

## Examination of types in the *Fragilaria vaucheriae*–*intermedia* species complex

Akihiro Tuji<sup>1\*</sup> and David M. Williams<sup>2</sup>

<sup>1</sup>Department of Botany, National Museum of Nature and Sciences,  
4–1–1, Amakubo, Tsukuba, Ibaraki 305–0005, Japan

<sup>2</sup>Department of Life Sciences, Natural History Museum,  
Cromwell Road, London SW7 5BD, U.K.

\*E-mail: tuji@kahaku.go.jp

(Received 9 August 2012; accepted 19 December 2012)

**Abstract** In a previous paper, we presented the results of type examination of the *Fragilaria pectinalis*–*capitellata* species complex, species which have a unilateral central area and fine striae. Here, we present the results of type examination of the *Fragilaria vaucheriae*–*intermedia* species complex, species which have a unilateral central area and coarse striae (<13 striae per 10  $\mu$ m). *Synedra vaucheriae* var. *doformis* Grunow and *S. vaucheriae* var. *distans* Grunow are synonyms of *F. vaucheriae* (Kütz.) J.B.Petersen. *F. intermedia* Grunow is also a synonym of *F. vaucheriae*. However, some of the figures for *F. intermedia* that were published by Van Heurck are a new taxon sometimes identified as *F. intermedia*. This new taxon is described here as *Fragilaria neointermedia*.

**Key words:** *Fragilaria neointermedia* sp. nov., *Fragilaria vaucheriae*, Lectotype, *Synedra vaucheriae* var. *doformis*, *Synedra vaucheriae* var. *distans*, typification.

### Introduction

The *Fragilaria capucina/vaucheriae* species complex *sensu* Lange-Bertalot in Krammer & Lange-Bertalot (2000) (which is referred to as the *Fragilaria vaucheriae*–*intermedia* species complex in this paper) is understood to be a cosmopolitan (and common) species, appearing in many freshwater diatom floras (e.g., Patrick & Reimer, 1966; Krammer & Lange-Bertalot, 1991, 2000); it often occurs in such abundance that it is the most important taxon for understanding the ecology of attached, freshwater diatom communities (Tuji, 2000). In spite of its frequency of occurrence, the identity of its component species remains problematic.

We have been tackling the components of this complex by examining type material using LM

and SEM (Tuji, 2004; Tuji & Williams, 2006a, 2006b, 2008).

In this contribution, we discuss our results of the examination of type material for the *Fragilaria vaucheriae*–*intermedia* species complex, species that have a unilateral central area and coarse striae (<13 striae per 10  $\mu$ m).

### Materials and Methods

Kützing's exsiccata "Algarum Aquae Dulcis Germanicarum" in Decas III, No. 24, housed in the Botanical Museum and Library, University of Copenhagen (C), a slide BM78023, housed in the Natural History Museum, London (BM) prepared from BM copy of the exsiccata material, and Kützing's packet material number 185, housed in the Natuurhistorisch Museum, Konin-

klijke Maatschappij voor Dierkunde van Antwerpen (AWH), were examined for specimens of *Fragilaria vaucheriae* (Kütz.) J.B. Petersen.

Grunow's original line drawings, an annotated copy of Van Heurck (1880–1885) (GVHS), his slides and raw material, all housed in Naturhistorisches Museum Wien (W), were used for the identification of Grunow's taxa and a search of his original type slides and the raw (unprocessed) accompanying material (Tuji & Williams, 2008). The method for observation of type material using LM and SEM follows Tuji & Williams (2008).

