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MONOGRAPH

Contribution to the knowledge of the freshwater algae of Sierra Leone (Tropical West Africa): diatoms from Loma Mountains and Bumbuna Falls, the Northern Province

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ABSTRACT The freshwater flora of Sierra Leone, in particular the northern province, is still poorly investigated. We describe here the diatoms found in small pools in two locations of the northern province: Peak Bintimani (Loma Mountains) and Bumbuna Falls. Altogether 65 taxa, belonging to 31 genera are described. About 32 dubious Holarctic taxa, suspected to be new to science, are noted as "cf. ", expecting a differential diagnosis later on after further SEM observations. This is the case of very interesting taxa belonging to the genera *Eunotia*, *Luticola*, *Frustulia* and *Brachysira*.

KEY WORDS Diatoms; Bacillariophyceae; tropical freshwaters; Sierra Leone; West Africa.

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INTRODUCTION

The freshwater diatom flora of Tropical West Africa is still poorly investigated, the most comprehensive papers being those of Zanon (1941, French West Africa), Foged (1966, Ghana; 1986, Gambia), Compère (1991, Senegal) and Compère & Riaux-Gobin (2009, Guinea).

In Sierra Leone, the most significant studies are those of Carter & Denny (1982; 1987; 1992) in which many new species were described. Fumanti et al. (1990), Fumanti (1994) and Alfinito et al. (1994) have published some contributions on the diatom flora of three locations in the Western Area. The Northern Province, where the samples object of this study were collected, is also rather poorly researched: Mölder (1962), Sula Hills, few scattered samples; Mazzoni (1986) River Dankale; Alfinito et al. (1989), pond near Kania; Carter & Denny (1992), Lake Sonfon.

In this paper, we describe the diatoms found in two locations of the Northern Province: Peak Bintimani (Loma Mountains) and Bumbuna Falls, River Seli.

MATERIALS AND METHODS

Study area

Sierra Leone is a small country located in the south western part of West Africa, bordered by Guinea, Liberia and the Atlantic Ocean. It is divided into four geographical regions: the Northern Province, Eastern Province, Southern Province and the Western Area. Sierra Leone has a tropical climate,

with a wet season from May to October and a dry season from November to April.

The Northern Province, in which the samples, object of this study, were collected, is composed of interior plateaux and mountains which rise to form Tingi Hills and Loma Mountains. The Loma Mountains Forest Reserve covers approximately 396 km^2 and is the largest montane forest in Sierra Leone. Peak Bintimani (1945 m a.s.l.) is the highest in West Africa.

Bumbuna Falls are just few kilometers from the city of Bumbuna (Tonkolili District). About 2,5 km downstream of Bumbuna Falls is located the Bumbuna dam, the first Sierra Leone hydropower dam, in the valley of the Sula Mountains.

Materials

Samplings were carried out in November 1984, just at the beginning of the rainy season, by Prof. Walter Rossi. The first sample was collected on the NE slope of Peak Bintimani, Loma Mountains, about 1650 m a.s.l. in very small pools formed by tuft of grass on granitic rock (some images of the sampling area are shown in Alfinito, 2011); the pools were very rich in filamentous green algae, mosses and in higher plants characteristic of these swampy areas, such as *Utricularia pubescens* Smith, *Utricularia micropetala* Smith v. *macrokeilos* P. Taylor and *Drosera pilosa* Exell et Laundon.

The second sample comes from Bumbuna Falls, River Seli and was collected in small but relatively deep pools formed in large granitic rocks emerging from the dried river.

The material was treated with a mix of sulphuric and nitric acid and rinsed several times with distilled water. The cleaned material was mounted in Hyrax for light microscope (LM) studies with a Zeiss Axioscope. For scanning electron microscope (SEM) investigations, the material was coated with gold and observed with a Cambridge 250 Scanning Electron Microscope.

Terminology used in this paper follows that suggested by Anonymous (1975), Krammer & Lange-Bertalot (1986; 1988; 1991a; 1991b; 2000) and Round et al. (1990). The classification follows Simonsen (1979), Round et al. (1990) and Krammer & Lange-Bertalot (2000).

For each taxon a reference to the author we followed for identification, valve dimensions, striae density and other LM or SEM characteristics are given, together with the distribution in Sierra Leone.

RESULTS

Taxonomic account

BACILLARIOPHYCEAE
CENTRALES

Familia THALASSIOSIRACEAE Lebour, 1930 emend. Hasle, 1973

Aulacoseira Thwaites, 1848

Aulacoseira granulata (Ehr.) Simonsen v. ***valida*** (Hustedt) Simonsen, 1979

Simonsen (1987) Pl. 278: 1-4

DESCRIPTION. Diameter 14-18 µm; 8-9 rows of areolae in 10 µm; 8-10 elliptic areolae in 10 µm (Fig. 1).

DISTRIBUTION. Bumbuna Falls, Peak Bintimani, quite frequent. New record for Sierra Leone.

Cyclotella (Kütz.) Brébisson, 1838

Cyclotella meneghiniana Kützing, 1844

Krammer & Lange-Bertalot (1991a) Pl. 44: 1-10
Synonym: *Cyclotella kuetzingiana* Thwaites, 1848

DESCRIPTION. Diameter 17-19 µm; 8-9 striae in 10 µm (Figs. 4-6).

DISTRIBUTION. Bumbuna Falls, rare. Other records: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); River Dankale (Mazzoni, 1986, sub *C. kuetzingiana* Thwaites); Bathurst Falls (Fumanti, 1994).

Fam. MELOSIRACEAE Kützing, 1844

Orthoseira Thwaites, 1849

Orthoseira roeseana (Rabenh.) O'Meara, 1876

Krammer & Lange-Bertalot (1991) Pl. 10: 1-11

Synonym: *Melosira roeseana* Rabenhorst, 1852

Description. Diameter 12-30 µm; 15-18 striae in 10 µm (Figs. 2-3).

Distribution. Bumbuna Falls, common. Other records, sub *Melosira roeseana* Rabenhorst: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Sonfon (Carter & Denny, 1992).

PENNALES

Familia FRAGILARIACEAE Hustedt, 1930

Fragilaria Lyngbye, 1819

Fragilaria cf. ***javanica*** Hustedt, 1938

Metzeltin & Lange-Bertalot (1998) Pl. 1: 1-6; Simonsen (1987) Pl. 322: 1-6

Description. Length 47 µm; breadth 4.5 µm; c. 22 striae in 10 µm (Fig. 13).

Distribution. Bumbuna Falls, only one specimen observed.

Remarks. the only observed specimen is very very close to Hustedt's taxon, unless the presence of marginal spines. The species *Fragilaria telum*, described by Carter in Carter & Denny (1987) for Lake Mabesi, Sierra Leone, is clearly related to *F. javanica* Hustedt, but lacks the marginal spines. As far as we know, *F. telum* was no more reported. Later on Metzeltin & Lange-Bertalot (1998) found *F. javanica* Hustedt in a spring stream near Santos (Brazil) and the specimens shown in their Pl. 1: 1-6 have no marginal spines. A more detailed analysis of the original material, involving SEM comparison, should be required in order to fully understand the taxonomical identity of both taxa.

Ctenophora (Grunow) Williams et Round, 1986

Ctenophora pulchella (Ralfs ex Kützing) Williams et Round, 1986

Hofmann et al. (2011) Pl. 4: 13-17
Synonym: *Synedra pulchella* Ralfs ex Kützing, 1844

Description. Length 45-70 µm; breadth 5-5.5 µm; 15-16 striae in 10 µm (Figs. 7-9).

Distribution. Bumbuna Falls, quite common. Other records, sub *Synedra pulchella* Ralfs ex Kützing: Sula Hills (Mölder, 1962); Lake Mabesi (Carter & Denny, 1987); Lake Sonfon, Lake Mabesi (Carter & Denny, 1992).

Staurosira Ehrenberg, 1843

Staurosira cf. ***longirostris*** (Frenguelli) Metzeltin, Lange-Bertalot et Garcia-Rodriguez, 2005

Sar et al. (2009) p. 152 fig. 21
Metzeltin et al. (2005) Pl. 13: 4-13

Description. Length 15-18 µm; breadth 8-8.5 µm (Fig. 11).

Distribution. Peak Bintimani, rare.

Remarks. this species, described by Frenguelli (1941) from the coastal lagoon of Mar Chiquita (Argentina), was reported also by Metzeltin et al. (2005) for Rio de la Plata and Laguna Merin (Uruguay).

Staurosira construens Ehrenberg, 1843

Hofmann et al. (2011) Pl. 10: 1-6
Synonym: *Fragilaria construens* (Ehr.) Grunow, 1862

Description. Length 10-12 µm; breadth 6 µm; c. 12 striae in 10 µm (Fig. 10).

Distribution. Bumbuna Falls, rare. Other records, sub *Fragilaria construens* (Ehr.) Grunow: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Mabesi, Lake Mape (Carter & Denny, 1987).

Staurosira venter (Ehr.) Grunow in Pantocsek, 1889

Hofmann et al. (2011) Pl. 10: 18-24
Synonym: *Fragilaria construens* Ehr. v. *construens* f. venter (Ehr.) Hustedt, 1957

Description. length 6-7 µm; breadth 5-6 µm; 12-14 striae in 10 µm (Fig. 12).

Distribution. Bumbuna Falls, rare. Other records: Lake Sonfon (Carter & Denny, 1992) sub

Fragilaria construens Ehr. v. *construens* f. *venter* (Ehr.) Hustedt.

Ulnaria (Nitzsch) Compère, 2001

Ulnaria cf. ***ulna*** (Nitzsch) Compère, 2001

Synonym: *Synedra ulna* (Nitzsch) Ehrenberg, 1832

DESCRIPTION. Length 57-60 µm; breadth 5-6 µm; c. 11 striae in 10 µm (Fig. 14).

DISTRIBUTION. Bumbuna Falls, quite common. Records for *U. ulna* sensu lato, sub *Synedra ulna* (Nitzsch) Ehrenberg: Sula Hills (Mölder, 1962); River Dankale (Mazzoni, 1986); Lake Sonfon (Carter & Denny, 1992).

REMARKS. Krammer & Lange-Bertalot (1991) and Hofmann et al. (2011) regard this taxon as a "sippenkomplex" that needs further thorough studies. Our specimens bear some resemblance to *Synedra ulna* (Nitzsch) Ehrenberg f. *impressa* (Hust.) Hustedt, 1957 as reported in Simonsen (1987) Pl. 54 fig. 3.

Familia EUNOTIACEAE Kützing, 1944

Actinella F. W. Lewis, 1863

Actinella brasiliensis Grunow in Van Heurck, 1881

Metzeltin & Lange-Bertalot (2007) Pl. 35: 1-7

DESCRIPTION. Length 77-140 µm; breadth 6-8.5 µm; 12-17 striae in 10 µm (Figs. 36-39; Figs 40-41; Fig. 51).

DISTRIBUTION. Bumbuna Falls, rare; Peak Bintimani, quite common. Other records: River Jong (Carter & Denny, 1982); Lake Mape, Lake Mabesi, River Waanje (Carter & Denny, 1987); Guma Dam (Fumanti et al., 1990); Lake Sonfon, Lake Popei (Carter & Denny, 1992); Bathurst Falls (Fumanti, 1994).

Eunotia Ehrenberg, 1837

Eunotia cf. ***crassula*** Metzeltin et Lange-Bertalot, 1998

DESCRIPTION. Length 50-78 µm; breadth 8-11 µm; c. 14 striae in 10 µm (Figs. 42-46).

DISTRIBUTION. Peak Bintimani, quite frequent.

Eunotia cf. ***crista-galli*** Cleve, 1891 and cf. ***tecta*** Krasske, 1939

DESCRIPTION. Length 29-33 µm; breadth 7-8 µm; 15-16 striae in 10 µm (Figs. 16-17).

DISTRIBUTION. Bumbuna Falls, rare; Peak Bintimani, rare. Records for *E. crista-galli* Cleve: Bathurst Falls (Fumanti, 1994); records for *E. tecta* Krasske: Lake Sonfon (Carter & Denny, 1992).

REMARKS. Both of the cf. are hardly similar.

Eunotia cf. ***minor*** (Kütz.) Grunow in Van Heurck, 1881

Synonym: : *E. pectinalis* (Kütz.) Rabenh. v. *minor* (Kütz.) Rabenhorst, 1864
E. pectinalis (Kütz.) Rabenh. v. *minor* (Kütz.) Rabenh. f. *impressa* (Ehr.) Hustedt, 1930

DESCRIPTION. Length 22-42 µm; breadth 3.5-5 µm; 12-14 striae in 10 µm (Figs. 25-26).

DISTRIBUTION. Bumbuna Falls, quite common; Peak Bintimani, rare. Records for *Eunotia minor* (Kütz.) Grunow in Van Heurck (sub *E. pectinalis* (Kütz.) Rabenh. v. *minor* (Kütz.) Rabenhorst, 1864 and *E. pectinalis* (Kütz.) Rabenh. *v. minor* (Kütz.) Rabenh. f. *impressa* (Ehr.) Hustedt): Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); River Dankale (Mazzoni, 1986); Lake Popei (Carter & Denny, 1992).

Eunotia naegelii Migula in Thomé, 1907

Krammer & Lange-Bertalot (1991) Pl. 140: 1-6
Synonym: *E. alpina* (Nägeli) Hustedt in Schmidt et al., 1913

DESCRIPTION. Length 32-68 µm; breadth 2-2.5 µm; 25-28 striae in 10 µm (Figs. 28-34).

DISTRIBUTION. Peak Bintimani, common. Other records: Sula Hills (Mölder, 1962), River Jong (Carter & Denny, 1982), Lake Mape (Carter & Denny, 1987) and Lake Popei (Carter & Denny, 1992) sub *E. alpina* (Nägeli) Hustedt in Schmidt et al., 1913; Bathurst Falls (Fumanti, 1994).

Eunotia rabenhorstiana (Grunow) Hustedt, 1949

Metzeltin & Lange-Bertalot (1998) Pl. 10: 1-13

Description. Length 63-87 µm; breadth 7-8 µm; 16-17 striae in 10 µm (Fig. 35).

Distribution. Bumbuna Falls, rare. New record for Sierra Leone.

Eunotia rabenhorstii Cleve et Grunow v. ***triodon*** Grunow in Van Heurck, 1881

Metzeltin et al. (2005) Pl. 20: 1-7

Description. length 33-35 µm; breadth 7 µm; 16-17 striae in 10 µm (Fig. 15).

Distribution. Bumbuna Falls, rare. New record for Sierra Leone.

Eunotia rhomboidea Hustedt, 1950

Simonsen (1987) Pl. 546: 3-8
Lange-Bertalot et al. (2011) Pl. 42: 1-8; Pl. 43: 12-14
Metzeltin & Lange-Bertalot (2002) Pl. 9: 1-4

Description. Length 8-18 µm; breadth 2-4.5 µm; 18-24 striae in 10 µm and c. 40 areolae in 10 µm (Figs. 18-24).

Distribution. Bumbuna Falls, Peak Bintimani, frequent. Other records: River Jong (Carter & Denny, 1982); Lake Sonfon (Carter & Denny, 1992); Bathurst Falls (Fumanti, 1994).

Eunotia vumbae Cholnoky, 1954

Cholnoky (1954) Figs. 54-58

Description. Length 15 µm; breadth 4 µm; more than 20 striae in 10 µm (Fig. 27).

Distribution. Bumbuna Falls, only one specimen observed. New record for Sierra Leone.

Familia ACHNANTHACEAE Kützing, 1844

Achnanthes Bory, 1822

Achnanthes inflata (Kützing) Grunow in Cleve & Grunow, 1880

Krammer & Lange-Bertalot (1991) Pl. 2: 9-10

Description. Length 35-64 µm, breadth 10-16 µm; c. 12 striae in 10 µm in both valvae (Figs. 62-64).

Distribution. Bumbuna Falls, quite rare. Other records: Kangari Sula (Mölder, 1962); River Dankale (Mazzoni, 1986).

Familia ACHNANTHIDIACEAE D. G. Mann 1990

Achnanthidium Kützing, 1844

Achnanthidium subhudsonis (Hustedt) Kobayasi in Kobayasi et al., 2006

Simonsen (1987) Pl. 68: 1-9

Description. length 18-26 µm, breadth 4-5 µm; striae in the raphe valve 18-20 in 10 µm and in the rapheless valve 22-23 in 10 µm (Figs. 52-57; Figs. 58-59).

Distribution. Bumbuna Falls, frequent. New record for Sierra Leone.

Achnanthidium taiaense (Carter in Carter & Denny) J. Taylor, Morales et Ector, 2011

Lange-Bertalot & Krammer (1989) Pl. 67: 25-28 (Holotypus, BM 78107, Sierra Leone)

Description. Length 14-16 µm; breadth 3 µm; more than 30 striae in 10 µm in the raphe valve and more than 40 in 10 µm in the rapheless valve (Figs. 47-50).

Distribution. Bumbuna Falls, rare. Other records: River Jong (Carter & Denny, 1982); Lake Mape, River Waanje, River Malen (Carter & Denny, 1987); Guma Dam (Fumanti et al., 1990); Lake Sonfon (Carter & Denny, 1992); Bathurst Falls (Fumanti, 1994).

Remarks. Carter in Carter & Denny (1982) described this species from the River Jong, Sierra Leone (as *Achnanthes taiaensis*).

Fam. COCCONEIDACEAE Kützing, 1844

Cocconeis Ehrenberg, 1838

Cocconeis pediculus Ehrenberg, 1838

Krammer & Lange-Bertalot (1991b) Pl. 57:1-4

DESCRIPTION. Length 26-28 µm; breadth 22-23 µm; striae in the raphe valve c.18 in 10 µm; puncta 20-22 in 10 µm; striae in the rapheless valve about 18 in 10 µm; puncta elongated, c. 10 in 10 µm (Fig. 60).

DISTRIBUTION. Bumbuna Falls, rare. Other records: River Jong (Carter & Denny, 1982); Lake Sonfon, Lake Popei (Carter & Denny, 1992).

Cocconeis placentula Ehrenberg, 1938

Krammer & Lange-Bertalot (1991b) Pl. 51: 1-5

DESCRIPTION. Length 20 µm; breadth 13 µm; c. 25 striae in 10 µm in the raphe valve (Fig. 61).

DISTRIBUTION. Bumbuna Falls, only one valve found. Other records: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Sonfon, Lake Popei (Carter & Denny, 1992).

Familia BRACHYSIRACEAE D. G. Mann, 1990

Brachysira (Kützing) Round et Mann, 1981

Brachysira cf. ***brebissonii*** Ross in Hartley, 1986

Synonym: *Anomoeoneis brachysira* (Bréb.) Grunow in Cleve, 1895
Synonym: *A. serians* (Bréb.) Cleve v. *brachysira* (Bréb.) Cleve in Cleve et Möller, 1882

DESCRIPTION. Length 20-24 µm; breadth 6-7 µm; 35-40 striae in 10 µm (Figs. 68-74; Fig. 75).

DISTRIBUTION. Bumbuna Falls, Peak Bintimani, quite frequent. Records for *A. brachysira* (Bréb.) Grunow sensu lato: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Mabesi (Carter & Denny, 1987); Kania (Alfinito et al., 1989); Guma Dam (Fumanti et al., 1990); Lake Sonfon (Carter & Denny, 1992); Bathurst Falls (Fumanti, 1994).

Brachysira cf. ***metzeltinii*** Lange-Bertalot in Lange-Bertalot & Moser, 1994

DESCRIPTION. Length 35-36 µm; breadth 6-6.5 µm; c. 28 striae in 10 µm (Figs. 76-78).

DISTRIBUTION. Peak Bintimani, rare.

Brachysira cf. ***wygaschii*** Lange-Bertalot in Lange-Bertalot & Moser, 1994

DESCRIPTION. Length 39-45 µm; breadth 9-10 µm; 22-24 striae in 10 µm. Compare Lange-Bertalot & Moser (1994, Fig. 13: 1-11).

DISTRIBUTION. Bumbuna Falls, Peak Bintimani, quite frequent (Figs. 79-83).

