Plant Ecology and Evolution 152 (2): 392–401, 2019
https://doi.org/10.5091/plecevo.2019.1601

SHORT COMMUNICATION

Typification of the puzzling diatom species *Neidium iridis* (Neidiaceae)

Paul B. Hamilton[1*], Katarzyna Stachura-Suchoples[2], Wolf-Henning Kusber[2], Andreanne Bouchard[1] & Regine Jahn[2]

[1]Research & Collections, Canadian Museum of Nature P.O. Box 3443, Station D, Ottawa K1P 6P4 Canada
[2]Botanischer Garten und Botanisches Museum Berlin, Freie Universität Berlin, Königin-Luise-Str. 6-8, 14195 Berlin, Germany
*Author for correspondence: phamilton@nature.ca

Background and aims – Confusion over the taxonomic identity of *Neidium iridis* (Ehrenb.) Cleve (= *Navicula iridis* Ehrenb.) has persisted for more than 130 years with identifications of valve shapes varying from elliptical to linear and sizes from 100 to 300 µm. This confusion can be linked to the rarity of the species and poor attention to the original line drawings of Ehrenberg. This study examines the type material of *Navicula iridis* and further uses additional material from North America to define the species *Neidium iridis*.
Methods – Mica and material from Christian Gottfried Ehrenberg's Collection were studied to examine *Navicula iridis*. Light and electron microscope techniques were used to document the variability of valve morphology of original material in comparison with other fossil and recent materials.
Key results – Ehrenberg designated no nomenclatural type for *Navicula iridis* at the place of its first description, and until recently the original material was not studied. One freshwater extant locality was identified (New York, West Point) in the original 1843 publication, and in his notes and drawings. Examination of the micas and material from the type locality, showed that *Navicula iridis* was very rare. Two specimens were found that matched the line drawing presented by Ehrenberg. In addition, we examined Ehrenberg's original material with SEM, as well as two other localities in North America and present LM and SEM documentation of additional valve forms. A further evaluation of the status of *Neidium columnaris*, *Neidium maximum* and an unknown taxon in relation to *Neidium iridis* is presented.
Conclusions – The findings of this study elucidate the taxon *Navicula iridis* (= *Neidium iridis*) as described by Ehrenberg in 1843. This will assist in the identification of other large *Neidium* taxa which to date have been associated with *Neidium iridis*.

Key words – *Neidium iridis*, Ehrenberg, taxonomy, lectotype, type material.

INTRODUCTION

The genus *Neidium* Pfitzer (1871: 39) represents a group of benthic freshwater diatoms with > 300 taxa. Some of the original species placed in the genus were identified by Ehrenberg (1843) from North America (Hamilton & Jahn 2005). More recently a number of the species described by Ehrenberg and Grunow have been genetically defined (Lefebvre & Hamilton 2015, *Neidium amphigomphus* (Ehrenb.) Pfitzer, *Neidium dilatatum* (Ehrenb.) Cleve, *Neidium tumescens* Grunow, *Neidium hitchcockii* (Ehrenb.) Cleve), but *Neidium iridis* (Eherenb.) Cleve (= *Navicula iridis* Ehrenb.) still remained an unknown entity. Ehrenberg first described *Navicula iridis* in his paper "das mikroskopische Leben in Süd- und Nord-Amerika" (Ehrenberg 1843: 382, 418) with a Latin description, location (New York, West Point) and two line drawings (pl. IV, fig. I.2a, b) of specimens. The drawings clearly show the shape, large size, small central area and number of canals (longitudinal lines) along the margin of the valve. *Neidium iridis* s. lat. currently contains 53 in-

Plant Ecology and Evolution is published by Meise Botanic Garden and Royal Botanical Society of Belgium
ISSN: 2032-3913 (print) – 2032-3921 (online)

fraspecific taxa, 34 varieties and 19 formae. Although little is known about Ehrenberg's *Neidium iridis* s. str. the erroneous concept of the species presented today is based on large elliptic valves with multiple marginal canals (e.g. Grunow in Van Heurck 1880–1885, Patrick & Reimer 1966, Krammer & Lange–Bertalot 1986). Indeed, subsequent to the original publication 10 authors up to the year 1966 presented line drawings of their specimens representing what they considered to be *Neidium iridis*; none of these matched the original concept of Ehrenberg (1843: 418, pl. IV, 2a, b). The wide diversity in valve morphology amongst the infraspecific taxa of *Neidium iridis* illustrates the identification problem of the nominate form and the broad concept that present authors maintain.

Researchers have looked through the New York mica's (West Point) for *Navicula iridis* (e.g. Lange-Bertalot, Senkkenberg Institute, Germany, pers. comm.) but were not able to find a specimen of *Navicula iridis*. Katarzyna Stachura-Suchoples and Wolf-Henning Kusber were able to find two specimens from the New York (West Point) micas matching the line drawing of Ehrenberg. In addition, original material was found. The objective of this study is to circumscribe and emend the species description of *Neidium iridis* using original and current samples from North America. Comparisons are also made with an unknown taxon, and two other closely related taxa *Neidium columnaris* (Ehrenb.) Mills and *Neidium maximum* (Cleve) F.Meister which have not been typified.

MATERIAL AND METHODS

The sample which contains original material of *Navicula iridis* is deposited in the Ehrenberg Collection, Institute of Paleontology, Museum für Naturkunde, Berlin (BHUPM). The following material was studied:
1. Reference: Ehrenberg (1843: 382, pl. IV: fig. 2: "New York, West-Point, 40°N 74°W, L. V. Greenw.").

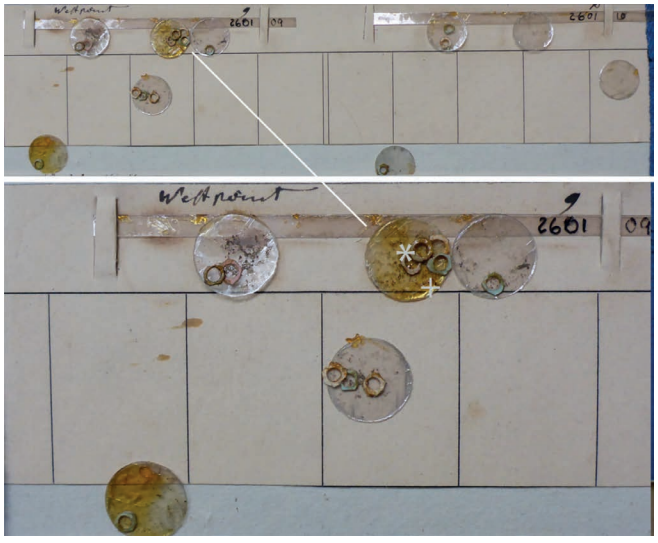

Figure 1 – *Neidium iridis*: Presentation of Ehrenberg's original micas from West Point (Strips 260100–260110). Bottom section, expansion of 260109, with white star and a white cross indicating locations of observed specimens on mica 260109 d.