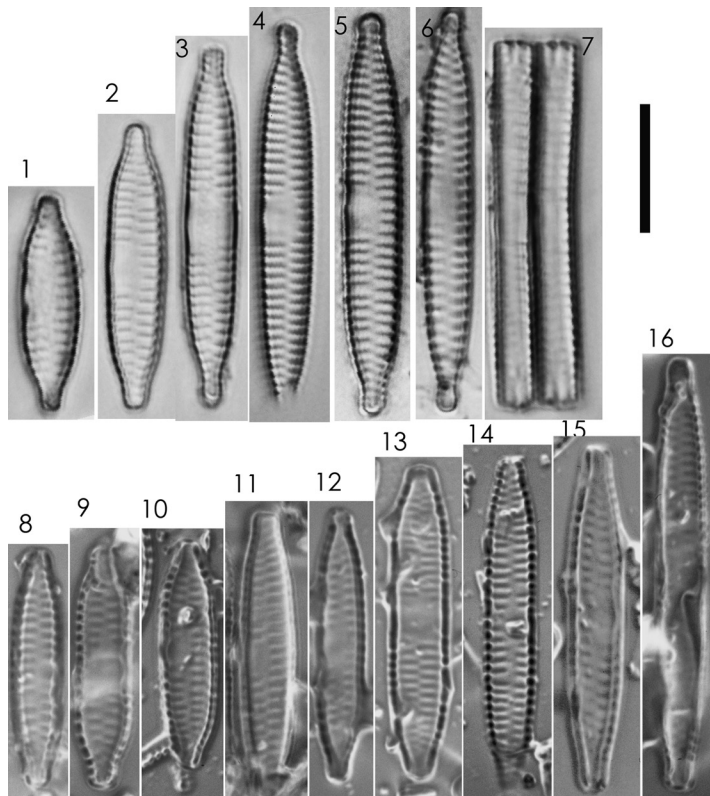
### Results and Discussion

*Fragilaria vaucheriae* (Kütz.) J.B. Petersen, *Bot. Not.* 122: 167. 1938.

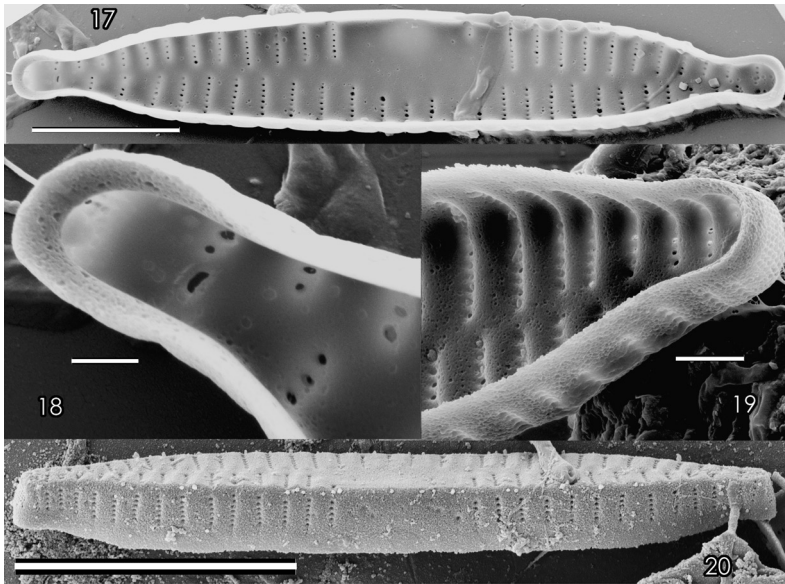
Basionym: *Exilaria vaucheriae* Kütz., *Alg. Aquae Dulcis Germ.* Dec. III. No. 24. 1833.

(Figs. 1–7, 17–20)

