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Checklist and illustrations of diatoms in Laguna de Bay, Philippines, with reference to water quality

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Abstract

A taxonomic survey of the diatom flora of Laguna de Bay, the largest lake in the Philippines, was conducted with special reference to the slightly brackish and heavily polluted water quality. Based on samples collected in 1976 and 1997, we identified 83 diatom taxa belonging to 37 genera. They are illustrated here together with 15 unidentified taxa. The predominant genus in term of species richness was *Gomphonema*, represented by 12 species. *Nitzschia* and *Navicula* were subdominant each represented by 10 species. A euhalobic species, *Giffenia cocconeiformis*, occurred despite the low salinity (<0.4‰). Regardless of the heavy organic content and high phosphorus concentration of the lake water, saprophilous species were not common, and some saproxenous species occurred.

Key index words: checklist, diatom, *Gomphonema*, Laguna de Bay, euhalobe, water quality

Introduction

The Philippines is an archipelagic country that is rather similar to Japan in many geographic respects except for the tropical climate. Because most Philippine rivers are short, rainfall in mountain areas generally flows to lakes or the sea in only about half a day. The prospects are poor, therefore, for biochemical purification in the rivers. The water quality goes bad to worse because of increasing water usage in cities, untreated industrial sewage from dispersed small factories, and modernized agriculture employing massive amount of chemical fertilizers and pesticides (Laguna Lake Development Authority 1995, 2005).

Laguna de Bay, the largest lake in the Philippines, is situated near the center of Luzon Island. Its surface area is approximately 900 km^2 but it has an average depth of only about 2.5 m (Laguna Lake Development Authority 1995). It sometimes becomes brackish because of the back current of the Pasig River which connects the lake to Manila Bay. The water quality has deteriorated because of pollutant load from the inflowing rivers, and fish culture in the lake also causes pollution (Laguna Lake Development Authority 2005). *Microcystis* blooms occur frequently (Okino 1994).

The diatoms of Laguna de Bay were first studied by Hustedt (1942). He listed 109 taxa, but we cannot re-evaluate his identifications because he illustrated only a small number of taxa, those he regarded as new or little-known. Later, Martinez-Goss (1997) reported three new taxa belonging to *Nitzschia* and *Tryblionela* from the lake.

Here we present a checklist of the diatoms of Laguna de Bay documented by microphotographic illustrations, as well as a brief discussion on the relation between the water quality and the diatom flora. Microphotographs appearing in the report were prepared and partly identified by

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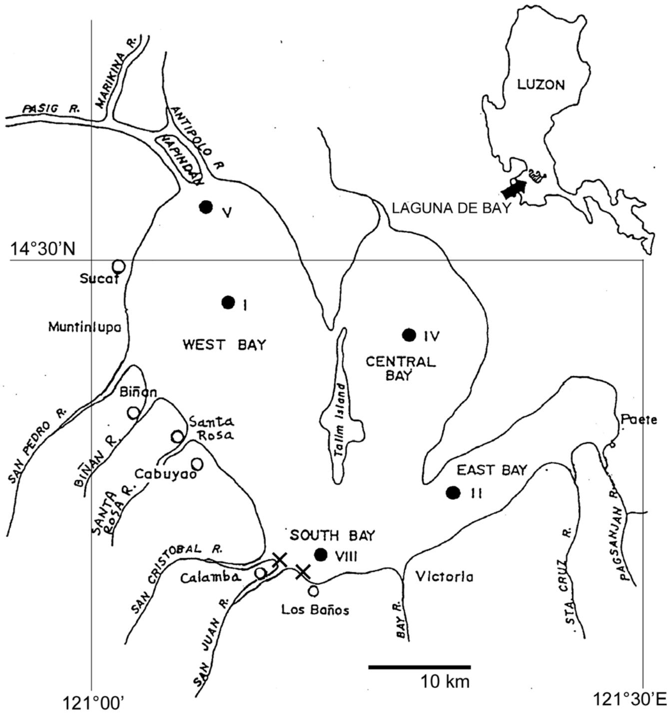


Fig. 1. Map of Laguna de Bay. × : sampling sites in 1997. ● : stations for water quality surveys conducted by the Laguna Lake Development Authority (LLDA).

late Prof. Dr. Toshiharu Watanabe during his lifetime, and have not previously been published.

Materials and methods

Diatom samples were collected in 1976 and 1997. No detailed description of the sampling program conducted in 1976 by Toshiharu Watanabe is available. However, in November 1997, Susumu Kato used a tooth brush to collect samples from a dock piling at Calamba, and from pebbles at a depth of 30 cm near the lake shore at Los Banos (Fig. 1).

In the laboratory, we made permanent slides of diatom frustules after acid cleaning. Morphological observations and film microphotography were performed using a Nomarski light microscope, Biophoto (Nikon, Tokyo, Japan), equipped with a UFX camera (Nikon, Tokyo, Japan). For identification, prints of all microphotographs were digitized by using a flatbed scanner and adjusted to a magnification of ×2000 using Photoshop Element 7 (Adobe, California, USA).

Results and Discussion

We identified 83 diatom taxa belonging to 37 genera. They and 15 unidentified diatom taxa are illustrated as light microphotographs. The predominant genus in terms of species richness was *Gomphonema*, represented by 12 species. *Nitzschia* and *Navicula* were subdominant, each represented by 10 species.

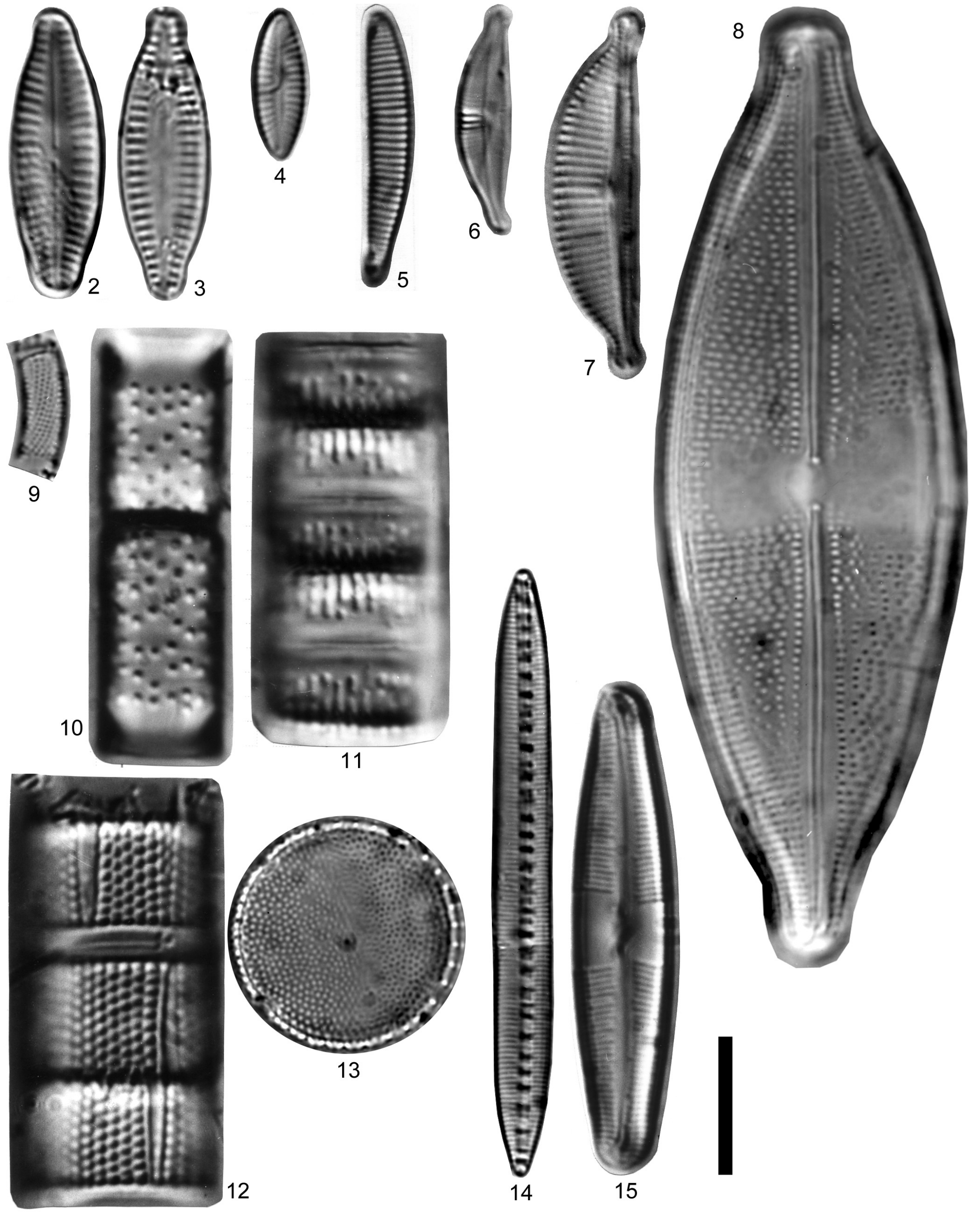
Achnanthes simplex **Hust.** ; cf. Simonsen 1987. p. 178. *pl. 280. f. 2-8.* (as *Achnanthes similis* Hust.)

