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Diatoms of Yamakado Moor in Shiga Prefecture, Japan

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Abstract

A taxonomic survey was carried out on the diatom flora of Yamakado Moor, a mixed *Sphagnum* moor located about 5 km north of Lake Biwa in west-central Honshu, Japan. In total, 123 diatom species belonging to 36 genera were identified and are illustrated here with seven unidentified species. The predominant genera were *Eunotia* and *Pinnularia*, each represented by 19 taxa, but their proportions are lower than in the high-moors of Honshu. Forty-one out of 51 taxa reported earlier from Yakumogahara Moor, another *Sphagnum* moor located in the watershed of Lake Biwa, were also observed in Yamakado Moor, although the taxa richness is much higher at the latter site. Similarly to the vascular plant flora and insect fauna, the diatom flora contained boreal or alpine components despite the moor's location in the warm-temperate zone.

Key index words : diatom flora, *Eunotia*, mixed *Sphagnum* moor, *Pinnularia*, Yamakado Moor.

Introduction

Yamakado Moor is a mixed *Sphagnum* moor located about 5 km north of Lake Biwa in Shiga Prefecture in west-central Honshu, Japan (35° 33'N, 136° 07'E), at an altitude of about 290 m with an area of 2×10^4 m^2 (Fig. 1). The moor is mainly covered by *Sphagnum palustre* L., and *Sphagnum cuspidatum* Hoffm. is also abundant in /around the pools. The vascular plant community in the moor is characterized by *Menyanthes trifoliata* L., *Ilex nipponica* Makino, and *Moliniopsis japonica* (Hack.) Hayata. Such vegetation is unusual in low-mountain areas of Western Japan, situated in the warm-temperate zone, because it usually develops in colder regions (Murase 1992). Many insects those are usually distributed in colder regions are also found here (Minami 1992). The Japanese Ministry of Environment has, therefore, designated this moor as one of 500 important wetlands in Japan (http://www.sizenken.biodic.go.jp/pc/wet_en/254/254.html).

Geographical studies have suggested the antiquity of the moor. Takahara (1993) estimated that the oldest moor sediments were deposited >30,000 yr BP based on pollen analysis. The moor appears to have been stably established since 10,000 yr BP (Fujimoto 1992).

Despite the floristic and biogeographic importance of this moor, its microbial biota is still very little known. As far as we know, Okano (1988) alone has reported on plankton in the pools. Here we attempt to document the diatom diversity of the moor, by means of showing a checklist and illustrations of the diatoms encountered in the present study.

Materials and Methods

We collected ten samples from four points in the moor on 6 May 2006 for a preliminary survey. On 23 November 2006 we again collected 36 samples from five points (Fig. 1). Samples were collected from the surface of algae, *Sphagnum*, living/dead spermatophytes, and mud in/around pools and streams. At each point, electric conductivity (EC) and pH were checked with a B-173 conductivity meter (Horiba, Kyoto, Japan) and a PRN-41 pH meter (Fujiwara Seisakusho, Tokyo, Japan), respectively.

In the laboratory, major anions and cations were analyzed by ion column chromatography

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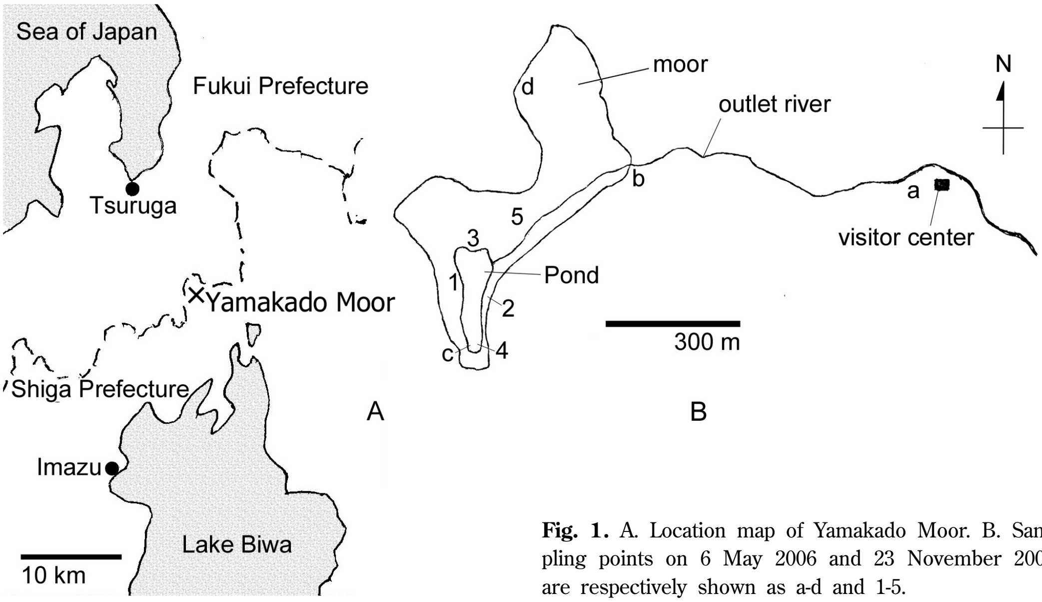

Fig. 1. A. Location map of Yamakado Moor. B. Sampling points on 6 May 2006 and 23 November 2006 are respectively shown as a-d and 1-5.

(DX-AQ : Nippon Dionex, Osaka, Japan). SRSi, SRP, NH_4-N, NO_2-N, and NO_3-N were colorimetrically determined using an autoanalyzer (AACS-II : Bran + Luebbe, Tokyo, Japan).

Diatom frustules were cleaned as follows. First, host plants and algae were shredded with scissors. A part of each sample was suspended in 1 N HCL at 60℃ and then repeatedly rinsed with distilled water to remove calcareous material. Next, it was cleaned to remove organic matter using heated H_2SO_4 and KNO_3. After repeated rinses, it was boiled in 10% H_2O_2 to oxidize all organic matter and again repeatedly rinsed. The cleaned frustules were mounted onto slides using Pleurax for light microscopy. For taking light micrographs, we used a compound microscope (Eclipse 80i : Nikon, Tokyo, Japan) with a digital micrographic camera (Digital Sight : Nikon, Tokyo, Japan). The photographs were adjusted to a uniform magnification and resolution of ×1,500 at 500 dpi using Photoshop Element 3 (Adobe, California, USA), and then identified.

Table 1. Water quality of the sampling sites. The values are arranged in order of minimum-median-maximum.

pH	4.5-5.6-6.6
EC (mS m^{-1})	3.2-3.6-4.1
NO_3-N (μmol L^{-1})	0.18-0.65-15.80
NO_2-N (μmol L^{-1})	0.04-0.07-0.28
NH_4-N (μmol L^{-1})	0.05-0.95-6.56
SRP (μmol L^{-1})	0.03-0.10-0.31
SRSi (μmol L^{-1})	2.0-45.1-269.8
Na^+ (mg L^{-1})	2.32-3.79-5.04
K^+ (mg L^{-1})	0.30-0.64-1.67
Mg^{2+} (mg L^{-1})	0.05-0.08-0.15
Ca^{2+} (mg L^{-1})	0.03-0.07-0.59
Cl^- (mg L^{-1})	5.12-6.59-7.78
SO_4^{2-} (mg L^{-1})	1.45-2.58-3.81

Results and Discussion

Water quality parameters at the sampling sites are summarized in Table 1.

We identified 123 diatom taxa in total, belonging 36 genera. These are listed below, together with seven unidentified taxa, in alphabetical order with illustrations (Figs 2-131).