2. Original sample: 1755a.
3. Geographical preparations (for details see Jahn & Kusber 2004, Lazarus & Jahn 1998): 260109 and 260110 (= Box/Kasten 26, folder/Buch 01, Mica strips 9 & 10) (fig.1).
4. Drawing sheet: No. 2074; two specimens labelled *Navicula iridis* are on this drawing sheet. On top of each specimen Ehrenberg notes the numbering: 2 / 10. b. w. g r / 9. d. w. e. / 3. /10. a. bl. D. br.

At BHUPM, selected micas were examined and photomicrographs of the observed specimen(s) were taken with an Olympus digital Camera DP 50 and BX 51, Objective: Olympus 80x: IC 80/0.75, 40x: UPlan Fl 40/0.75, 20x: UPlan Fl 20/0.50. In Berlin at the BGBM, non-sputtered original material for SEM study was examined with Hitachi FE SEM 8010.

Subsamples of the original material (Box 1755a), were also examined in the Canadian lab of PBH. In addition, a slide (ANSP [Academy of Natural Sciences of Philadelphia] GC. 53463) from a fossil deposit in Maryland (Lower Potomac, St. 5A Composite, U.S.A.) and material from Vancouver (CANA [Algal Collection, Canadian Museum of Nature Herbarium] 128318, VanDusen Gardens, British Columbia Canada) were examined. The specific location for the type of *Navicula iridis* (e.g. New York, West-Point) is not known, therefore materials with *Neidium iridis* from the collections of ANSP and CANA were used to further valid morphology, distribution and in the future genetic signature of this taxon in North America. The Canadian material was acid cleaned and washed with distilled water to remove the acid. The cleaned liquid samples were subsampled and dried on coverglass and mounted onto microscope slides with Naphrax. Additional subsamples were dried onto aluminium foil and mounted onto SEM stubs following the protocol of Siver (1987). SEM were examined uncoated or with a thin gold palladium coat; the coating was completed using a Denton Vacuum DESK II sputter coater. LM studies were conducted using a Leica DMR HC microscope with Phase, DIC and Brightfield optics: 40x: Plan Apo HCX 40/1.25 and 100x: Plan Apo HCX 100/1.35 objectives. Samples for SEM study were observed with an FEI XL30 (ESEM), or a FEI APREO (FEG) using 2–10 KV with a working Distance < 10 mm under high vacuum. Terminology used to describe morphological structures follows von Stosch (1975), Ross et al. (1979), Krammer & Lange-Bertalot (1986) and Siver et al. (2003). For old *Neidium* names and concepts VanLandingham (1978) was consulted.

RESULTS

Observations on Ehrenberg's notes, drawings and mica

In 1843 Ehrenberg wrote: "Ausser diesen fossilen, dicht unter der Oberfläche eines Torfmoors vorkommenden, mithin vielleicht sämmtlich auch der Jetztwelt angehörigen Formen habe ich nur noch Gelegenheit gehabt, von West-Point auch noch eine grosse Reihe von entschieden jetzt lebenden und sogar im lebenden Zustande in Berlin zu beobachten. Herr Prof. Bailey sandte mir in Jahre 1842 einige Gläschen voll Torf-Wasser aus West-Point mit vielen lebenden Bacillarien. Diese waren am 2. April 1842 dort mit dem Wasser gefüllt

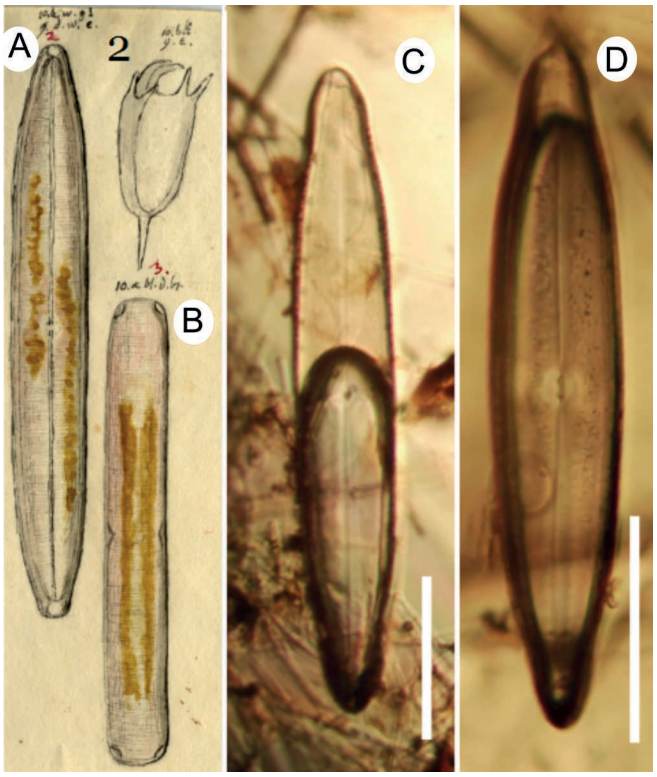

Figure 2 – *Neidium iridis*: A & B, line drawing of original specimens; C & D, LM images of original specimens (C: lectotype specimen). Scale bars = 100 µm.

worden, und am 16. Juni darauf konnte ich sie der Akademie in Berlin noch zahlreich lebend vorzeigen. (1) Ich habe mich bemüht, diese lebendigen oder doch sämmtlich als Jetztwelt mit Sicherheit angehörigen Formen Nord-Amerikas mit den europäischen möglichst genau zu vergleichen und habe deshalb alle gezeichnet." Translation, "Apart from these fossil forms, which occur just below the surface of a peat bog, and perhaps all of which belong to the world of the present, I have had occasion to observe from West Point only a great number of resolutely living and in still living conditions in Berlin. In the year 1842, Prof. Bailey sent me from West Point some jars full of peat water with many living Bacillaria. These had been filled with water on April 2, 1842, and on June 16, I was able to show them to the Academy in Berlin still numerously alive. I have endeavoured to compare as closely as possible all these forms of North America which are alive or certainly belong to the world of the present with the European ones, and have therefore drawn all of them."

In total 60 micas identified as from West Point (New York) are present in the Ehrenberg Collection. Seven of these micas have been displaced from the original strips and their identification position on the strips is therefore uncertain. Four of the 60 micas did not have (or have lost) circles marking identified specimens. Twenty-one micas had one circle identifying specimens, 17 had two, 16 had three and three had four circles marking on the micas. For this study, mica strips 260109 and 260110 (fig. 1), as noted above the specimens on the drawing sheet (fig. 2A & B), were examined.