Idei & Nagumo (2002) observed this species under SEM and TEM and pointed out its affinity to the genus *Kolbesia*. They did not, however, assign it to that genus because its araphid valve has monoareolate striae ; on the contrary, that of *Kolbesia* species usually have striae composed of two or three areolae (Round & Bukhtiyarova 1996). Figs 2, 3

A. subhudsonis **Hust.** ; cf. Simonsen 1987. p. 54. *pl. 68. f. 1-9.* Fig. 4

Actinella **sp.**

This species is similar to *Actinella subperonioides* var. *linearis* nom. nud. (Watanabe *et al.* 2005. p. 106. *pl.* IIB_1*-17. f. 22-27*), but the head pole is less bloated. *Actinella parva* K.Vanhoutte et Sabbe (Sabbe *et al.* 2001. p. 331. *f. 62-78*) is also similar in its valve shape, but it has much narrower valve (1.5-2.3 μm vs. 3.6 μm for the present form). Fig. 5



Figs 2, 3. *Achnanthes simplex.* **Fig. 4**. *A. subhudsonis.* **Fig. 5**. *Actinella* sp. **Fig. 6**. *Amphora montana.* **Fig. 7**. *A. tumida.* **Fig. 8**. *Anomoeoneis sphaerophora.* **Fig. 9**. *Aulacoseira ambigua.* **Fig. 10**. *A. crassipunctata.* **Fig. 11**. *A. perglabra.* **Figs 12, 13**. *A. granulata.* **Fig. 14**. *Bacillaria paxillifer.* **Fig. 15**. *Caloneis moralis.* Scale bar = 10 μm.

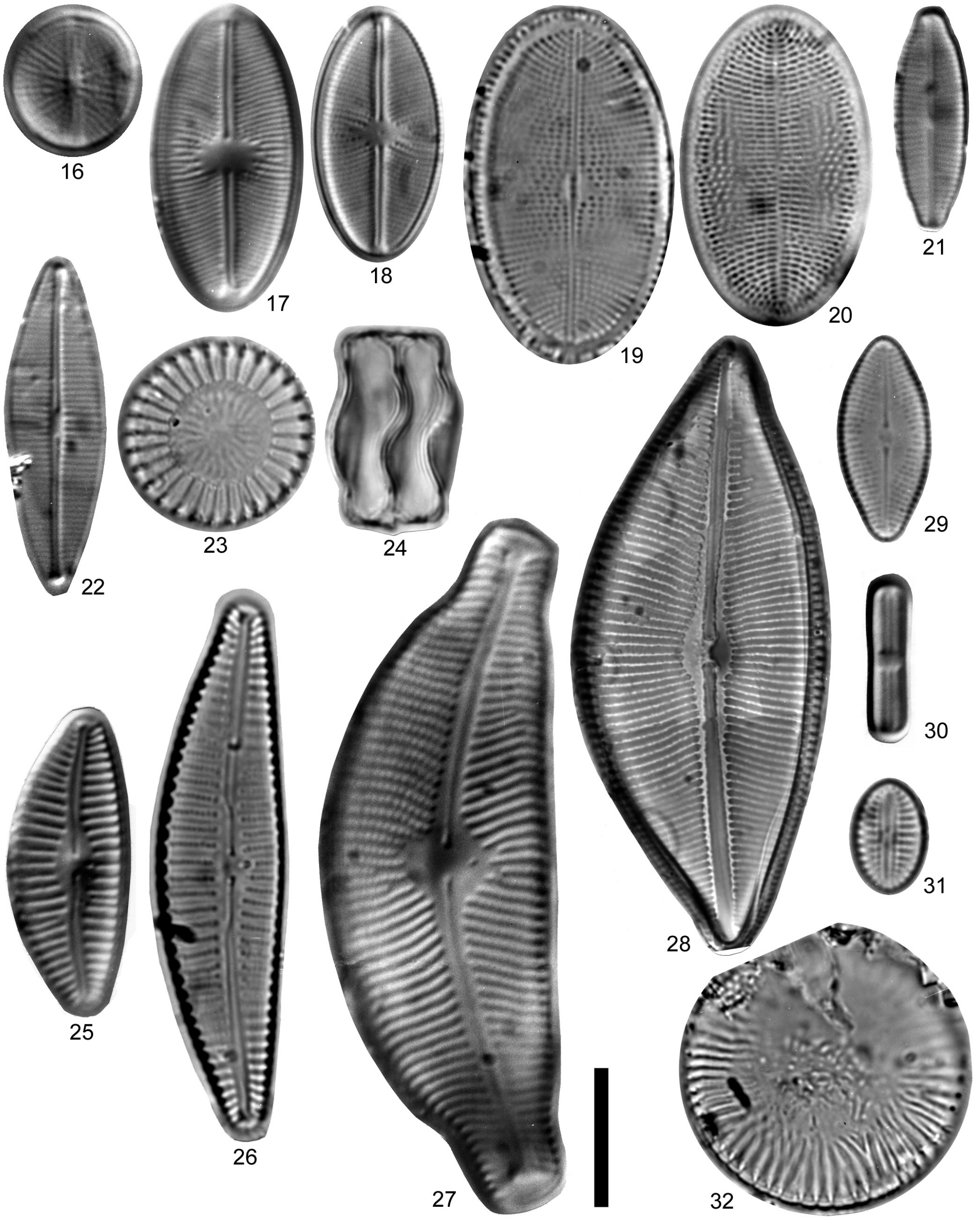


Fig. 16. *Cavinula pseudoscutiformis.* **Figs 17, 18**. *Cavinula* (?) sp. **Figs 19, 20**. *Cocconeis placentula.* **Fig. 21**. *Craticula molestiformis.* **Fig. 22**. *C. subhalophila.* **Figs 23, 24**. *Cyclotella meneghiniana.* **Fig. 25**. *Cymbella kolbei.* **Fig. 26**. *C. parva.* **Fig. 27**. *C. tumida.* **Fig. 28**. *Cymbopleura inaequalis.* **Fig. 29**. *Diadesmis confervacea.* **Fig. 30**. *D. contenta.* **Fig. 31**. *Diploneis* sp. **Fig. 32**. *Ellerbeckia arenaria.* Scale bar = 10 μm except for Figs 28 and 32 (= 20 μm).