Familia CYMBELLACEAE Greville, 1833

Cymbella C. Agardh, 1830

Cymbella kappii (Cholnoky) Cholnoky, 1956

Krammer (2002) Pl. 52: 1-15

DESCRIPTION. Length 28-32 µm; breadth 8-9 µm; 14 striae and c. 24 puncta in 10 µm (Figs. 92-95).

DISTRIBUTION. Bumbuna Falls, quite common. New record for Sierra Leone.

Encyonema Kützing, 1833

Encyonema cf. ***auerswaldii*** Rabenhorst, 1853

DESCRIPTION. Length 13-30 µm; breadth 6-10 µm; 11-14 striae and c. 24 puncta in 10 µm (Figs. 98-101).

DISTRIBUTION. Bumbuna Falls, Peak Bintimani, frequent.

Encyonema cf. ***javanicum*** (Hustedt) D. G. Mann, 1990

Synonym: *Cymbella javanica* Hustedt, 1938

DESCRIPTION. Length 18 µm; breadth 6 µm; c. 10 striae in 10 µm (Fig. 102).

DISTRIBUTION. Bumbuna Falls, only one specimen observed. Records for *E. javanicum* (Hustedt) D. G. Mann: River Jong (Carter & Denny, 1982) sub *Cymbella javanica* Hustedt, 1938.

Encyonema neogracile Krammer var. ***tenuipunctata*** Krammer, 1997

Krammer (1997) Pl. 85: 1-6

Description. Length 50-55 µm; breadth 7 µm; 14 striae and 30-32 puncta in 10 µm (Fig. 97).

Distribution. Bumbuna Falls, rare. New record for Sierra Leone.

Encyonema neomesianum Krammer, 1997
Krammer (1997) Pl. 40: 6-9

Description. Length 32-36 µm; breadth 9-9.5 µm; 9-10 striae in 10 µm (Fig. 96).

Distribution. Peak Bintimani, rare. New record for Sierra Leone.

Encyonema cf. ***subelginense*** Krammer, 1997

Description. Length 24 µm; breadth 8 µm; c. 10 striae and 25-26 puncta in 10 µm (Fig. 105).

Distribution. Bumbuna Falls, only one specimen observed.

Encyonema cf. ***ventricosum*** (Ag.) Grunow in Schmidt et al., 1885

Morphotype 3 in Krammer (1997) Pl. 6: 14-18

Description. Length 15 µm; breadth 4.5 µm; c. 14 striae in 10 µm (Fig. 104).

Distribution. Bumbuna Falls, only one specimen observed.

Remarks. Very often in the literature more or less similar taxa are errouneously identified as *E. ventricosum* such as, for instance, *Encyonema* sp. 4 in Kulikowskiy et al., 2012 Pl. 8: 6-7).

Encyonopsis Krammer, 1997

Encyonopsis cf. ***schubartii*** (Hustedt) Krammer, 1997

Description. Length 19-22.5 µm; breadth 5-5.5 µm; 11-12 striae in 10 µm (Fig. 103).

Distribution. Bumbuna Falls, rare.

Familia AMPHIPLEURACEAE Grunow, 1862

Frustulia Rabenhorst, 1853

Frustulia cf. ***crassinervia*** (Bréb.) Lange-Bertalot et Krammer in Lange-Bertalot & Metzeltin, 1996

Lange-Bertalot & Metzeltin (1996) Pl. 38: 7-9
Synonym: *F. rhomboides* (Ehr.) De Toni v. *crassinervia* (Bréb.) Ross, 1947

Description. Length 58-60 µm; breadth 16 µm; striae very fine, c. 35 in 10 µm (Figs. 115-118).

Distribution. Peak Bintimani, frequent; Bumbuna Falls, quite common. Other records for *F. crassinervia* (Bréb.) Lange-Bertalot et Krammer: Bathurst Falls (Fumanti, 1994) sub *F. rhomboides* (Ehr.) de Toni v. *crassinervia* (Bréb.) Ross.

Frustulia cf. ***saxonica*** Rabenhorst, 1853

Lange-Bertalot & Metzeltin (1996) Pl. 39: 10 from Julma Ölkky (Finland)
Synonym: *F. rhomboides* (Ehr.) De Toni v. *saxonica* (Rabenh.) Pfitzer, 1872

Description. Length 69-70.5 µm; breadth 15 µm; c. 27 striae in 10 µm and 24-25 areolae in 10 µm (Figs. 111-114).

Distribution. Peak Bintimani, Bumbuna Falls, quite frequent. Other records for *F. saxonica* Rabenhorst, sub F. *rhomboides* (Ehr.) de Toni v. *saxonica* (Rabenh.) Pfitzer: Sula Hills (Mölder, 1962); Guma Dam (Fumanti et al., 1990); Bathurst Falls (Fumanti, 1994).

Frustulia cf. ***undosa*** Metzeltin et Lange-Bertalot, 1998

Metzeltin & Lange-Bertalot (1998) Pl. 116: 14-18

Description. Length 34-43 µm; breadth 8-9 µm; striae very fine, difficult to count by LM, c. 40 in 10 µm; 50-52 areolae in 10 µm (Figs. 119-123; Figs. 124-126).

Distribution. Peak Bintimani, Bumbuna Falls, quite frequent.

Familia GOMPHONEMATACEAE Kützing, 1844

Gomphonema Ehrenberg, 1832

Gomphonema pseudoaugur Lange-Bertalot, 1979

Krammer & Lange-Bertalot (1986) Pl. 159: 1-4

DESCRIPTION. Length 15-25 µm; breadth 5.5-7.5 µm, c. 13-14 striae in 10 µm (Figs. 109-110) .

DISTRIBUTION. Bumbuna Falls, quite common. New record for Sierra Leone.

Gomphonema cf. ***lagenula*** Kützing, 1844

Synonym: *Gomphonema parvulum* Kütz. v. *lagenula* (Kütz.) Frenguelli, 1923

DESCRIPTION. Length 22-29 µm; breadth 6-8.5 µm; 14-16 striae in 10 µm (Fig. 108).

DISTRIBUTION. Bumbuna Falls, quite common. Records for *G. lagenula*, sub *G. parvulum* Kütz. v. *lagenula* (Kütz.) Frenguelli: River Jong (Carter & Denny, 1982); River Dankale (Mazzoni, 1986); River Waanje (Carter & Denny, 1987).

Familia CATENULACEAE Mereschkowsky, 1902

Halamphora (Cleve) Levkov, 2009

Halamphora veneta (Kütz.) Levkov, 2009

Hofmann et al. (2011) Pl. 92: 20-25
Synonym: *Amphora veneta* Kützing, 1844

DESCRIPTION. Length 20 µm; breadth 4 µm; c. 24 striae in 10 µm (Fig. 106).

DISTRIBUTION. Bumbuna Falls, only one specimen observed. Other records (sub *Amphora veneta* Kützing): Lake Sonfon (Carter & Denny, 1992); York (Alfinito et al., 1994).

FAMILY NOT DESIGNATED

Kobayasiella Lange-Bertalot, 1999

Kobayasiella cf. ***subtilissima*** (Cleve) Lange-Bertalot, 1999

Synonym: *Navicula subtilissima* Cleve, 1891

DESCRIPTION. Length 31-38 µm; breadth 4.5-5 µm. Striae very delicate, difficult to resolve by LM (Fig. 107).

DISTRIBUTION. Peak Bintimani, not common. Other records for *Kobayasella subtilissima* (Cleve) Lange-Bertalot (sub *Navicula subtilissima* Cleve): Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Mape, Lake Mabesi (Carter & Denny, 1987); Kania (Alfinito et al., 1989); Guma Dam (Fumanti et al., 1990); Bathurst Falls (Fumanti, 1994).

Familia DIADESMIDIACEAE D. G. Mann, 1990

Luticola D. G. Mann in Round et al., 1990

Luticola aequatorialis (Heiden) Lange-Bertalot et Ohtsuka in Ohtsuka, 2002

Simonsen (1992) Pl. 56: 8-11
Rumrich et al. (2000) Pl. 61: 15

DESCRIPTION. Length 16-17 µm; breadth 6.5-7 µm; c. 14 striae in 10 µm (Fig. 131).

DISTRIBUTION. Bumbuna Falls, rare. First record for Sierra Leone.

Luticola muticoides (Hustedt) D. G. Mann in Round et al., 1990

Rumrich et al. (2000) Pl. 62: 9-12
Synonym: *Navicula muticoides* Hustedt, 1949

DESCRIPTION. Length 17-18 µm; breadth 8-8.5 µm; 30-32 striae in 10 µm (Figs. 129-130).

DISTRIBUTION. Peak Bintimani, Bumbuna Falls, rare. Other records (sub *Navicula muticoides* Hustedt): Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Mabesi (Carter & Denny, 1987); Guma Dam (Fumanti et al., 1990); Lake Sonfon, Lake Popei (Carter & Denny, 1992); York (Alfinito et al., 1994).

Luticola cf. ***mutica*** (Kütz.) D. G. Mann in Round et al., 1990

Synonym: *Navicula mutica* Kützing, 1844

DESCRIPTION. Length 26-31 µm; breadth 8-8.5 µm; 20-22 striae in 10 µm (Fig. 132).

DISTRIBUTION. Peak Bintimani, Bumbuna Falls, rare. Other records for *L. mutica* (Kütz.) D. G. Mann (sub *Navicula mutica* Kütz.): Sula Hills (Mölder, 1962); River Dankale (Mazzoni, 1986); Lake Mabesi (Carter & Denny, 1987); Guma Dam (Fumanti et al., 1990); Lake Sonfon, Lake Popei (Carter & Denny, 1992).

Luticola cf. ***muticopsis*** (Van Heurck) D. G. Mann in Round et al., 1990

Synonym: *Navicula muticopsis* Van Heurck, 1909

DESCRIPTION. Length 24-25 µm; breadth 9 µm, 19-20 striae in 10 µm (Figs. 127-128).

DISTRIBUTION. Peak Bintimani, very rare. Other records for *L. muticopsis* (Van Heurck) D. G. Mann: Kania (Alfinito et al., 1989) sub *Navicula muticopsis* Van Heurck.

REMARKS. *Luticola muticopsis* s. str. is known from Antarctic and sub-Antarctic regions, not from tropical zones. Other similar taxa are *L. ventricosa* (Kützing) D. G. Mann in Round et al., 1990 and *L. ventriconfusa* Lange-Bertalot in Lange-Bertalot et al., 2003, both from Europe and possessing lower size dimensions (Lange-Bertalot et al., 2003, pp. 72-74, Pl. 73). The just two specimens observed are very similar to *Luticola* species cf. *muticopsis* in Rumrich et al. (2000), Pl. 61: 9-12.

Luticola cf. ***terminata*** (Hustedt) Johansen in Johansen et al., 2004

DESCRIPTION. Length 43-45 µm; breadth 9-9.5 µm; c. 20 striae in 10 µm at the centre and 24-25 towards the apices (Fig. 134).

DISTRIBUTION. Bumbuna Falls, rare.

Familia MASTOGLOIACEAE Mereschkowsky, 1903

Mastogloia Thwaites in W. Smith, 1856

Mastogloia cf. ***smithii*** Thwaites in W. Smith, 1856

DESCRIPTION. Length 37-39 µm; breadth 8-8.5 µm; c. 20 striae in 10 µm (Figs. 139-140).

DISTRIBUTION. Bumbuna Falls, rare.

REMARKS. This is very probably not a homogeneous taxon; the common concepts are much too broad, it needs a fundamental revision.

Familia NEIDIACEAE Mereschkowsky, 1903

Neidium Pfitzer, 1871

Neidium cf. ***hercynicum*** Mayer, 1915 v. ***hercynicum*** f. ***subrostratum*** Wallace in Reimer, 1959

DESCRIPTION. Length 32-33 µm; breadth 7.5-8 µm; 25-27 striae in 10 µm (Figs. 135-136).

DISTRIBUTION. Bumbuna Falls, rare. Records for *N. hercynicum* Mayer f. *subrostratum* Wallace: River Waanje (Carter & Denny, 1987).

FAMILY NOT DESIGNATED

Nupela Vyverman et Compère, 1991

Nupela cf. ***encyonopsis*** Metzeltin et Lange-Bertalot, 1998

Metzeltin & Lange-Bertalot (1998) Pl. 72: 35-37

DESCRIPTION. Length 17 µm; breadth 4 µm; striae too fine to be resolved by LM (Fig. 67).

DISTRIBUTION. Bumbuna Falls.

REMARKS. As only one specimen was observed, we were not able to carry out SEM examination.

Nupela cf. ***vyvermanii*** Moser, Lange-Bertalot et Metzeltin, 1998

Moser et al. (1998) Pl. 31 : 7-10

DESCRIPTION. Length 14-15 µm; breadth 4-5 µm; c. 30 striae in 10 µm (Figs. 65-66).

DISTRIBUTION. Bumbuna Falls, rare.

REMARKS. Very rare, only two specimens observed, SEM examination is needed.

Familia PINNULARIACEAE D. G. Mann, 1990

Pinnularia Ehrenberg, 1843

Pinnularia borealis Ehrenberg, 1843

Krammer (2000) Pl. 7: 6-13

DESCRIPTION. Length 31-32 µm ; breadth 8 µm; c. 6 striae in 10 µm (Fig. 146).

DISTRIBUTION. Bumbuna Falls, rare. Other records: River Dankale (Mazzoni, 1986).

Pinnularia cf. ***borealis*** Ehrenberg, 1843

DESCRIPTION. Length 37-38 µm; breadth 6-7 µm; c. 5 striae in 10 µm (Figs. 147-149).

DISTRIBUTION. Bumbuna Falls, only two specimens observed.

Pinnularia divergens W. Smith, 1853 v. ***divergens*** sensu lato

DESCRIPTION. Length 50-72 µm; breadth 10-12 µm; c. 10 striae in 10 µm (Fig. 137).

DISTRIBUTION. Bumbuna Falls, not rare. Other records: Sula Hills (Mölder, 1962); Lake Mabesi (Carter & Denny, 1987); Lake Popei (Carter & Denny, 1992).

Pinnularia cf. ***gibbiformis*** Krammer, 1992

DESCRIPTION. Length 82 µm; breadth 8,5 µm; c. 11 striae in 10 µm (Fig. 138).

DISTRIBUTION. Bumbuna Falls, only one specimen observed.

Pinnularia cf. ***graciloides*** Hustedt, 1937

DESCRIPTION. Length 52-69 µm; breadth 8-10 µm; 12-13 striae in 10 µm (Figs. 141-144; Figs. 150-151; Figs. 152-153).

DISTRIBUTION. Bumbuna Falls, not common. Records for *P. graciloides* Hustedt: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Popei (Carter & Denny, 1992).

Pinnularia graphica Carter in Carter & Denny, 1992

Carter & Denny (1992) Pl. 8: 5

DESCRIPTION. Length 39-50 µm; breadth 5-7 µm; 12-14 striae in 10 µm (Figs. 154-155; Figs. 156-159).

DISTRIBUTION. Bumbuna Falls, common; Peak Bintimani, rare. Other records: Lake Sonfon (Carter & Denny, 1992).

REMARKS. Carter in Carter & Denny (1992) described this species from a stream entering Lake Sonfon in S.E. Sector.

Pinnularia cf. ***stricta*** Hustedt, 1937

DESCRIPTION. Length 23-27 µm; breadth 5-5.5 µm; 15-16 striae in 10 µm (Fig. 133).

DISTRIBUTION. Bumbuna Falls, rare.

Familia RHOICOSPHENIACEAE Chen et Zhu, 1983

Rhoicosphenia Grunow, 1860

Rhoicosphenia abbreviata (Agardh) Lange-Bertalot, 1980

Krammer & Lange-Bertalot (1986) Pl. 91: 20-28
Synonym: *R. curvata* (Kütz.) Grunow in Rabenhorst, 1864

DESCRIPTION. Length 26-29 µm. Only seen in girdle view (Figs. 166-167).

DISTRIBUTION. Bumbuna Falls, rare. Other records sub *R. curvata* (Kütz.) Grunow: Sula Hills (Mölder, 1962); River Jong (Carter & Denny, 1982); Lake Mabesi (Carter & Denny, 1987).

Familia STAURONEIDACEAE D. G. Mann, 1990

Stauroneis Ehrenberg, 1843

Stauroneis legumen sensu auct. nonnull. non *S. legumen* (Ehr.) Kützing, 1844

Description. Length 52 µm; breadth 13 µm; c. 28 striae in 10 µm (Fig. 145).

Distribution. Only one specimen observed in Bumbuna Falls samples. Other records for *S. legumen* (Ehr.) Kützing: Lake Mabesi (Carter & Denny, 1987).

Stauroneis resoluta Moser, Lange-Bertalot et Metzeltin, 1998

Moser et al. (1998) Pl. 31: 15; Pl. 32: 1-6.
Metzeltin & Lange-Bertalot (2002) Pl. 46: 6-7

Description. Length 30-35 µm; breadth 7.5-8 µm; c. 28 striae in 10 µm (Figs. 160-165; Figs. 168-169).

Distribution. Bumbuna Falls, not common. New record for Sierra Leone.

Remarks. The size range is slightly higher than that mentioned by Moser et al. (1998).

Familia BACILLARIACEAE Ehrenberg, 1840

Nitzschia Hassall 1845

Nitzschia cf. ***microcephala*** Grunow in Van Heurck, 1881

Description. Length 11-12 µm; breadth 2.5-3 µm; c. 18 fibulae in 10 µm (Figs. 170-171).

Distribution. Bumbuna Falls, rare. Records for *N. microcephala* Grunow in Van Heurck: Sula Hills (Mölder, 1962).

Familia RHOPALODIACEAE (Karsten) Topachevskyi et Oksiyuk, 1960

Synonym: Epithemiaceae sensu Karsten in Engler & Prantl, 1928

Epithemia Brébisson ex Kützing, 1844

Epithemia adnata (Kütz.) Brébisson, 1838

Hofmann et al. (2011) Pl. 119: 5-9

Synonym: *Epithemia zebra* (Ehr.) Kützing, 1844

Description. Length 49-50 µm; breadth 8-10 µm; striae 13-15 in 10 µm and 3.5-4.5 transapical ribs in 10 µm (Fig. 173).

Distribution. Bumbuna Falls, rare. Other records: Lake Sonfon (Carter & Denny, 1992) sub *Epithemia zebra* (Ehr.) Kützing.

Epithemia sorex Kützing, 1844

Hofmann et al. (2011) Pl. 121: 1-7

Description. Length 30 µm; breadth 8.5 µm; c. 14 striae in 10 µm and c. 8 transapical ribs in 10 µm (Fig. 172).

Distribution. Bumbuna Falls, only one specimen observed. New record for Sierra Leone.

Familia SURIRELLACEAE Kützing, 1844

Stenopterobia Brébisson ex Van Heurck, 1896

Stenopterobia cf. ***delicatissima*** (Lewis) Brébisson ex Van Heurck, 1896

Krammer & Lange-Bertalot (1988) Pl. 174: 1-12
Metzeltin & Lange-Bertalot (2002) Pl. 86: 3-4
Synonym: *Surirella delicatissima* Lewis, 1864

Description. Length 38-76 µm; breadth 4-5 µm; c. 28-30 striae in 10 µm (Figs. 174-177; Figs. 178-180).

Distribution. Peak Bintimani, rare; Bumbuna Falls, quite frequent. Other records: Kangari Sula (Mölder, 1962), River Jong (Carter & Denny, 1982), Carter & Denny, 1987 (without localities), Guma Dam (Fumanti et al., 1990), Lake Sonfon, Lake Popei (Carter & Denny, 1992) sub *Surirella delicatissima* Lewis; Bathurst Falls (Fumanti, 1994).

Surirella Turpin, 1828

Surirella linearis W. Smith, 1853 v. ***constricta*** Grunow, 1862

Huber-Pestalozzi (1942) Fig. 602 c

DESCRIPTION. Length 71-73 µm; breadth 16-17 µm; c. 25-26 alar canals in 100 µm (Figs. 181-183; Figs. 184-185).

DISTRIBUTION. Bumbuna Falls, not common. Other records: Kangari Sula (Mölder, 1962); River Jong (Carter & Denny, 1982); River Dankale (Mazzoni, 1986); Lake Mabesi (Carter & Denny, 1987); Lake Sonfon (Carter & Denny, 1992).