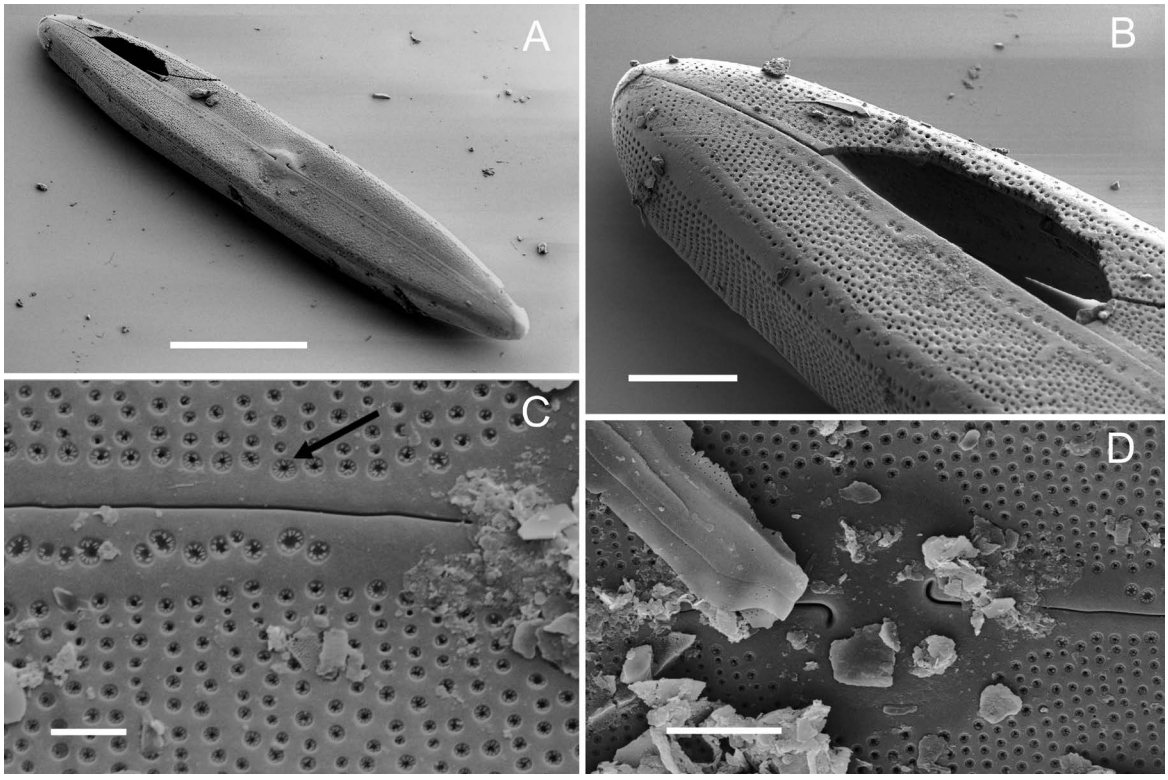

Figure 3 – *Neidium iridis*, external valve SEM images from original material: A, whole valve; B, apex; C, areolae on the valve face next to the central area. Radiating cribra formation (arrow); D, central area with small hooked central raphe endings. Scale bars: A = 50 µm; B = 10 µm; D = 5 µm; C = 2 µm.

The Latin description for *Navicula iridis* reads "testula magna elongate bacillaris, lateribus planis, apicibus leviter attenuates obtusis, superficie subtilissime transverse et longitude. Lineolate iridis coloerm emittente. Icon! An sui generis forma?" In this description Ehrenberg (1843: 382) notes the large elongate frustule with obtuse tapering apices and that the valve surface is composed of fine transverse lines (striae) which show a rainbow of colour under the microscope. Finally, he notes, "Icon! Or is the form of its own kind(?)"; this indicates that Ehrenberg recognized that this was likely not a *Navicula* but a species which belonged to another genus. The genus *Neidium* (as typified by Hamilton & Jahn 2005) was not erected until 1871 (Pfitzer 1871) and *Neidium iridis* was later transferred to *Neidium* by Cleve (1894: 69).

The original description presents only a few characters to ascribe to the species. However, Ehrenberg had an attention for detail in his drawings, which present additional character clues for the species. Ehrenberg (1843: pl. IV, fig. 2a, b, also on drawing sheet no 2074) presents a large linear diatom with cuneate apices (fig. 2). Two black lines document the narrow axial area with a central area extending approximately 1/3 across the valve. Two small half circle lines within the central area document a central nodule. The striae are presented as linear (not radiate) with individual dots suggesting that areolae could be observed within the striae. The original drawing of the valve (specimen on mica 261109) has two lines (widely spaced) running along each margin indicating one or two longitudinal canals. A circular solid spot is present at both apices interrupting the parallel lines along the margin. In girdle the frustule (specimen on mica 261110 [a, blue circle]) is rectangular with clearly punctate striae. Three-four lines extend along the margins and recessed indentations are present on both valves in the mid-region. Line drawn (indentations/spots) are also present at each apex. In both line drawings residual pigments are presented indicating the species was extant as indicated in Ehrenberg's original text.

Description of type material

Neidium iridis (Ehrenb.) Cleve (Cleve 1894: 69).
Figs 2–4
(Specimens [from micas and type material] = 5)

Basionym ≡ *Navicula iridis* Ehrenb. (Ehrenberg 1843: 382, 418, pl. IV: fig. I.2).

Type – BHUPM Ehrenberg collection, Mica: 260109d (represented by fig. 2C) (lecto-: BHUPM, **designated here**).