Amphora montana **Krasske**; cf. Lange-Bertalot *et al.* 1996. p. 40. *pl. 37. f. 8, 8'.* Fig. 6

A. tumida **Hust.**; cf. Simonsen 1987. p. 437. *pl. 654. f. 12-19.* Fig. 7

Anomoeoneis sphaerophora **(Ehrenb.) Pfitzer**; cf. Krammer & Lange-Bertalot 1986. *pl. 92. f. 1-2.* Fig. 8

Aulacoseira ambigua **(Grunow) Simonsen**; cf. Kobayasi & Nozawa 1981. p. 167. *f. 1-23.* Fig. 9

A. crassipunctata **Krammer**; cf. Krammer & Lange-Bertalot 1991a. p. 39. *pl. 37. f. 1-10.* Fig. 10

A. granulata **(Ehrenb.) Simonsen**; cf. Kobayasi *et al.* 2006. p. 8. *pl. 11, 12.* Figs 12, 13

A. perglabra **(Østrup) E.Y.How.**; cf. Krammer & Lange-Bertalot 1991a. p. 37. *pl. 33. p. 12-17.* Fig. 11

Bacillaria paxillifer **(O.F.Müll.) Hendey**; cf. Krammer & Lange-Bertalot 1988. p. 8. *pl. 87. f. 4-7.* (as *Bacillaria paradoxa*) Fig. 14

Caloneis moralis **(Grunow) Krammer**; cf. Krammer & Lange-Bertalot 1986. p. 394. *pl. 174. f. 16-21.* Fig. 15

Cavinula pseudoscutiformis **(Hust.) D.G. Mann et Stickle in Round *et al.***; Simonsen 1987. p. 120. *pl. 194. f. 11, 12.* (as *Navicula pseudoscutiformis*) Fig. 16

***Cavinula*(?) sp.**

This species is similar to *Cavinula weinzierlii* (Schim.) Czarn. (cf. Krammer & Lange-Bertalot *et al.* 1986. p. 202. *pl. 73. f. 1, 2*; as *Navicula weinzierlii*), but the valve is elliptical rather than lanceolate. Possibly the specimens are raphid valves of *Psammothidium* sp., but we cannot find any matching species in the literature. Figs 17, 18

Cocconeis placentula **Ehrenb.**; cf. Kobayasi *et al.* 2006. p. 117. *pl. 146, 147.* Figs 19, 20

Craticula molestiformis **(Hust.) Lange-Bert.**, Diatoms Europe **2**: 116. *pl. 93. f. 19-28.* 2001. Fig. 21

C. subhalophila **(Hust.) Lange-Bert.**, Biblioth. Diatomol. **25**: 16. *pl. 72. f. 5-8.* 1993. Fig. 22

Cyclotella meneghiniana **Kütz.**; cf. Kobayasi *et al.* 2006. p. 34. *pl. 47.* Figs 23, 24

Cymbella kolbei **Hust.**; cf. Simonsen 1987. p. 352. *pl. 538. f. 1-7.* Fig. 25

C. parva **(W.Sm.) Kirchn. in Cohn**; cf. Krammer 2002. p. 35. *pl. 16. f. 1-19. pl. 17. f. 1-20.* Fig. 26

C. tumida **(Bréb.) Van Heurck**; cf. Krammer & Lange-Bertalot 1986. p. 318. *pl. 130. f. 4-6.* Fig. 27

Cymbopleura inaequalis **(Ehrenb.) Krammer**, Diatoms Europe **4**: 25. *pl. 29. f. 1-9. pl. 32. f. 1a, 2-8. pl. 33. f 1, 2. pl. 34. f. 1-3.* 2003. Fig. 28

Diadesmis confervacea **Kütz.**; cf. Rumrich *et al.* 2000. *pl. 80. f. 1-11. pl. 81. f. 11, 12.* Fig. 29

D. contenta **(Grunow) D.G.Mann in Round *et al.***; cf. Lange-Bertalot & Werum 2001. p. 6. *f. 1-3.* Fig. 30

***Diploneis* sp.**

This species resembles *Diploneis puella* (Schum.) Cleve (cf. Krammer & Lange-Bertalot 1986. p. 289. *pl. 109. f. 15, 16*) but is smaller, 8.4 μm×5.7 μm vs. 13-25 μm×8-14 μm for the latter. Fig. 31

Ellerbeckia arenaria **(Moore in Ralfs) R.M. Crawford**; cf. Krammer & Lange-Bertalot 1991a. p. 17. *pl. 14. f. 1-5. pl. 15. f. 1-4.* Fig. 32

Encyonema paucistriatum **(A.Cleve) D.G. Mann in Round *et al.***; cf. Krammer 1997. p. 68. *pl. 22. f. 1-15.* Fig. 33

Eolimna minima **(Grunow) Lange-Bert. in G. Moser *et al.***; cf. Watanabe *et al.* 2005. p. 284. *pl. IIB₃-20. f. 1-13.* (as *Navicula minima*) Figs 34-36

Eunotia curvata **(Kütz.) Lagerst.**; cf. Kawashima & Kobayasi 1996. p. 15. *f. 1D, E.* Fig. 37

E. meisteri **Hust.**; cf. Simonsen 1987. p. 116. *pl. 191. f. 12-16.* Fig. 39

E. praerupta **Ehrenb.**; cf. Krammer & Lange-Bertalot 1991a. p. 526. *pl. 148. f. 1-3.* Fig. 38

E. submonodon **Hust.**; cf. Simonsen 1987. p. 39. *pl. 38. f. 1-5.* Fig. 40

Fallacia pygmaea **(Kütz) Stickle et D.G. Mann in Round *et al.***; cf. Witkowski *et al.* 2000. p. 211. *pl. 72. f. 28-30.* Fig. 41

F. tenera **(Hust.) Stickle et D.G.Mann in Round *et al.***; cf. Simonsen 1987. p. 162. *pl. 255. f. 6-10.* (as *Navicula uniseriata* Hust.) Fig. 42

Giffenia cocconeiformis **(Grunow) Round et Basson**, Diatom Res. **12**: 348. *f. 1-12.* 1997. Fig. 43

