Gomphonema supersaprophilum sp. nov., a new diatom species (Gomphonemataceae, Bacillariophyceae) from Flemish rivers (Belgium)

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Abstract

During a biomonitoring survey of the Flemish rivers, an unknown *Gomphonema* taxon was observed. After detailed light and scanning electron microscopy research and careful analysis with similar species in literature, the taxon is described as *Gomphonema supersaprophilum* sp. nov. The new species can be separated from similar species from the *G. parvulum-saprophilum* complex by its larger width, the shape of the head pole and the shape of the areolae. The new species was typically found in highly eutrophic waters.

Key-words

Biomonitoring, Europe, eutrophic waters, Flanders, *Gomphonema*, morphology, new species

Introduction

Ehrenberg (1832) proposed in 1832 the genus *Gomphonema* with *G. acuminatum* Ehrenberg (1832: 88) as conserved type. According to Algaebase (Guiry & Guiry 2023), there are almost 600 accepted species names with another 260 accepted infraspecific taxa and several hundreds of synonyms and taxa names with an unclear status. The past few years, the catch-all genus *Gomphonema* was revised based on morphological and molecular evidence (Abarca *et al.* 2014, 2020, 2023, Jahn *et al.* 2019. Several (including previously described but later with *Gomphonema* lumped) genera were reseparated again such as *Gomphoneis* and *Gomphonella* (Jahn *et al.* 2019, whereas others were described to accommodate part of the species formerly placed in *Gomphonema*, such as for instance the recently described genus *Gomphadelpha* Abarca *et al.* (in Abarca *et al.* 2023). Abarca *et al.* (2020) defined, based on both morphological and genetic methods, the complex of species around *G. acuminatum* as the *Gomphonema* core group, separating this group from other clusters such as the *G. parvulum* complex and the *G. augur* group. At present, all clades discussed in Abarca *et al*. (2020) remained, however, in the genus *Gomphonema*, although this will change in the near future (Abarca, pers. comm.).

The group of species around *G. parvulum* is often reported in water quality surveys and belongs to some of the most common *Gomphonema* taxa in European rivers, often indicating higher levels of pollution (Lange-Bertalot *et al.* 2017). During a regular water quality monitoring survey of the rivers in Flanders, the northern part of Belgium, a fairly large and several very small populations of an unknown, broad-celled *Gomphonema* taxon were observed that could at present not be identified using the currently available literature. Scanning electron microscopy observations showed that the unknown species morphologically belongs to the complex of species related to *Gomphonema parvulum*. Moreover, the species showed a high resemblance to several members of the *G. parvulum*-group especially *G. saprophilum*, but the valve dimensions

were at least 30% larger with a valve width never inferior to 8 µm, considered to be the maximum width of *G. saprophilum* (6–8 µm, sensu Lange-Bertalot *et al.* 2017). Following a comparison of the morphology of the unknown taxon (based on light (LM) and scanning electron microscopy (SEM) observations) with similar European taxa, it was clear that the unknown taxon should be described as a new species: *Gomphonema supersaprophilum* Van de Vijver & E.Reichardt *sp. nov*.

Material & Methods

During the annual biomonitoring survey of rivers in Flanders (Belgium), the unknown Gomphonema taxon was found in several samples. The largest sample, sample APM23_73 collected by the Vlaamse Milieu Maatschappij (coll. date 24.viii.2023), was taken from the Devebeek (Ingelmunster, West-Vlaanderen, Belgium). A subsample of APM23_73 was prepared for LM and SEM observations following the method described in van der Werff (1955). Small amounts of each sample were cleaned by adding 37% H_2O_2 and heating to 80°C for about 1 h, after which the reaction was completed by addition of saturated $KMnO_4$. Following digestion and centrifugation (three times for 10 minutes at 3700 × rpm), the resulting cleaned material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides. Cleaned diatom material was mounted in Naphrax (refraction index 1.73) and analysed using an Olympus BX53 microscope at 1000x magnification (N.A. 1.30), equipped with Differential Interference Contrast (Nomarski) optics and the Olympus UC30 Imaging System, connected to the Cell Sense Standard program. For each taxon, the number of specimens, measured at random on the slide, is indicated (n=X). Stria density was determined by counting striae from the central area onwards to the apices. Middle striae are often more spaced, underestimating the actual stria density.