REMARKS. It is not unlikely that this African population is heterospecific vs. holarctic *S. linearis* (compare Werum & Lange-Bertalot, 2004, Pls. 98-99).

TAXONOMICAL AND BIOGEOGRAPHIC CONCLUSION

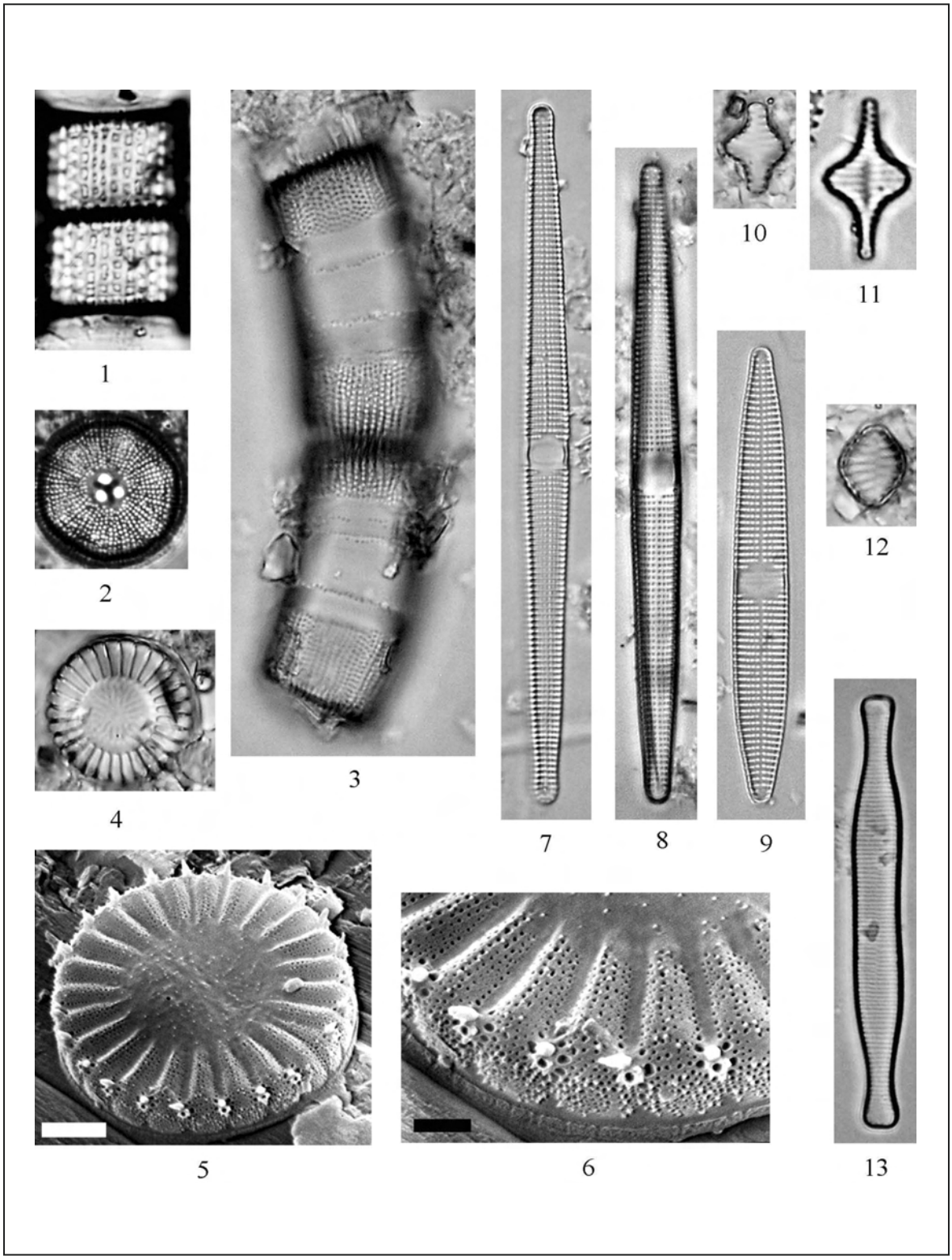
During the present study a total of 65 taxa, beloging to 31 genera, were identified. Of these, 12 are reported for the first time in Sierra Leone. Considering the two sites, Bumbuna Falls is significantly richer, with 58 taxa, while diversity in the samples from Peak Bintimani is much lower, with only 22 Taxa. Numerous dubious holarctic taxa, marked with cf. that need further SEM observations, are very probably new to science.

It is a matter of fact that in tropical regions not only the vascular plants but likewise the diatom flora of higher mountains differs fundamentally from that of plains and lower to medium altitude mountain ranges. This was shown for instance for the Neotropics in a strict sense in comparison to the High Andes (Metzeltin & Lange-Bertalot, 1998; 2007; Rumrich et al., 2000). In West Africa, belonging to the Paleotropics, the situation is as yet less well known. In particular a critical analysis of diatom records for the highlands is necessary here. Checklists of various authors (Woodhead & Tweed, 1958; Alfinito, 2011) record numerous taxa commonly known from Holartic regions of Eurasia and North America, together with a minor number of geographically restricted West African taxa which were described during later decades of the 20th century, mainly by Carter & Denny (1982; 1987; 1992). Some others have been noted which were described originally from subtropical areas of South Africa by Cholnoky (e.g. 1957; 1958; 1960; 1962; 1966). Whilst occurrence of African indigenous taxa is widely incontestable mainly identifications as Holarctic species appear doubtful and need a critical revision. Since description of new taxa is not the aim of this preliminary paper such dubious Holarctic species, suspected to be new to science, are noted here as "cf." (species to compare to) expecting a differential diagnosis later on. Appropriate examples are the illustrated species (LM and SEM) of the genera *Frustulia* and *Brachysira* that roughly resemble "prominent" Holarctic species concerning valve outlines and size dimensions but clearly differ when the entire set of morphological characters is compared (see Figs. 65-91 and 111-126).

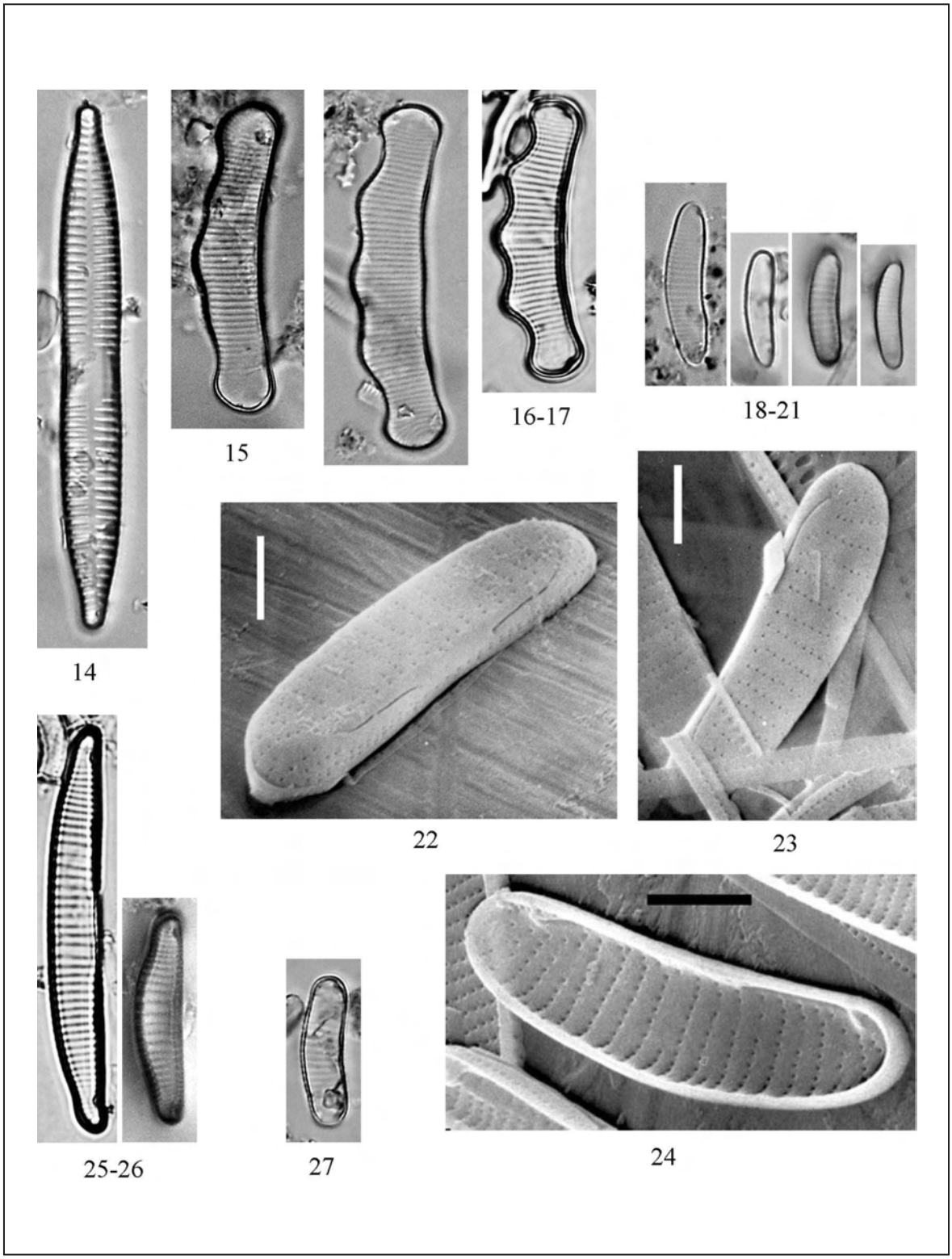
Without doubt, cosmopolitan taxa do exist, particularly in intermittently dry/wet habitats as rockpools. Common examples are *Orthoseira roeseana*, *Achnanthes inflata*, *Pinnularia borealis* sensu lato, *Luticola* spp. or *halophilous* taxa like *Ctenophora pulchella*. Moreover, the true identity of rarely occurring *Epithemia adnata*, *E. sorex* or *Cocconeis pediculus* is barely questionable. However, a majority of the frequent and / or abundant diatoms is as yet unknown; many may represent "elements" either of the tropical African flora or of the Paleotropics more generally, both insufficiently investigated up to recently. *Frustulia* cf. *undosa* (Figs. 119 - 126) appears rather closely related to that Neotropical taxon. It is an example among few other ones which shows more or less resemblance to "sister taxa" from the Neotropics. *Cymbella kappii*, originally widespread only in Africa could be observed later on likewise in a lake of Bosnia, the Balkans (Krammer, 2002, p. 71).

Actinella brasiliensis may serve as an example for a Pantropical taxon of the Eunotiaceae but it has to be taken into consideration that a heterogeneous species complex is concerned in this case including the questionable variety *sierra-leonensis* Woodhead et Tweed, 1957.

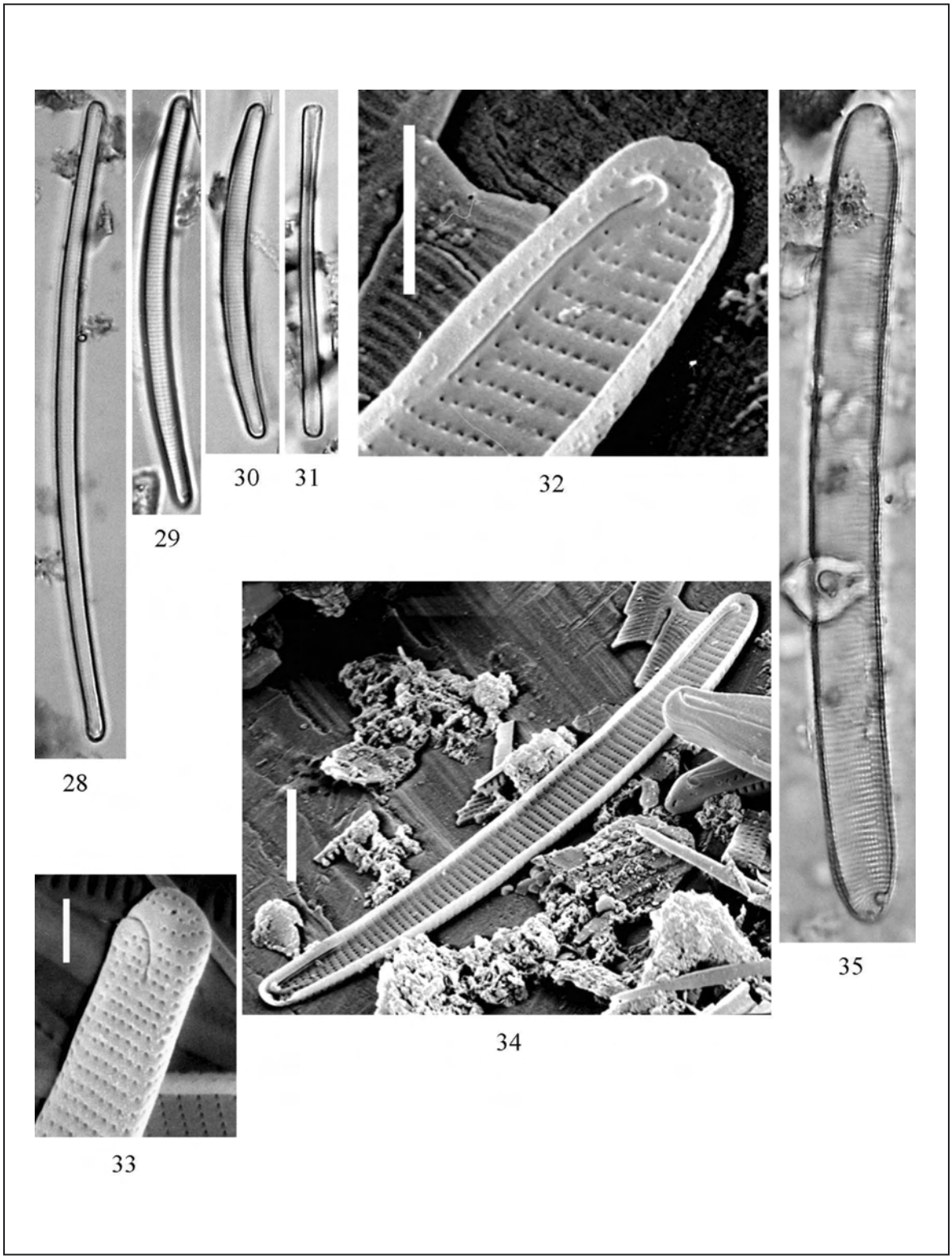
The majority of the observed *Eunotia* species of the investigated montaneous areas of Sierra Leone seem to be undescribed from elsewhere. They may represent endemicities of tropical Africa or prove as more widespread taxa of the Paleotropics, provided that more detailed knowledge can be achieved in the future from this,specifically for diatoms, widely neglected plant realm.



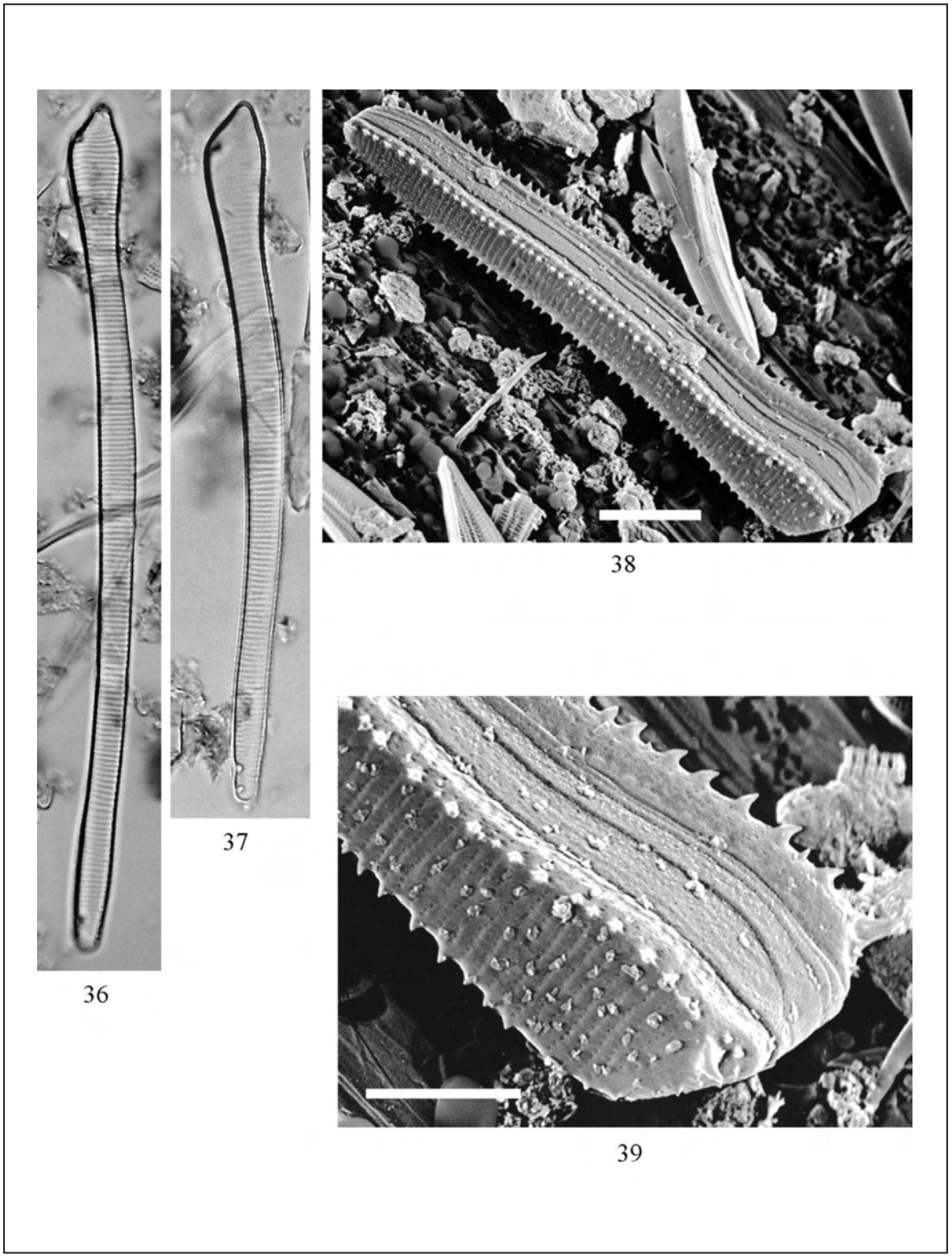
Figures 1-13. LM: x1500. Fig. 1: *Aulacoseira granulata* v. *valida*. Figs. 2, 3: *Orthoseira roeseana*. Figs. 4-6: *Cyclotella meneghiniana*. Figs. 5, 6: idem, SEM, valve outside (5: scale bar = 2 µm; 6: scale bar = 1 µm). Figs. 7-9: *Ctenophora pulchella.* Fig. 10: *Staurosira construens*. Fig. 11: *Staurosira* cf. *longirostris*. Fig. 12: *Staurosira venter*. Fig. 13: *Fragilaria* cf. *javanica*.



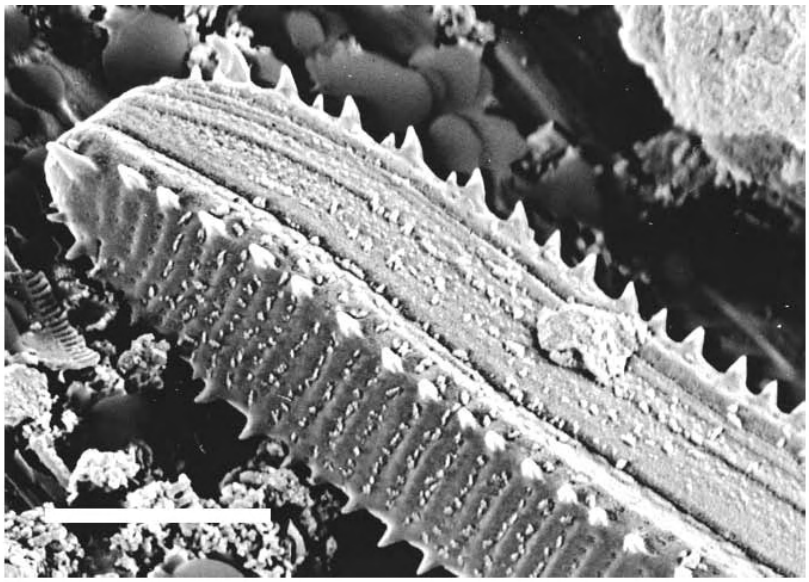
Figures 14-27. LM: x1500; SEM: Figs. 22-24 scale bar = 2 µm. Fig. 14: *Ulnaria* cf. *ulna*. Fig. 15: *Eunotia rabenhorstii* v. *triodon*. Figs. 16, 17: *E.* cf. *cristagalli* and cf. *tecta*. Figs. 18-24: *E. rhomboidea* (Figs. 22, 23 valve outside; Fig. 24 valve inside). Figs. 25-26: *E.* cf. *minor*. Fig. 27: *E. vumbae*.