Achnanthidium lineare **W.Sm.** ; cf. Krammer & Lange-Bertalot 1991b. p. 68. *pl. 37. f. 19-23*. Fig. 2

A. macrocephalum **(Hust.) Round et Bukhtiy.** ; cf. Simonsen 1987. p. 211. *pl. 325. f.*

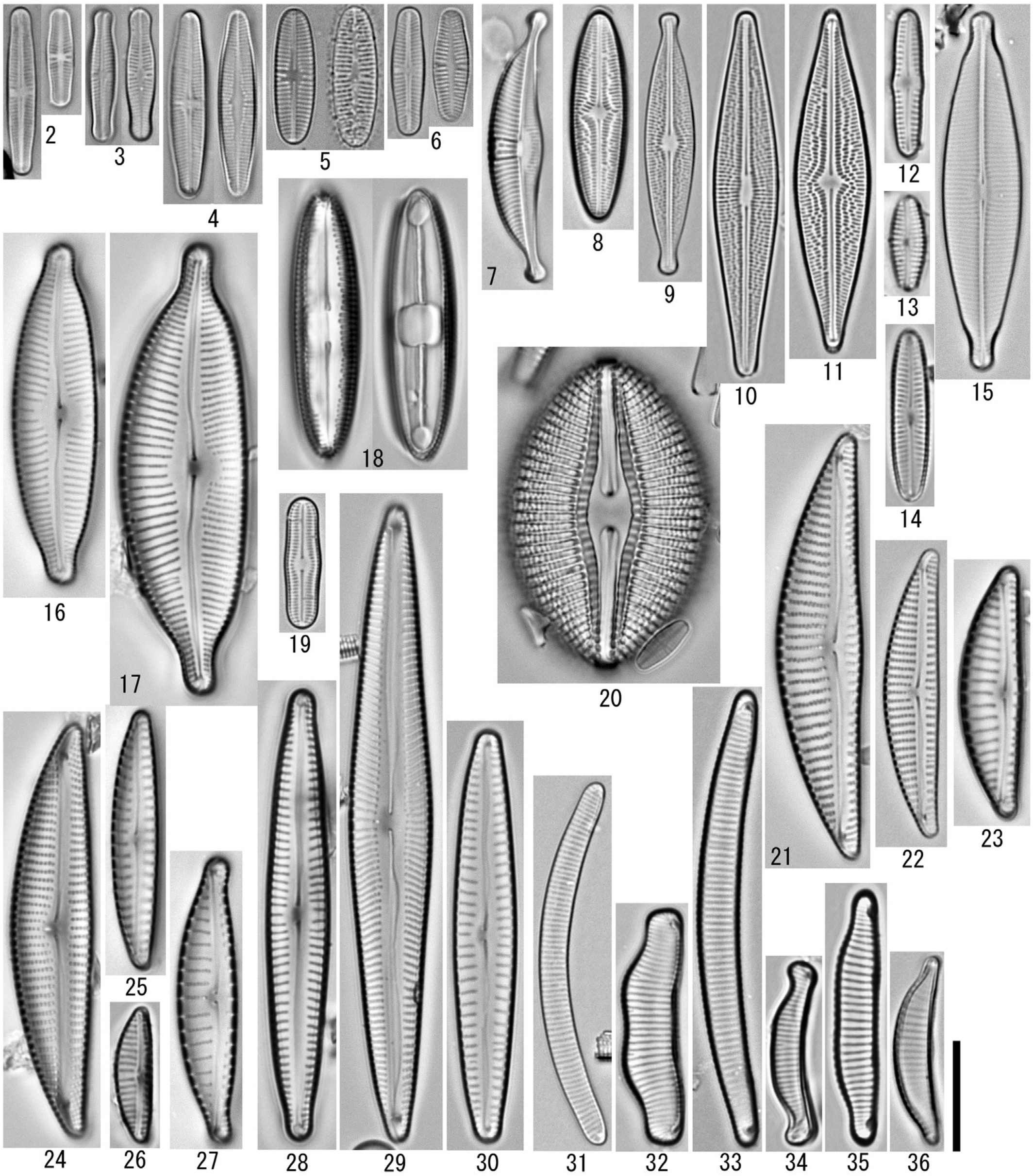

Fig. 2. *Achnanthidium lineare*. **Fig. 3.** *A. macrocephalum*. **Fig. 4.** *A. minutissimum*. **Fig. 5.** *A. pusillum*. **Fig. 6.** *A. saprophilum*. **Fig. 7.** *Amphora oligotraphenta*. **Fig. 8.** *Brachysira brebissonii*. **Fig. 9.** *B. microcephara*. **Fig. 10.** *B. procera*. **Fig. 11.** *B. wygaschii*. **Fig. 12.** *Chamaepinnularia mediocris*. **Fig. 13.** *C. vyvermanii*. **Fig. 14.** *C. weikertii*. **Fig. 15.** *Craticula riparia* var. *mollenhaueri*. **Fig. 16.** *Cymbopleura naviculiformis*. **Fig. 17.** *C. peranglica*. **Fig. 18.** *Diatomella balfouliana*. **Fig. 19.** *Diadesmis brekkaensis*. **Fig. 20.** *Diploneis smithii*. **Fig. 21.** *Encyonema jemtlandicum*. **Fig. 22.** *E. neogracile*. **Fig. 23.** *E. paucistriatum*. **Fig. 24.** *E. pergracile*. **Fig. 25.** *E. perpusillum*. **Fig. 26.** *E. subnorvegicum*. **Fig. 27.** *Encyonema* sp. **Fig. 28.** *Encyonopsis neoamphioxys*. **Fig. 29.** *E. spicula*. **Fig. 30.** *Encyonopsis* sp. **Fig. 31.** *Eunotia bilunaris* var. *mucophila*. **Fig. 32.** *E. circumborealis*. **Fig. 33.** *E. curvata*. **Fig. 34.** *E. exigua*. **Fig. 35.** *E. fallax*. **Fig. 36.** *E. friedel-hintzae*. Scale bar = 10 μm.

13-22 (as *Achnanthes minutissima* var. *macrocephala*). Fig. 3

A. minutissimum **(Kütz.) Round et Bukhtiy.**; cf. Krammer & Lange-Bertalot 1991b. p. 56. *pl. 32. f. 1-9* (as *Achnanthes minutissima*). Fig. 4

A. pusillum **(Grunow) Czarn.**; cf. Kobayasi *et* *al.* 2006. p. 126. *pl. 158*. Fig. 5

A. saprophilum **(H.Kobayasi et Mayama) Round et Bukhtiy.**; cf. Kobayasi *et al.* 2006. p. 128. *pl. 161*. Fig. 6

Amphora oligotraphenta **Lange-Bert.**; cf. Lange-Bertalot & Metzeltin 1996. p. 28. *pl. 96. f. 21-22*. Fig. 7

Brachysira brebissonii **R.Ross in B.Hartley**; cf. Lange-Bertalot & Moser 1994. p. 20. *pl. 41. f. 1-18*. Fig. 8

B. microcephala **(Grunow) Compère**; cf. Wolfe & Kling 2001. p. 250. *f. 14-22*. Fig. 9

B. procera **Lange-Bert. et G.Moser**, Biblioth. Diatomol. **29**: 55. *pl. 7. f. 8-18*. 1994. Fig. 10

B. wygaschii **Lange-Bert. in Lange-Bert. et G.Moser**, Biblioth. Diatomol. **29**: 72. *pl. 13. f. 1-11*. 1994. Fig. 11

Chamaepinnularia mediocris **(Krasske) Lange-Bert.**; cf. Lange-Bertalot *et al.* 1996. p. 127. *pl. 22. f. 43-45*. (as *Navicula mediocris*) Fig. 12

C. vyvermanii **Lange-Bert.**; cf. Krammer & Lange-Bertalot 1985. *pl. 26. f. 1-6*. Fig. 13

C. weikertii **(Manguin) Metzeltin et Lange-Bert.**, Iconogr. Diatomol. **18**: 64. *pl. 140. f. 12-14*. 2007. Fig. 14

Craticula riparia **var. *mollenhaueri*** **Lange-Bert.**; cf. Lange-Bertalot 2001. p. 117. *pl. 92. f. 9-12*. Fig. 15

Cymbopleura naviculiformis **(Auersw.) Krammer**, Diatoms Europe **4**: 56. *pl. 76. f. 1 -11*. 2003. Fig. 16

C. peranglica **Krammer**, Diatoms Europe **4**: 158. *pl. 84. f. 1-4*. 2003. Fig. 17

Diadesmis brekkaensis **(J.B.Petersen) D.G. Mann in Round *et al.***; cf. Lange-Bertalot & Werum 2001. p. 6. *f. 30-32, 91, 98, 99*. Fig. 19

Diatomella balfouliana **Grev.**; cf. Krammer & Lange-Bertalot 1986. p. 436. *pl. 205. f. 4-8*. Fig. 18

Diploneis smithii **(Bréb. ex W.Sm.) Cleve**; cf. Kobayasi *et al.* 2006. p. 143. *pl. 178*. Fig. 20

Encyonema jemtlandicum **Krammer**, Biblioth. Diatomol. **36**: 166. *pl. 35. f. 1-9*. 1997. Fig. 21