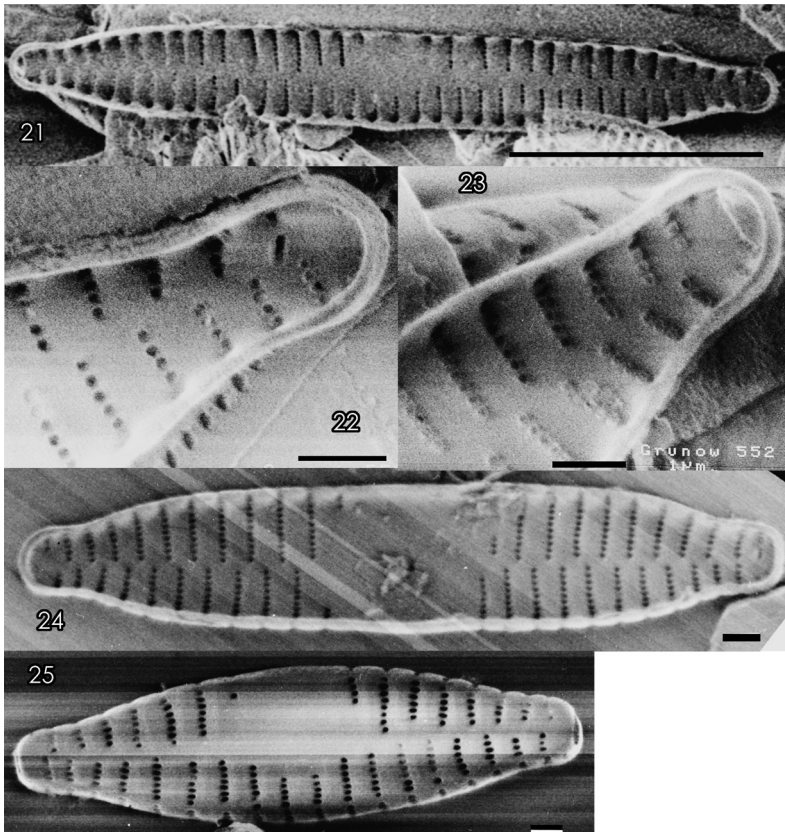
Kützing's published *Exilaria vaucheriae* Kützing in his famous exsiccata set *Algarum Aquae Dulcis Germanicarum* in Decas III, No. 24 in 1833 (Kützing 1833a), but without description or figure. The description and figures were published in Kützing (1833b: p. 560. f. 38). Recent examination of this material, using LM, was undertaken by Lange-Bertalot (1980) who used the a slide BM78023 from Kützing (1833a). Williams & Round (1987) referred to this species as a type of genus *Fragilaria*. Tuji & Williams (2006b) presented the photographs of valve view and girdle view of type material of *F. vaucheriae* and compared them with the micrographs of *Fragilaria rumpens* (Kütz.) G.W.F. Carlson and



Figs. 1–16. 1–7. *Fragilaria vaucheriae* (Kütz.) J.B. Petersen. LM. *Algarum Aquae Dulcis Germanicarum* Decas III, No. 24. Bar = 10  $\mu$ m. 8–16. *Fragilaria intermedia* (Grunow) Grunow. LM. Grunow slide 552, lectotype. Bar = 10  $\mu$ m.



Figs. 17–20. *Fragilaria vaucheriae* (Kütz.) J.B. Petersen. SEM. *Algarum Aquae Dulcis Germanicarum* Decas III, No. 24 in C. Bar = 10 $\mu$ m.



Figs. 21–25. *Fragilaria intermedia* (Grunow) Grunow. LV-SEM. Grunow material 552, iso-lectotype. Bar = 10 $\mu$ m.



*Fragilaria capucina* Desm.

Morphological variation of specimens found in Kützing's packet 185 in AWH (Figs. 1–7) and the exsiccata copy of *Algarum Aquae Dulcis*

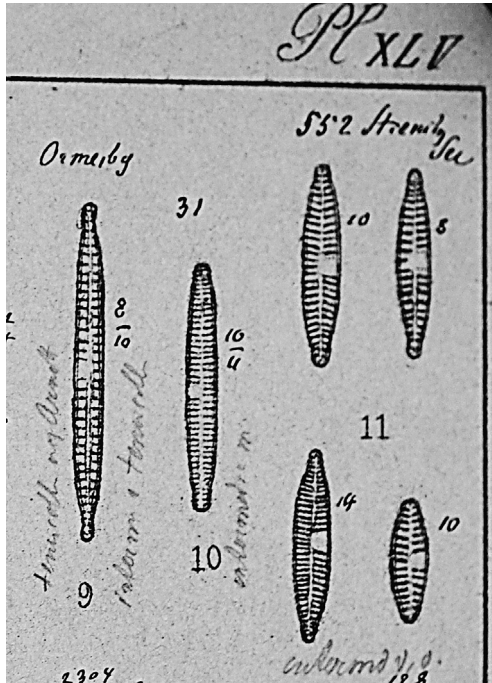


Fig. 26. *Fragilaria intermedia* (Grunow) Grunow. An annotated copy of Van Heurck (1880–1885) with hand writing information by Grunow (GVHS), plate 45, figures 9–11.