Figures 28-35. LM: x1500. SEM: Fig. 32 scale bar = 2 µm; Fig. 34 scale bar = 5 µm; Fig. 33 scale bar = 1 µm. Figs. 28-34: *Eunotia naegelii* (Figs. 32, 34 valve inside; Fig. 33 valve outside). Fig. 35: *E. rabenhorstiana*.



Figures 36-39. LM: Fig. 36 x1000; Fig. 37 x1500; SEM: Fig. 38 scale bar = 10 µm; Fig. 39 scale bar = 5 µm. Figs. 36-39: *Actinella brasiliensis* (Figs. 38, 39 valve outside).



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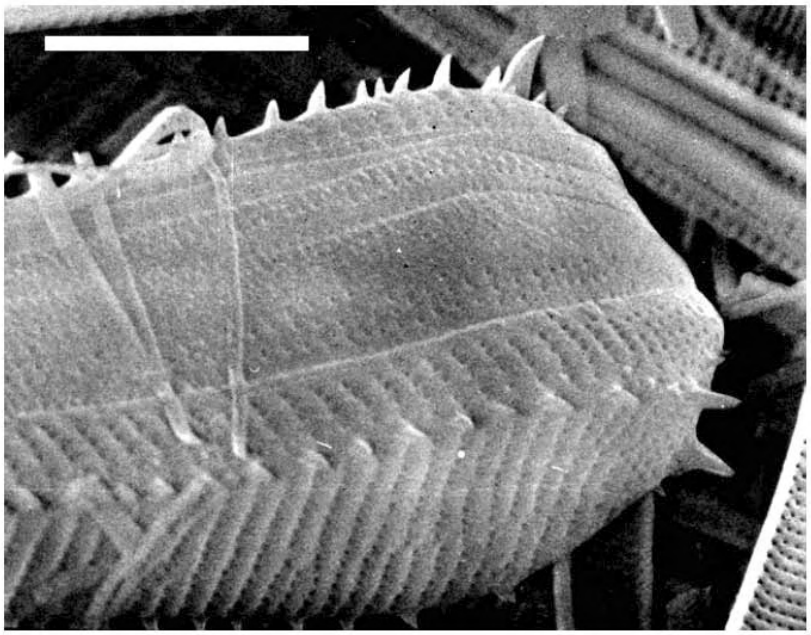

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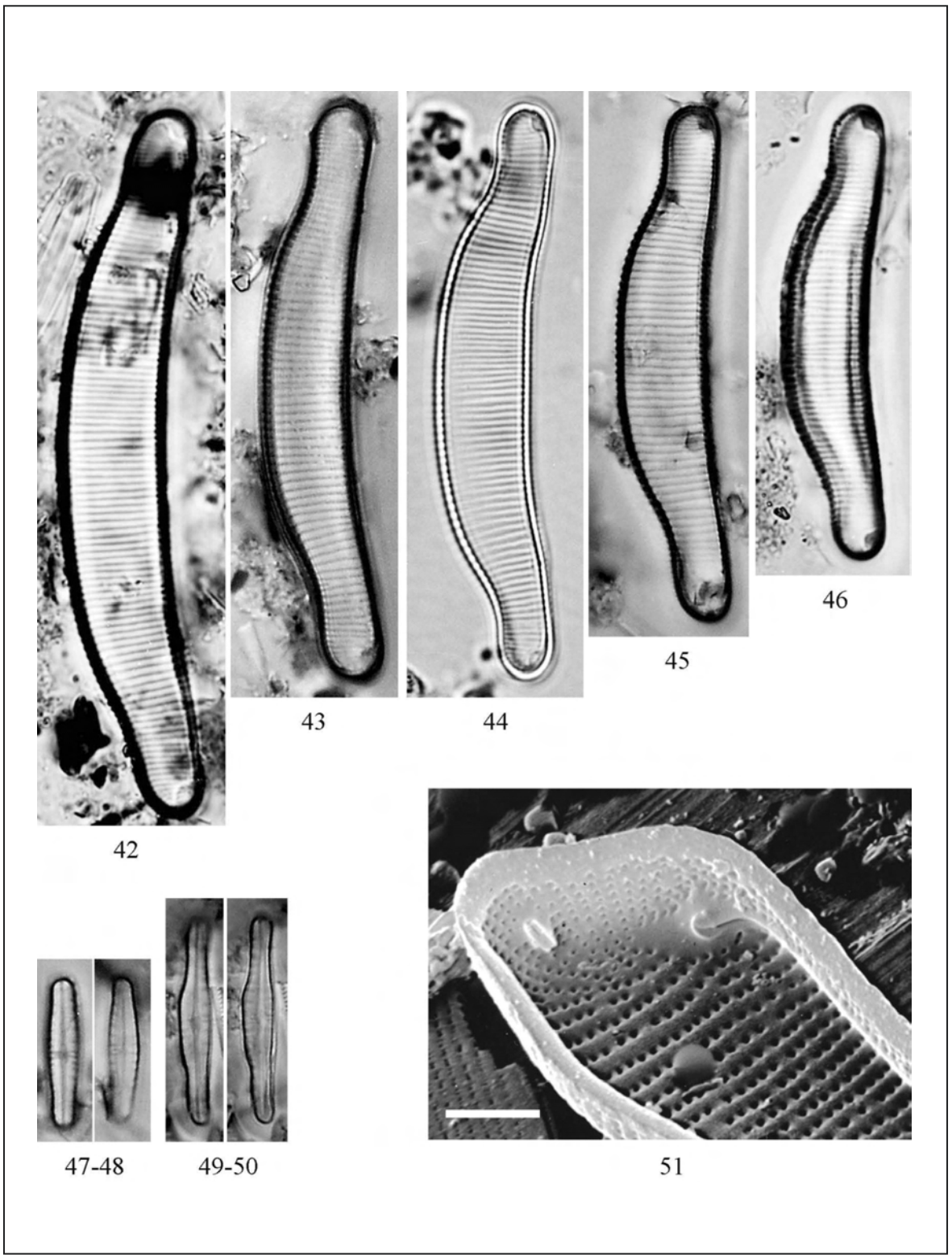
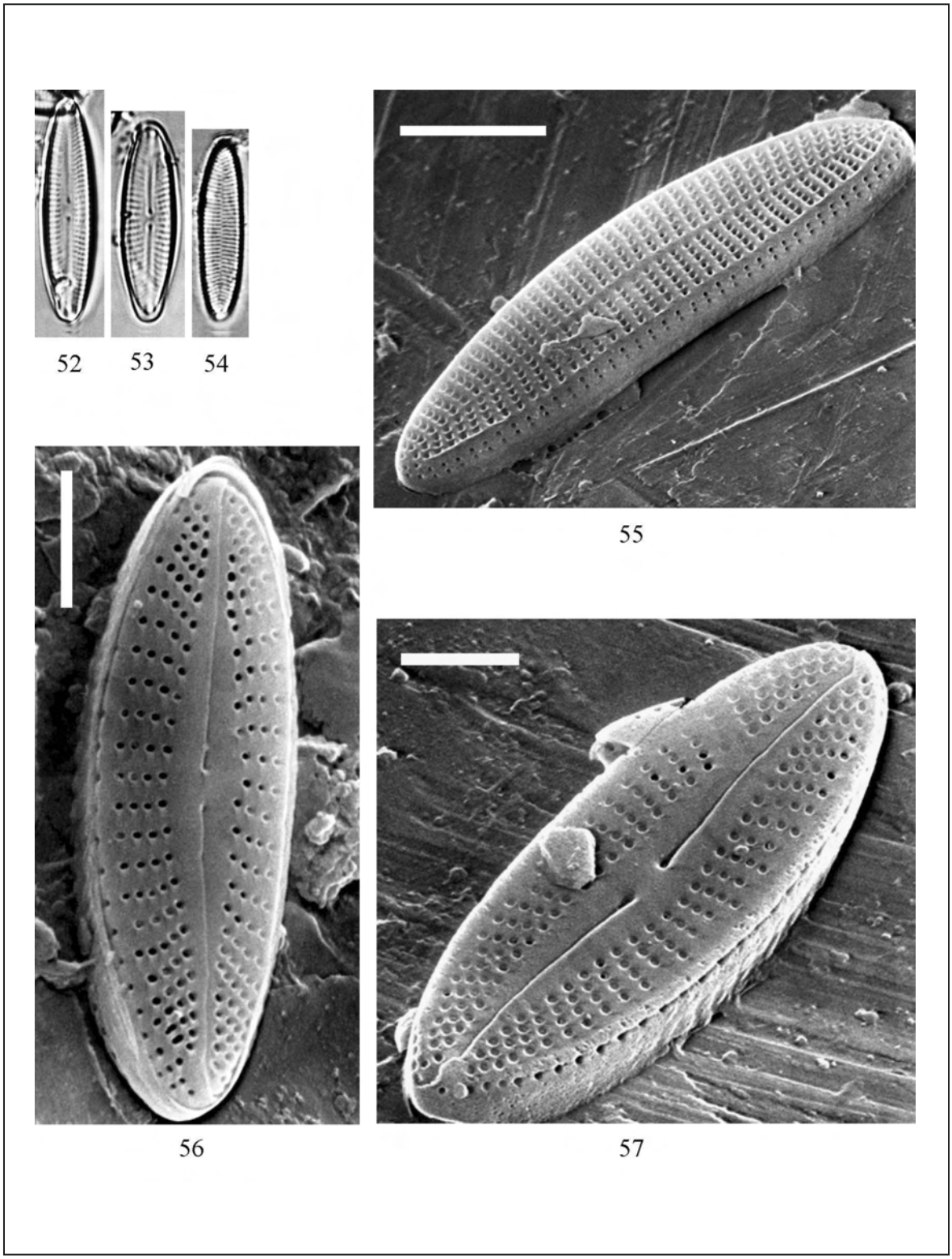
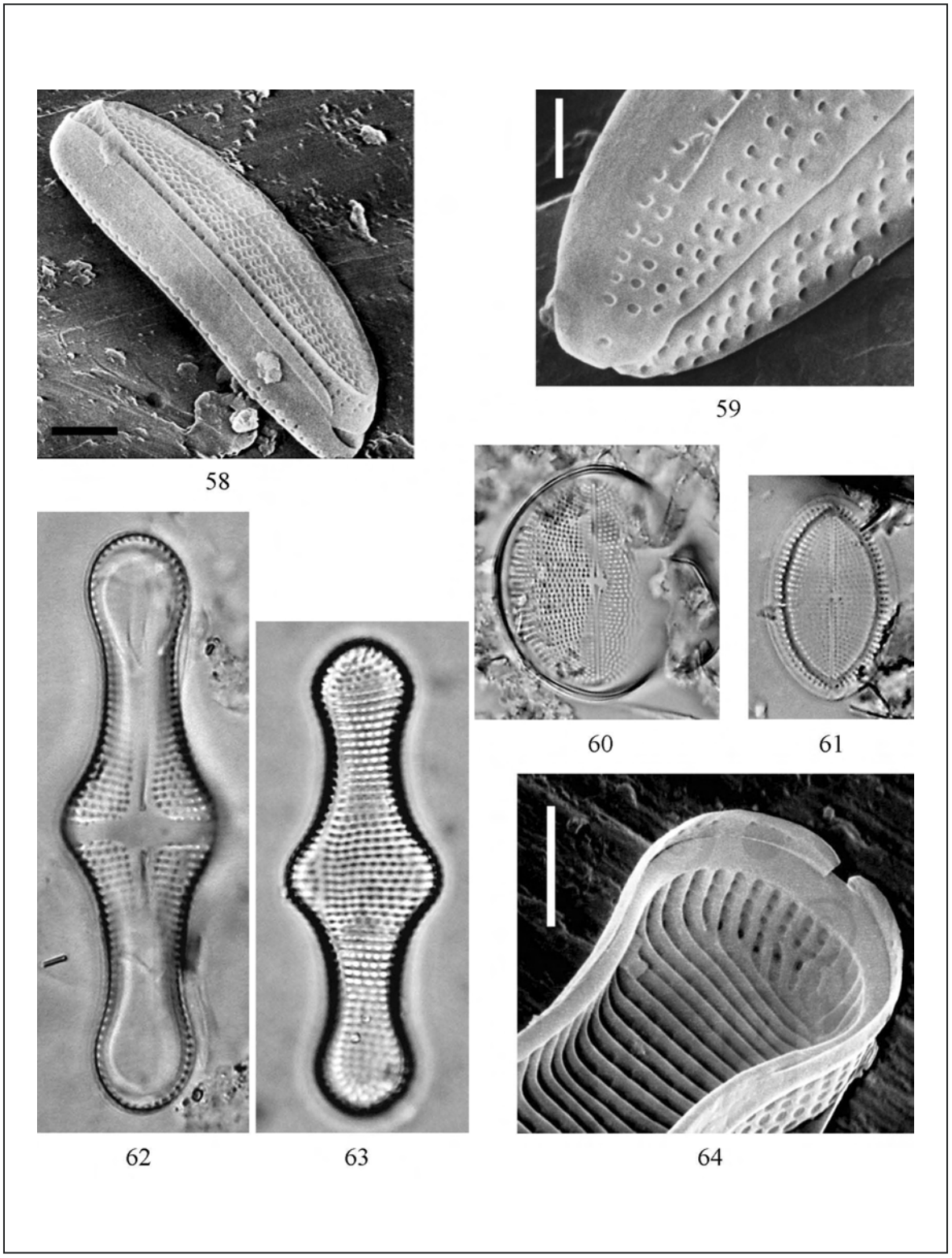
Figures 40, 41. *Actinella brasiliensis*, valve outside, SEM, scale bar = 5 μm.



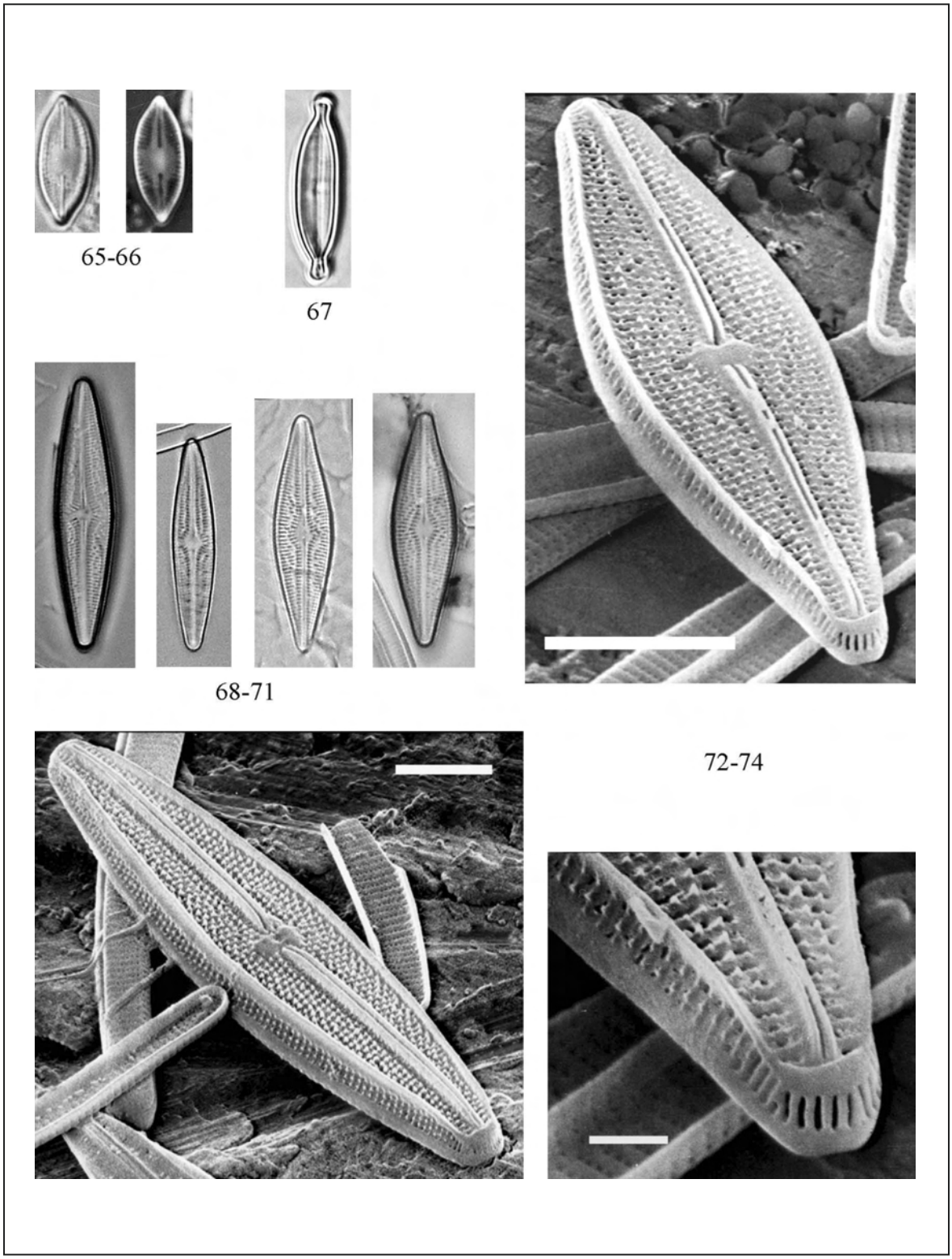
Figures 42-51. LM: x1500; SEM: scale bar = 2 µm. Figs. 42-46: *Eunotia* cf. *crassula*. Figs. 47, 48: *Achnanthidium taiaense*. Figs. 49, 50, idem, possible post-initial cell. Fig. 51: *Actinella brasiliensis*, valve inside.



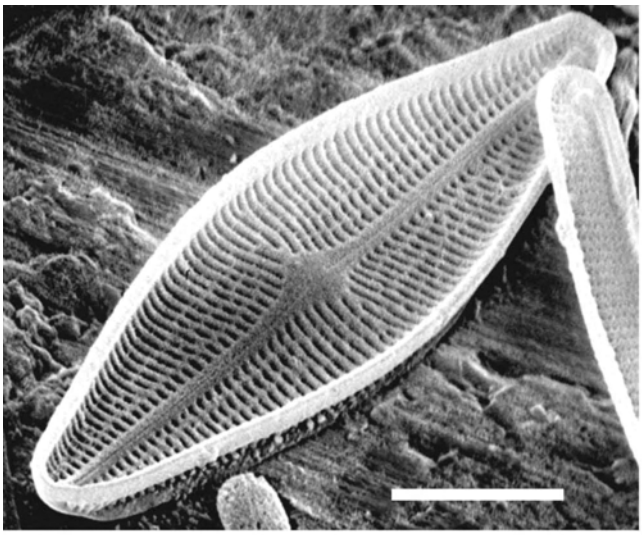
Figures 52-57. LM: x1500; SEM: Fig 55 scale bar = 5 µm; Fig. 56 scale bar = 2 µm; Fig. 57 scale bar = 1 µm. Figs. 52-57: *Achnanthidium subhudsonis*. Fig. 55: rapheless valve outside. Figs. 56-57: raphe valve outside.