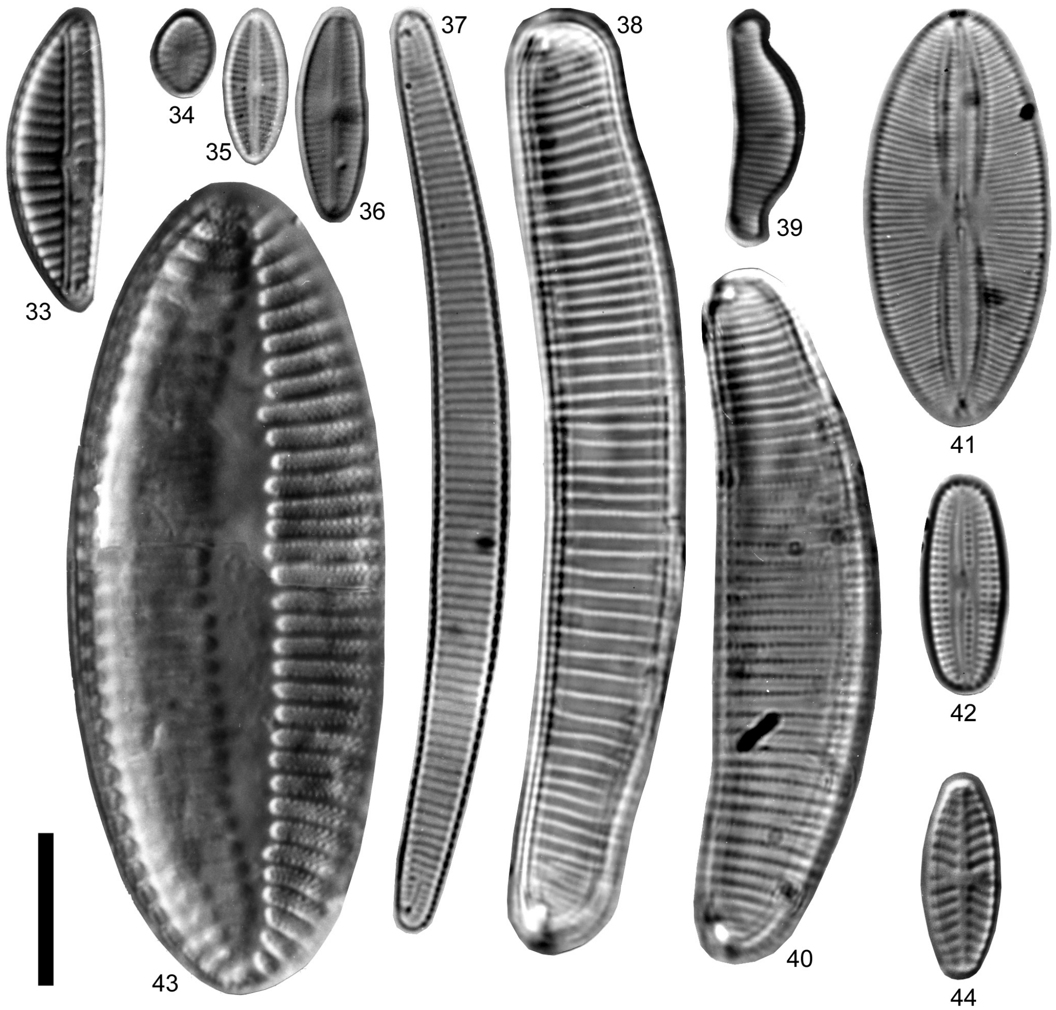


Fig. 33. *Encyonema paucistriatum.* **Figs 34-36**. *Eolimna minima.* **Fig. 37**. *Eunotia curvata.* **Fig. 38**. *E. praerupta.* **Fig. 39**. *E. meisteri.* **Fig. 40**. *E. submonodon.* **Fig. 41**. *Fallacia pygmaea.* **Fig. 42**. *F. tenera.* **Fig. 43**. *Giffenia cocconeiformis.* **Fig. 44**. *Geissleria acceptata.* Scale bar = 10 μm.

Geissleria acceptata **(Hust.) Lange-Bert. et Metzeltin**; cf. Lange-Bertalot 2001. p. 120. *pl. 97. f. 1, 2.* Fig. 44

Gomphonema affine **Kütz.**; cf. Reichardt 1999. p. 13. *pl. 7. f. 1-9. pl. 8. f. 1-14. pl. 9. f. 1-14.* Fig. 45

G. bozenae **Lange-Bert. et E.Reichardt**, Iconogr. Diatomol. **2**: 48. *pl. 65. f. 11-15. pl. 121. f. 4-5.* 1996. Fig. 46