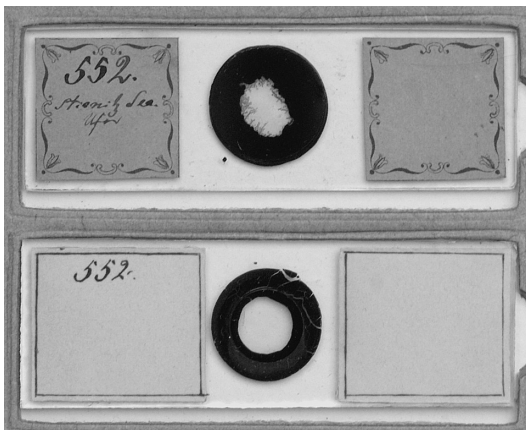


Fig. 27. *Fragilaria intermedia* (Grunow) Grunow. Slides numbered 552 in Grunow collection in W. Upper: lectotype.

*Germanicarum* (Dec. III. No. 24) located in C (Figs. 8–16) agrees with the morphological variation found in slide BM78023 (= Kützing Alg. Eur. Dec. III no. 24).

Previously, it was noted that the rimoportulae occur near the poles, one per valve and the large apical pore fields are rectangular, spines either do not exist or are very small, and they do not link with sibling cells.

*Fragilaria intermedia* (Grunow) Grunow in van Heurck, Synopsis des diatomées de Belgique pl. 45. fig. 11. 1881 (not figs. 9 or 10).

Basionym: *Fragilaria mutabilis* var. *intermedia* Grunow, Verh. kais.-königl. Zool.-Bot. Ges. 12: 55 (369); pl. 4/7, fig. 9 a–c. 1862.

(Figs. 8–16, 21–25, 26)

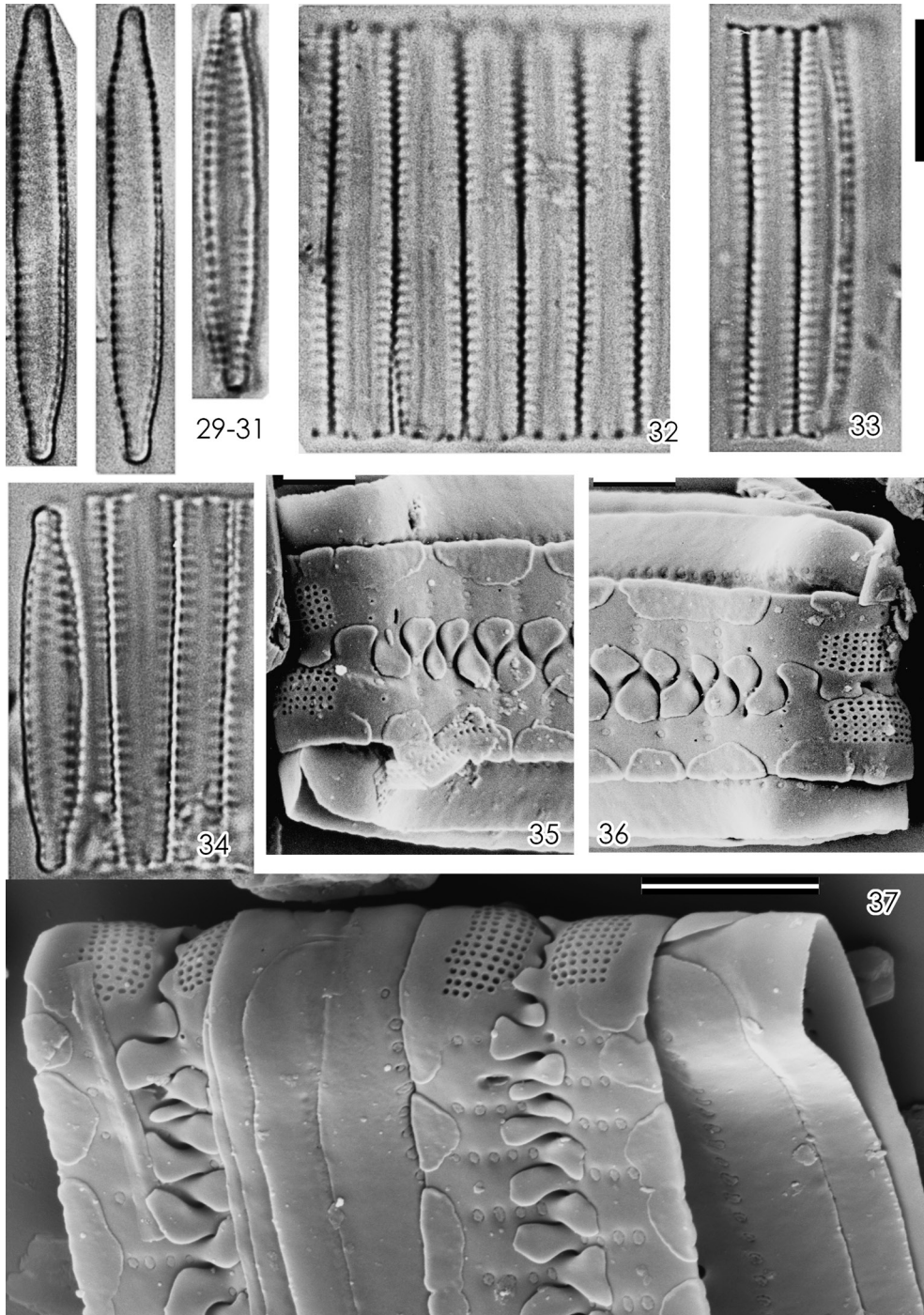
Lectotype (designated here): slide 552 with blue label in Grunow collection in W