E. neogracile **Krammer**, Biblioth. Diatomol. **36**: 177. *pl. 82. f. 1-7, 12, 13*. 1997. Fig. 22

E. paucistriatum **(A.Cleve) D.G.Mann in Round *et al.***; cf. Krammer 1997b. p. 68. *pl. 22. f. 1-15*. Fig. 23

E. pergracile **Krammer**, Biblioth. Diatomol. **36**: 178. *pl. 88. f. 1-8*. 1997. Fig. 24

E. perpusillum **(A.Cleve) D.G.Mann in Round *et al.***; cf. Krammer 1997b. p. 29. *pl. 110. f. 1-16*, *pl. 111. f. 1-8*. Fig. 25

E. subnorvegicum **Krammer**, Biblioth. Diatomol. **37**: 186. *pl. 112. f. 1-6*. 1997. Fig. 26

Encyonema **sp.**

This taxon is similar to *E. paucistriatum* (see above) but it differs in its capitate valve ends. It is also similar to *Cymbellopsis persantosana* Metzeltin et Krammer (cf. Krammer 2003. p. 142. *pl. 158. f. 8, 9*), but it has a more convex ventral side. Fig. 27

Encyonopsis neoamphioxys **Krammer**, Biblioth. Diatomol. **37**: 141. *pl. 168. f. 1-9, 11-13*. 1997. Fig. 28

E. spicula **(Hust.) Krammer**, Biblioth. Diatomol. **37**: 145. *pl. 170. f. 1-3*. 1997. Fig. 29

Encyonopsis **sp.**

This specimen is similar to the type specimen of *Encyonopsis difficilis* (Krasske) Krammer (cf. Krammer 1997b. p.121. *pl. 121. f. 9-19*.), but it has narrower valves with more acute ends. Fig. 30

Eunotia bilunaris **var. *mucophila*** **Lange-Bert. et Nörpel**, Nova Hedwigia **53**: 195. *pl. 5. f. 12-21*. 1991. Fig. 31

E. circumborealis **Lange-Bert. et Nörpel**; cf. Krammer & Lange-Bertalot 1991a. p. 197. *pl. 143. f. 16-23*. Fig. 32

E. curvata **(Kütz.) Lagerst.**; cf. Kawashima & Kobayasi 1996. p. 15. *f. 1D, E*. Fig. 33

E. exigua **(Bréb. ex Kütz.) Rabenh.**; cf. Krammer & Lange-Bertalot 1991a. p. 199. *pl. 153. f. 5-43*. Fig. 34

E. fallax **A.Cleve**; cf. Krammer & Lange-Bertalot 1991a. p. 203. *pl. 150. f. 10-24*. Fig. 35

E. flexosa **(Bréb.) Kütz.**; cf. Krammer & Lange-Bertalot 1991a. p. 182. *pl. 140. f. 8-18*. Fig. 37

E. friedel-hintzae **Metzeltin et Lange-Bert.**, Iconogr. Diatomol. **18**: 97. *pl. 103. f. 45-51*. 2007. Fig. 36

E. incisa **W.Greg.**, Quart. J. Microscop. Sci. **2**: 96. *pl. 4. f. 4*. 1854. Fig. 38

E. minor **(Kütz.) Grunow in Van Heurck**, Types Syn. Diatom. Belg. *pl. 33. f. 20, 21*.

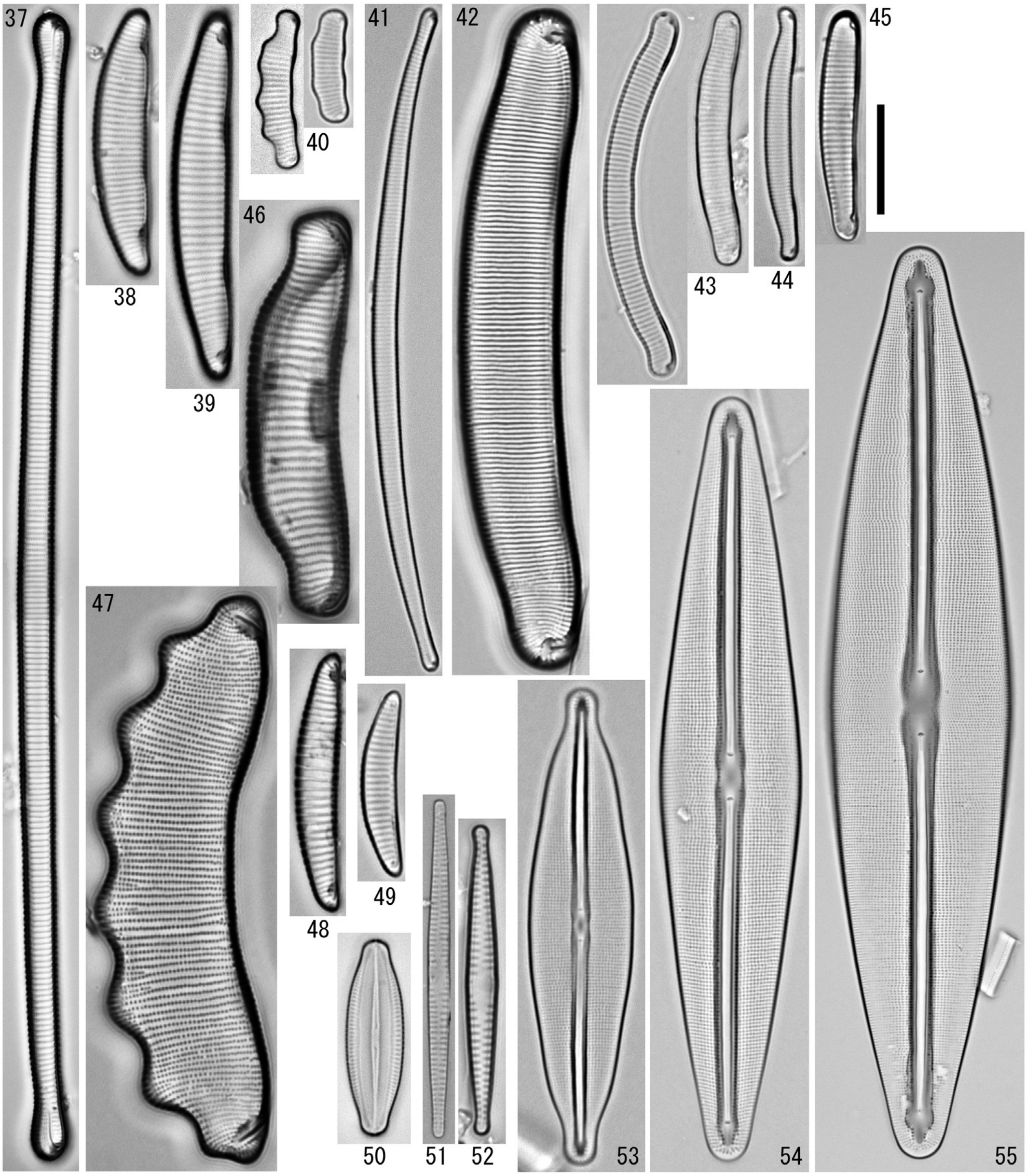

Fig. 37. *Eunotia flexosa*. **Fig. 38.** *E. incisa*. **Fig. 39.** *E. minor*. **Fig. 40.** *E. muscicola*. **Fig. 41.** *E. naegelii*. **Fig. 42.** *E. nipponica*. **Fig. 43.** *E. nymanniana*. **Fig. 44.** *E. paludosa*. **Fig. 45.** *E. rhomboidea*. **Fig. 46.** *E. praerupta*. **Fig. 47.** *E. serra*. **Fig. 48.** *E. siolii*. **Fig. 49.** *E. subarcuatoides*. **Fig. 50.** *Fallacia vitrea*. **Fig. 51.** *Fragilaria gracilis*. **Fig. 52.** *F. rumpens* var. *scotica*. **Fig. 53.** *Frustulia crassinervia*. **Fig. 54.** *F. saxonica*. **Fig. 55.** *Frustulia* sp. Scale bar = 10 μm except for Figs 37 and 55 (= 15 μm).