Figures 58-64. LM: x1500; SEM: Fig. 58 scale bar = 2 µm; Fig. 59 scale bar = 1 µm; Fig. 64 scale bar = 5 µm. Figs. 58, 59: *Achnanthidium subhudsonis* (Fig. 58: rapheless valve outside; Fig. 59: raphe valve outside). Fig. 60: *Cocconeis pediculus*. Fig. 61: *Cocconeis placentula*. Figs. 62-64: *Achnanthes inflata*. (Fig. 64: rapheless valve inside).



Figures 65-74. LM: x1500; SEM: scale bar = 5 µm. Figs. 65, 66: *Nupela* cf. *vyvermanii*. Fig. 67: *Nupela* cf. *encyonopsis*. Figs. 68-74: *Brachysira* cf. *brebissonii* (Figs. 72-74: valve outside).



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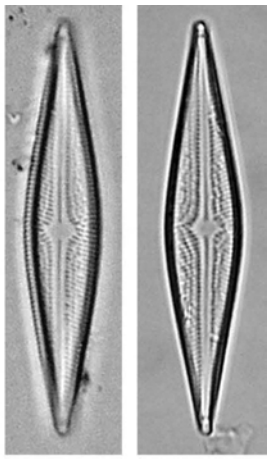

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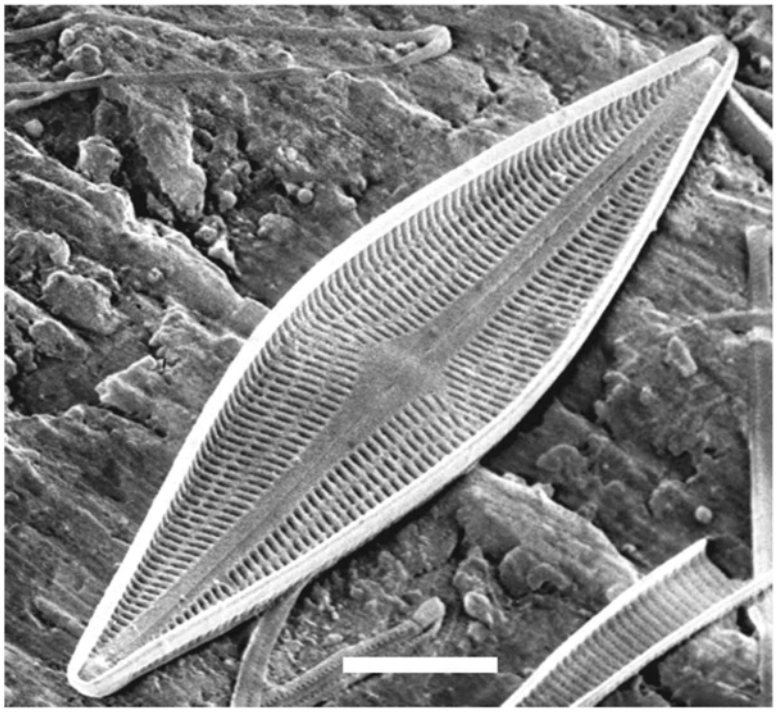

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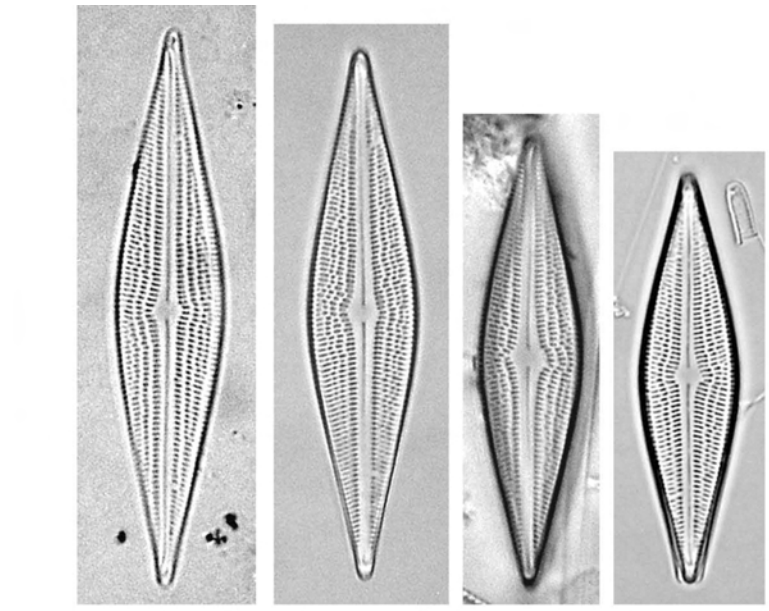
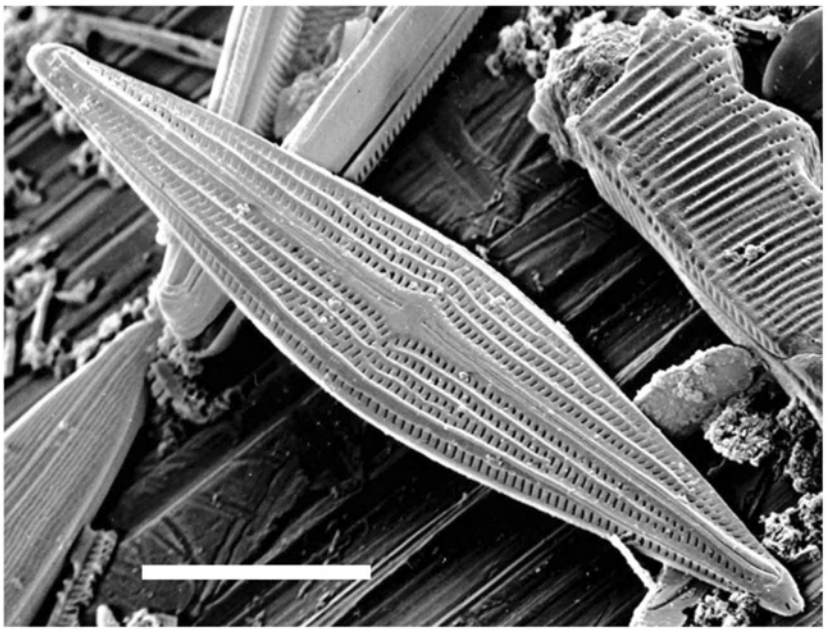
Figures 75-78. LM: x1500; SEM: scale bar = 5 µm. Fig. 75: *Brachysira* cf. *brebissonii*, valve inside. Figs. 76-78: *Brachysira* cf. *metzeltinii* (Fig. 78: valve inside).



79 80 81 82



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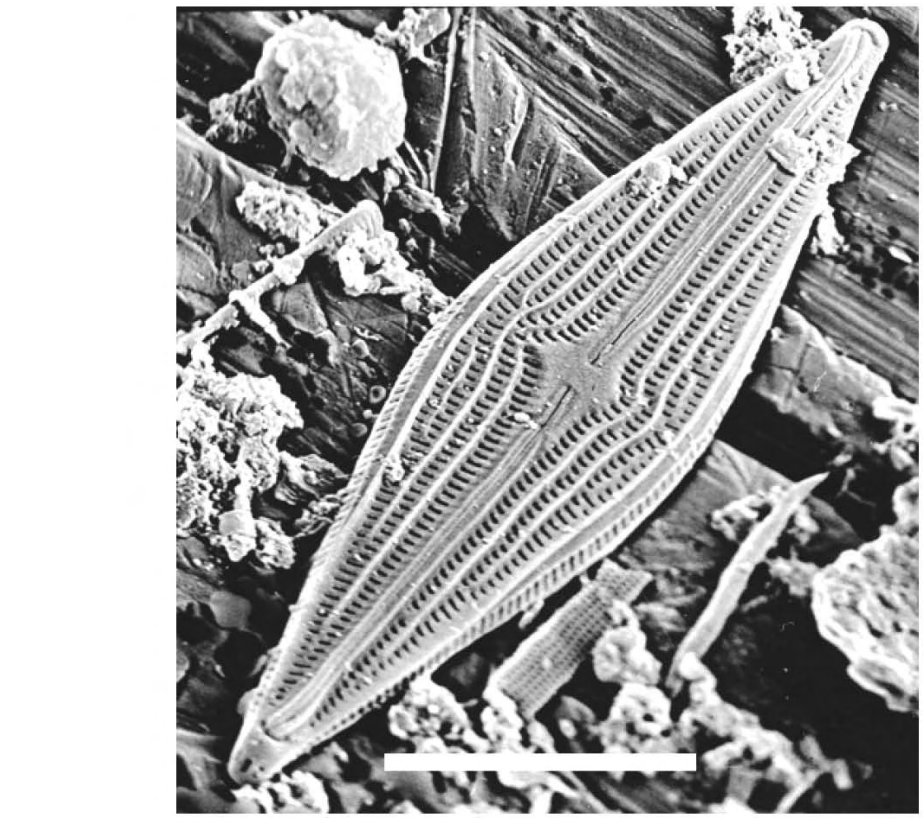
Figures 79-83. LM: x1500; SEM: scale bar = 10 µm. Figs. 79-83: *Brachysira* cf. *wygaschii* (Fig. 83: valve outside).



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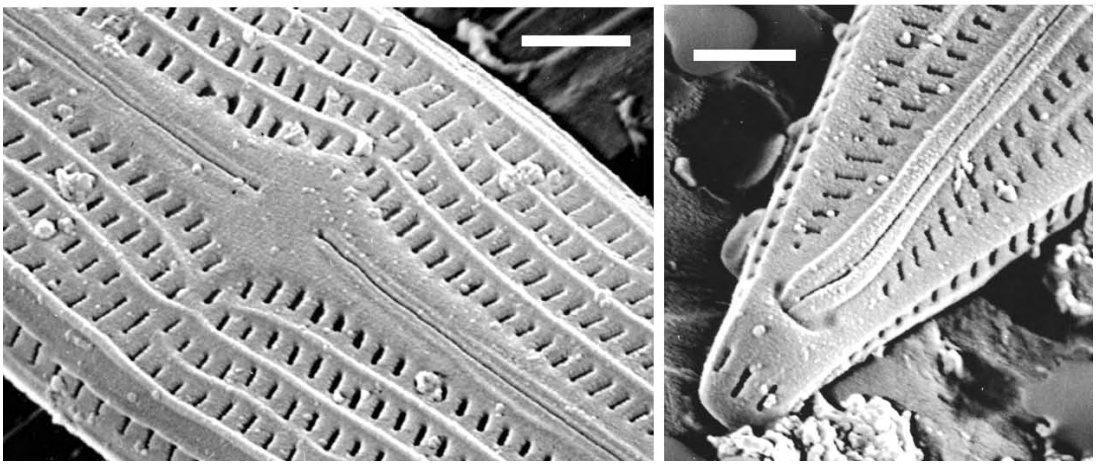
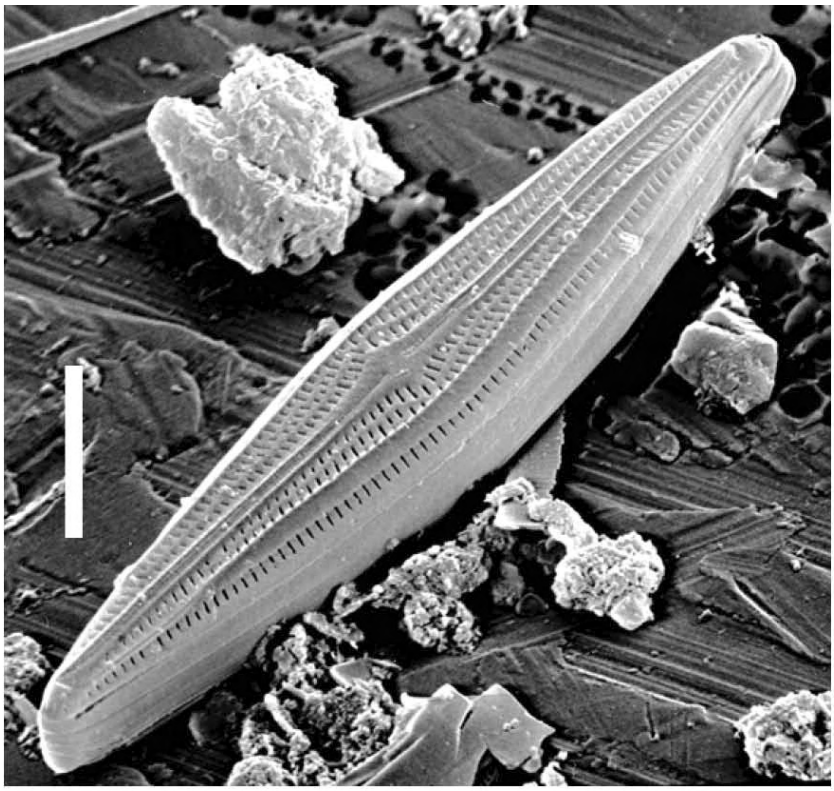


Figures 84-86. SEM: Fig. 84 scale bar = 10 µm; Fig. 85 scale bar = 2 µm; Fig. 86 scale bar = 1 µm. Figs. 84-86: *Brachysira* cf. *wygaschii*, valve outside.



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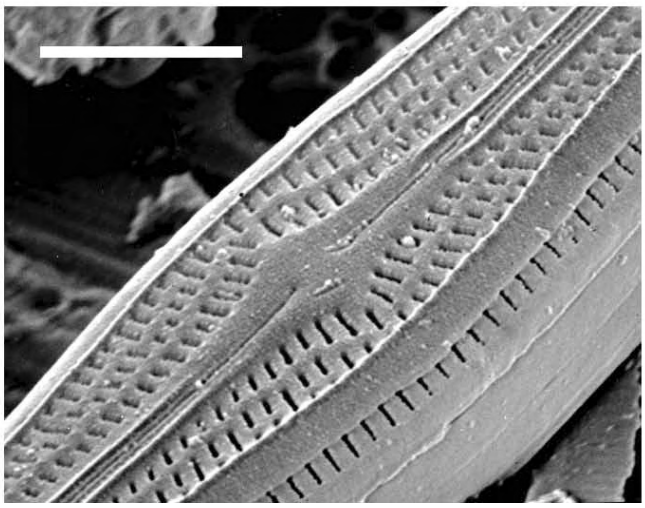
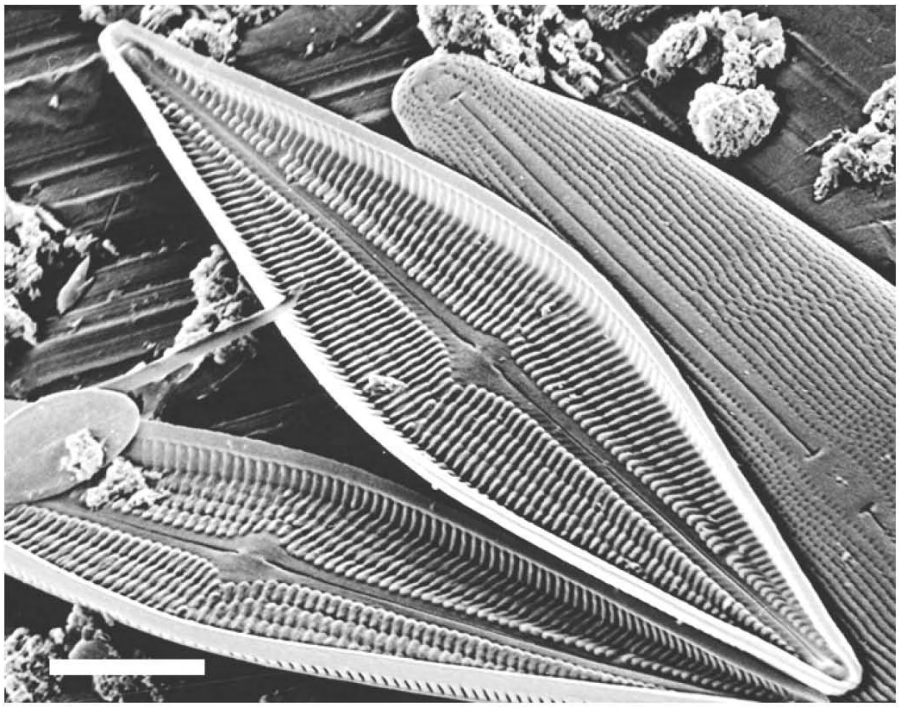


Figures 87-88. SEM: Fig. 87 scale bar = 5 µm; Fig. 88 scale bar = 2 µm. Figs. 87, 88: *Brachysira* cf. *wygaschii*, valve outside.



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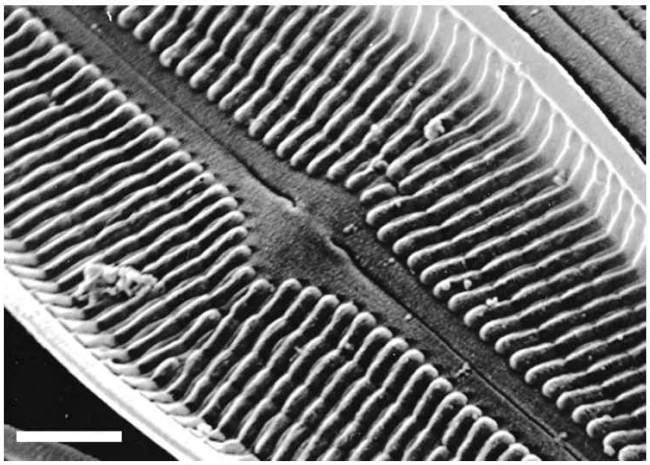

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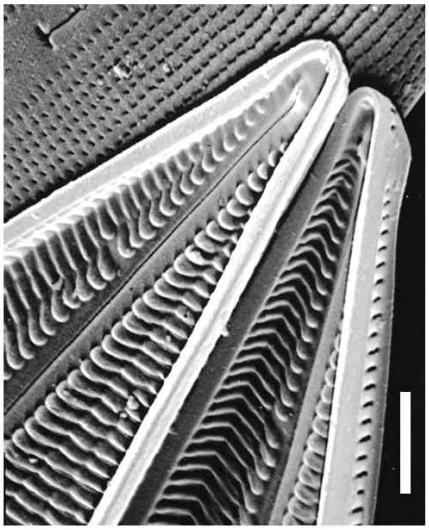