Registration: http://phycobank.org/100398

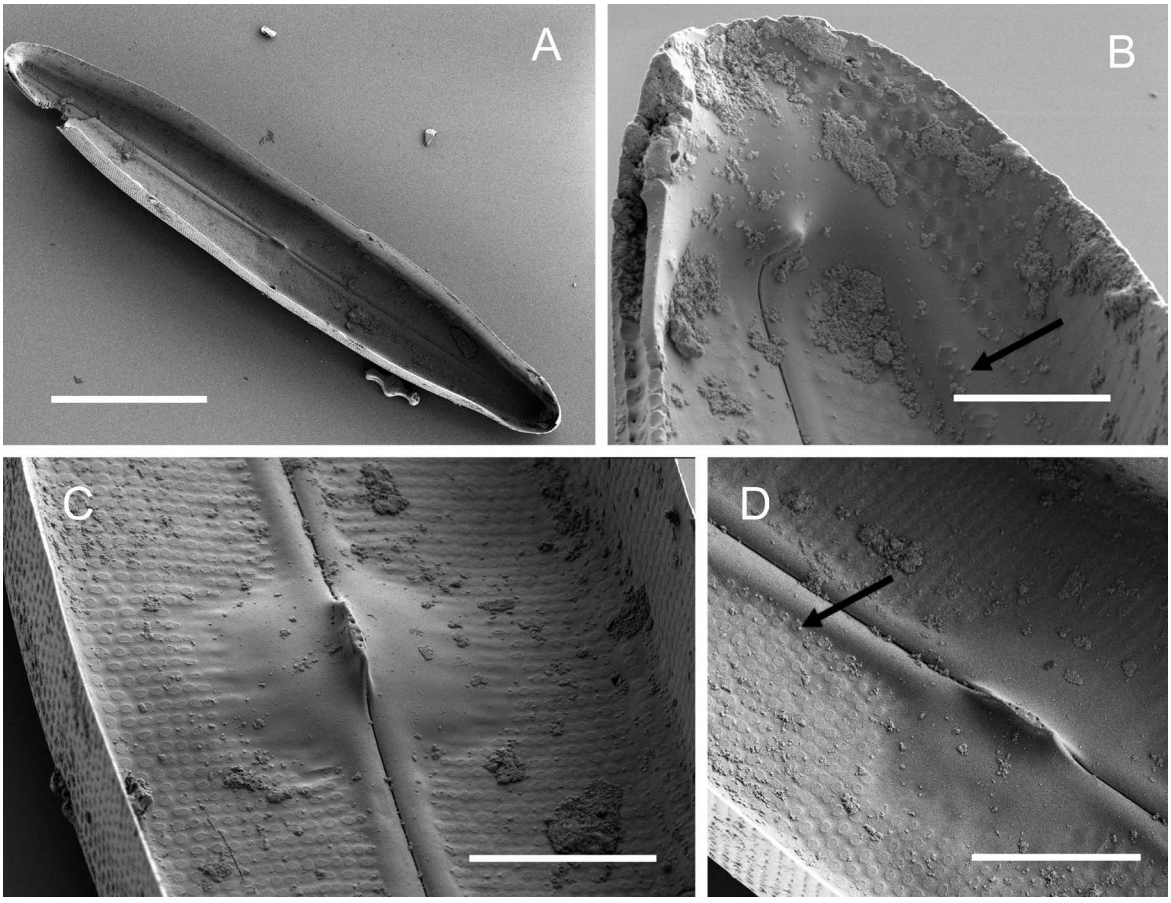

Figure 4 – *Neidium iridis*, internal valve SEM images of *Navicula iridis* from original material: A, whole valve; B, apex; Helictoglossa away from the apices, deflected and hooked back towards center of the valve. A broken longitudinal canal on left. Renilimbi around areolae (arrow); C, elevated central nodule with fused helictoglossae forming a ridge-like extension; D, central area showing the hymen covers over the areolae and renilimbi (arrow) scattered around selected areolae. Scale bars: A = 50 µm; C & D = 10 µm; B = 5 µm.

Original material – BHUPM Ehrenberg collection, 1755a, collected by Prof. Bailey, 2 April 1842.

Description – Frustules isovalvar. Valves linear to linear elliptic with narrowing obtuse to sagittate apices. Length 214–306 µm long, 26–33 µm wide, 14–15 striae in 10 µm and 14–15 areolae in 10 µm. One large longitudinal canal present along each valve margin. Striae parallel at centre, parallel to weakly convergent at apices (figs 3 & 4). Axial area narrow, linear to linear elliptic from centre to apex. Scattered areolae in the axial area present (fig. 3B & C). Externally, central area round to weakly elliptic and slightly raised, covers approximately 1/3 of transverse mid-region of valve (fig. 3A & D). In LM, raphe lateral with tightly curved proximal raphe ends and terminal fissures end at lacinia (Fig. 3B & D). On valve face, areolae round (c. 0.3 µm diameter) to weakly elliptical and covered by a recessed stellate cribrum (fig. 3C). Externally, 14–15 areola per stria and one areola opens into longitudinal canal (fig. 3B). Mantle deep with >10 areolae per stria extending uninterrupted down to margin. Internally, central nodule elevated and sternum appearing as a pseudosepta; raphe straight (fig. 4B & C). Central helictoglossae fused forming a long linear structure (fig. 4C & D). Terminal helictoglossae raised bent from valve face; associated with a terminal pseudoseptum (fig. 4B). Internal areolae openings covered with a hymen (fig. 4B–D). Scattered renilimbi 1–4 per areola concentrated along longitudinal canal and next to axial and central areas (fig. 4D, arrow).

Emended description based on type and North American material

Neidium iridis **(**Ehrenb.) Cleve emend. P.B.Ham. & Stachura-Suchoples
Figs 5–7
(Specimens = 14)

Emended description – Frustule 26 µm in depth. Valves linear to linear elliptic with narrowing obtuse to sagittate apices. Length 198–320 µm long, 26–41 µm wide, 12–15 striae in 10 µm and 12–15 areolae in 10 µm. Areolae opening into longitudinal canal scattered, small and large (fig. 6C). A single row of ghost areolae or open areolae with radiating cribra present along axial area (fig. 6D–F). Cingulum composed of at least four open copulae with two rows of small pores. Copula even in width around the frustule.

DISCUSSION

Specimens of *Navicula iridis* were not found (at least by P.B. Hamilton) on the West Point mica preparations labelled with *Navicula iridis* in the associated text (fig. 1). K. Stachura-Suchoples and W.-H. Kusber, after an extensive search through the micas, found two unobstructed specimens of *Navicula iridis* (strip 260109, mica d); they were found on those mica strips which Ehrenberg had mentioned but somewhat outside the colored ring. There are no handwritten notes underneath the mica (see fig. 1), which explains the extended time to find this taxon. It is now evident that *Navicula iridis* (*Neidium iridis*) was accurately and effectively presented in the line drawings of Ehrenberg. This is a rare species which to date has only been observed in a few samples both fossil and extant from North America. At the type locality, *Neidium iridis* is associated with centric diatoms, and the diatoms *Pinnularia* spp. and *Tabellaria* sp., as well as with typical moorland desmids such as *Cosmarium* spp. and *Euastrum* spp. It is easily identified by the large linear valves with one large longitudinal canal along each margin and extended rostrate to sagittate apices. This taxon also has renilimbi (figs 4D & 7F), small oppositely deflected central raphe ends and a lacinia (bifurcate terminal raphe ends, fig. 3B) which places this taxon morphologically well within the genus. *Neidium iridis* is currently the longest *Neidium* species, although there are some large unidentified taxa with a similar size and shape. These unidentified taxa from the Americas have multiple longitudinal canals, do not have well developed pseudosepta, and do not have sagittate apices (e.g. Metzeltin & Lange-Bertalot 2007: pl. 170, figs 3–5; pers. obs. from North America). In the future, with better documentation, we anticipate that a few more large *Neidium* species will be distinguished.