(Fig. 27 upper)

In Van Heurck's annotated copy of *Synopsis des diatomées de Belgique* (GVHS: plate 45 fig. 9–11 in Van Heurck 1881), Grunow gives two localities for this taxon (Fig. 26). Fig. 11 in plate 45 of *Synopsis des diatomées de Belgique* agrees with original illustration in Grunow (1860) and the specimens on slide number is '552'. Figs. 9

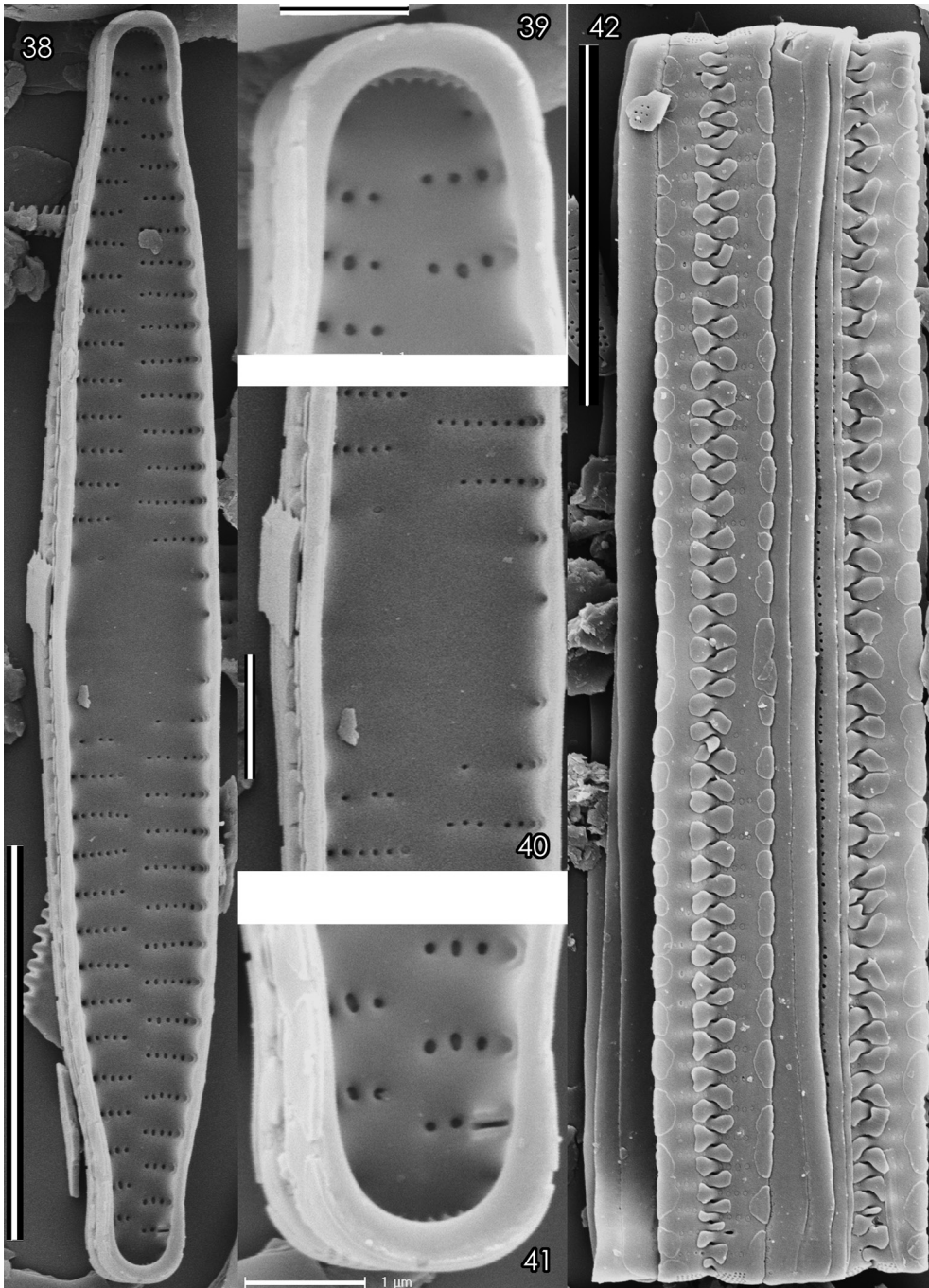


Fig. 28. *Fragilaria neointermedia* Tuji et D.M. Williams, sp. nov. = *Fragilaria intermedia* (Grunow) Grunow sensu Grunow (1881) part. Slides numbered 31 in Grunow collection in W. Lower: holotype slide of *Fragilaria neointermedia* sp. nov. Tuji et D.M. Williams.



Figs. 29–37. *Fragilaria neointermedia* Tuji et D.M. Williams, sp. nov. Slides numbered 31 in Grunow collection in W. 29–34. LM. Lower: holotype slide.





Figs. 38–42. *Fragilaria neointermedia* Tuji et D.M. Williams, sp. nov. Material numbered 31 in Grunow collection in W. 29–34. SEM. 38–41. inner view of frustule showing one rimoportula per a frustule on valve surface–girdle junction. 42. girdle view showing linking spines.

and 10 were illustrated from specimens on slide '31'.

There are two air-mounted slides numbered 552 (Fig. 27) and uncovered material on glass slide. We have examined these materials using LM (Figs. 8–16) and low-vacuum SEM (Figs. 21–25).