G. clavatulum **E.Reichardt**, Iconogr. Diatomol. **8**: 25. *pl. 25. f. 1-23, 27-28.* 1999. Fig. 47

G. gracile **Ehrenb.**; cf. Kobayasi *et al.* 2006. p. 100. *pl. 123.* Fig. 48

G. inaequilongum **(H.Kobayasi) H.Kobayasi in Mayama *et al.***; cf. Kobayasi *et al.* 2006. p. 101. *pl. 124.* Fig. 49

G. insigne **W.Greg.**; cf. Reichardt 1999. p. 9. *pl. 1. f. 1-14. pl. 2. f. 1-8.* Fig. 50

G. minusculum **Krasske**; cf. Lange-Bertalot *et al.* 1996. p. 90. *pl. 39. f. 16-17.* Fig. 51

G. parvulum **(Kütz.) Kütz.**; cf. Krammer & Lange-Bertalot 1986. *pl. 154. f. 1, 2.* Fig. 52

G. pseudoaugur **Lange-Bert.**, Arch. Hydrobiol. Suppl. **56**: 202. *f. 11-16.* 1979. Fig. 53

G. punctatum **Hust.**, Arch. Hydrobiol. Suppl. **15**: 443. *pl. 27. f. 20.* 1938. Fig. 55

G. sinestigma **E.Reichardt, Jüttner et E.J.Cox**, Diatom Res. **19**: 251. *f. 67-77.* 2004. Fig. 54

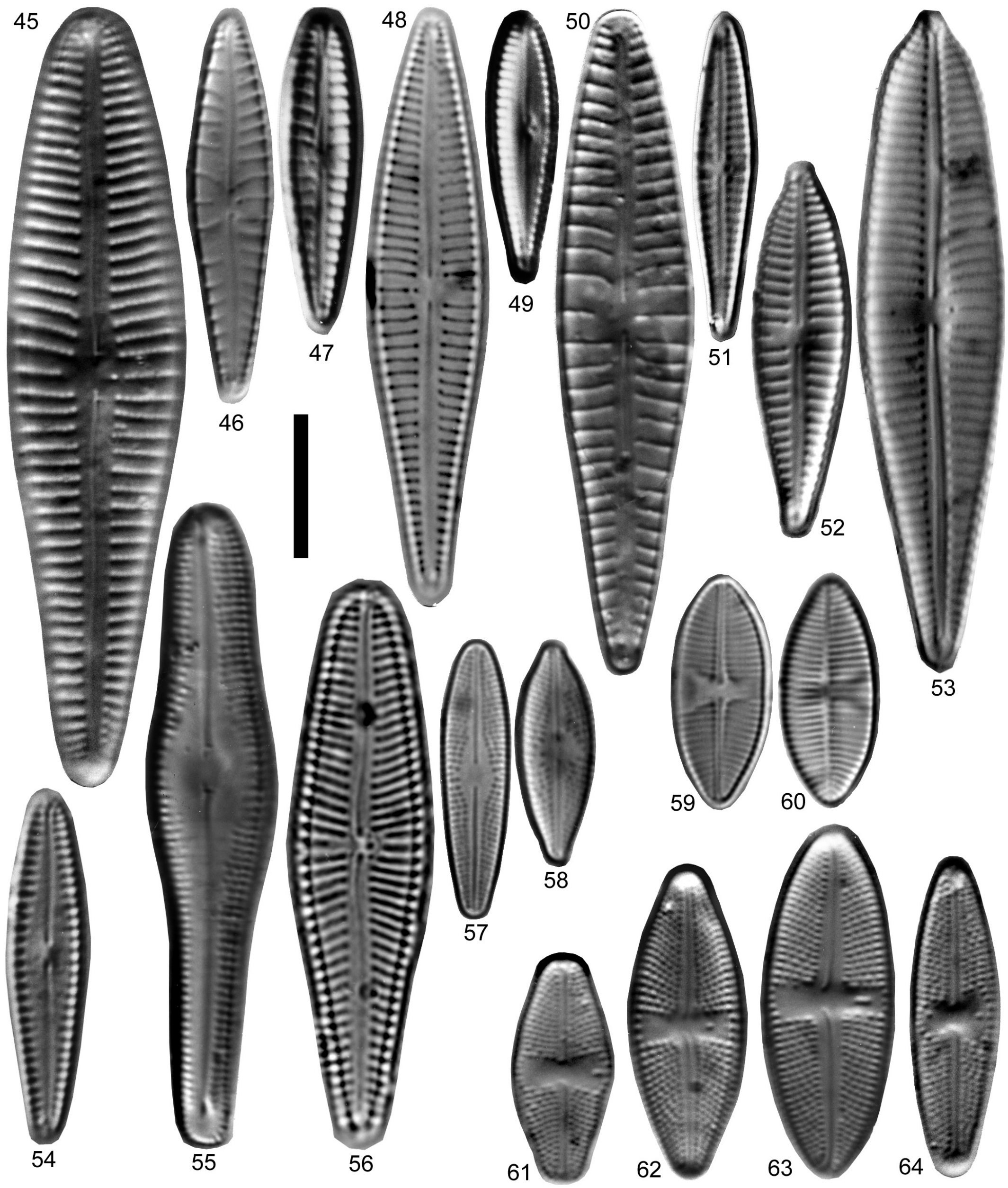


Fig. 45. *Gomphonema affine.* **Fig. 46**. *G. bozenae.* **Fig. 47**. *G. clavatulum.* **Fig. 48**. *G. gracile.* **Fig. 49**. *G. inaequilongum.* **Fig. 50**. *G. insigne.* **Fig. 51**. *G. minusculum.* **Fig. 52**. *G. parvulum.* **Fig. 53**. *G. pseudoaugur.* **Fig. 54**. *G. sinestigma.* **Fig. 55**. *G. punctatum.* **Fig. 56**. *Gomphonema* sp. **Figs 57, 58**. *Gomphosphenia tenerrima.* **Figs 59, 60**. *Lemnicola hungarica.* **Fig. 61**. *Luticola aequatorialis.* **Fig. 62**. *L. goeppertiana.* **Fig. 63**. *L. peguana.* **Fig. 64**. *Luticola* sp. Scale bar = 10 μm.

***Gomphonema* sp.**

This species is similar to *Gomphonema subclavatum* Grunow in Van Heurck (cf. Krammer & Lange-Bertalot 1986. *pl. 163. f. 7*) but the striae are finer. Fig. 56

***Gomphosphenia tenerrima* (Hust.) E.Reichardt**, Iconogr. Diatomol. **8** : 57. *pl. 66. f. 13-16. pl 67. f. 14-15.* 1999. Figs 57, 58

***Lemnicola hungarica* (Grunow) Round et Basson**, Diatom Res. **12** : 77. *f. 4-7, 26-31.*

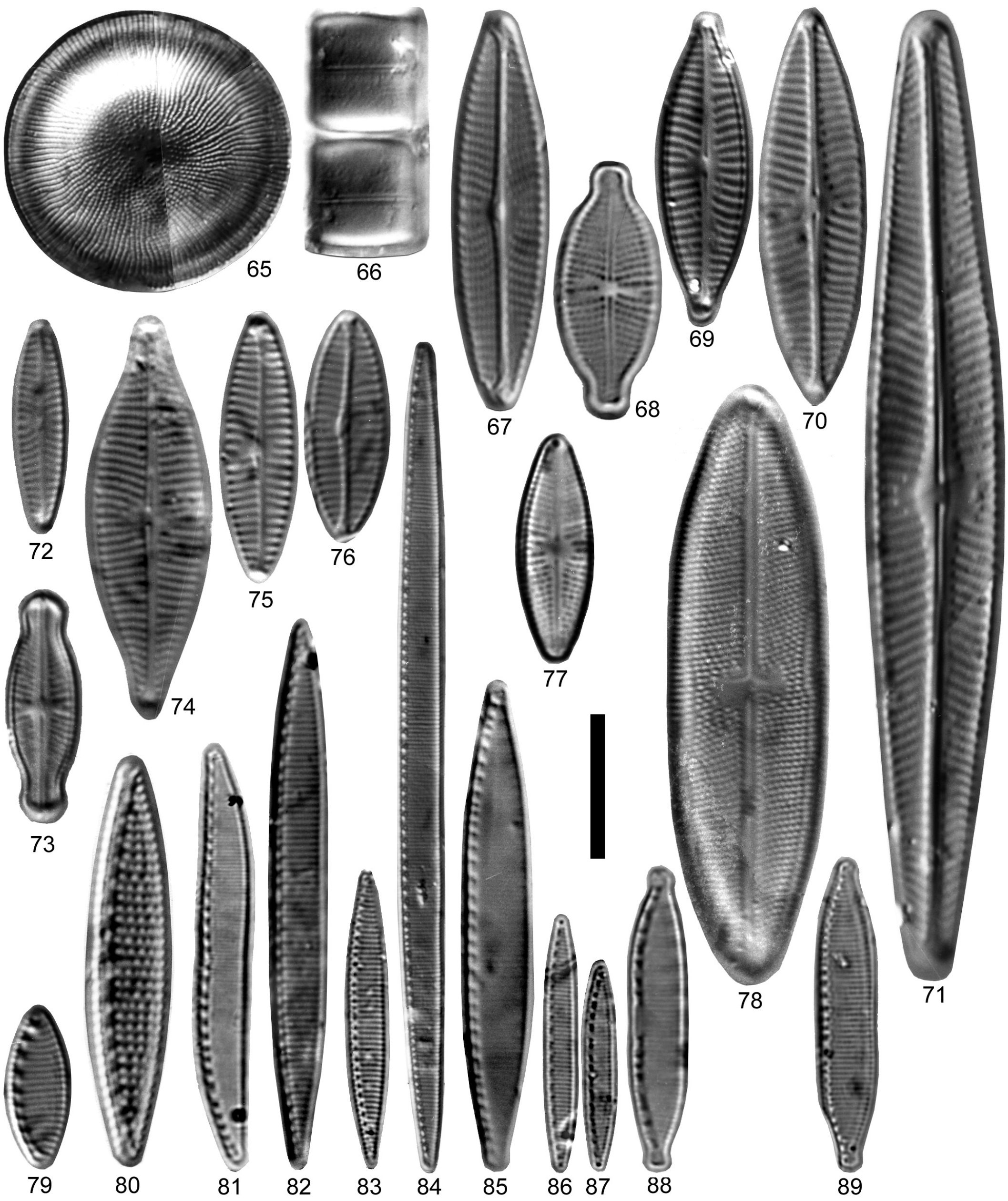


Fig. 65. *Melosira undulata*. **Fig. 66**. *M. varians*. **Fig. 67**. *Navicula erifuga*. **Fig. 68**. *N. kotschyi*. **Fig. 69**. *N. leistikowii*. **Fig. 70**. *N. nipponica*. **Fig. 71**. *N. radiosa*. **Fig. 72**. *N. tenelloides*. **Fig. 73**. *N. thienemannii*. **Fig. 74**. *Navicula* sp. 1. **Figs 75, 76**. *Navicula* sp. 2. **Fig. 77**. *Navicula* sp. 3. **Fig. 78**. *Neidium ampliatum*. **Fig. 79**. *Nitzschia alpina*. **Fig. 80**. *N. amphibia*. **Fig. 81**. *N. clausii*. **Fig. 82**. *N. frustulum*. **Fig. 83**. *N. liebetruthii*. **Fig. 84**. *N. intermedia*. **Fig. 85**. *N. palea*. **Figs 86, 87**. *N. perminuta*. **Fig. 88**. *N. pseudoamphioxys*. **Fig. 89**. *N. tibetana*. Scale bar = 10 μm except for Figs 65 and 84 (= 20 μm).