For SEM analysis, part of the suspension was filtered through 5-µm Isopore™ polycarbonate membrane filters (Merck Millipore), pieces of which were affixed with conductive double-sided adhesive carbon-tabs to aluminum stubs after air–drying. Stubs were coated with a platinum layer of 15 nm, and studied using a JEOL-JSM-7100F field emission scanning electron microscope at 2 kV and a working distance of 4 mm. Slides and stubs are stored at the BR-collection (Meise Botanic Garden, Belgium). Plates were prepared using Photoshop CS5.

Terminology used in the description of the various structures of the siliceous cell wall is based on Ross et al. (1979, areola structure), Cox & Ross (1981, stria structure), Round et al. (1990, raphe structure), and Reichardt (1999, genus features for *Gomphonema*). The new species was compared with different *Gomphonema* taxa described mainly in Europe (Reichardt 1999; Levkov *et al.* 2016).

For typification of the species, we chose to use the entire slide as the type, following article 8.2 of the International Code for Botanical Nomenclature (Turland *et al.* 2018). Diatoms show a broad variability along their cell cycle making the choice for the entire population on the slide more obvious, but because of admixtures, one valve was indicated to illustrate the taxon best (see Figures). All novelties are registered proactively according to Art. 42.3 (Turland *et al.* 2018).

Results

Gomphonema supersaprophilum* Van de Vijver & E.Reichardt *sp. nov. (Figs 1–20 LM, 21–27 SEM)

Valves clavate, elliptic-lanceolate with broadly rounded valve margins, more strongly tapering towards the acutely ending footpole than towards the broadly rounded, typically protracted, rostrate headpole. Larger, more lanceolate valves, naviculoid valve outline (Figs 1, 2). Valve dimensions (n=25): length 24–52 µm, width 7.5–10.0 µm, the largest width almost at or slightly

above the valve middle. Axial area linear, narrow, only 1/6 of the total valve width. Irregular pattern of very shallow depressions present in the axial area, not discernible in LM (Figs 21–23). Central area asymmetrical with shortened striae. On the primary side, one stria hardly shortened, terminated by a small, rounded isolated pore, clearly different in size and shape from the areolae (Figs 21–23). On the secondary side, stria either missing (Figs 1, 9, 13) or shortened. Raphe clearly lateral with undulating outer branches. Central raphe endings inflated, almost straight to weakly deflected (Figs 21–23). Terminal raphe fissures elongated onto the valve mantle, hooked (Figs 21, 22, 24). Striae uniseriate, 10–12 in 10 µm. Striae composed of slit-like, elongated, to weakly comma-shaped areolae (Figs 23–24), continuing onto the mantle. Mantle areolae likewise slit-like, terminating before the mantle edge, leaving a moderately broad hyaline zone at the edge (Fig. 22). Apical pore field at the footpole rather smaller, bisected by the terminal raphe fissure, composed of several densely packed rows of small, rounded pores. Internally, areolae located in shallow grooves, presenting slit-like foramina (Figs 25–27). Silica struts very small, not forming bars separating the areolae (Fig. 26). Central raphe endings hooked and recurved (Figs 25–26). Terminal raphe endings terminating onto distinct helictoglossae (Figs 25, 27). Internal foramen of the isolated pore slit-like, long (Fig. 27). Small pseudosepta present on both footpole and headpole (Fig. 25).

Type:—BELGIUM. Devebeek, Ingelmunster, West-Vlaanderen, Belgium, sample APM23_73 (coll. date 24.viii.2023), leg. Vlaamse Milieu Maatschappij (holotype slide BR-4831= Fig. 6, isotype slide 436, University of Antwerp, Belgium).

Registration:— http://phycobank.org/104391

Etymology:—The specific epithet "*supersaprophilum*" refers to the superficial resemblance to *G. saprophilum* in combination with the much larger valve dimensions.

Ecology & associated diatom flora:—Sample APM23-73 was collected from submerged *Phalaris arundinacea* stems in the Devebeek, a small lowland river in Flanders, the northern part of Belgium, not far from the small town of Ingelmunster. The diatom flora in the river is characterised by high frequencies of *Craticula subminuscula* (Manguin 1942: 139) C.E.Wetzel & Ector (in Wetzel *et al*. 2015: 229), *Gomphonema parvulum* (Kützing 1844: 83) Kützing (1849: 65), *Melosira varians* C.Agardh (1827: 628), *Navicula trivialis* Lange-Bertalot (1980: 31), *N. veneta* Kützing (1844: 95), and several *Nitzschia* species such as *N. amphibia* Grunow (1862: 574), *N. palea* (Kützing 1844: 63) W.Smith (1856: 89) and *N. pseudofonticola* Hustedt (1942: 209). According to the ecological data in Lange-Bertalot *et al*. (2017), this diatom community is typical for alkaline, eutrophic, electrolyte-rich, up to polysaprobic waters, indicating a high level of pollution.