The individuals observed on the type slides agree with the original illustration given in Grunow (1860), and should be considered synonymous with *F. vaucheriae*, as previously discussed by Petersen (1938).

Taxonomic confusion relative to this taxon was caused by the other illustrations in the *Synopsis des diatomees de Belgique*, figures 9 and 10 Van Heurck (1881), derived from specimens on slide number 31. The specimens on slide 31 have spines and poorly delimited striae, forming long colonies (Figs. 29–42). These specimens differ from those on slide 552.

However, in some cases figures 9 and 10 from the *Synopsis des diatomees de Belgique* Van Heurck (1881) from slide 31, have been referred to for identification of *F. intermedia* (e.g. Patrick & Reimer 1966). Below, we describe the specimens from slide 31 as a new taxon: *Fragilaria neointermedia*.

***Fragilaria neointermedia*** Tuji et D.M. Williams, sp. nov.

Holotype: slide 31 mounted with styraX in Grunow collection in W. (slide illustrated in figure 28, last slide of bottom two marked '31'; figs. 29–42; plate XLV, figure 9 (Van Heurck 1881))

Isotype: slide 31 air-mounted (slide illustrated in figure 28, first slide of bottom two marked '31') and raw material 31 in Grunow collection in W; TNS-AL-56395 in TNS.