1997. Figs 59, 60

Luticola aequatorialis **(Heiden) Lange-Bert. et Ohtsuka in Ohtsuka**; cf. Simonsen 1992. p. 56. *pl. 56. f. 8-11.* (as *Navicula aequatorialis*)

Fig. 61

L. goeppertiana **(Bleisch) D.G.Mann in Round *et al.***; cf. Krammer & Lange-Bertalot 1986. p. 150. *pl. 62. f. 1-7.* (as *Navicula goep-*

pertiana) Fig. 62

L. peguana **(Grunow) D.G.Mann in Round *et al.***; cf. Krammer & Lange-Bertalot 1986. p. 151. *pl. 62. f. 10, 11.* (as *Navicula goeppertiana* var. *peguana*) Fig. 63

Luticola **sp.**

This species is similar to *Luticola paramutica* (W.Bock) D.G.Mann in Round *et al.* (cf. Bock 1963. p. 237. *pl. 1. f. 77-82*; as *Navicula paramutica*), but the valve outline is lanceolate without attenuated ends. Fig. 64

Melosira undulata **Kütz.**; cf. Watanabe *et al.* 2005. p. 10. *pl. I-1. f. 10, 11.* Fig. 65

M. varians **C.Agardh**; cf. Krammer & Lange-Bertalot 1991a. p. 7. *pl. 3. f. 8. pl. 4. f. 1-8.* Fig. 66

Navicula erifuga **Lange-Bert. in Lange-Bert. et Krammer**, Biblioth. Diatomol. **9**: 69. *pl. 17. f. 10-12. pl. 27. f. 3, 4.* 1985. Fig. 67

N. kotschyi **Grunow**; cf. Krammer & Lange-Bertalot 1886. p. 169. *pl. 60. f. 10-15.* Fig. 68

N. leistikowii **Lange-Bert.**, Biblioth. Diatomol. **27**: 118. *pl. 50. f. 1-8.* 1993. Fig. 69

N. nipponica **(Skvortzov) Lange-Bert.**; cf. Ohtsuka & Tuji 2002. p. 247. *f. 22, 23.* (as *Navicula radiosa* fo. *nipponica*) Fig. 70

N. radiosa **Kütz.**; cf. Lange-Bertalot 2001. p. 59. *pl. 8. f. 1-7. pl. 67. f. 1, 2.* Fig. 71

N. tenelloides **Hust.**; cf. Simonsen 1987. p. 221. *pl. 329. f. 27.* Fig. 72

N. thienemannii **Hust.**; cf. Simonsen 1987. p. 192. *pl. 303. f. 1-7.* Fig. 73

Navicula **sp. 1**

This species is similar to *Navicula supergregaria* Lange-Bert. et Rumrich in Rumrich *et al.* (cf. Rumrich *et al.* 2000. p. 171. *pl. 45. f. 4-8*), but the valve is somewhat wider and the central area is smaller. Fig. 74

Navicula **sp. 2**

Probably this species belongs to the same species as *Navicula ramosissima* sensu Witkowski *et al.* 2000 (*pl. 136. f. 11-17*), but the specimens do not match their own description (p. 301). Figs 75, 76

Navicula **sp. 3**

This species is similar to *N. kotschyi* (see above), but the valve ends are not protracted. Fig. 77

Neidium ampliatum **(Ehrenb.) Krammer in Krammer et Lange-Bert.**; cf. Patrick & Reimer 1966. p. 388. *pl. 34. f. 5.* (as *Neidium iridis* var. *ampliatum*) Fig. 78

Nitzschia alpina **Hust.**; cf. Simonsen 1987. p. 313. *pl. 471. f. 6-11.* Fig. 79

N. amphibia **Grunow**; cf. Krammer & Lange-Bertalot 1988. p. 108. *pl. 78. f. 13-21.* Fig. 80

N. clausii **Hantzsch**; cf. Krammer & Lange-Bertalot 1988. p. 31. *pl. 19. f. 1-6A.* Fig. 81

N. frustulum **(Kütz.) Grunow in Cleve et Grunow**; cf. Krammer & Lange-Bertalot 1988. p. 94. *pl. 68. f. 1-8.* Fig. 82

N. intermedia **Hantzsch ex Cleve et Grunow**; cf. Krammer & Lange-Bertalot 1988. p. 87. *pl. 61. f. 1.* Fig. 84

N. liebetruthii **Rabenh.**; cf. Krammer & Lange-Bertalot 1988. p. 96. *pl. 69. f. 14-17.* Fig. 83

N. palea **(Kütz.) W.Sm.**; cf. Krammer & Lange-Bertalot 1988. p. 85. *pl. 59. f. 1, 2.* Fig. 85

N. perminuta **(Grunow) M.Perag.**; cf. Krammer & Lange-Bertalot 1988. p. 99. *pl. 72. f. 1-23A.* Figs 86, 87

N. pseudoamphioxys **Hust.**; cf. Simonsen 1987. p. 292. *pl. 431. f. 7-14.* Fig. 88

N. tibetana **Hust.**; cf. Simonsen 1987. p. 68. *pl. 87. f. 13-21.* Fig. 89

***Orthoseira*(?) sp.**

We could not identify this species because no corresponding valve face was photographed. Fig. 90

Pinnularia latarea **Krammer**, Diatoms Europe **1**: 224. *pl. 80. f. 1-6. pl. 84. f. 13-15.* 2000. Fig. 91

P. lundii **Hust.**; cf. Krammer 2000. p. 98. *pl. 75. f. 7-9.* Fig. 92

P. valdetolerans **Mayama et H.Kobayasi in M.Idei et Mayama**, Lange-Bertalot-Festschrift 270. *f. 30-53.* 2001. Fig. 93

Pinnularia **sp.**

This species is similar to *Pinnularia rhombarea* var. *halophila* Krammer (cf. Krammer 2000. p. 76. *pl. 54. f. 6-11*) in its outline and dimensions, but the terminal areas are much larger. Fig. 94

***Pinnunavis*(?) sp.**

Meister (1932) reported this species as *Navicula yarrensis* var. *dewittiana* (Kain et E.A. Schultze) Cleve from Saigon. His identification was, however, not correct because the original drawing (Kain & Schultze 1889. *pl. 43. f. 5*) is