Discussion

The unique morphological combination of elliptic-lanceolate valve outline and the rather large valve width, allows the separation of *Gomphonema supersaprophilum* from other similar *Gomphonema* taxa. Table 1 presents a comparison of several *Gomphonema* taxa showing similarity to *G. supersaprophilum*. *Gomphonema parvulum* and its sister species *G. saprophilum* have smaller valve dimensions with *G. parvulum* presenting a width not exceeding 7.5 µm and *G. saprophilum* not exceeding 8 µm (Abarca *et al.* 2014). In addition, *G. parvulum* differs significantly in outline characterised by more elliptic valves with a distinctly protracted to subcapitate headpole contrary to the elliptic-lanceolate valves with weakly protracted and never subcapitate headpole in *G. supersaprophilum* (see for instance Reichardt 2018: plate 314, figs 1–13). This representation of *G. parvulum* contradicts the general idea of *G. parvulum* having truncated, shortly rostrate apices as for instance illustrated in Lange-Bertalot *et al*. (2017, plate

101, figs 1–5). The areolae in *G. parvulum* and *G. saprophilum* show some variety in shape and size generally ranging from c- to kidney-shaped but at present not slit-like, almost straight as in *G. supersaprophilum*. Although *G. saprophilum* has broader valves than *G. parvulum*, they can still be easily separated from *G. supersaprophilum* based on their more elongate valve outline. Abarca *et al*. (2014) studied a large number of strains of both *G. parvulum* and *G. saprophilum*, but none of their illustrated valves resembles any of the *G. supersaprophilum* valves observed in the present study. *Gomphonema lippertii* E.Reichardt & Lange-Bertalot (in Reichardt 1999: 21) has similar valve dimensions (width 8–11 µm) and partly a comparable valve outline although longer valves tend to be more narrowly lanceolate (see Reichardt 1999, plate 21, figs 1 & 2). The headpole in *G. lippertii* is more elongated and tapers more gradually lacking the broadly rounded apex, compared to *G. supersaprophilum*. Ecologically, both taxa distinctly differ with *G. lippertii* typical for calcium-carbonate rich, more oligotrophic lakes in Central Europe (Reichardt 1999, Lange-Bertalot *et al.* 2017). Another taxon with a comparable valve outline and valve width (7–10 µm) is *G. pseudoaugur* Lange-Bertalot (1979: 202) but the latter differs in the shape of the headpole that is typically cuneate (contrary to *G. supersaprophilum* that has a more rostrate headpole), and the position of the maximum valve situated well above the valve middle (see Lange-Bertalot 1979, figs 11–19). *Gomphonema pseudoaugur* has a lower stria density (9–12 in 10 µm versus 11–14 in 10 µm) although there is a slight overlap (Lange-Bertalot 1979, Lange-Bertalot *et al.* 2017). However, *G. supersaprophilum* valves with a stria density inferior to 11 in 10 µm, have so far not been seen in the different populations. The areolae in *G. pseudoaugur* are kidney-shaped and do not seem to be slit-like as is the case in *G. supersaprophilum*.

Other *Gomphonema* taxa bearing this combination of morphometric and morphological features could not be found in the currently available literature (Reichardt 1999, 2018, Levkov *et al.*

2016), justifying the description of this unknown European taxon as new. The description of *G. supersaprophilum* will help to refine the use of these species as bio-indicators in the biomonitoring of European water bodies.