Neidium iridis **s. str.**

Neidium iridis is distinguished from the type species for the genus (*Neidium affine* (Ehrenb.) Pfitzer) by the number and formation of the longitudinal canals (one large canal versus 2–3 smaller canals), the extremely large size, and the sagittate to cuneate apices versus rostrate to subrostrate apices in *Neidium affine*. In LM examination the large size (comparable to large *Pinnularia* taxa) is the most striking feature for *Neidium iridis.* Kützing (1844: 2, pl. 28:42) copied and modified the light micrographs of Ehrenberg with no striae and the taxon was only noted from the type locality (New York, North America). In 1877, Schmidt (1874–1959: pl. 49:1) illustrated a specimen he identified tentatively as *Navicula columnaris* Ehrenb. from Monticello (Fossil, New York, U.S.A.). Schmidt's comment "fraglich, aehnlich der viel kleineren" indicated that he recognized that this was much larger than *Navicula columnaris* s.str., and indeed the line drawing matches Schmidt's identification of another specimen as *Neidium iridis* (fig. 49: 2) is not correct, but should be *Neidium dilatatum* (Ehrenb.) Cleve (see Cleve 1894: 70). Cleve (1894) identified a taxon *Neidium affine* [var. *genuinum* "genuina"] f. *maximum* "maxima" Cleve from the fossil deposit at Monticello, New York. Although he did not present a line drawing, the size (180–300 µm long, 40 µm wide, 12–17 striae in 10 µm and 14–15 puncta in 10 µm) matches *Neidium iridis* and the specimen image of Schmidt. Later Reimer (1959: 30, pl. 4:1) illustrated *Neidium affine* [var. *genuinum*] f. *maximum* (*Neidium iridis*) from the Monticello fossil deposit; first he identified valves as *Neidium schmidtii* sp. nov. (syn. *Neidium affine* [var. *genuinum*] f. *maximum*) and later as *Neidium maximum* (Cleve) F.Meister (Patrick & Reimer 1966: 400, pl. 37:1). The examination of slide GC53463 (Monticello, New York) from the diatom collection at the Academy of Natural Sciences of Drexel University confirms that *Neidium iridis* s.str. was the taxon presented (fig. 5A–G). In the transfer of *Neidium affine* [var. *genuinum*] f. *maximum* to *Neidium maximum*, Meister (1912) illustrated a European specimen from Zürichsee, Bächau, which is not *Neidium iridis* s. str. This form is not *Neidium affine* [var. *genuinum*] f. *maximum* and requires further investigation.

Boyer (1916: 82, pl. 21:11) also illustrated *Neidium affine* [var. *genuinum*] f. *maximum* Cleve from Pensauken (Artesian well, New Jersey, U.S.A.) which is clearly *Neidium iridis* s.str. Size 238 µm long, stria density 14 and puncta density 15 in 10 µm match *Neidium iridis*. Okuno (1952: 41, pl. 12:3, pl. 20:5; 1964: pl. 475) documented a smaller form resembling *Neidium*. *iridis* (ca. 166 µm long) from an Upper Pliocene deposit at Iriono, Oita Prefecture, Japan. However, the LM picture of Okuno is difficult to clearly identify, but it is similar to *Neidium iridis*. More recently, Hamilton (in Siver et al. 2005: p. 351, pl. 51:1) illustrated a smaller specimen similar to *Neidium iridis* (160 µm long, 28 µm wide) from Cape Cod as *Neidium ampliatum* (Ehrenb.) Krammer s. lat. Their specimen is smaller with sagittate apices similar to larger *Neidium iridis* valves.

Taxonomic transformation to confusion

Large linear to linear-elliptic valves with multiple canals and rounded to obtuse apices is the current concept of this taxon by different authors (= *Neidium iridis* [according to many authors]). A linear to linear-elliptic valve with multiple canals (multiple lines along the valve margin) was first illustrated by Donkin (1871: 30, pl. 5:6). At that time Donkin noted an affinity to *Navicula firma* Kütz. (Kützing 1844: 92, pl. 21:10). Schmidt (1877: pl. 49:2) illustrated a more elliptic-linear

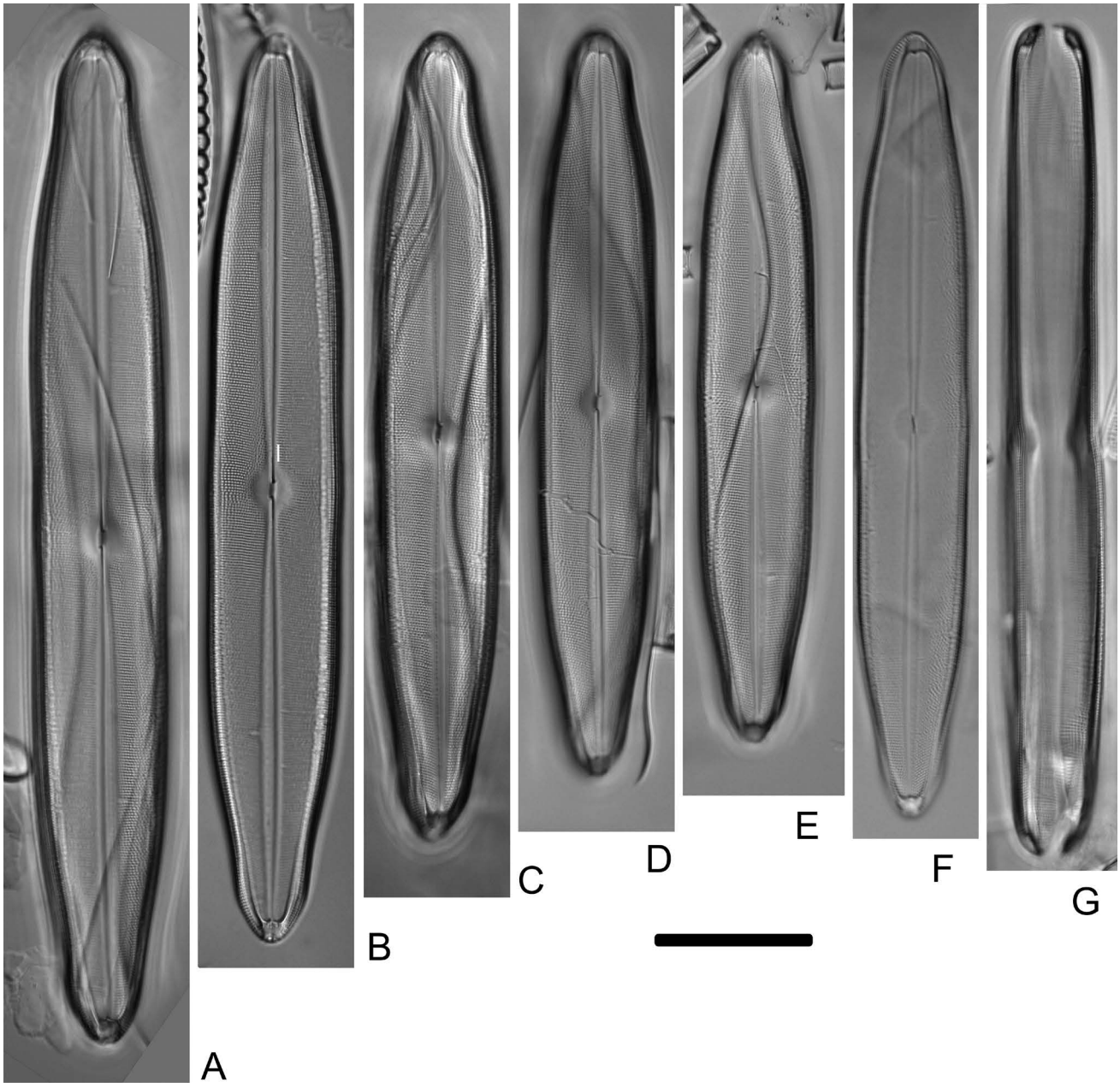

Figure 5 – *Neidium iridis*, LM images of *Neidium iridis* from slide GC53463 (ANSP collection): A–F, size diminution series; C, showing four constricted copulae near the apex; G, girdle view showing the central nodule on each valve and the round septa-like structures at each apex. Scale bar = 50 µm.