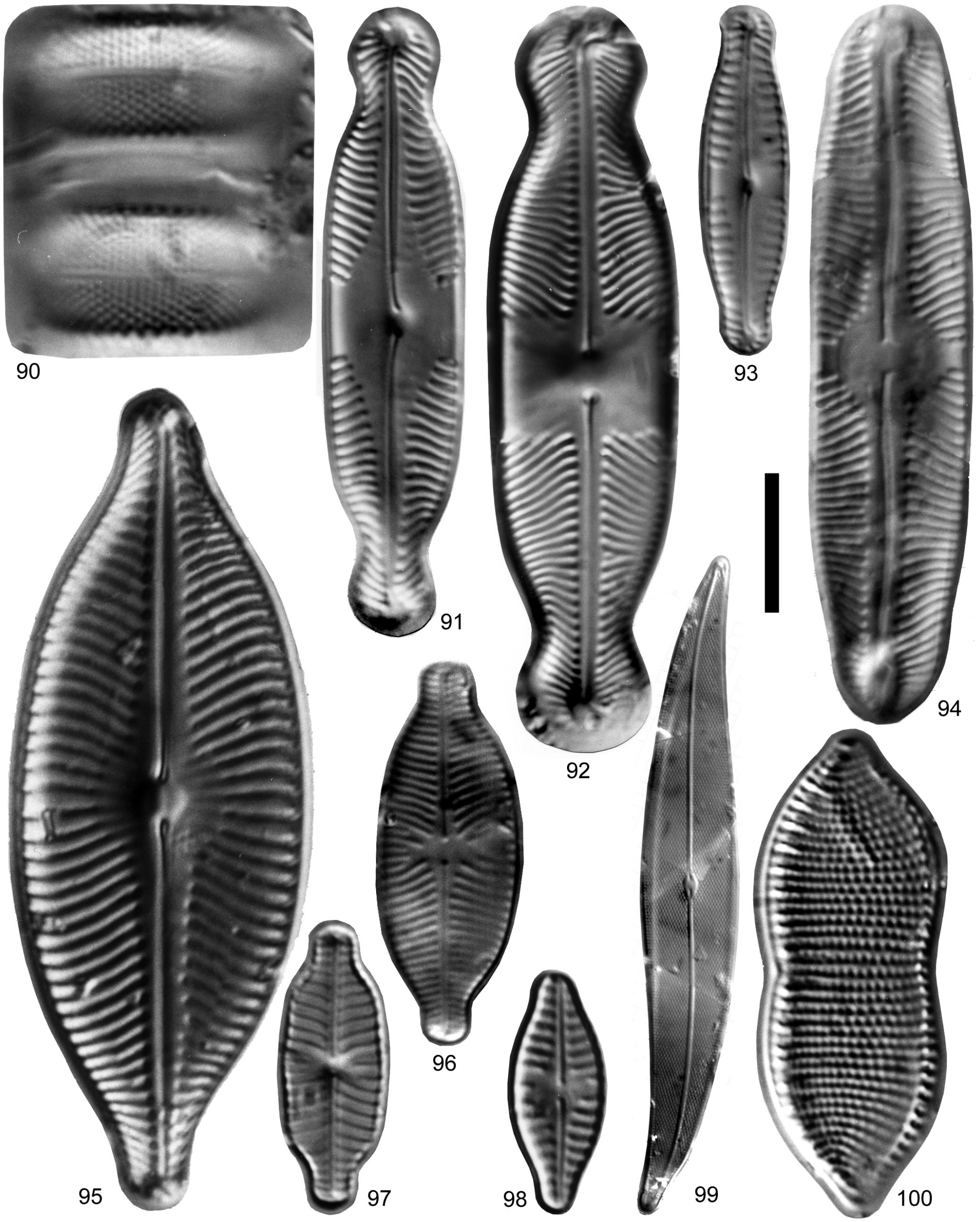


Fig. 90. *Orthoseira* (?) sp. **Fig. 91**. *Pinnularia latarea.* **Fig. 92**. *P. lundii.* **Fig. 93**. *P. valdetolerans.* **Fig. 94**. *Pinnularia* sp. **Fig. 95**. *Pinnunavis* (?) sp. **Fig. 96**. *Placoneis exiguiformis.* **Fig. 97**. *Placoneis undulata.* **Fig. 98**. *Planothidium* sp. **Fig. 99**. *Pleurosigma salinarum.* **Fig. 100**. *Psammodictyon* sp. Scale bar = 10 μm except for Fig. 99 (= 20 μm).

of a much larger valve with broader lanceolate axial area and radiate striae throughout. It is also similar to *Navicula elegantoides* Hust. (cf. Simonsen 1987. p. 277. *pl. 411. f. 1-4. pl. 412. f. 1-4*) which was originally reported from Laguna de Bay, but the valve is much smaller (44-48 μm

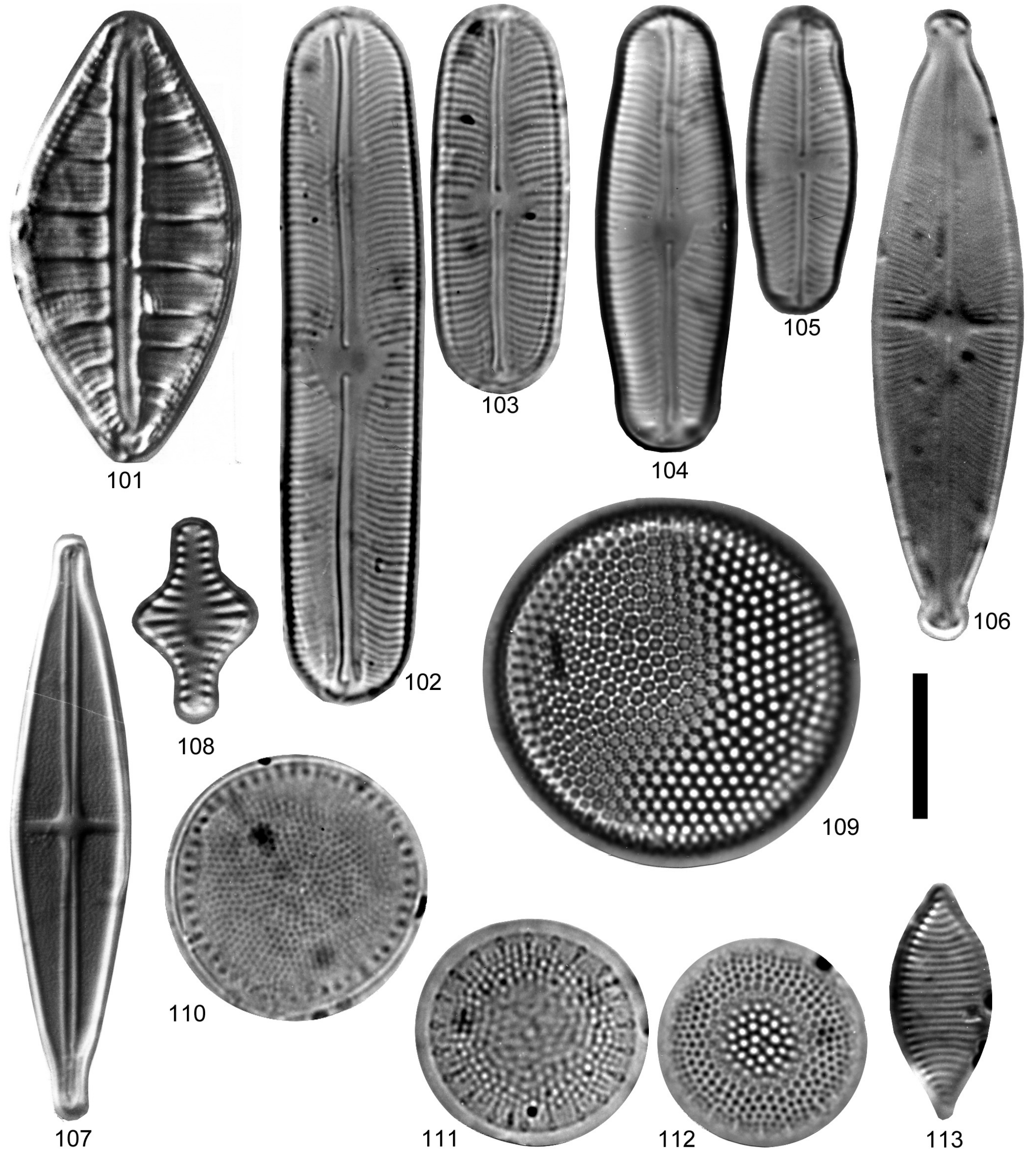


Fig. 101. *Rhopalodia operculata.* **Figs 102, 103**. *Sellaphora fusticulus.* **Figs 104, 105**. *Sellaphora* sp. **Fig. 106**. *Stauroneis angustevittata.* **Fig. 107**. *S. gracilor.* **Fig. 108**. *Staurosira construens.* **Fig. 109**. *Thalassiosira* (?) sp. **Fig. 110**. *T. simplex.* **Figs 111, 112**. *T. visurgis.* **Fig. 113**. *Tryblionella chutteri* var. *aestuarii.* Scale bar = 10 μm.