1881. Fig. 39

E. muscicola **Krasske**; cf. Lange-Bertalot *et al.* 1996. p. 72. *pl. 68. f. 1-38*. Fig. 40

E. naegelii **Migula in Thomé**; cf. Krammer & Lange-Bertalot 1991a. p. 182. *pl. 140. f. 1-6*. Fig. 41

E. nipponica **Skvortsov**; cf. Kobayasi *et al.* 1981. p. 94. *pl. 1. f. 3-7*. Fig. 42

E. nymanniana **Grunow**; cf. Mayana 1997. p. 31. *f. 8-11*.

Formerly we have reported this species as an unidentified *Eunotia* (Kihara *et al.* 2007. p. 86. *f.*

22-24) because the curve of the valve is weaker than the type of *Eunotia steinecki* J.B.Petersen. In the present study, however, we identified it as above following the synonymization by Mayama (1997), who found that the strength of curve varies among specimens. Fig. 43

E. paludosa **Grunow**; cf. Krammer & Lange-Bertalot 1991a. p. 203. *pl. 155. f. 1-20*. Fig. 44

E. praerupta **Ehrenb.**; cf. Krammer & Lange-Bertalot 1991a. p. 526. *pl. 148. f. 1-3*. Fig. 46

E. rhomboidea **Hust.**; cf. Krammer & Lange-Bertalot 1991a. p. 223. *pl. 164. f. 11-20*. Fig. 45

E. serra **Ehrenb.**; cf. Krammer & Lange-Bertalot 1991a. p. 219. *pl. 146. f. 1, 2*. Fig. 47

E. siolii **Hust.**; cf. Simonsen 1987. p. 379. *pl. 571. f. 11-15*. Fig. 48

E. subarcuatoides **Alles, Nörpel et Lange-Bert.**, Nova Hedwigia **53**: 188. *pl. 4. f. 1-36*. 1991. Fig. 49

Fallacia vitrea **(Østrup) D.G.Mann in Round *et al.***; cf. Krammer & Lange-Bertalot 1986. p. 200. *pl. 72. f. 1-7.* (as *Navicula festiva*) Fig. 50

Fragilaria gracilis **Østrup**; cf. Tuji 2007. p. 11. *f. 1-8*. Fig. 51

F. rumpens **var. *scotica*** (Grunow) Gemeinhardt; cf. Patrick & Reimer 1966. p. 144. *pl. 6. f. 2*. (as *Synedra rumpens* var. *scotica*) Fig. 52

Frustulia crassinervia **(Bréb.) Lange-Bert. et Krammer in Lange-Bert. et Metzeltin**; cf. Lange-Bertalot 2001. p. 164. *pl. 127. f. 7-15*. Fig. 53

F. saxonica **Rabenh.**; cf. Lange-Bertalot & Jahn 2000. p. 172. *pl. 126. f. 1-7. pl. 127. f. 1-6*. Fig. 54

Frustulia **sp.**

Formerly we have reported this taxon as part of our materials of *F. saxonica* from Yakumogahara Moor (Kihara *et al.* 2007. *f. 30*), but it differs in size, outline, and areolae density. It is similar to *Frustulia pangaeopsis* Lange-Bert. (2001. p. 171, 220. *pl. 130. f. 1-6*.), but the valve is wider (about 25 μm versus 16-18.5 μm in *F. pangaeopsis*). It is also similar to *Frustulia magna* Metzeltin et Lange-Bert. (1998. p. 98. *pl. 110. f. 1-4. pl. 113. f. 6*), but the valve is narrower with finer striae and areolae (respectively 27 and 22 in 10 μm, but 20-22 and 18-20 in *F. magna*). The “porte-crayon” helictogrossae separate it from *Frustulia bahulsii* Edlund et Brant (1997. p. 209. *f. 1-18*), which has spatulate ones, although they have almost the same dimensions. Fig. 55

Gomphonema acidoclinatum **Lange-Bert. et E.Reichardt**, Iconogr. Diatomol. **13**: 84. *pl. 92. f. 1-5*. 2004. Fig. 56

G. bohemicum **ssp. *angustiminus*** **Reichardt**, Iconogr. Diatomol. **8**: 53. *pl. 62. f. 1-13*. 1999. Fig. 58

G. hebridense **W.Greg.**; cf. Krammer & Lange-Bertalot 1991b. *pl. 79. f. 13-17*. Fig. 57

G. parvulum **var. *exilissimum*** **Grunow**; cf. Krammer & Lange-Bertalot 1991b. *pl. 76. f. 14-20*. Fig. 59

G. parvulum **var. *parvulius*** **Lange-Bert. et E.Reichardt**; cf. Krammer & Lange-Bertalot 1991b. *pl. 76. f. 22-29*. Fig. 60

Hantzschia amphioxys **(Ehrenb.) Grunow**; cf. Lange-Bertalot 1993. p. 77. *pl. 85. f. 1-11*. Fig. 61

Kobayasiella madumensis **(E.G.Jørg.) Lange-Bert.**; cf. Jørgensen 1948. p. 60. *pl. 2. f. 26*. (as *Navicula madumensis*) Fig. 62

K. micropuncutata **(H.Germ.) Lange-Bert.**; cf. Kobayasi & Nagumo 1988. p. 247. *f. 38-41*. (as *Navicula micropunctata*) Fig. 63

K. okadae **(Skvortsov) Lange-Bert.**; cf. Skvortzov 1938. p. 52. *pl. 1. f. 37, 38.* (as *Anomoeoneis okadae*) Fig. 64

Luticola aequatrialis **(Heiden) Lange-Bert. et Ohtsuka**; cf. Simonsen 1992. p. 56. *pl. 56. f. 8-11*. (as *Navicula aequatorialis*) Fig. 65

Meridion constrictum **Ralfs**; cf. Krammer & Lange-Bertalot 1991a. p. 102. *pl. 101. f. 8-14*. (as *Meridion circulare* var. *constrictum*) Fig. 66

Microcostatus maceria **(Schimanski) Lange-Bert.**; cf. Krammer & Lange-Bertalot 1986. p. 201. *pl. 72. f. 17-20*. (as *Navicula maceria*) Fig. 67

Navicula angusta **Grunow**; cf. Lange-Bertalot 2001. p. 15. *pl. 2. f. 1-8*. Fig. 68