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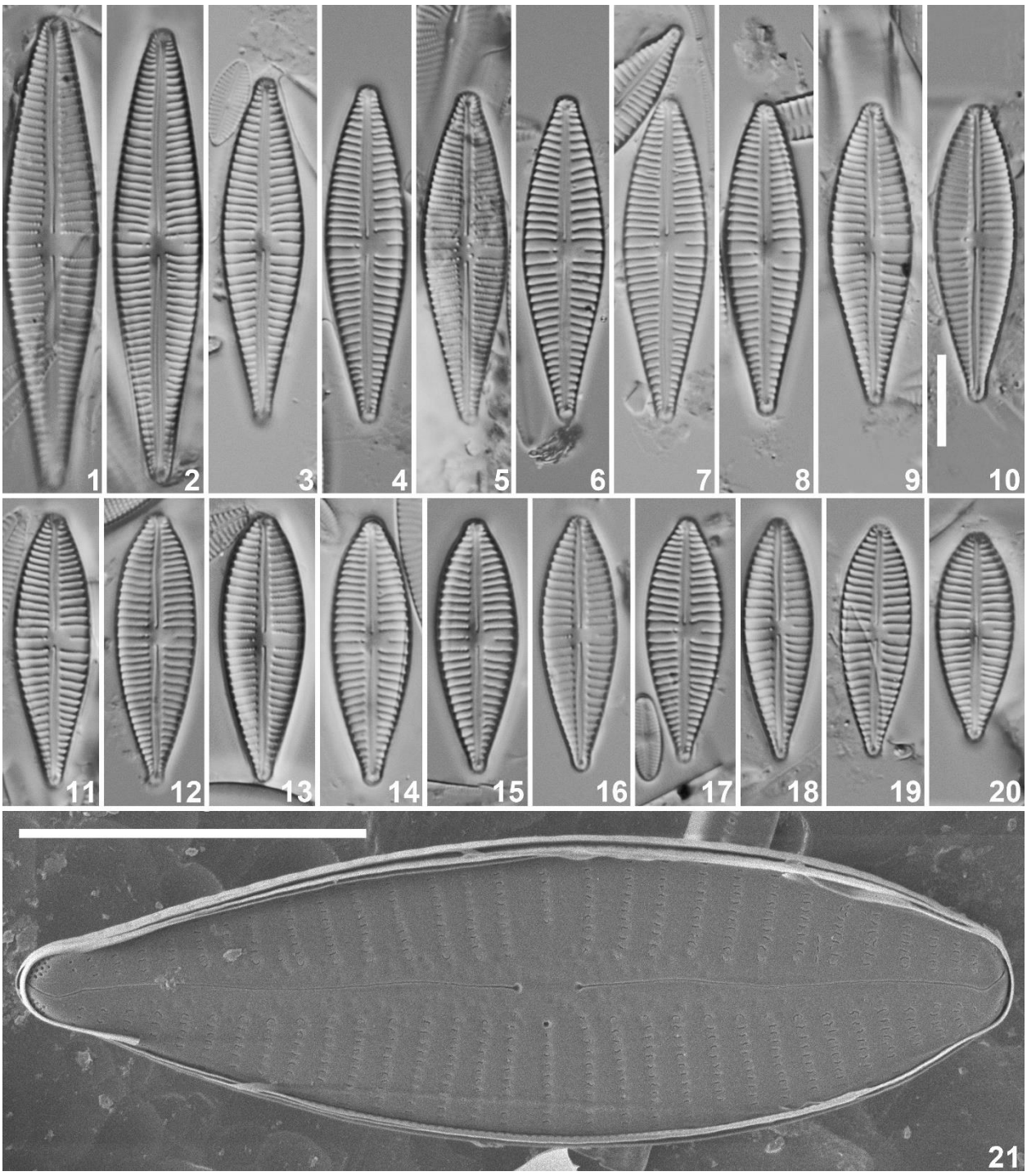
Table 1. Morphological and morphometric details of species showing some similarity with *G. superparvulum*.

	Gomphonema supersaprophilum	*Gomphonema saprophilum*	*Gomphonema parvulum*	*Gomphonema lippertii*	*Gomphonema pseudoaugur*
original author	sp. nov.	(Lange-Bertalot & E.Reichardt) Abarca et al.	(Kützing) Kützing	E.Reichardt & Lange-Bertalot	Lange-Bertalot
year of publication	this study	2014	1849	1999	1979
length (µm)	24-52	22-27	22-29	23.5-37.5	25-55
width (µm)	7.5-10	6-8	5-7.5	8.3-10.7	7-10
striae (in 10 µm)	10-12	12-20	12-20	11-14	9-12
valve outline	elliptic-lanceolate valves	clavate-lanceolate, rather rhomboid	lanceolate, linear-lanceolate or elliptic heteropolar	lanceolate to rhombic-lanceolate, longer valves more lanceolate, occasionally cymbelloidly bent	oval to lanceolate-club shaped, largest width above the valve middle
apices	weakly protracted, never subcapitate headpole	slightly rostrate, broad headpole	distinctly protracted to subcapitate headpole	elongated, tapering more gradually lacking the broadly rounded apex	cuneate headpole

Figure captions

Figures 1–21. *Gomphonema supersaprophilum* Van de Vijver & E.Reichardt, *sp. nov*. LM and SEM images taken from the holotype sample (BR-4831, Devebeek, Ingelmunster, Wet-Vlaanderen, Belgium, sample APM23-73). 1–20. LM views of the population arranged in decreasing length. 21. SEM external view of an entire valve. Scale bars = 10 µm.