×16-18 μm vs. 80-130 μm×33-39 μm for *N. elagantoides* ; Hustedt 1942) and the striae are finer. Fig. 95

Placoneis exiguiformis* (Hust.) Lange-Bert. in Metzeltin *et al. ; cf. Simonsen 1987. p. 317. *pl. 475. f. 5-7.* (as *Navicula exiguiformis*) Fig. 96

P. undulata* (Østrup) Lange-Bert. in U.Rumrich *et al., Iconogr. Diatomol. **9** : 212. *pl. 60. f. 11, 12.* 2000. Fig. 97

***Planothidium* sp.**

We could not identify this species because only a raphid valve was photographed. Fig. 98

***Pleurosigma salinarum* Grunow** ; cf. Potapova 1995. p. 95. Fig. 99

***Psammodictyon* sp.**

Morphologically this specimen is almost consistent with *Nitzschia oliffii* Cholnoky (1956. p. 84. *f. 116, 117*), reported from a freshwater stream in Natal, South Africa. Similar specimens were also reported, however, by Archibald (1983) as *Nitzschia corpulenta* Hendey from the estuary of the Sunday River, South Africa. Therefore we leave this species unidentified for the meantime. Fig. 100

Rhopalodia operculata **(C.Agardh) Håk.**, cf. Krammer & Lange-Bertalot 1988. p. 165. *pl. 115. f. 9-12.* Fig. 101

Sellaphora fusticulus **(Østrup) Lange-Bert. in U.Rumrich *et al.***, Iconogr. Diatomol. **9**: 216. *pl. 68, f. 11, 12.* 2000. Figs 102, 103

Sellaphora **sp.**

This species is similar to *Sellaphora blackfordensis* D.G.Mann et S.Droop in Mann *et al.* (cf. Mann *et al.* 2004. p. 476. *f. 4g-i, 19, 33-37*), but the striae are coarser. Figs 104, 105

Stauroneis angustevittata **E.Reichardt**; cf. Simonsen 1987. p. 278. *pl. 280. f. 9-11.* (as *Stauroneis anceps* var. *javanica*) Fig. 106

S. gracilor **E.Reichardt**, Iconogr. Diatomol. **1**: 34. *pl. 18. f. 1-15.* 1995. Fig. 107

Staurosira construens **Ehrenb.**; cf. Kobayasi *et al.* 2006. p. 71. *pl. 89.* Fig. 108

Thalassiosira **(?) sp.**

This species is similar to *Thalassiosira eccentrica* (Ehrenb.) Cleve (cf. Wegener 1995. p. 109), but we could not identify it because most characters which are important for identification, for instance, location of processes and presence/absence of spine, were unclear. Fig. 109

T. simplex **Hust.**; cf. Simonsen 1987. p. 433. *pl. 649. f. 1-3.* Fig. 110

T. visurgis **Hust.**; cf. Simonsen 1987. p. 439. *pl. 657. f. 1-9.* Figs 111, 112

Tryblionella chutteri **var.** ***aestuarii*** **Martinez-Goss**, Proc. Acad. Nat. Sci. Philadelphia **147**: 121. *f. 4.* 1997. Fig. 113

The water quality of Laguna de Bay in 1976 and 1997 may have had some influence on the diatom assemblages. The following discussion is based on Kato (1999), IIEC (http://www.ilec.or.jp/database/asi/asi-13.html), and personal communication with the Laguna Lake Development Authority. Salinity of surface water estimated from chloride concentration was always less than 0.4‰ in both years, indicating an essentially freshwater nature. The concentration of dissolved inorganic phosphorus (DIP) was 0.08-1.00 mg L^{-1} (2.6-32 μmol L^{-1}) in 1976, but it was distinctly lower, 0.04-0.13 mg L^{-1} (1.4-4.2 μmol L^{-1}), in 1997. Nitrate (NO_3-N) concentration was 0.03-0.40 mg L^{-1} (2.1-29 μmol L^{-1}) in 1976 and also lower, 0.004-0.15 mg L^{-1} (0.3-11 μmol L^{-1}), in 1997. Ammonium (NH_4-N) concentration in 1997 was 0.01-0.40 mg L^{-1} (0.7-29 μmol L^{-1}) and usually higher than that of NO_3-N. The low ratio of dissolved inorganic nitrogen to dissolved inorganic nitrogen (DIN/DIP), 0.5-12 in molar ratio, in 1997 indicates that algal growth was mainly restricted by nitrogen availability. In 1997, COD (by the potassium dichromate method) was 10-84 mg L^{-1}, showing strong organic pollution. In 1976, pH was 7.0-7.9 but it rose to 7.9-8.8 in 1995-1998. Dissolved oxygen (DO) at a depth of 0.5 m was mostly- to super-saturated in both 1976 and 1995-1998, but the bottom was often anoxic.

The occurrence of euhalobe (Kolbe 1932), i. e., species usually occurs only in marine water or similar concentration of saline water, *Giffenia cocconeiformis* (Kosugi 1988) is notable, because the salinity was low enough for the lake to be as freshwater. The species was not listed by Hustedt (1942) in spite of its distinct morphology. It is difficult to explain the occurrence even taking into account the salinity intrusion caused by the back current of the Pasig River. Nevertheless, the valves were possibly mortal remains which had been transferred from the sea before the construction of the weir to stem the back current. Indeed, the other diatom species encountered were mostly halophilous or indifferent freshwater species, which are in accordance with the lake's salinity.

Despite the heavy organic content and high phosphorus concentration, saprophilous diatom species were not common. Out of the 85 identified species, 37 species can be classified into three groups relating to organic pollution according to Watanabe *et al.* (2005). Among them, only eight, *Cyclotella meneghiniana*, *Diadesmis confervacea*, *Fallacia tenera*, *Gomphonema pseudoaugur*, *Luticola goeppertiana*, *Nitzschia amphibia*, *N. palea*, and *Pinnularia valdetolerans* can be categorized as saprophilous. On the other hand, six saproxenous species, *Achnanthes subhudsonis*, *Cymbella parva*, *C. tumida*, *Eunotia praerupta*, *Navicula nipponica*, and *Staurosira construens*, were found. The co-occurrence of saprophilous and saproxenous species appears to contradict the "law of coexistence of different ecological groups" (Watanabe *et al.* 1990). It may be explained by the hypertrophic but not polysaprobic nature (i.e., oxygen-rich) of the shallow part of the lake. In addition, springs around Los Banos and a river inflowing at Calamba were possible source of the saproxenous diatoms.

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