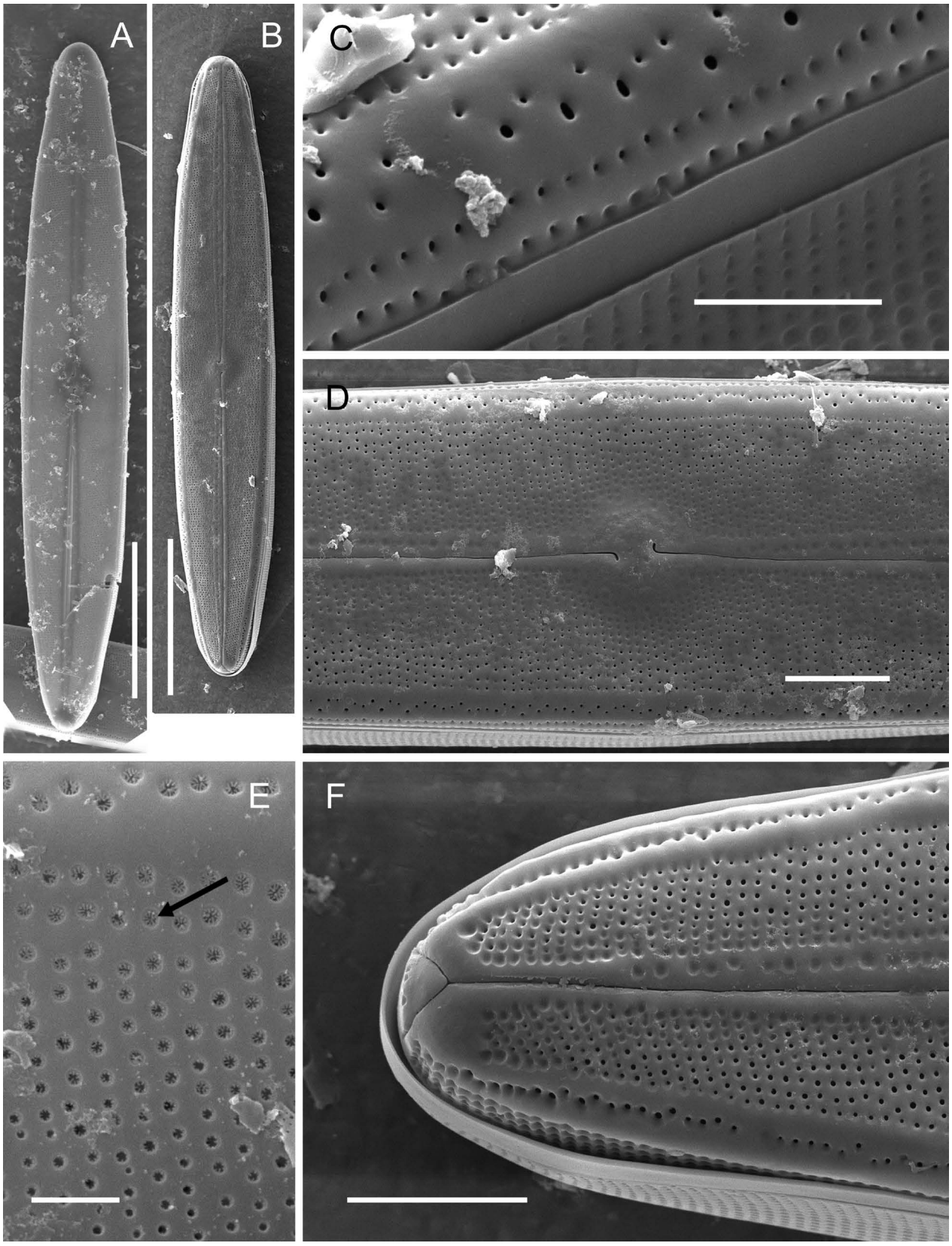

Figure 6 – *Neidium iridis*, external valve SEM images of *Neidium iridis* from Vancouver (B.C., Canada) material: A & B, whole valves; C, valve mantle showing longitudinal canal and a copula; D, valve cross section, with elevated central area with small hooked central raphe fissures; E, areolae showing the star-burst radiating expansion of the cribra (arrow); F, apex with a defined lacinia and one longitudinal canal along each margin. Scale bars: A & B = 50 µm; D & F = 10 µm; C = 5 µm; E = 2 µm.

valve with multiple canals, followed by Grunow in Van Heurck (1880, as "*Navicula iridis* var." [approaching *Navicula iridis* var. *firma* sensu Grunow, but larger]). Pelletan (1888: 272, fig. 209) and Van Heurck (1896: pl. 5: 212) copied the image of Grunow. Wolle (1890: pl. 18:4; 19:10) illustrated an even broader elliptical valve with rounded apices for *Navicula iridis* and a smaller similar valve for *Navicula firma*. Pantoscek (1902: 54, pl. 6:134) showed a small linear-elliptic valve (115 µm long, 21.6 µm wide) as *Navicula iridis* but it is in line with *Navicula firma* var. *major* Grunow (1860: 542, pl. 3(V):1). Later additional broadly elliptic valves were illustrated for "*Neidium iridis*" (Meister 1912: 108, pl. 15:2; Hustedt 1930: 245, fig. 379; Hanna 1933: 85, pl. 4:4; Sabelina et al. 1951: 380, pl 232:1; Cleve Euler 1955: 119, 1174c; Patrick & Reimer 1966: 386, pl. 34:1). The current "auct. nonnulli" concept of *Neidium iridis* is based on large

