) D.G.Mann.