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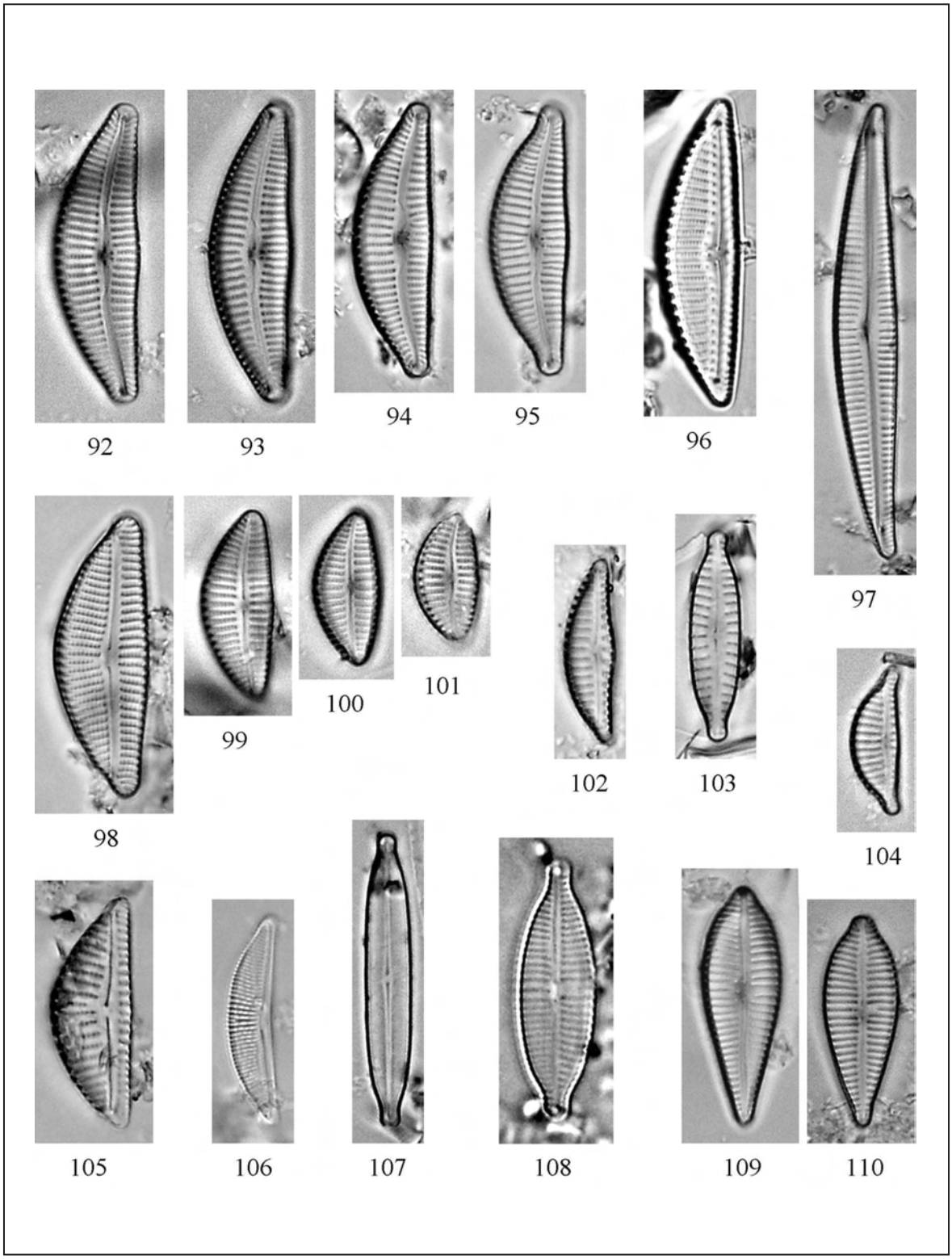
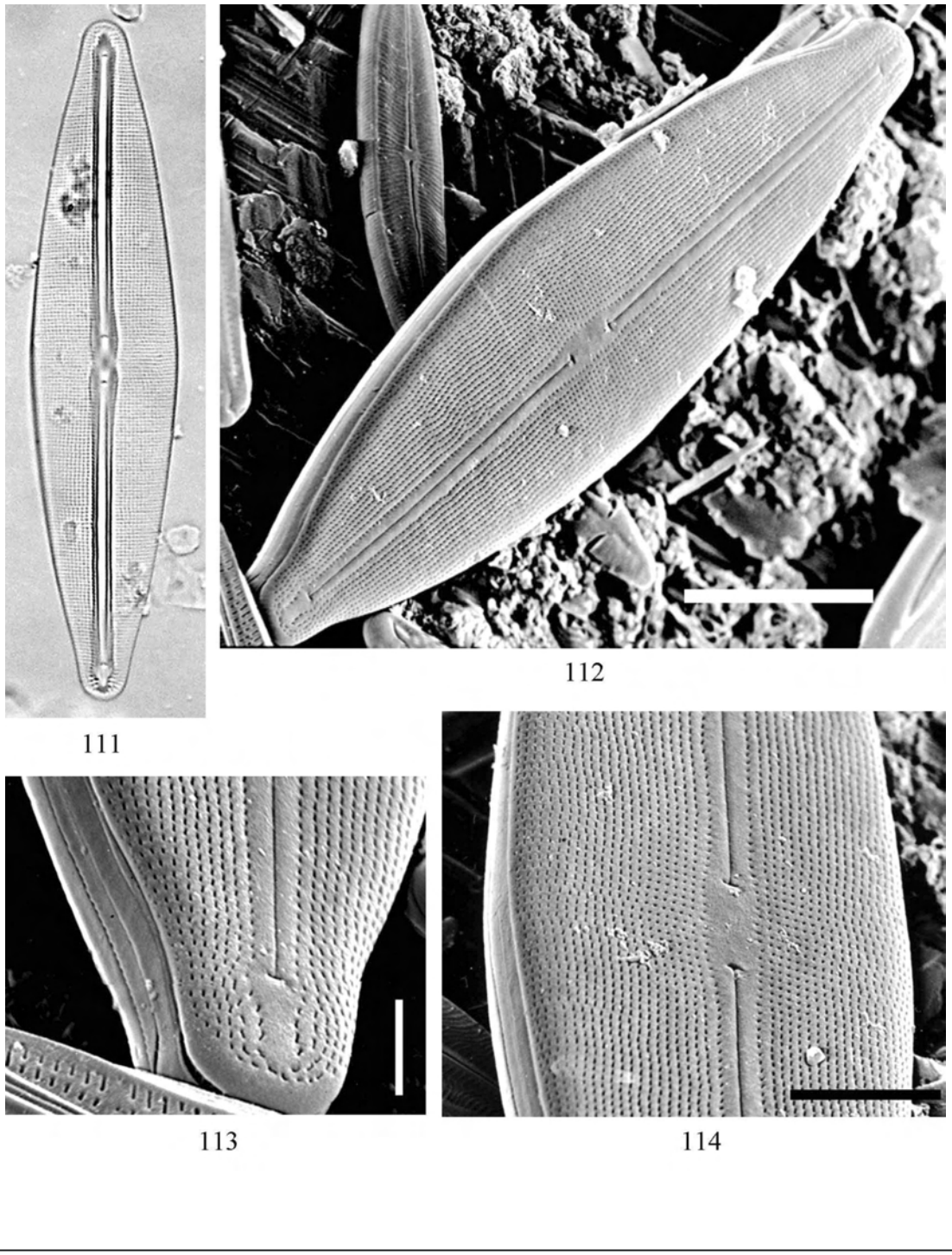
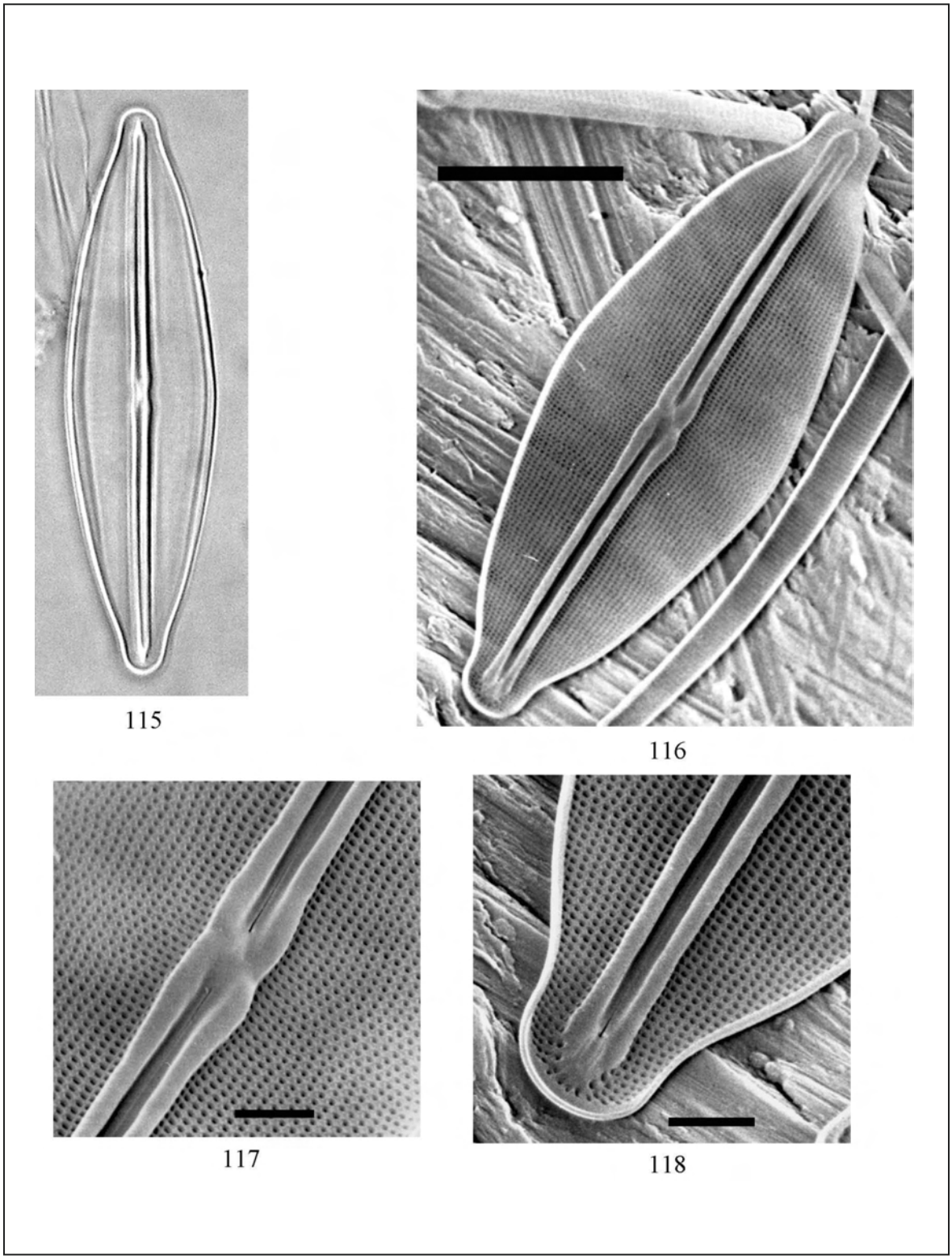
Figures 89-91. SEM: Fig. 89 scale bar = 5 µm; Figs. 90, 91 scale bar = 2 µm. Figs. 89-91: *Brachysira* cf. *wygaschii,* valve inside.



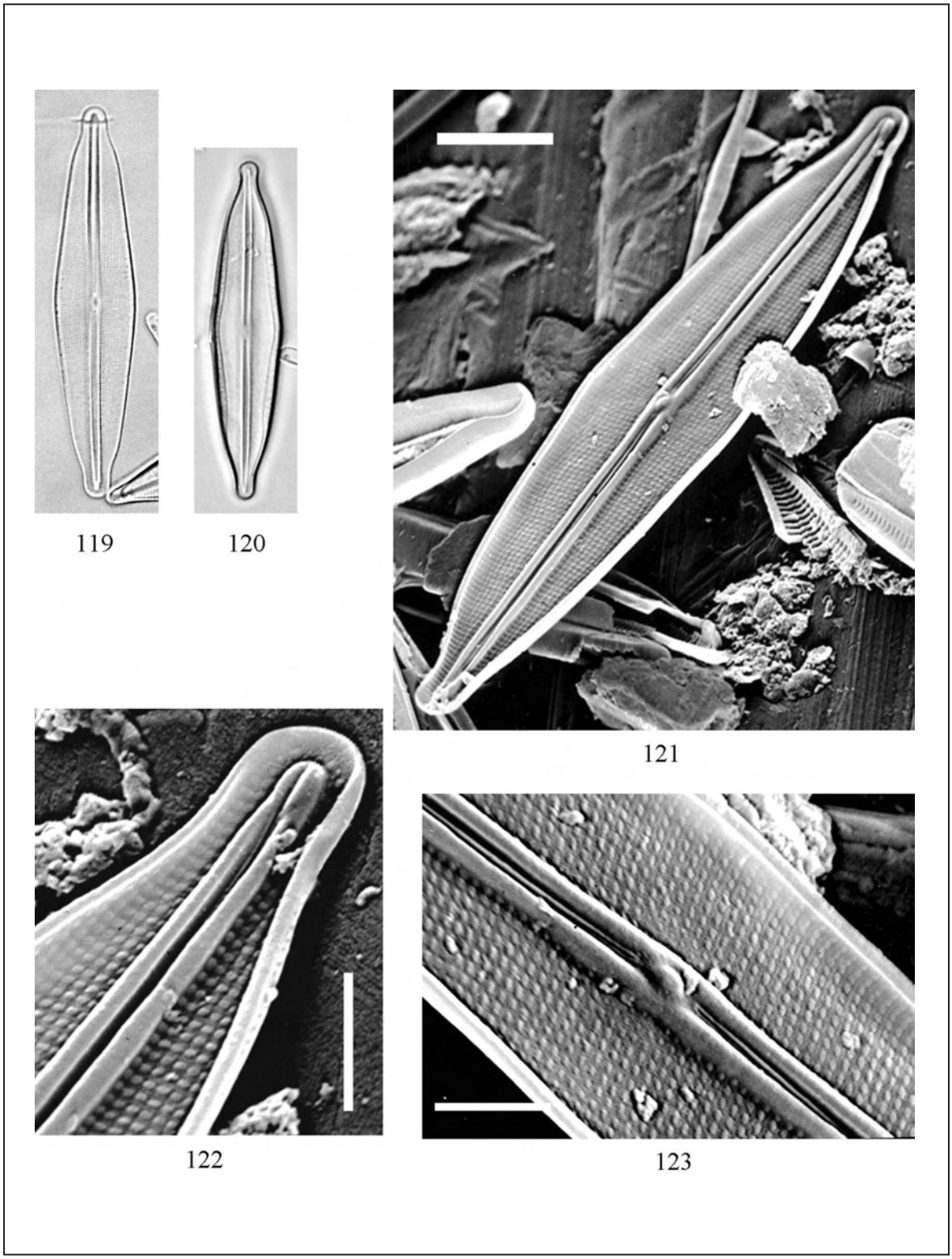
Figures 92-110. LM: x1500. Figs. 92-95: *Cymbella kappii*. Fig. 96: *Encyonema neomesianum*. Fig. 97: *E. neogracile* var. *tenuipunctata*. Figs. 98-101: *E.* cf. *auerswaldii*. Fig. 102: *E.* cf. *javanicum*. Fig. 103: *Encyonopsis* cf. *schubartii*. Fig. 104: *Encyonema* cf. *ventricosum*. Fig. 105: *Encyonema* cf. *subelginense*. Fig. 106: *Halamphora veneta*. Fig. 107: *Kobayasiella* cf. *subtilissima.* Fig. 108: *Gomphonema* cf. *lagenula*. Figs. 109-110: *G. pseudoaugur.*



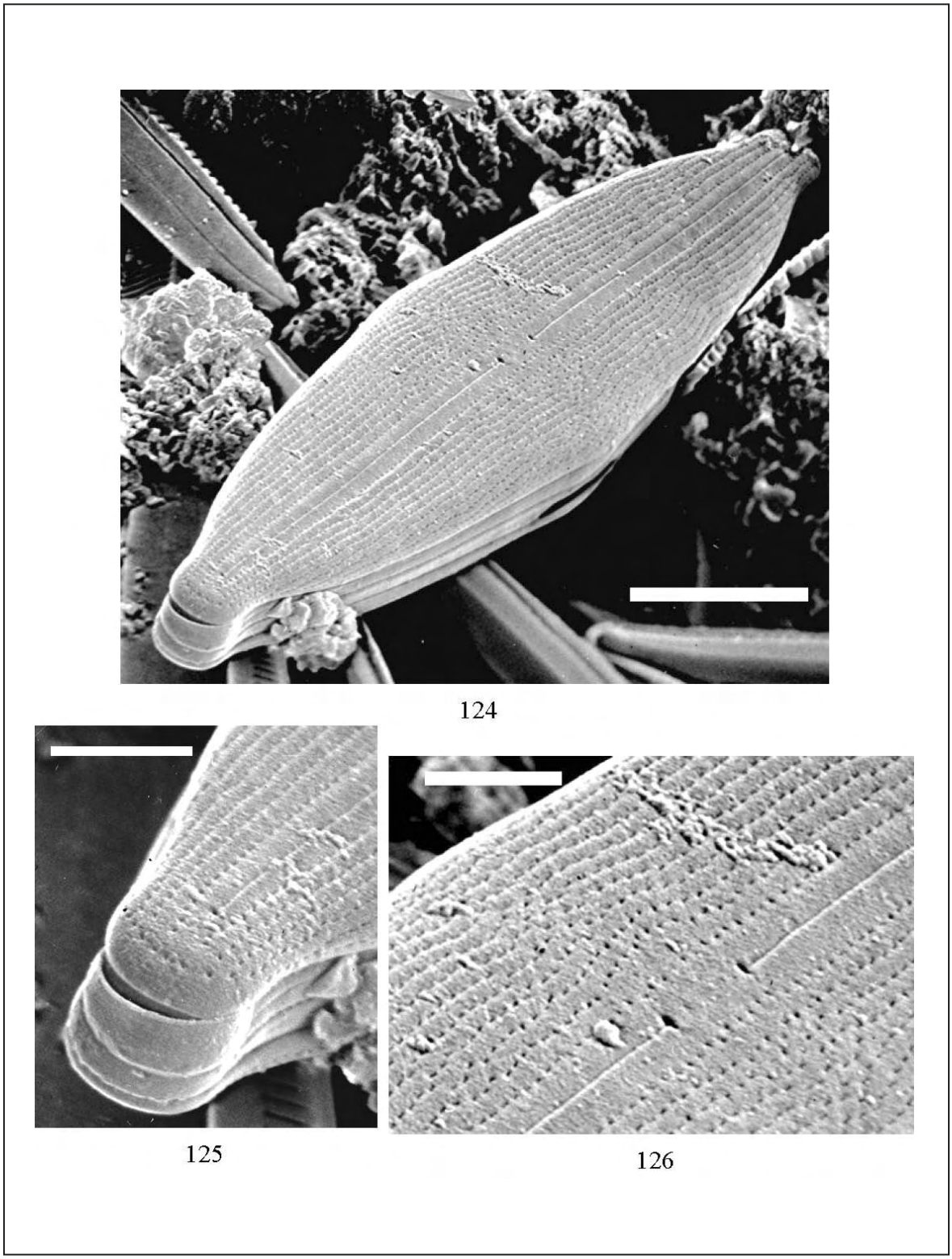
Figures 111-114. LM: x1500; SEM: Fig. 112 scale bar = 10 µm; Fig. 113 scale bar = 5 µm; Fig. 114 scale bar = 2 µm. Figs. 111-114: *Frustulia* cf. *saxonica* (Figs. 112-114: valve outside).



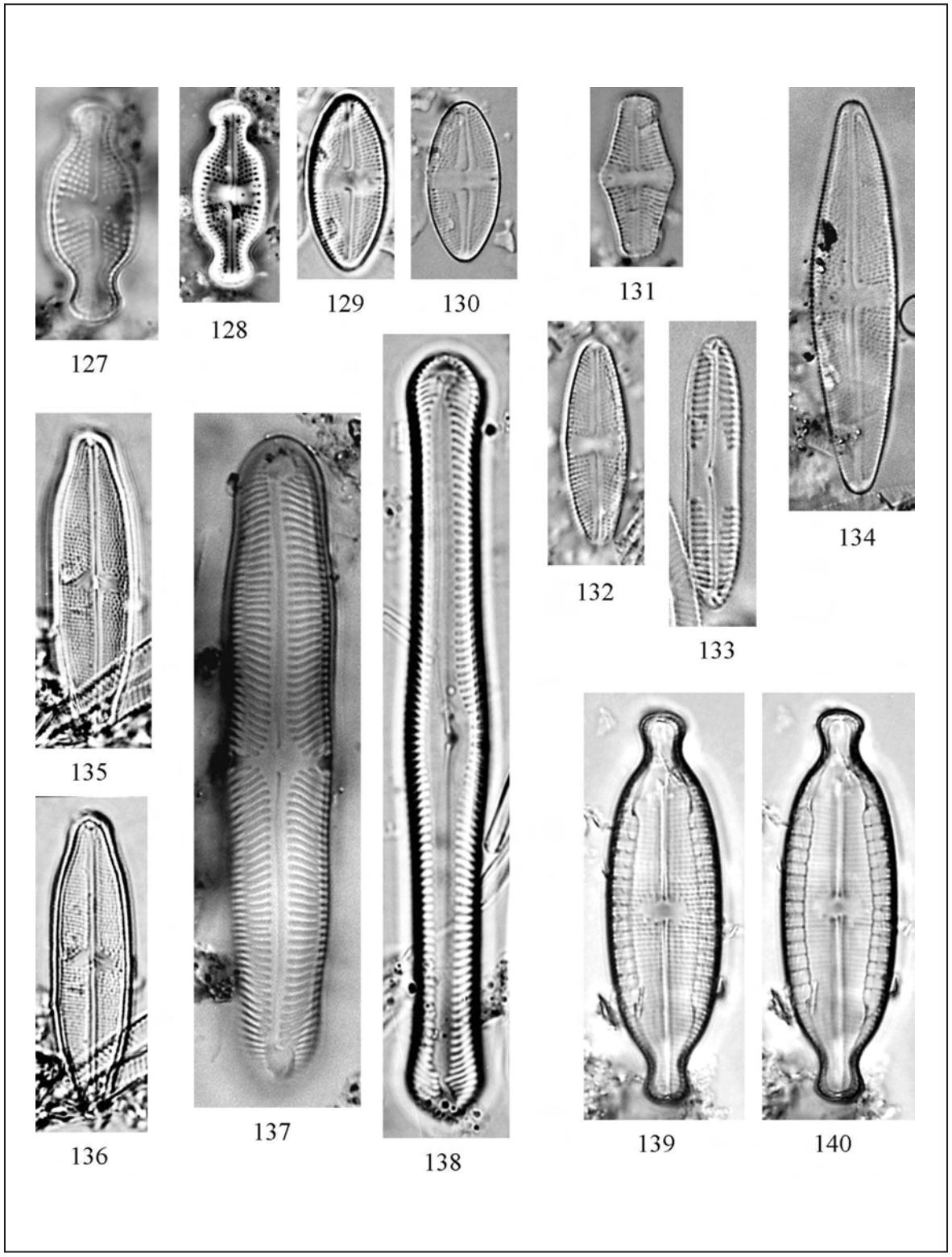
Figures 115-118. LM: x1500; SEM: Fig. 116 scale bar = 10 µm; Figs. 117, 118 scale bar = 2 µm. Figs. 115-118: *Frustulia* cf. *crassinervia* (Figs. 116-118: valve inside).