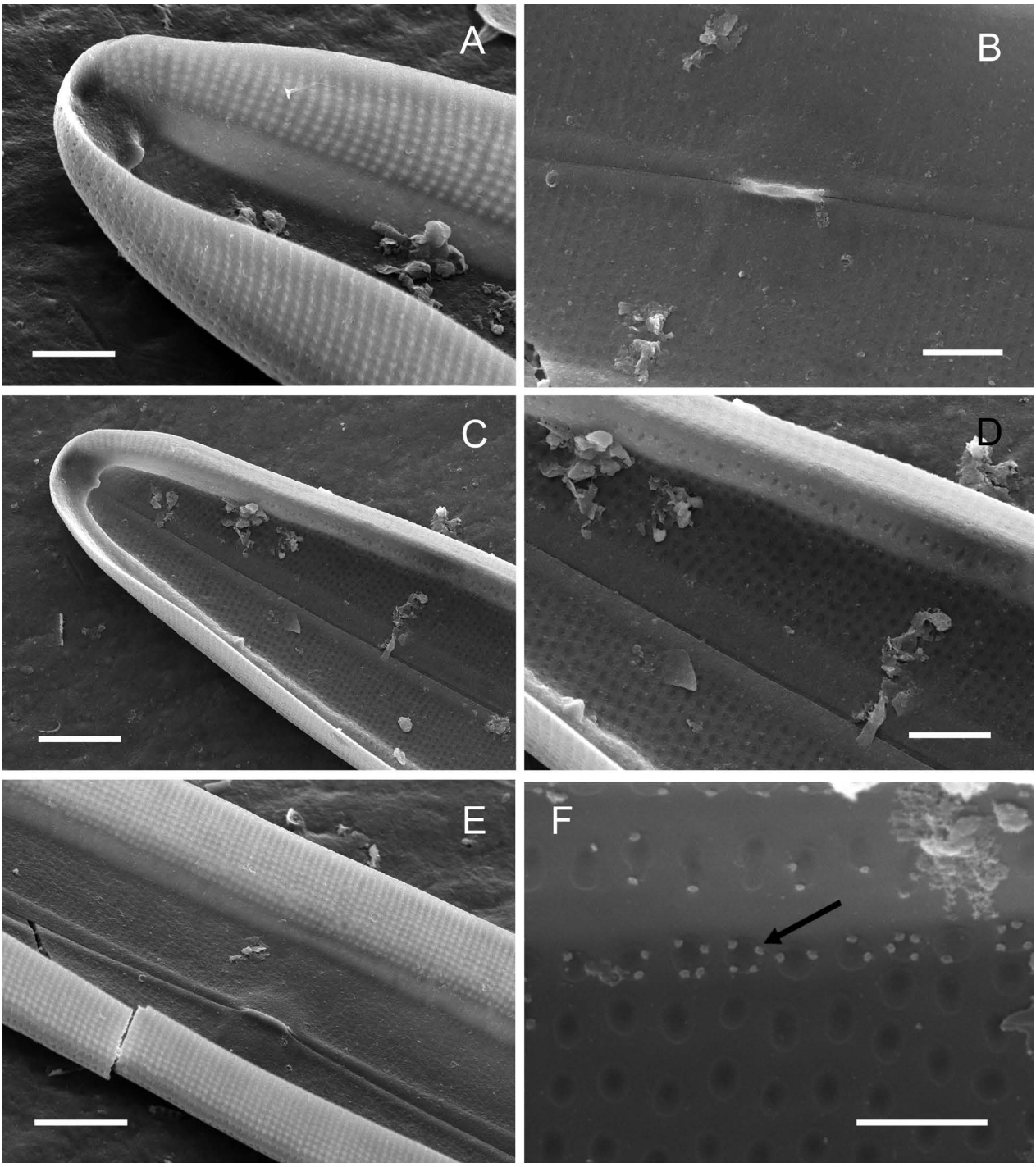

Figure 7 – *Neidium iridis*, internal valve SEM images of *Neidium iridis* from Vancouver (B.C. Canada) material: A & C, apex; B & E, central area; D, axial area and areolae mid-way along the valve. One internal longitudinal canal evident; F, areolae on the valve face and canal with some showing 1–4 surrounding renilimbi (arrow). Scale bars: A = 10 µm; B & D = 5 µm; C & E = 10 µm; F = 2 µm.

broadly elliptical valves with multiple canals; these mainly represent specimens of *Neidium dilatatum* and *Neidium amphigomphus*.

Germain (1981: pl. 57:1) observed an elliptic linear valve (180 µm long, 26 µm wide) which has a similar shape form to *Neidium iridis* but with multiple longitudinal canals and should be compared to the line drawing of Meister (as *Neidium maximum*, pl. 15:5). *Navicula firma* Kütz. and *Navicula firma* var. *major* Grunow were mixed together with *Navicula iridis* by Gunow in Van Heurck (1880).

The original line drawing and description of *Navicula firma* Kütz. (Kützing 844: 82, pl. 21:10) presents a smaller valve (150–161 µm long by 38 µm wide) than *Neidium iridis*. Lefebvre et al. (2017) examined a type slide (prepared by R. Ross) for *Navicula firma* and have emended that taxonomic description. *Navicula firma* var. *major* needs further study.

Neidium iridis, with distinct obtuse to sagittate apices, can be aligned with other smaller sagittate taxa, including *Neidium cape-codense* Siver & P.B.Ham., *Neidium gracile* Hust., *Neidium pseudogracile* H.Kobayasi, *Neidium tokyoense* H.Kobayasi, *Neidium indicum* Gonzalves & H.P.Gandhi and *Neidium indicum* f. *undulatum* "undulata" Gonzalves & H.P.Gandhi. These smaller taxa are distributed around the world suggesting that the sagittate shape-form is not biogeographically restricted. The relationship among these taxa (genetic and morphological if any) is yet to be determined.

CONCLUSION

Neidium iridis is an extant species which to date has primarily been observed s. str. from North America. Reports from Japan suggest that this taxon extends beyond North America; however, to date no positive identifications have been recorded for South America (Metzeltin & Lange-Bertalot 2007) and Europe (e.g. Krammer & Lange-Bertalot 1986). The valves are large linear, to weakly linear-elliptic with rostrate to sagittate apices. One large longitudinal canal is present along the valve face-mantle margin. The termination of the longitudinal canals do not extent to the apex, thereby forming a circular-type cavity at the apex which is easily seen in LM. Externally, the central raphe endings are small deflected hooks and the terminal ends form a lacinia. Areolae can be covered by a dense radiating cribra. Internally, renilimbi form around selected areolae, especially along the longitudinal canals and the axial area. The internal central helictoglossae fuse to form a single line projection and the terminal helictoglossae are bent away from the internal valve face. The extensive documentation of species (line drawings and marked specimens) by Ehrenberg and his daughter Clara has given us the opportunity to find, document and further emend the species *Neidium iridis* using finer examination tools.

ACKNOWLEDGEMENTS

We are thankful to David Lazarus for access to the Ehrenberg collection. The work of R. Jahn and W.-H. Kusber in the Ehrenberg Collection was part of the AlgaTerra Project financed by the German Federal Ministry of Education and Research, BMBF [grant 01 LC 0026], PhycoBank is granted by Deutsche Forschungsgemeinschaft (DFG) [JA 874/8-1]. This work was funded by a RAC-2014–2017 grant to P.B. Hamilton from the Canadian Museum of Nature. A special thanks to two reviewers for helpful suggestions on the manuscript.

REFERENCES

Boyer C.S. (1916) The Diatomaceae of Philadelphia and vicinity. Philadelphia, J.B. Lippincott.

Cleve P.T. (1894) Synopsis of the naviculoid diatoms. Part I. Kongliga Svenska-Vetenskaps Akademiens Handlingar 26(2): 1–194.

Cleve-Euler A. (1955) Die Diatomeen von Schweden und Finnland. Teil IV, Biraphidae 2. Kongliga Svenska Vetenskaps-Akademiens Handlingar, Fjärde Serien 5(4): 1–232.