N. heimansioides **Lange-Bert.**, Biblioth. Diatomol. **27**: 113. *pl. 62. f. 7-8*. 1993. Fig. 69

N. leptostriata **E.G.Jørg.**; cf. Lange-Bertalot 2001. p. 88. *pl. 40. f. 1-8*. Fig. 70

N. longicephala **Hust.**; cf. Simonsen 1987. p. 316. *pl. 474. f. 6-10*. Fig. 72

N. notha **J.H.Wallace**; cf. Lange-Bertalot 2001.

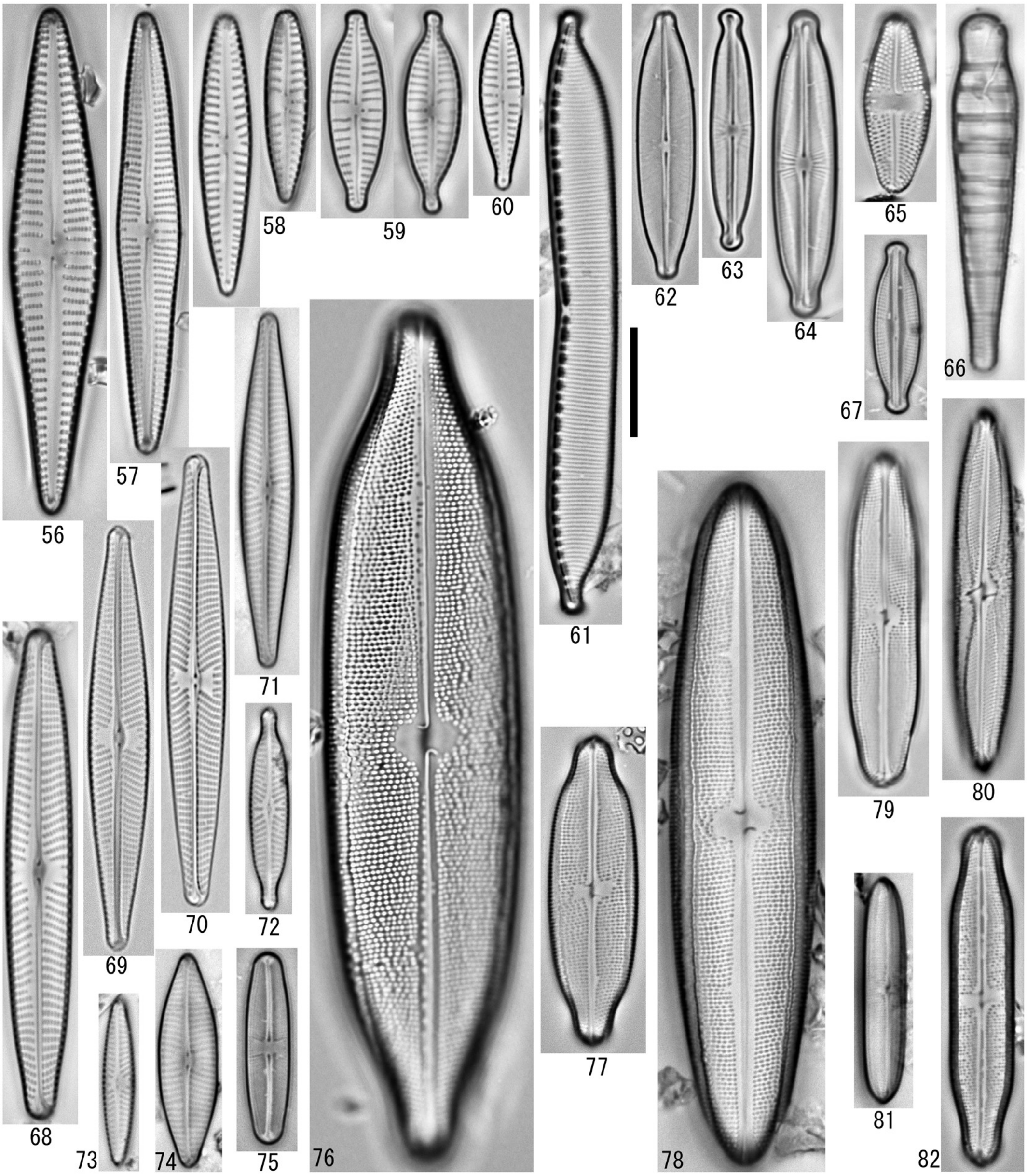

Fig. 56. *Gomphonema acidoclinatum*. **Fig. 57.** *G. hebridense*. **Fig.58.** *G. bohemicum* ssp. *angustiminus*. **Fig. 59.** *G. parvulum* var. *exilissimum*. **Fig. 60.** *G. parvulum* var. *parvulius*. **Fig. 61.** *Hantzchia amphioxys*. **Fig. 62.** *Kobayasiella madumensis*. **Fig. 63.** *K. micropuncutata*. **Fig. 64.** *K. okadae*. **Fig. 65.** *Luticola aequatrialis*. **Fig. 66.** *Meridion constrictum*. **Fig. 67.** *Microcostatus maceria*. **Fig. 68.** *Navicula angusta*. **Fig. 69.** *N. hemimansioides*. **Fig. 70.** *N. leptostriata*. **Fig. 71.** *N. notha*. **Fig. 72.** *N. longicephala*. **Fig. 73.** *N. vilaplanii*. **Fig. 74.** *Navicula* sp. **Fig. 75.** *Naviculadicta ambiguissima*. **Fig. 76.** *Neidium affine* var. *humerus*. **Fig. 77.** *N. affine*. **Fig. 78.** *N. ampliatum*. **Fig. 79.** *N. hercynicum*. f. *subrostratum*. **Fig. 80.** *N. javanicum*. **Fig. 81.** *N. tenuissimum*. **Fig. 82.** *Neidium* sp. Scale bar = 10 μm.

p. 89. *pl. 40. f. 17-21.* Fig. 71

N. vilaplanii **(Lange-Bert. et Sabater) Lange-Bert. et Sabater in U.Rumrich *et al.*** ; cf. Lange-Bertalot 2001. p. 78. *pl. 32. f. 48-53.* Fig. 73

***Navicula* sp.**

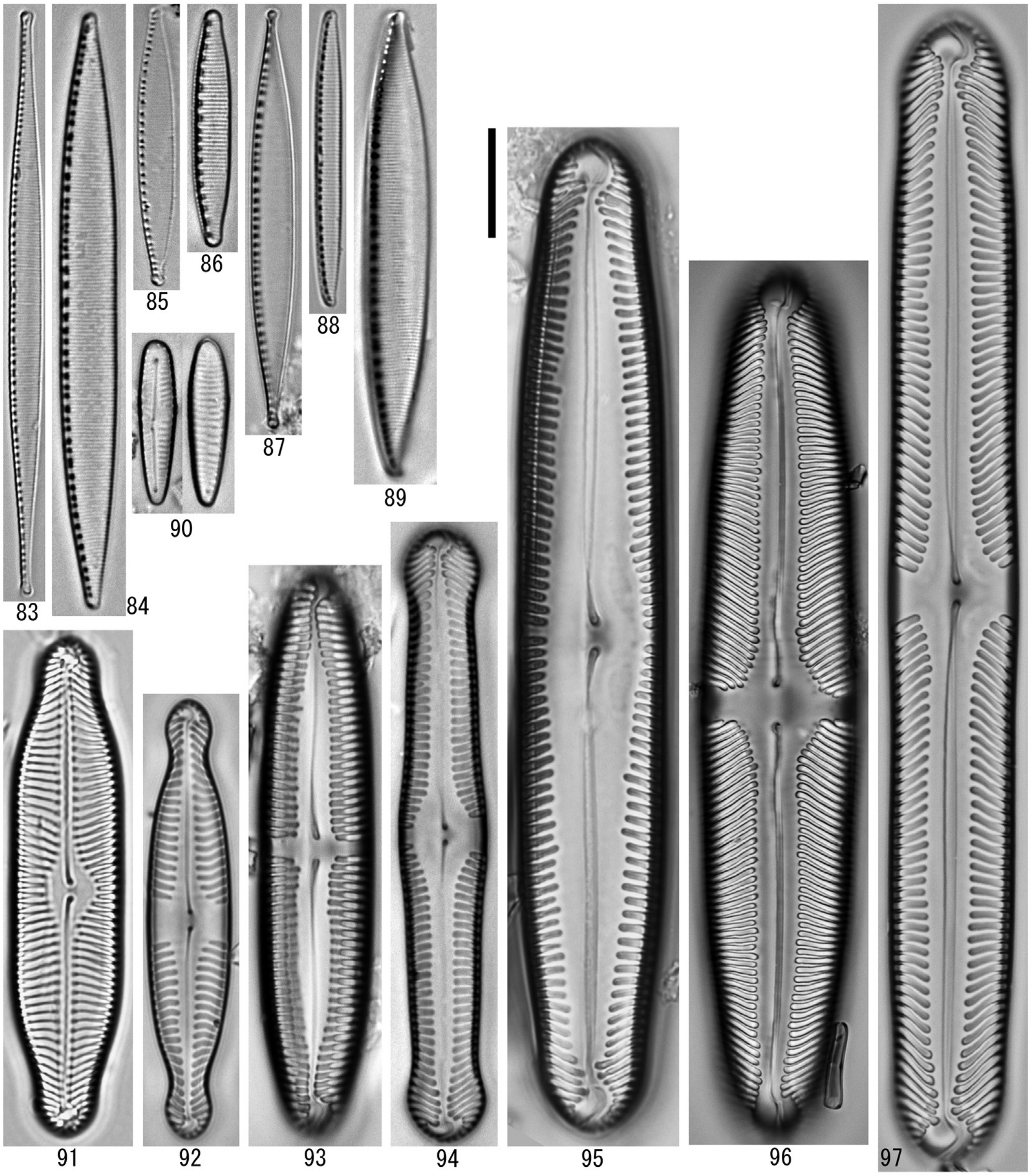

Fig. 83. *Nitzschia gracilis*. **Fig. 84.** *N. palea*. **Fig. 85.** *N. palea* var. *debilis*. **Fig. 86.** *N. perminuta*. **Fig. 87.** *N. pseudofonticola*. **Fig. 88.** *N. ruttneri*. **Fig. 89.** *N. solita*. **Fig. 90.** *Peronia fibula*. **Fig. 91.** *Pinnularia anglica*. **Fig. 92.** *P. brauniana*. **Fig. 93.** *P. hemipteriformis*. **Fig. 94.** *P. hilseana* var. *japonica*. **Fig. 95.** *P. aquilonaris*. **Fig. 96.** *P. divergens*. **Fig. 97.** *P. macilenta*. Scale bar = 10 μm.