Synonym: *Fragilaria intermedia* sensu Grunow in Van Heurck (1881, Plate 45, figs. 9, 10, not fig. 11).

Valves lanceolate, narrowing toward rostrate, rounded apices. Sternum narrow. Central area slightly to one side of valve. Striae parallel or slightly radiate, 8–10 in 10  $\mu\text{m}$  (figs. 29–34).

Valve length 25–35  $\mu\text{m}$ , breadth, 3.5–4.5  $\mu\text{m}$ . Apical pore fields situated at each apex (figs. 35–36). Spathulate linking spines present (figs. 37, 42). One rimoportula per frustle, situated on valve face–mantle junction (figs. 38–41).

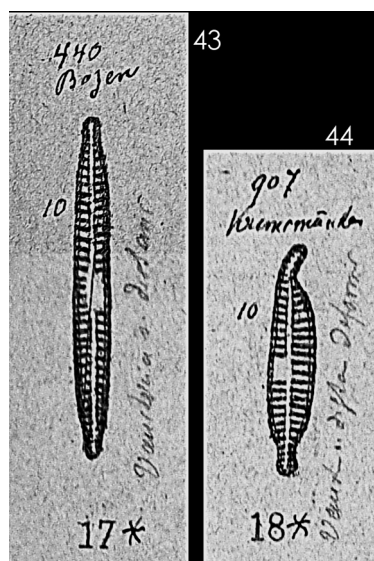
While *Fragilaria neointermedia* is very similar to *Fragilaria vaucheriae*, it can be clearly distinguished by its linking spines and the long colonies formed from these attachments (figs. 32–34, 42).

***Synedra vaucheriae* var. *distans*** Grunow in van Heurck *Synopsis des diatomees de Belgique* pl.40. f. 17. 1881.

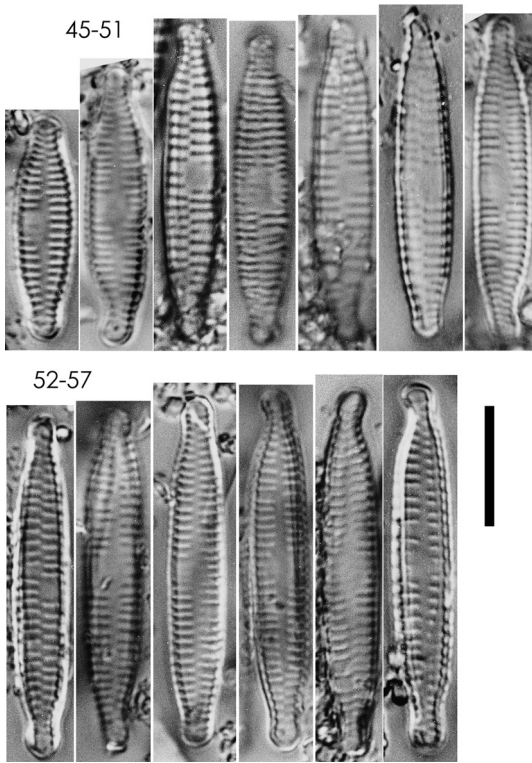
Type: slide 440 in Grunow collection (not located).

(Fig. 43)

In Van Heurck's annotated copy of *Synopsis des diatomees de Belgique* (GVHS: plate 40 fig. 17 from Van Heurck 1881), Grunow registered '440' for this taxon (Fig. 43). However, no slide has been found with that number. The illustration Van Heurck (1881, pl. 40, fig. 17) provided agrees with the current concept of *F. vaucheriae*,



Figs. 43, 44. Van Heurck's annotated book plate 40 figs 17 and 18 in Van Heurck (1881). 17. *Synedra vaucheriae* var. *distans* Grunow. 18. *Synedra vaucheriae* var. *deformis* Grunow.



Figs. 45–57. *Synedra vaucheriae* var. *deformis* Grunow. Slides numbered 907 in Grunow collection in W. Lectotype. LM.

hence *Synedra vaucheriae* var. *distans* should be considered a synonym of *F. vaucheriae*.

***Synedra vaucheriae* var. *deformis*** Grunow in van Heurck, *Synopsis* pl.40. f. 18. 1881.

Lectotype (designated here): slide 907 in Grunow collection in W.