Donkin A. (1871) The Natural history of British Diatomaceae. Part 2. London, J. van Voorst. https://doi.org/10.5962/bhl.title.56448

Ehrenberg C.G. (1843) Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika. Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin 1841: 291–446.

Germain H. (1981) Flore de diatomées eaux saumâtres du Massif Armoricain et des contrées voisines d'Europe occidentale. Paris, Société Nouvelle des Éditions Boubée.

Grunow A. (1860) Über neue oder ungenügend gekannte Algen. Erste Folge, Diatomeen, Familie Naviculaceen. Verhandlungen der kaiserlich-königlichen zoologisch-botanischen Gesellschaft in Wien 10: 503–582.

Hamilton P.B., Jahn R. (2005) Typification of Navicula affinis Ehrenberg: Type for the name of the genus Neidium Pfitzer. Diatom Research 20: 281–294. https://doi.org/10.1080/0269249X.2005.9705637

Hanna G.D. (1933) Diatoms of the Florida peat deposits. Florida State Geological Survey 23 and 24th Annual Report: 68–119. Tallahassee, Florida.

Hustedt F. (1930) Bacillariophyta. In: Pascher A. (ed.) Süßwasserflora von Mitteleuropa. Jena, Gustav Fischer Verlag.

Jahn R., Kusber W.-H. (2004) Algae of the Ehrenberg collection 1. Typification of 32 names of diatom taxa described by C.G. Ehrenberg. Willdenowia 34: 577–595. https://doi.org/10.3372/wi.34.34219

Krammer K., Lange-Bertalot H. (1986) Bacillariophyceae. 1. Teil: Naviculaceae. In: Ettl H., Gerloff J., Heynig H., Mollenhauer D. (eds) Süsswasserflora von Mitteleuropa, vol. 2/1. Stuttgart, Gustav Fischer Verlag.

Kützing F.T. (1844) Die kieselschaligen Bacillarien oder Diatomeen. Nordhausen, W. Köhne. https://doi.org/10.5962/bhl.title.64360

Lazarus D., Jahn R. (1998) Using the Ehrenberg collection. Diatom Research 13: 273–291. https://doi.org/10.1080/0269249X.1998.9705451

Lefebvre K.E., Hamilton P.B. (2015) Morphology and molecular studies on large Neidium species (Bacillariophyta) of North America, including an examination of Ehrenberg's types. Phytotaxa 220: 201–223. https://doi.org/10.11646/phytotaxa.220.3.1

Lefebvre K., Hamilton P.B., Pick F.R. (2017) A comparison of molecular markers and morphology from Neidium taxa (Bacillariophyta) from eastern North America. Journal of Phycology 53: 680–702. https://doi.org/10.1111/jpy.12537

Meister F. (1912) Die Kieselalgen der Schweiz. Beiträge zur Kryptogamenflora der Schweiz vol. 4(1). Bern, [publisher J. Wyss].

Metzeltin D., Lange-Bertalot H. (2007) Tropical diatoms of South America II. Special remarks on biogeographic disjunction. Iconographia Diatomologica 18: 1–877.

Okuno H. (1964) Diatomeenschalen im elektronenmikroskopischen Bild. Teil V. Fossil diatoms. Weinheim, J. Cramer.

Pantoscek J. (1902) Die Bacillarien des Balatonsees (section 1). In: Die Biologie des Balatonsees, Resultate der wissenschaftlichen Erforschung Balatonsees (Zweiter Band), eds. Balatonsee-Commission der UNG. Wien, Geographischen Gesellschaft.

Patrick R., Reimer C.W. (1966) The diatoms of the United States. vol. l: Fragilariaceae, Eunotiaceae, Achnanthaceae, Naviculaceae. Philadelphia, Monographs of the Academy of Natural Sciences of Philadelphia.

Pelletan J. (1888) Les diatomées. Histoire naturelle, préparation, classification & description des principales espèces. Paris, Journal de Micrographie. https://doi.org/10.5962/bhl.title.929

Pfitzer E. (1871) Untersuchungen über Bau und Entwickelung der Bacillariaceen (Diatomaceen). In: Hanstein J. (ed.) Botanische Abhandlungen aus dem Gebiet der Morphologie und Physiologie. Bonn, Adolph Marcus.

Reimer C.W. (1959) The diatom genus Neidium. I. New species, new records and taxonomic revisions. Proceedings of the National Academy of Natural Sciences of Philadelphia 111: 1–35.

Ross R., Cox E.J., Karayeva N.I., Mann D.G., Paddock T.B.B., Simonsen R., Sims P.A. (1979) An amended terminology for the siliceous components of the diatom cell. Nova Hedwigia Beiheft 64: 513–533.

Sabelina M.M., Kiselev I.A., Proshkina-Lavrenko A.I., Sheshukova V.S. (1951) Diatomovye vodorosli (redakmor eynuska A.I. Proschkina-Lavrenko). Opredelitely presnovodnykh vodoroslei S.S.S.R. VYPUSK 4. Moskva, Gosudarstvennoe Izdatelystvo Sovetskaya Nauka.

Schmidt A.W.F. (1874–1959) Atlas der Diatomaceenkunde. Leipzig, O.R. Reisland. https://doi.org/10.5962/bhl.title.64396

Siver P.A. (1987) The distribution and variation of Synura species (Chrysophyceae) in Connecticut, USA. Nordic Journal of Botany 7: 107–116. https://doi.org/10.1111/j.1756-1051.1987.tb00922.x

Siver P.A., Hamilton P.B., Stachura-Suchoples K., Kociolek J.P. (2003) Morphological observations of Neidium species with sagittate apices, including the description of N. cape-codii sp. nov. Diatom Research 18: 131–148. https://doi.org/10.1080/02699249X.2003.9705578

Siver P.A., Hamilton P.B., Stachura-Suchoples K., Kociolek J.P. (2005) Diatoms of North America: The freshwater flora of Cape Cod, Massachusetts, U.S.A. Iconographia Diatomologica 14: 1–463.

Stosch H.A. von (1975) An amended terminology of the diatom girdle. Nova Hedwigia 53: 1–35.

VanLandingham S.L. (1978) Catalogue of the fossil and recent genera and species of diatoms and their synonyms. Part VI. Neidium through Rhoicosigma 6: 2964–3605. Vaduz, J. Cramer.

Van Heurck H. (1880–1885) Synopsis des diatomées de Belgique. Atlas, taf. 1–30 (1880), taf. 31–77 (1881), taf. 78–103 (1882), taf. 104–132 (1883), taf. A, B, C (1885), table alphabétique, texte (1885). Anvers, édité par l'auteur.

Van Heurck H. (1896) A treatise on the Diatomaceae. London, Wesley & Son. https://doi.org/10.5962/bhl.title.2002

Wolle F. (1890) Diatomaceae of North America. Bethlehem, Pennsylvania, Comenius Press. https://doi.org/10.5962/bhl.title.45949

Managing Editor: David G. Mann

Submission date: 3 Nov. 2018

Acceptance date: 8 Feb. 2019