This taxon is similar to *Navicula phylleptosoma* Lange-Bert. (cf. Lange-Bertalot & Genkal 1999. p. 69. *pl. 13. f. 1-5*), but the raphe sternum appears not to be strongly thickened as in that species. Fig. 74

Naviculadicta ambiguissima* Gerd Moser *et al., Biblioth. Diatomol. **38**: 202. *pl. 20. f. 1-7*. 1998 Fig. 75

***Neidium affine* (Ehrenb.) Pfitzer**; cf. Patrick & Reimer 1966. p. 390. *pl. 35. f. 2*. Fig. 77

***N. affine* var. *humerus* Reimer in R.M.Patrick et Reimer**, Monogr. Acad. Nat. Sci., Philadelphia **13**: 392. *pl. 35. f. 5*. 1966. Fig. 76

N. 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

N. hercynicum **f.** ***subrostratum*** **J.H.Wallace in Reimer**, Proc. Acad. Nat. Sci. Philadelphia **111**: 24. *pl. 2. f. 7*. 1959. Fig. 79

N. javanicum **Hust.**; cf. Simonsen 1987. p. 233. *pl. 340. f. 7-8*. Fig. 80

N. tenuissimum **Hust.**; cf. Simonsen 1987. p. 312. *pl. 470. f. 12-14*. Fig. 81

Neidium **sp.**

This taxon is similar to *Neidium septentrionale* A.Cleve (cf. Krammer & Lange-Bertalot 1986. p. 273. *pl. 101. f. 8-12*), but the valve is not clearly tri-undulated and the bent portion of the proximal raphe fissure is longer. It is also similar to *Neidium longiceps* W.Greg. (cf. Patrick & Reimer 1966. p. 393. *pl. 35. f. 4*; as *N. affine* var. *longiceps*), but the central area is much wider. Fig. 82

Nitzschia gracilis **Hantzsch**; cf. Krammer & Lange-Bertalot 1988. p. 93. *pl. 66. f. 1-11*. Fig. 83

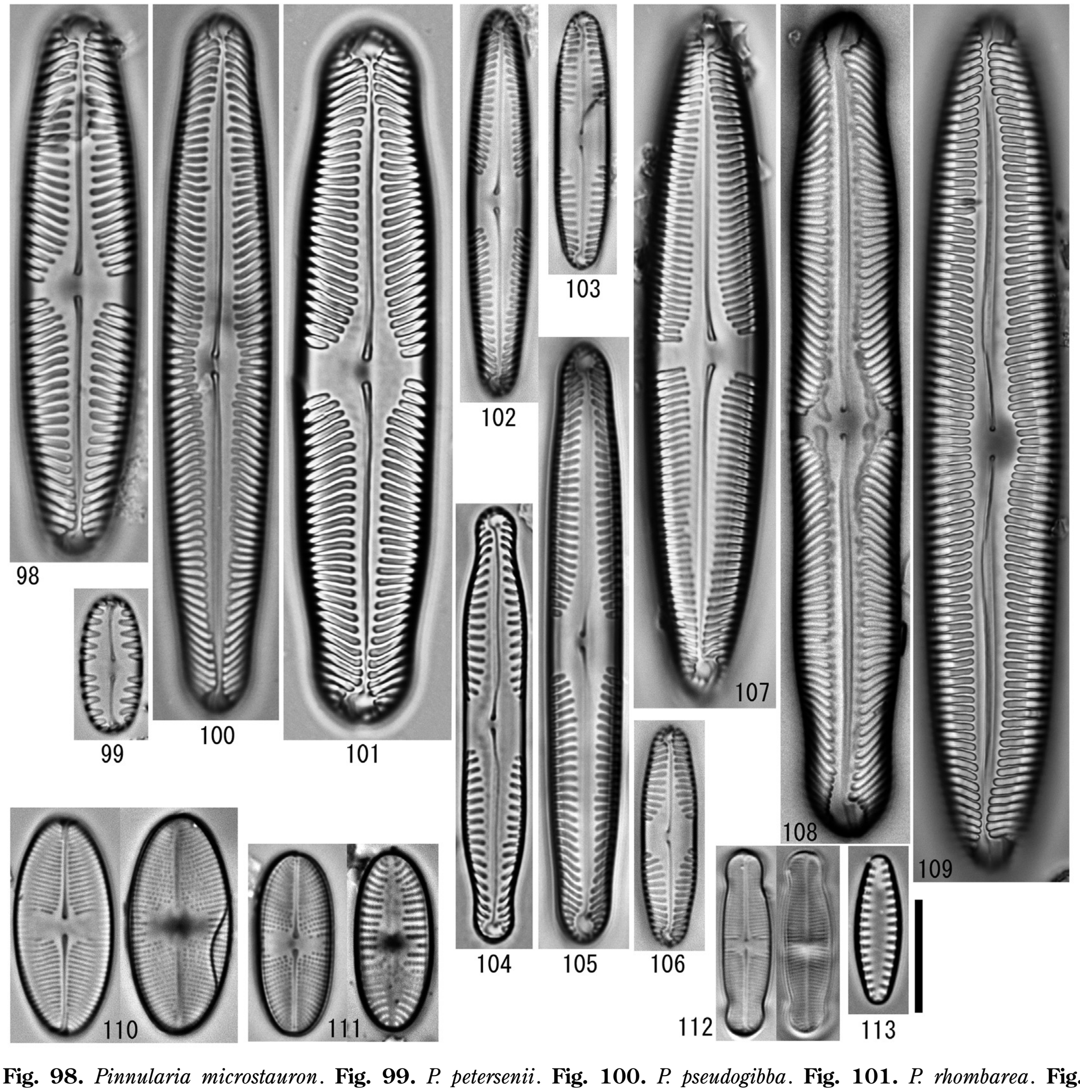

Fig. 98. *Pinnularia microstauron*. **Fig. 99.** *P. petersenii*. **Fig. 100.** *P. pseudogibba*. **Fig. 101.** *P. rhombarea*. **Fig. 102.** *P. lenticuloides*. **Fig. 103.** *P. sinistra*. **Fig. 104.** *P. subcapitata* var. *elongata*. **Fig. 105.** *P. subcapitata* var. *subrostrata*. **Fig. 106.** *P. subcapitata* var. *paucistriata*. **Fig. 107.** *P. subrupestris*. **Fig. 108.** *P. substomatophora*. **Fig. 109.** *P. viridiformis*. **Fig. 110.** *Psammothidium bioretii*. **Fig. 111.** *P. oblongellum*. **Fig. 112.** *P. pseudoswazi*. **Fig. 113.** *Pseudostaurosira brevistriata*. Scale bar = 10 μm except for Fig. 109 (= 15 μm).