(Figs. 44, 45–57)

In Van Heurck's annotated copy of *Synopsis des diatomees de Belgique* (GVHS: plate 40 fig. 18 from Van Heurck 1881), Grunow registered '907' for this taxon. Specimens from slide 907 in the Grunow collection agree with the current concept of *F. vaucheriae*, hence *Synedra vaucheriae* var. *deformis* should be considered a synonym of *F. vaucheriae*.

## Acknowledgments

We extend special thanks to Dr. Pasauer Uwe, Naturhistorisches Museum Wien (W). His generous help in the diatom herbarium and the loan and gift of specimens were essential to this work. We are grateful to Dr. Ruth Nielsen of the Botanical Museum and Library, University of Copenhagen (C) and Dr Guido Van Steenberg, Dr Henri van Heurck Museum, Antwerp (AWM) for assistance in their herbarium and the loan of specimens.

## References

- Grunow, A. 1860. Ueber neue oder ungenugend gekannte Algen. Erste Folge, Diatomeen, Familie Naviculaceen. Verhandlungen der kaiserlich königlichen zoologisch botanischen Gesellschaft in Wien. 10: 503–582, Tab. III–VII.
- Krammer, K. and Lange-Bertalot, H. 1991. Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. In: Ettl, H., J. Gerloff, H. Heynig and D. Mollenhauer (eds.), *Süßwasserflora von Mitteleuropa*. Gustav Fischer Verlag, Jena, 576 pp.
- Krammer, K. and Lange-Bertalot, H. 2000. Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. *Süßwasserflora von Mitteleuropa* 2: 598.
- Kützing, F. T. 1833a. *Algarum Aquae Dulcis Germanicarum*. Decas III. Collegit Fridericus Traugott Kützing, Societ. Bot. Ratisbon. Sodalis. Halis Saxonum in Commissis C.A. Schwetschkii et Fil. 3. 4 pp.
- Kützing, F. T. 1833b. *Synopsis Diatomacearum oder Versuch einer systematischen Zusammenstellung der Diatomeen*. *Linnaea* 8: 529–620, pls. XIII–XIX.
- Lange-Bertalot, H. 1980. Zur systematischen bewertung der bandförmigen kolonien bei *Navicula* und *Fragilaria*. *Nova Hedwigia* 33: 723–787.
- Patrick, R. and Reimer, C. W. 1966. *The diatoms of the United States, exclusive of Alaska and Hawaii*, Academy of Natural Sciences of Philadelphia, Philadelphia, 688 pp.
- Petersen, J. B. 1938. *Fragilaria intermedia-Synedra Vaucheriae* ? *Botaniska Notiser* 1938: 167–170, fig. 161.
- Tuji, A. 2000. Observation of developmental processes in loosely attached diatom (Bacillariophyceae) communities. *Phycological Research* 48: 75–84.
- Tuji, A. 2004. Type examination of the ribbon-forming *Fragilaria capucina* complex described by Christian Gottfried Ehrenberg. In: M. Poulin (ed.), *Proceedings of the 17th International Diatom Symposium*. Biopress



- Limited, Bristol, pp. 411–422.
- Tuji, A. and Williams, D. M. 2006a. Examination of the type material of *Synedra rumpens* = *Fragilaria rumpens*, Bacillariophyceae. *Phycological Research* 54: 99–103.
- Tuji, A. and Williams, D. M. 2006b. Typification of *Conferva pectinalis* O. F. Müll. (Bacillariophyceae) and the identity of the type of an alleged synonym, *Fragilaria capucina* Desm. *Taxon* 55: 193–199.
- Tuji, A. and Williams, D. M. 2008. Examination of types in the *Fragilaria pectinalis*–*capitellata* species complex. In: Y. Likhoshway (ed.), *Proceedings of the Nineteenth International Diatom Symposium*. Biopress Limited, Bristol, pp. 125–139.
- Van Heurck, H. 1880–1885. Synopsis des diatomées de Belgique. Atlas. *Ducaju & Cie., Anvers*, 235 pp.
- Williams, D. M. and Round, F. E. 1987. Revision of the genus *Fragilaria*. *Diatom Research* 2: 267–288.