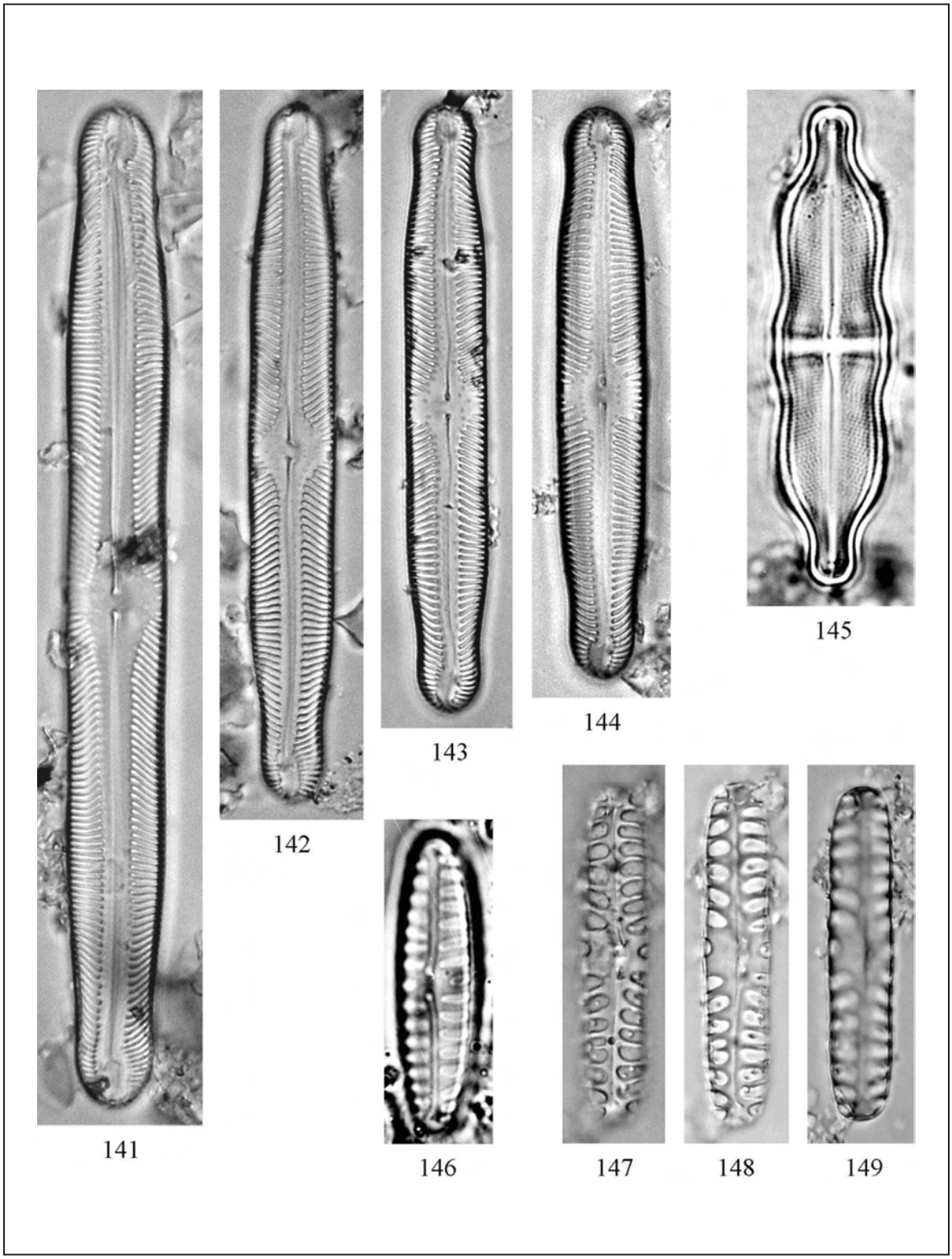
Figures 119-123. LM: x1500; SEM: Fig. 121 scale bar = 10 µm; Figs. 122, 123 scale bar = 2 µm. Figs. 119-123: *Frustulia* cf. *undosa* (Figs. 121-123: valve inside).



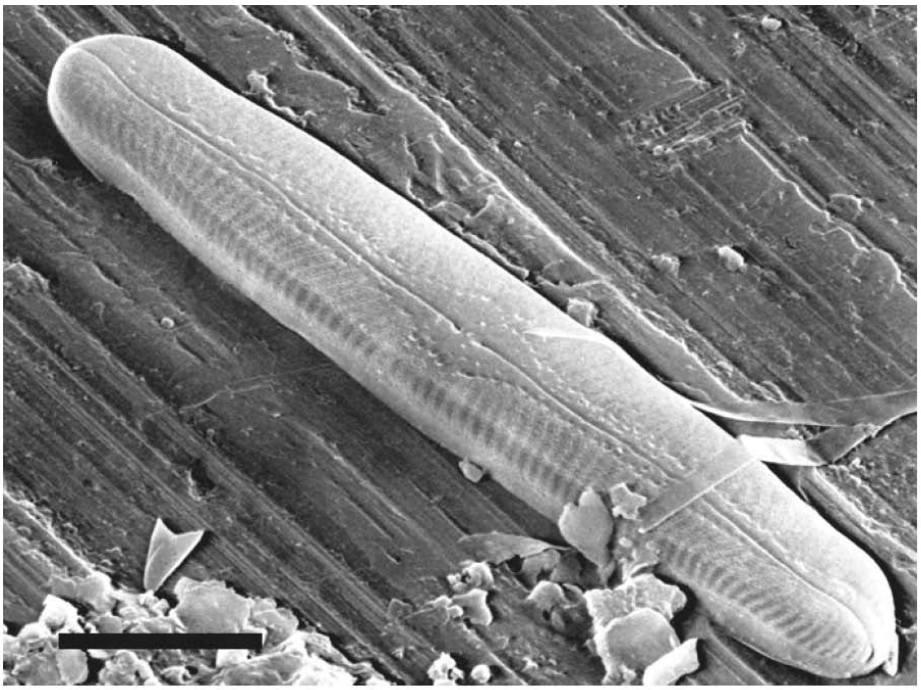
Figures 124-126. SEM: Fig. 124 scale bar = 5 µm; Figs. 125, 126 scale bar = 2 µm. Figs. 124-126: *Frustulia* cf. *undosa*, valve outside.



Figs. 127-140. LM: x1500. Figs. 127, 128: *Luticola* cf. *muticopsis*. Figs. 129, 130: *Luticola muticoides*. Fig. 131: *L. aequatorialis*. Fig. 132: L. cf. *mutica*. Fig. 133: *Pinnularia* cf. *stricta*. Fig. 134: *Luticola* cf. *terminata*. Figs. 135, 136: *Neidium* cf. *hercynicum* v. *hercynicum* f. *subrostratum.* Fig. 137: *Pinnularia divergens* v. *divergens* sensu lato. Fig.138: *P.* cf. *gibbiformis*. Figs. 139, 140: *Mastogloia* cf. *smithii*.



Figures 141-149. LM: x1500. Figs. 141-144: *Pinnularia* cf. *graciloides*. Fig. 145: *Stauroneis legumen* sensu auct. non-null., non *S. legumen* (Ehr.) Kützing, 1844. Fig. 146: *Pinnularia borealis*. Figs. 147-149: *P.* cf. *borealis*.



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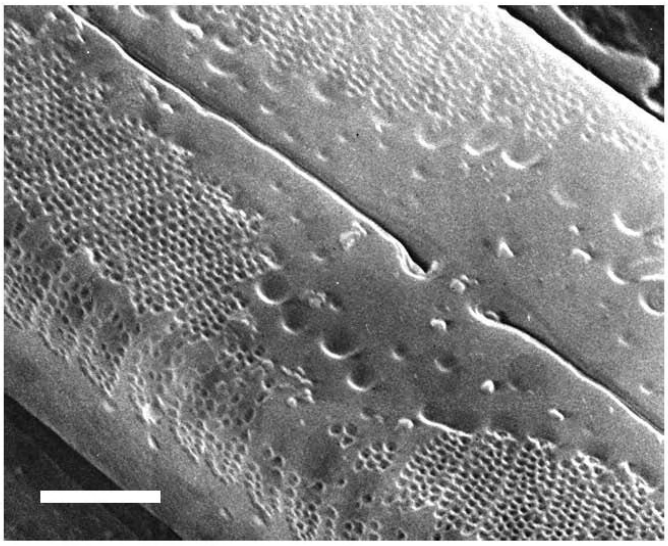
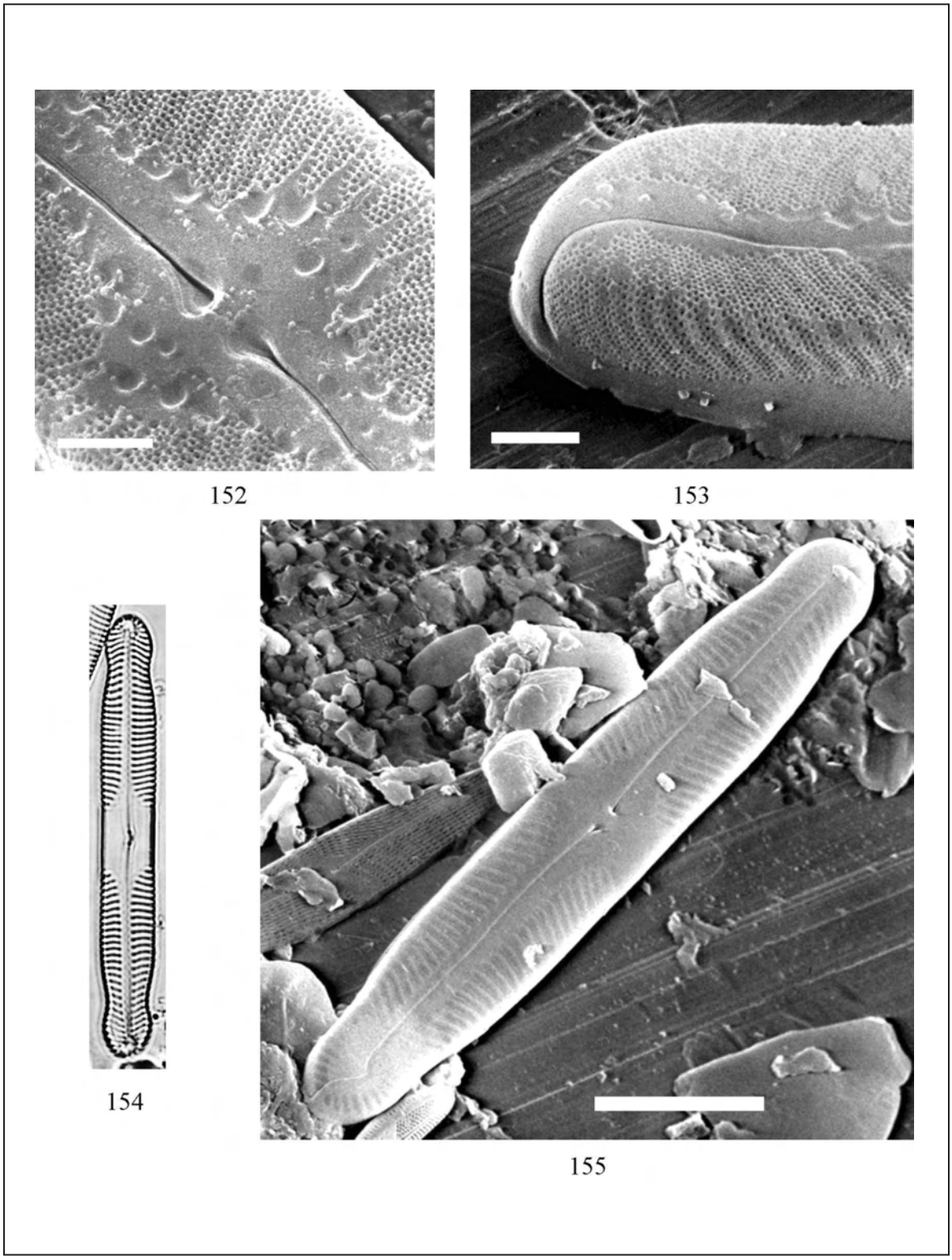
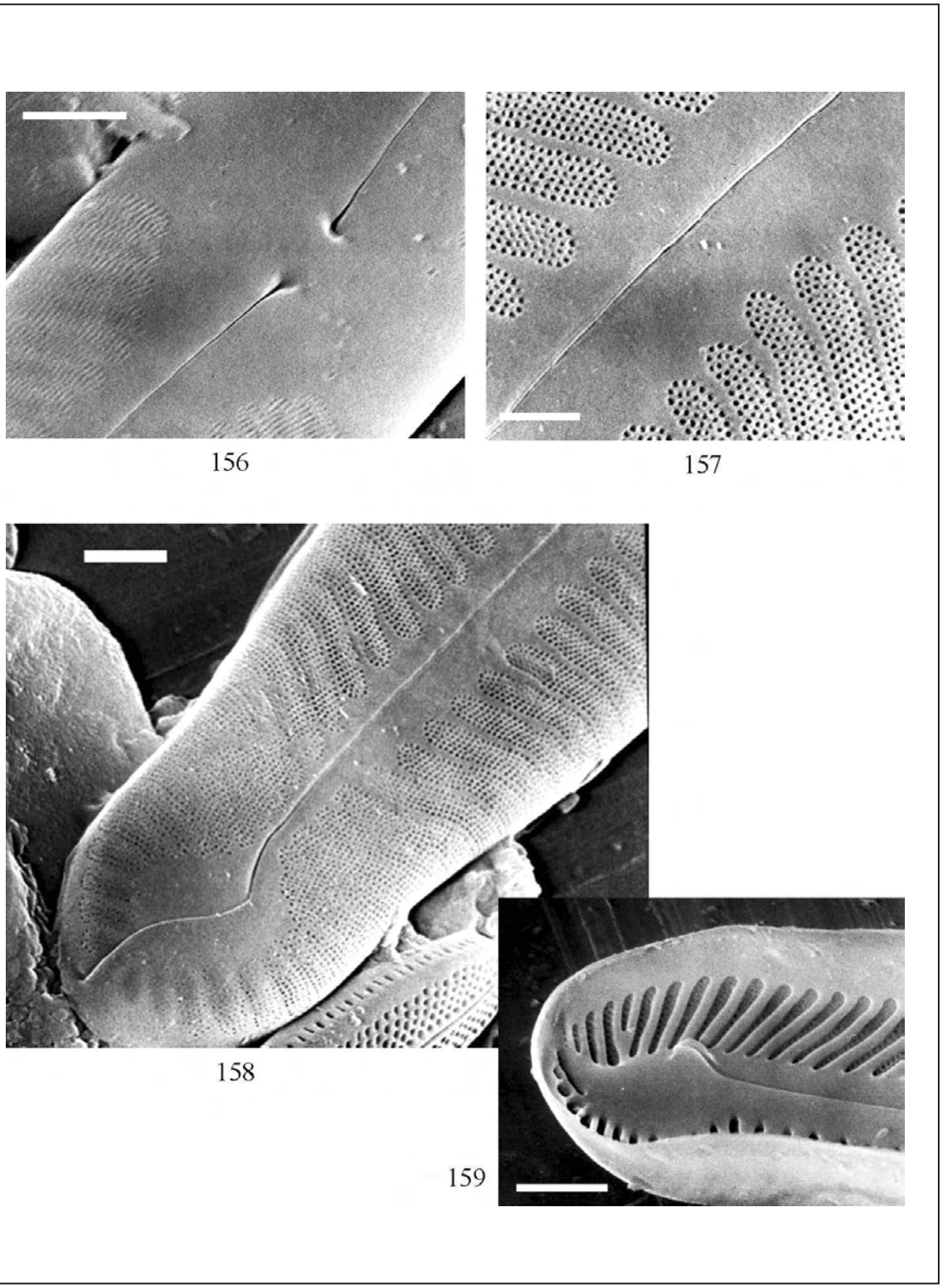


151

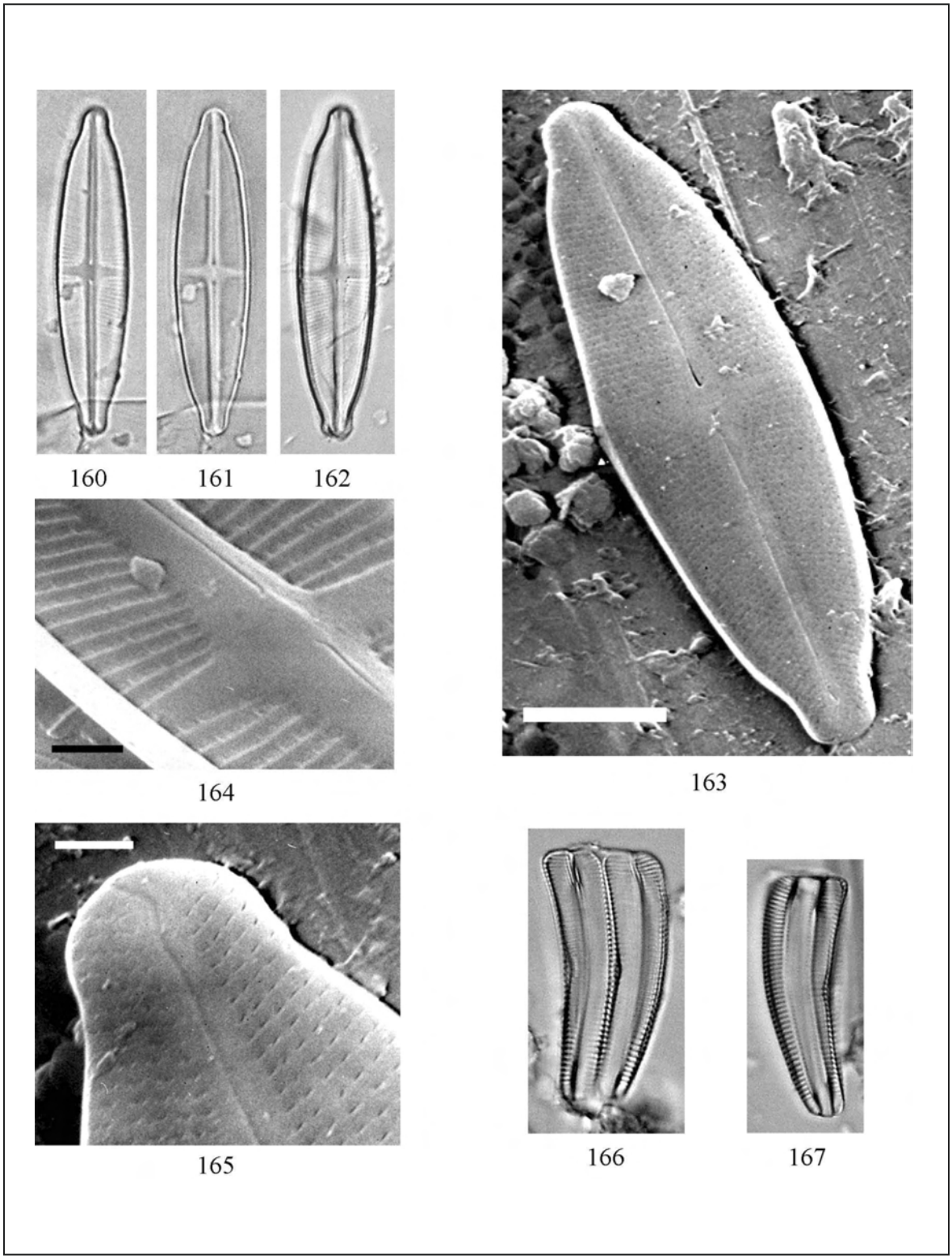
Figures 150, 151. SEM: Fig. 150 scale bar = 10 µm; Fig. 151 scale bar = 2 µm. Figs. 150, 151: *Pinnularia* cf. *graciloides*, valve outside.