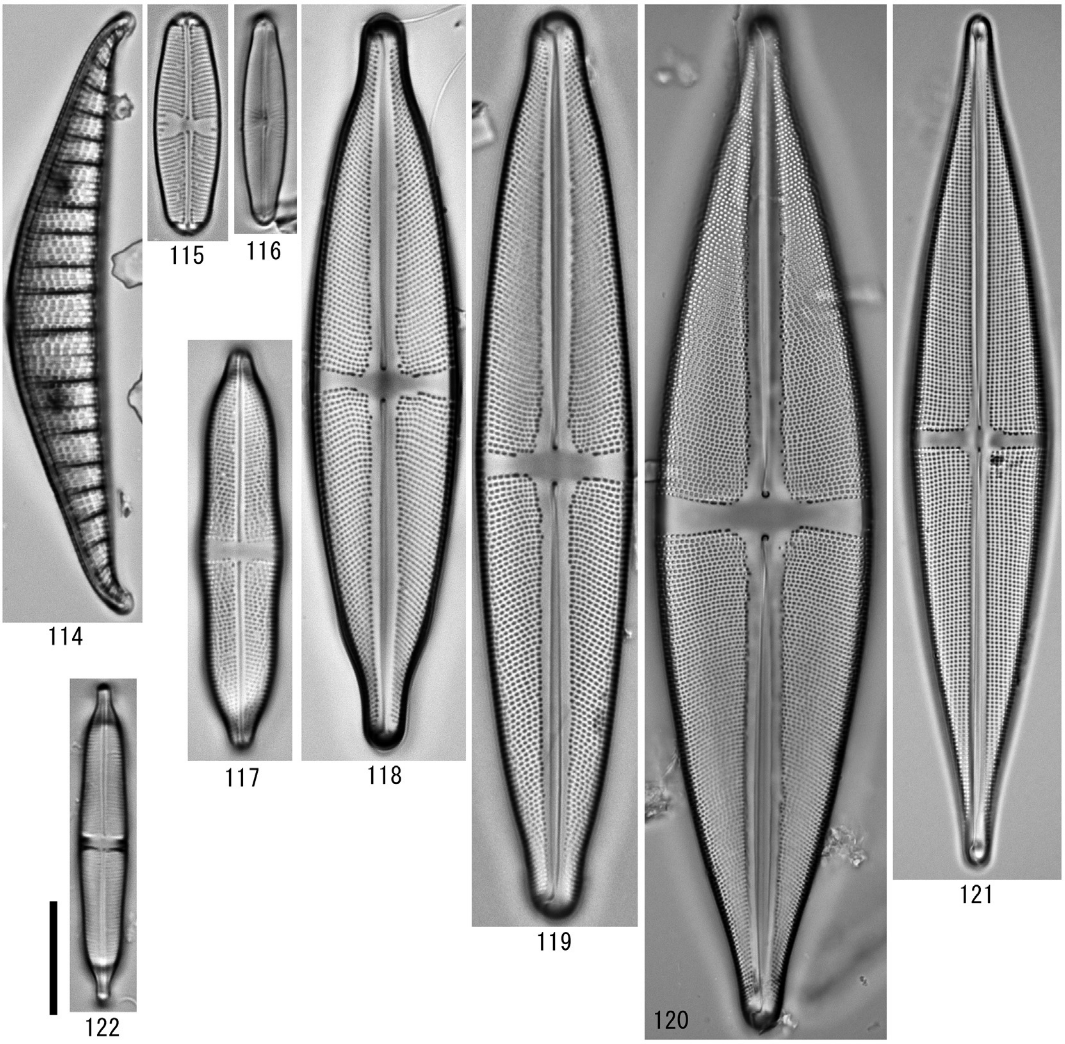

Fig. 114. *Rhopalodia acuminata*. **Fig. 115.** *Sellaphora pupula*. **Fig. 116.** *Sellaphora* sp. **Fig. 117.** *Stauroneis legumen*. **Fig. 118.** *S. anceps*. **Fig. 119.** *S. gracilis*. **Fig. 120.** *S. phoenicenteron*. **Fig. 121.** *S. staurolineata* var. *japonica*. **Fig. 122.** *S. tenera*. Scale bar = 10 μm except for Figs 120 and 121 (= 15 μm).

N. palea **(Kütz.) W.Sm.**; cf. Krammer & Lange-Bertalot 1988. p. 85. *pl. 59. f. 1*. Fig. 84

N. palea **var. *debilis*** **(Kütz.) Grunow**; cf. Krammer & Lange-Bertalot 1988. p. 86. *pl. 60. f. 1*. Fig. 85

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

N. pseudofonticola **Hust.**; cf. Simonsen 1987. p. 306. *pl. 459. f. 16-20*. Fig. 87

N. ruttneri **Hust.**; cf. Simonsen 1987. p. 243. *pl. 355. f. 8-15*. Fig. 88

N. solita **Hust.**; cf. Simonsen 1987. p. 395. *pl. 594. f. 20-21*. Fig. 89

Peronia fibula **(Bréb. ex Kütz.) R.Ross**; cf. Kobayasi *et al.* 2006. p. 94. *pl. 114. f. 1-13*. Fig. 90

Pinnularia anglica **Krammer**, Biblioth. Diatomol. **26**: 171. *pl. 40. f. 21-23*. 1992. Fig. 91

P. aquilonaris **M.H.Hohn et Hellerman**; cf. Krammer 2000. p. 146. *pl. 126. f. 1*.

Pinnularia kitterii reported from Yakumogahara moor (Kihara *et al.* 2007. p. 86. *f. 48*) is probably a smaller valve of this species, but the morphological succession accompanying size reduction must be studied for certain identification.

Fig. 95

P. brauniana **(Grunow) Mills**; cf. Krammer 2000. p. 112. *pl. 86. f. 10-19*. Fig. 92

P. divergens **W.Sm.**; cf. Krammer 2000. p. 61. *pl. 28. f. 1-4*. Fig. 96

P. hemipteriformis **Krammer et Metzeltin**, Diatoms of Europe **1**: 147. *pl. 127. f. 6, 7*. 2000. Fig. 93

P. hilseana **var. *japonica*** **H.Kobayasi**, Bull. Tokyo Gakugei Univ. **29**: 246. *pl. 6. f. 44-46*. 1977. Fig. 94

P. macilenta **Ehrenb.**; cf. Krammer 2000. p. 86. *pl. 62. f. 1-6. pl. 63. f. 1-5. pl. 66. f. 1, 2*. Fig. 97

P. lenticuloides **H.Kobayasi in H.Kobayasi et Kaz.Ando**, Bull. Tokyo Gakugei Univ. Ser. IV **27**: 195. *f. 74-77*. 1975. Fig. 102

P. microstauron **(Ehrenb.) Cleve**; cf. Krammer 2000. p. 74. *pl. 50. f. 1-12. pl. 52. f. 14-20. pl. 55. f. 3-6*. Fig. 98

P. petersenii **Krammer et Lange-Bert. in Lange-Bert. et Genkal**, Iconogr. Diatomol. **6**: 86. *pl. 52b. f. 4-7*. 1999. Fig. 99

P. pseudogibba **Krammer**, Biblioth. Diatomol. **26**: 174. *pl. 48. f. 8-14*. 1992. Fig. 100

P. rhombarea **Krammer in Metzeltin et Lange-Bert.**; cf. Krammer 2000. p. 45. *pl. 53. f. 1-10*. Fig. 101

P. sinistra **Krammer**, Biblioth. Diatomol. **26**: 175. *pl. 37. f. 1-16*. 1992. Fig. 103

P. subcapitata **var. *elongata*** **Krammer**, Biblioth. Diatomol. **26**: 176. *pl. 38. f. 1-11*. 1992. Fig. 104

P. subcapitata **var. *paucistriata*** **(Grunow in Van Heurck) Cleve**; cf. Van Heurck 1880-1885. *pl. 6. f. 23*. (as *Navicula subcapitata* var. *paucistriata*) Fig. 106

P. subcapitata **var. *subrostrata*** **Krammer**, Biblioth. Diatomol. **26**: 177. *pl. 38. f. 12-18*. 1992. Fig. 105

P. subrupestris **Krammer**, Biblioth. Diatomol. **26**: 177. *pl. 53. f. 8-13*. 1992. Fig. 107

P. substomatophorea **Hust.**; cf. Simonsen 1987. p. 161. *pl. 260. f. 1, 2, non* 3. Fig. 108

P. viridiformis **Krammer**, Biblioth. Diatomol. **26**: 160. *pl. 1. f. 4. pl. 4. f. 1-4. pl. 68. f. 1-4. pl. 69. f. 1-5*. 1992. Fig. 109

Psammothidium bioretii **(Germain) Bukhtiy. et Round**; cf. Krammer & Lange-Bertalot 1991b. p. 19. *pl. 12. f. 1-9* (as *Achnanthes bioretii*). Fig. 110

P. oblongellum **(Østrup) Van de Vijver**, Biblioth. Diatomol. **46**: 107. *pl. 27. f. 18-25*. 2002. Fig. 111

P. pseudoswazi **(J.R.Carter) Bukhtiy. et Round**; cf. Krammer & Lange-Bertalot 1991b. p. 41. *pl. 24. f. 1-7*. (as *Achnanthes pseudoswazi*) Fig. 112

Pseudostaurosira brevistriata **(Grunow) D. M.Williams et Round**; cf. Krammer & Lange-Bertalot 1991a. *pl. 130. f. 9-10* (as *Fragilaria brevistriata*). Fig. 113

Rhopalodia acuminata **Krammer**; cf. Krammer & Lange-Bertalot 1988. p. 162. *pl. 112. f. 1-6*. Fig. 114

Sellaphora pupula **(Kütz.) Mereschk.**, Ann. Mag. Nat. Hist. 2nd Ser., **7/9**: 187. *f. 1-5*. 1902. Fig. 115

Sellaphora **sp.**

This taxon is similar to *Sellaphora nana* (Hust.) Lange-Bert. *et al.* (cf. Simonsen 1987. p 440. *pl. 658. f. 12-14*; as *Stauroneis nana*), but the valve ends are wider and the central area is narrower. Fig. 116

Stauroneis anceps **Ehrenb.**; cf. Reichardt 1995. p. 25. *pl. 16. f. 1-12*. Fig. 118

S. gracilis **Ehrenb.**; cf. Reichardt 1995. p. 34. *pl. 19. f. 1-6*. Fig. 119

S. legumen **(Ehrenb.) Kütz.**; cf. Kobayasi & Ando 1978. p. 278. *f. 13-16*. Fig. 117

S. phoenicenteron **(Nitzsch) Ehrenb.**; cf. Krammer & Lange-Bertalot 1986. p. 239. *pl. 84. f. 1-3*. Fig. 120

S. staurolineata **var. *japonica*** **H.Kobayasi et Ando**, Jpn. J. Phycol. **26**: 15. *pl. 2. f. 18-20*. 1978.

Some specimens have weak longitudinal ribs passing through the fascia, suggesting a continuity to the nominate variety. Fig. 121

S. tenera **Hust.**; cf. Simonsen 1987. p. 215. *pl. 329. f. 6-10*. Fig. 122

Stenopterobia curvula **(W.Sm.) Krammer**; cf. Krammer & Lange-Bertalot 1988. p. 209. *pl. 171. f. 5-9*. Fig. 123