Figures 22–27. *Gomphonema supersaprophilum* Van de Vijver & E.Reichardt, *sp. nov*. SEM images taken from the holotype sample (BR-4831, Devebeek, Ingelmunster, Wet-Vlaanderen, Belgium, sample APM23-73). 22. SEM external view of an entire valve in oblique view showing the valve mantle. 23. SEM external detail of the central area showing the isolated pore (arrow) and the slit-like areolae. 24. SEM external detail of the footpole with the apical pore field bisected by the terminal raphe fissure. 25. SEM internal view of an entire valve. 26. SEM internal detail of the central area showing the isolated pore (arrow) and the hooked central raphe endings. Note the reduced silica struts. 27.SEM internal detail of the footpole with the helictoglossa. Scale bars = 10 µm (Figs 22, 25) = 1 µm (Figs 23, 24, 26, 27).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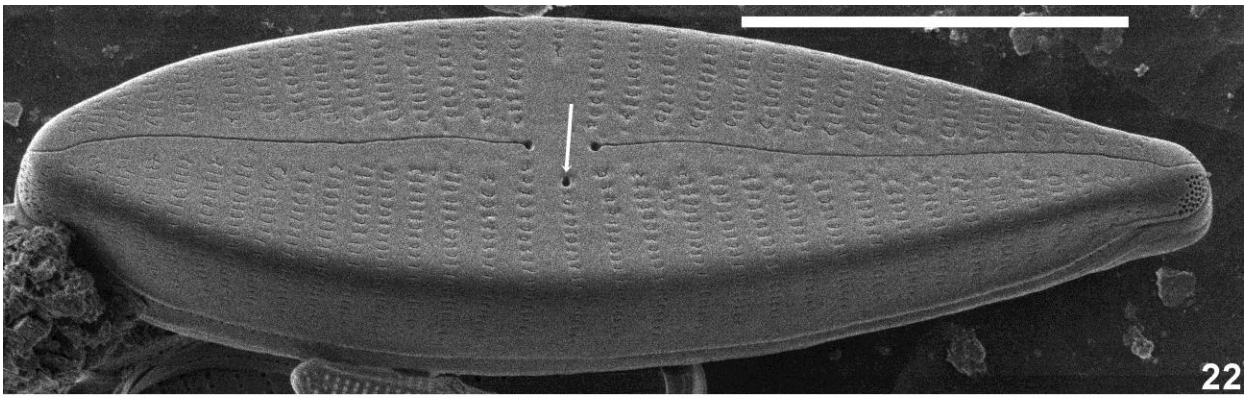
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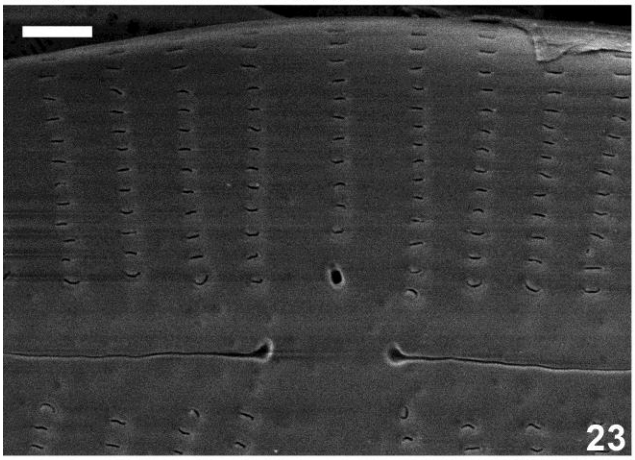
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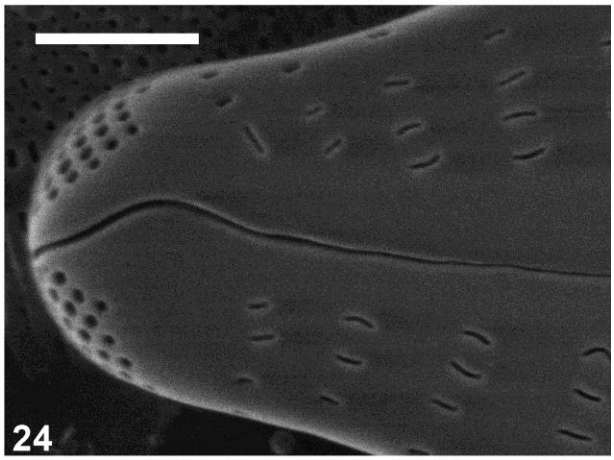
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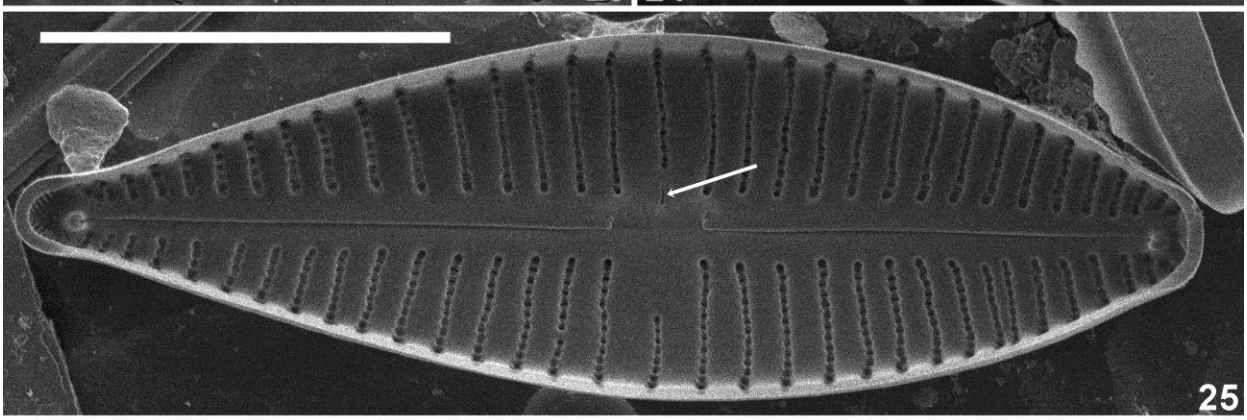
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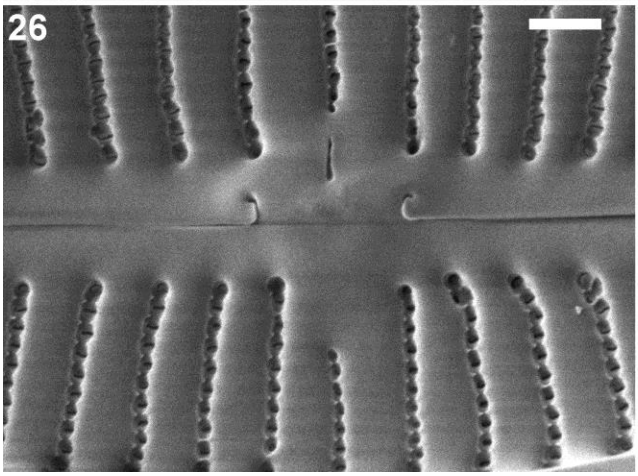
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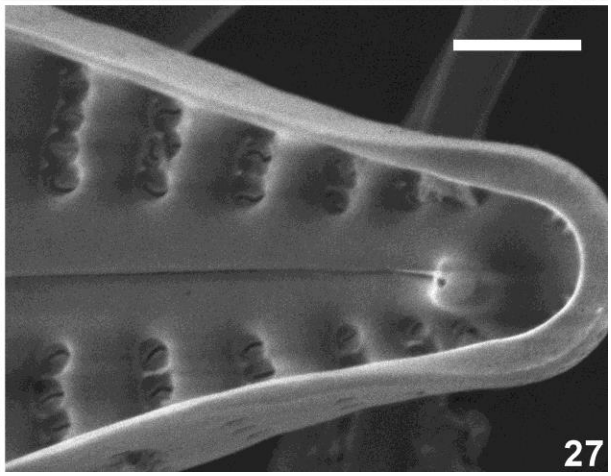
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