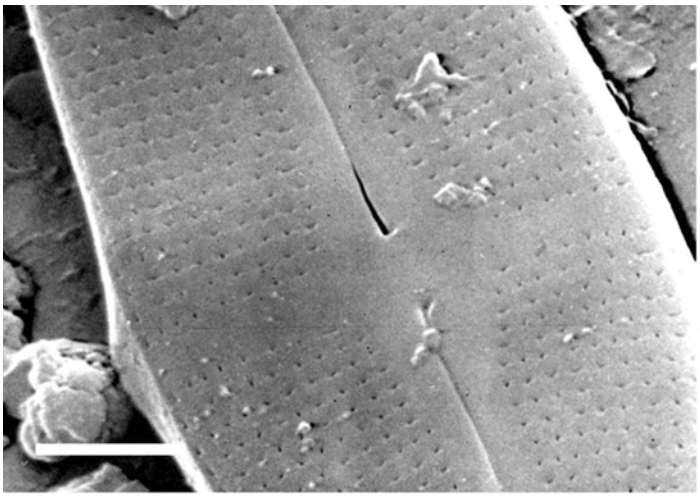
Figures 152-155. LM: x1500; SEM: Figs. 152, 153 scale bar = 2 µm; Fig. 155 scale bar = 10 µm. Figs. 152, 153: *Pinnularia* cf. *graciloides*, valve outside. Figs. 154, 155: *P. graphica* (Fig. 155: valve outside).



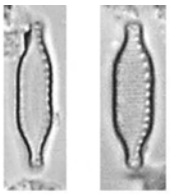
Figures 156-159. SEM: Figs 156, 158, 159 scale bar = 2 µm; Fig. 157 scale bar = 1 µm. Figs. 156-159: *Pinnularia graphica* (Figs. 156-158: valve outside; Fig. 159: valve inside).



Figures 164-167. LM: x1500; SEM: Fig. 163 scale bar = 10 µm; Figs. 164, 165 scale bar = 1 µm. Figs. 160-165: *Stauroneis resoluta* (Figs. 163, 164: valve outside; Fig. 165: valve inside). Figs. 166, 167: *Rhoicosphenia abbreviata*.



168



170 171

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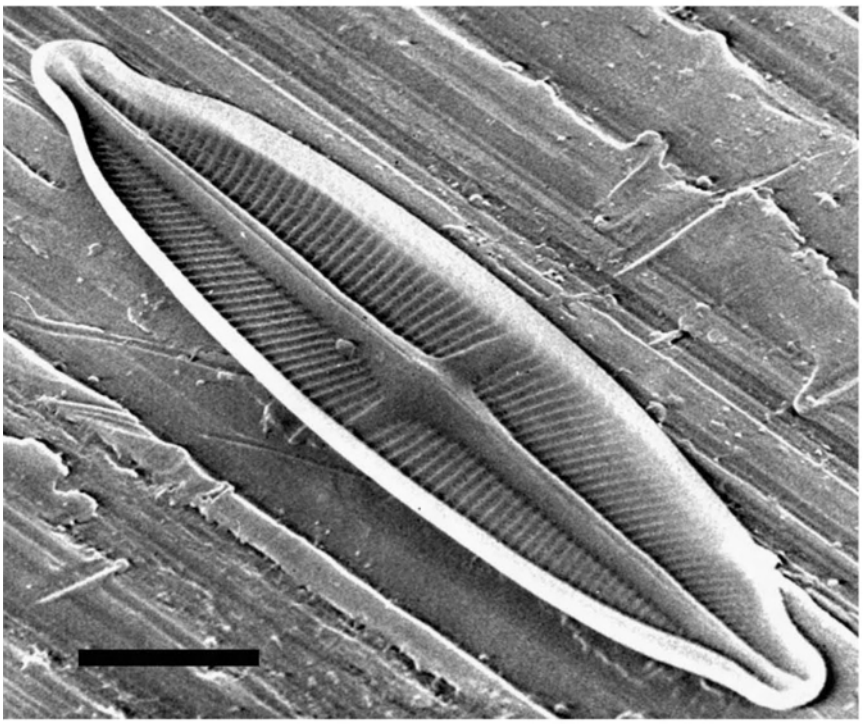

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173

Figures 168, 173. LM: x1500; SEM: Fig. 168 scale bar = 2 µm; Fig. 169 scale bar = 5 µm. Figs. 168, 169: *Stauroneis resoluta* (Fig. 168: valve outside; Fig. 169: valve inside). Figs. 170, 171: *Nitzschia* cf. *microcephala*. Fig. 172: *Epithemia sorex*. Fig. 173: *E. adnata*.

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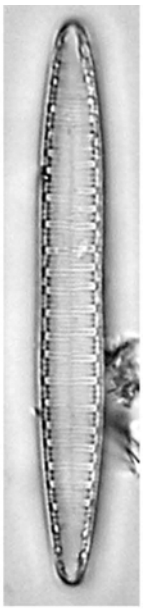
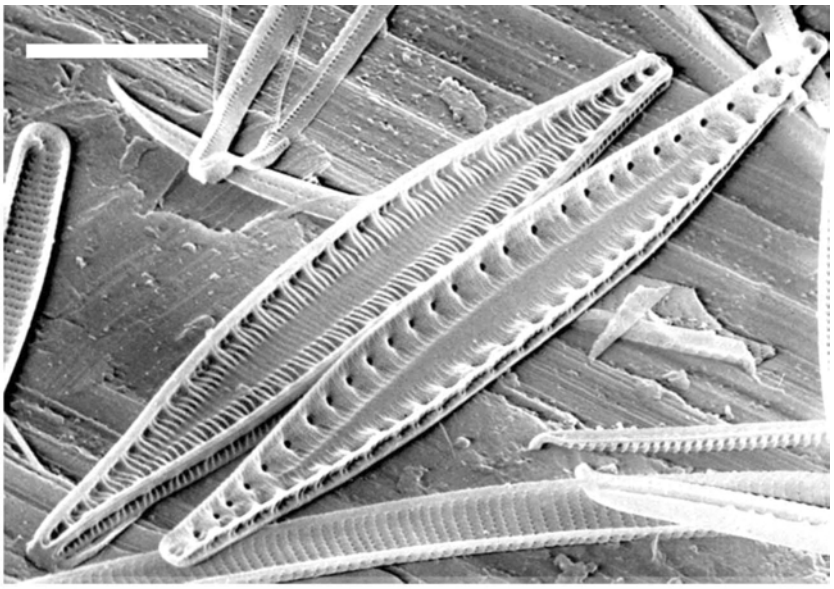


175



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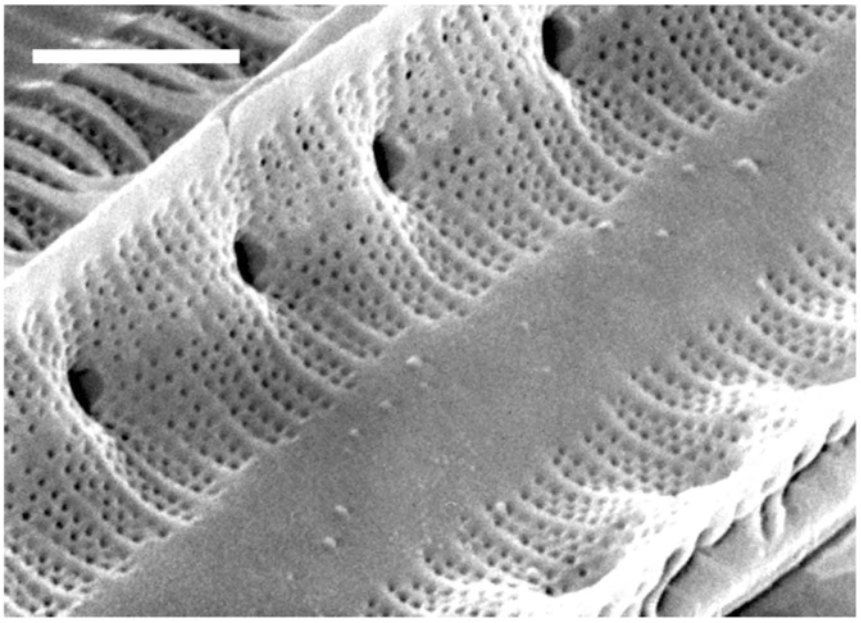
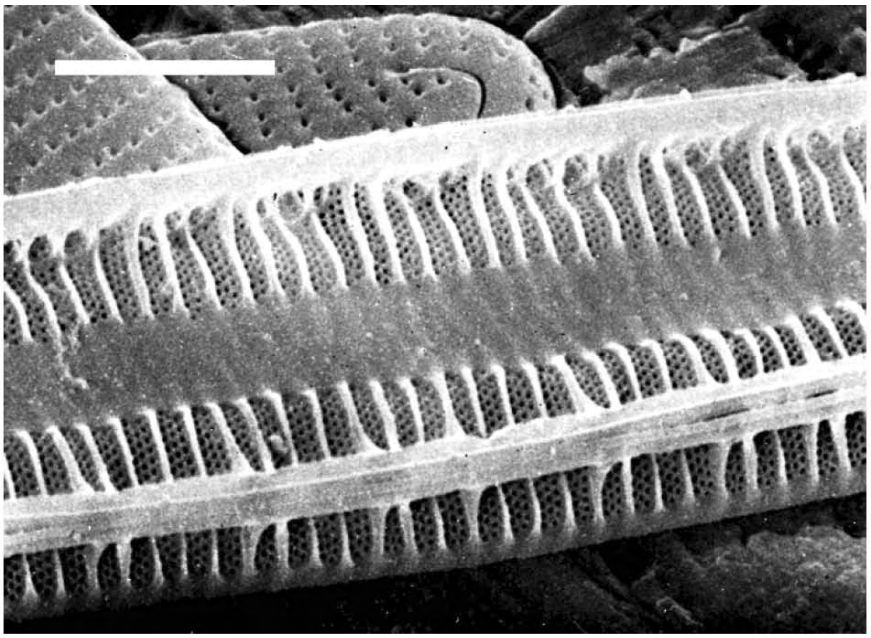


177

Figures 174-177. LM: x1500; SEM: Fig. 176: scale bar 5 µm; Fig. 177: scale bar = 2 µm. Figs. 174-177: *Stenopterobia* cf. *delicatissima* (Fig. 176 left: valve outside; Fig. 176 right: valve inside; Fig. 177: valve inside).



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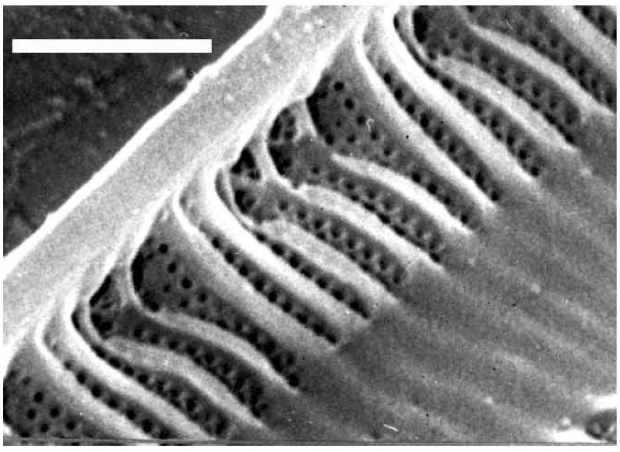

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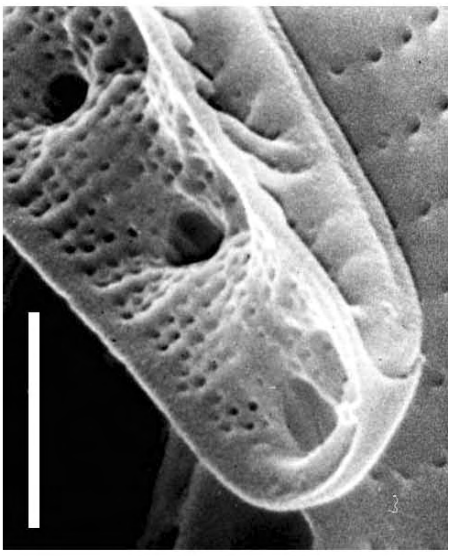
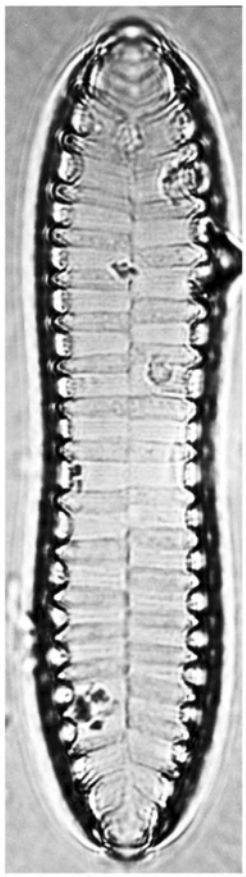
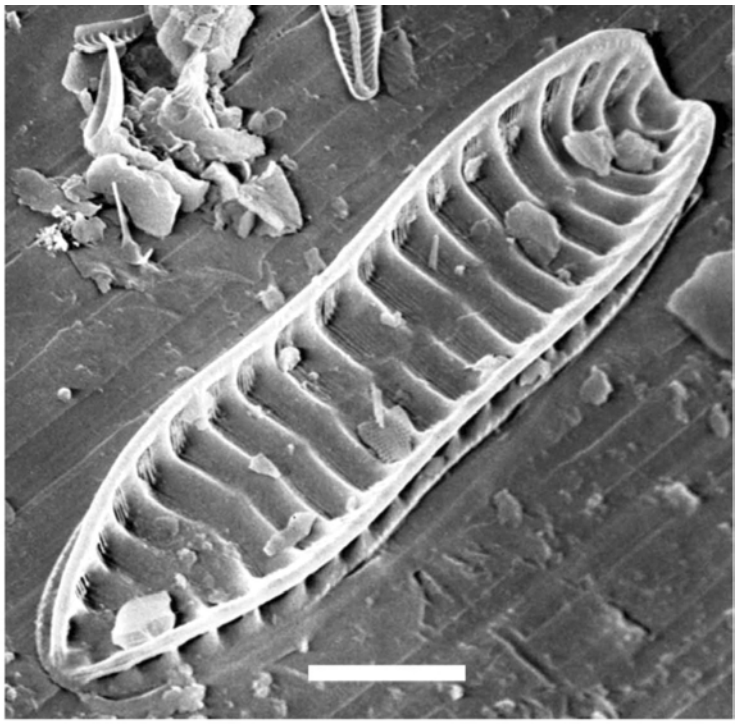


180

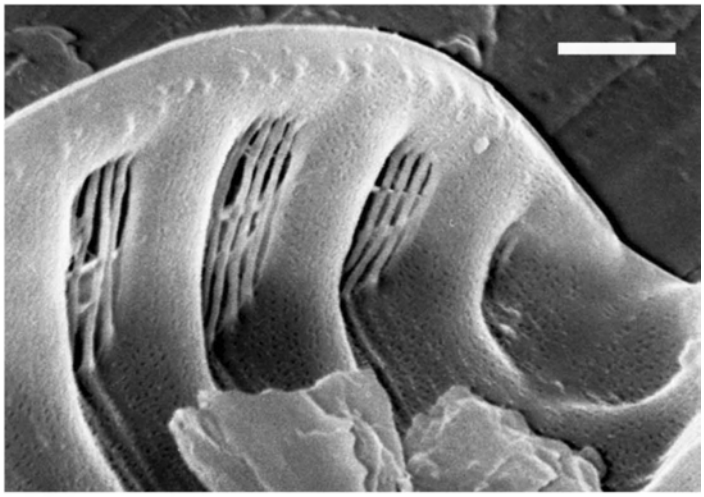
Figures 178-180. SEM: Fig. 178: scale bar = 2 µm; Figs. 179, 180: scale bar = 1µm. Figs. 178-180: *Stenopterobia* cf. *delicatissima* (Figs. 178, 179: valve outside; Fig. 180 valve inside).



181

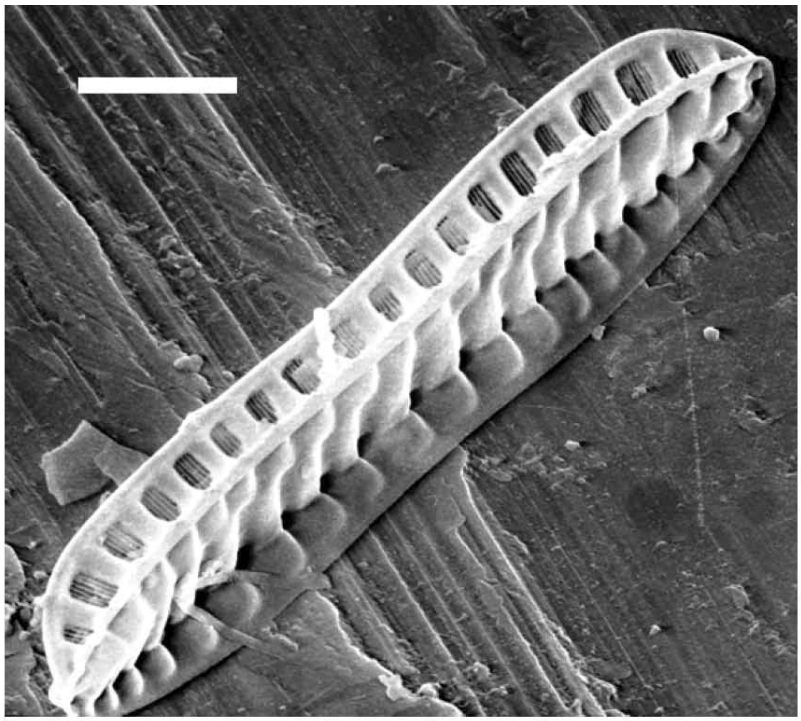


182



183

Figures 181-183. LM: x1500; SEM: Fig. 182: scale bar = 10 µm; Fig. 183: scale bar = 2 µm. Figs. 181-183: *Surirella linearis* v. *constricta*; Figs. 182, 183: valve outside.



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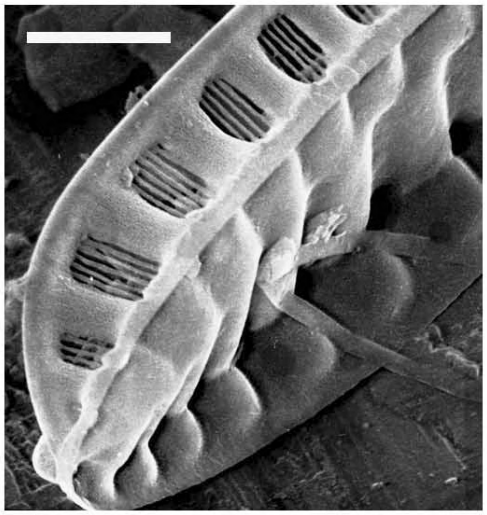

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Figures 184-185. SEM. Fig. 184. scale bar = 20 µm; Fig. 185: scale bar = 5 µm. Figs. 184, 185: *Surirella linearis* v. *constricta*, valve outside.

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