S. delicatissima **(F.W.Lewis) Bréb. ex Van Heurck**; cf. Krammer & Lange-Bertalot 1988. p. 210. *pl. 173. f. 5, 6. pl. 174. f. 1-10*. Fig. 125

Stenopterobia **sp.**

Hirano (1972) reported this species from

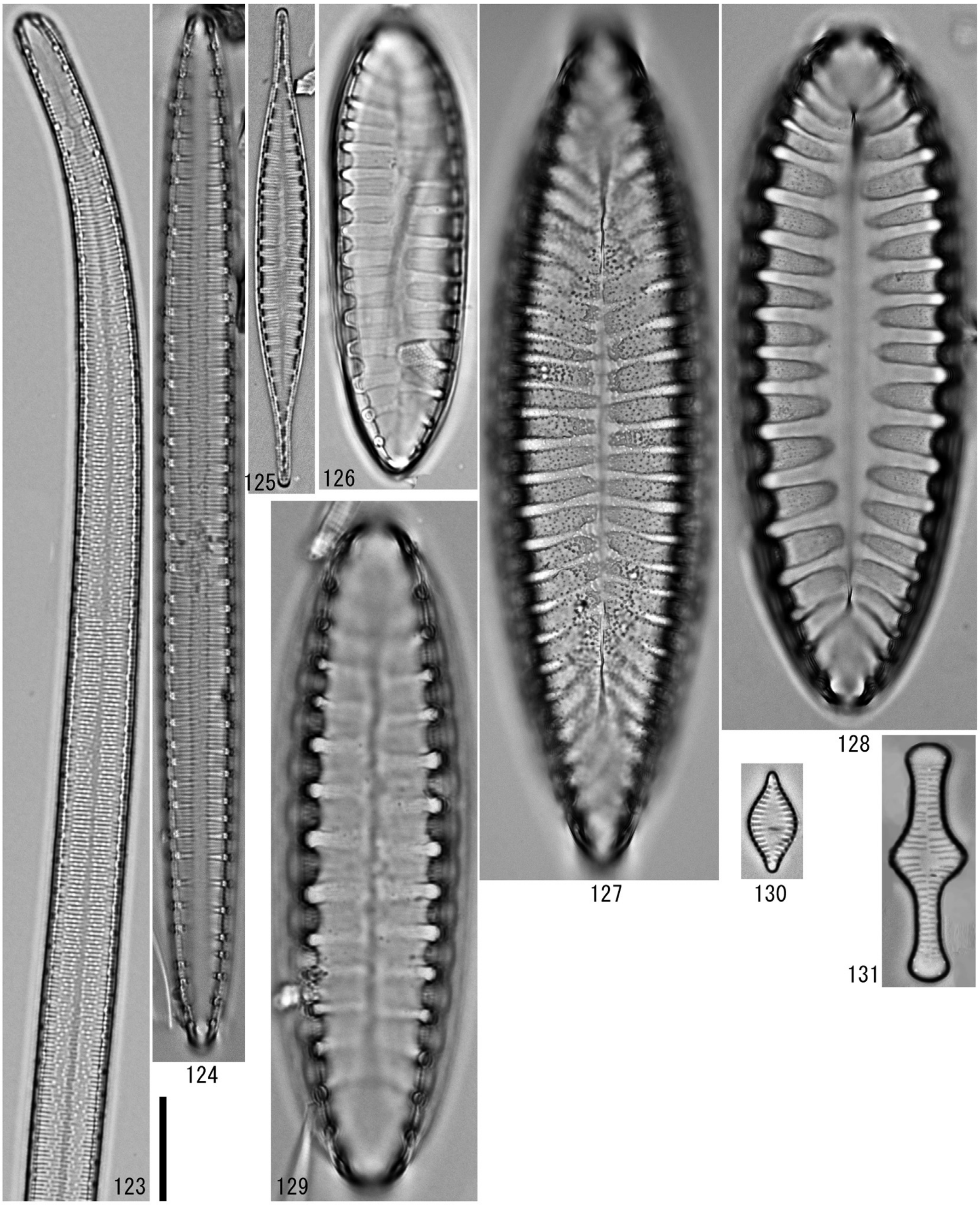

Fig. 123. *Stenopterobia curvula*. **Fig. 124.** *Stenopterobia* sp. **Fig. 125.** *S. delicatissima*. **Fig. 126.** *Surirella bohemica*. **Fig. 127.** *S. bifons*. **Fig. 128.** *S. tenera*. **Fig. 129.** *S. linealis*. **Fig. 130.** *Synedrella parasitica*. **Fig. 131.** *Tabellaria flocculosa*. Scale bar = 10 μm except for Figs 127 and 128 (= 15 μm).

Kurobe-genryu-daira Moor, Toyama Prefecture, Japan, as *Surirella lapponica* A.Cleve (p. 30. *pl. 5. f. 1, 2*), but *S. lapponica* shown by Krammer & Lange-Bertalot (1988) has a wider valve (p. 188. *pl. 135. f. 15-17*), which puts Hirano's identification in doubt. The same species has also been reported from Daisetsuzan National Park (Hirano & Iwaki 1970, 1972) and Mt. Yûbari (Hirano & Iwaki 1977), Hokkaido, and Sawano-ike Pond, Kyoto, Japan (Yoshikawa 2007).

Fig. 124

***Surirella bifrons* Ehrenb.**; cf. Krammer & Lange-Bertalot 1991a. p. 196. *pl. 145. f. 2-4. pl. 146. f. 1-4. pl. 147. f. 1-5. pl. 150. f. 4-6.* Fig. 127

***S. bohemica* G.Maly**; cf. Krammer & Lange-Bertalot 1988. p. 204. *pl. 155. f. 2-9.* Fig. 126

***S. linealis* W.Sm.**; cf. Krammer & Lange-Bertalot 1988. p. 198. *pl. 149. f. 1-9.* Fig. 129

***S. tenera* W. Greg.**; cf. Krammer & Lange-Bertalot 1988. p. 203. *pl. 164. f. 1-4.* Fig. 128

***Synedrella parasitica* (W.Sm.) Round et Maidana**, Diatom Res. **17**: 24. *f. 11-14.* 2001. Fig. 130

***Tabellaria flocculosa* (Roth) Kütz.**; cf. Kobayasi *et al.* 2006. p. 91. *pl. 110. f. 1-9.* Fig. 131

The dominant genera in terms of taxa richness in Yamakado Moor were *Eunotia* and *Pinnularia*; each is represented by 19 taxa. The percentage of these taxa among all diatom taxa (E+P; Hirano 1981) is, however, 29% and is lower than in high-moors in Honshu, Japan (Hirano 1981) and other *Sphagnum* moor or pond in the watershed of Lake Biwa (Kihara *et al.* 2007, 2008). The diatom flora of the Yamakado Moor is therefore not like those of high-moors in its entirety, although it does contain high-moor components.

Forty-one out of 51 taxa reported from Yakumogahara Moor were also found in Yamakado Moor (Kihara *et al.* 2007), but the taxa richness of the former is less than half that of the latter. Evidently the diverse and heterogeneous environment of the latter moor contains components similar to those in the former. In contrast, only 31 out of 105 taxa reported from Kurozo Moor, a mixed *Sphagnum* moor situated in the warm-temperate zone in Shikoku Island, Japan, were common to Yamakado Moor (Mieno *et al.* 1997; the taxonomy of that work was partly reassessed by us based on the published microphotographs).

The diatom flora of Yamakado Moor includes boreal or alpine elements despite the fact that the moor is situated in the warm-temperate zone. A similar pattern has been noted for the moor's vascular plant flora (Murase 1992) and insect fauna (Minami 1992). Among the diatoms, *Encyonema neogracile*, *E. perglacile*, *Eunotia circumborealis*, *Kobayasiella okadae*, and *Pinnularia subcapitata* var. *subrostrata* are boreal components mainly distributed in northern parts of Europe (Krammer 1997a, 2000, Krammer & Lange-Bertalot 1986, 1988). Indeed, *E. neogracile* and *P. subcapitata* var. *subrostrata* are regarded as alpine taxa (Krammer 1997a, 2000). *Eunotia nipponica* is also considered an alpine diatom, because it is very common in alpine moors in Hokkaido (Hirano & Iwaki 1974) and Eastern Honshu (Hirano 1977), but rare in other habitats (Watanabe *et al.* 2005). These taxa except *E. pergracile* were shared with Yakumogahara Moor (Kihara *et al.* 2007).

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