Observations on and typification of *Gomphonema micropus* Kützing (*Gomphonemataceae*, *Bacillariophyceae*) with notes on the type of *G. commune* Rabenhorst*

Bart Van de Vijver[1], Wolf-Henning Kusber[2], Erwin Reichardt[3] & Ingrid Jüttner[4]

[1]*Meise Botanic Garden, Research Department, Nieuwelaan 38, 1860 Meise, Belgium & University of Antwerp, Department of Biology – ECOSPHERE, Universiteitsplein 1, B-2610 Wilrijk, Belgium* (correspondence: bart.vandevijver@plantentuinmeise.be)

[2]*Botanischer Garten und Botanisches Museum, Freie Universität Berlin, Königin-Luise-Str. 6-8, 14195 Berlin, Germany*

[3]*Bubenheim 136, 91757 Treuchtlingen, Germany*

[4]*Department of Natural Sciences, Amgueddfa Cymru –Museum Wales, Cathays Park, Cardiff, CF10 3NP, UK*

Gomphonema micropus Kützing (1844: 84, pl. 8: fig. XII), a widespread and relatively common *Gomphonema* species in European rivers (Lange-Bertalot & al. 2017), was described from a sample collected from *Vaucheria clava* (Vaucher) A.P.de Candolle [currently *Vaucheria bursata* (O.F.Müller) C.Agardh] near Nordhausen (Germany). In the catalogue of the Kützing collection made by Eulenstein in 1868, held partly in the Natural History Museum, London (**BM**), and partly in Meise Botanic Garden (**BR**), only two samples are listed for *G. micropus*; however, both are from Falaise (Normandy, France), certainly based on material collected and sent by L.A. de Brébisson (1798–1872). Lange-Bertalot & Krammer (1986: 752), who considered *G. micropus* a synonym of *G. angustatum* (Kützing) Rabenhorst, chose the sample *Kützing 370*, collected by de Brébisson in Falaise, as lectotype for *G. micropus*, but since the material from Falaise was not part of the original material used to describe the species in 1844, it has no standing as a lectotype (ICN Art. 9.19). Kützing (1849: 63) added, however, that material from France, sent to him by de Brébisson, contained *G. micropus* (*Specimina gallica misit amic. De Brébisson*). Later, Krammer & Lange-Bertalot (1991: 396, caption of figs 1–8) reported on the same material but considered that it was a "neotype" since the material was not from the location mentioned in the protologue ('*Neotypus und nicht Lectotypus, weil es nicht mit dem Typenhabitat im Protolog übereinstimmt*'), and stated that *Gomphonema micropus* Kützing 1844 has priority over *Sphenella angustata* Kützing 1844 syn. *Gomphonema angustatum* (Kützing) Rabenhorst 1864. Lange-Bertalot (1993: 310) designated slide **BM** 18607, prepared from sample *Kützing 370* and kept in **BM** (Natural History Museum, London, UK) as "(Lectotype)/Neotype" for the species.

In the catalogue of the Kützing collection (**BR**), a handful of samples collected in or near Nordhausen (Thuringia, Germany) were listed. For none of these samples, *G. micropus* was listed among the taxa observed in the sample (Van de Vijver, pers. obs.). Analysis of these samples by one of us (BVDV) resulted, however, in the finding of a small population of a *Gomphonema* species, showing all the features of *G. micropus* as outlined by Kützing (1844). The population in this sample, *Kützing 209*, is here further analysed using light and scanning electron microscopy, to document the morphology of *G. micropus*.

Reichardt (1999: 134, pl. 36: figs 1–4, 11–12) added another *Gomphonema* taxon, *G. commune* Rabenhorst (1864: 283), as a synonym to *G. micropus*, stating that after analysis of the type material (*Rabenhorst 1322*), *G. commune* and *G. micropus* can be considered conspecific. This publication was the first linking *G. commune* and *G. micropus*. Older publications mentioning *G.*

* This was one of the last manuscripts we were working on as a team with our friend and colleague Luc Ector (1963–2022) before he passed away too early. The manuscript was left aside for more than a year and is now dedicated to his memory.

commune always linked the latter to *G. angustatum*. Grunow (in Van Heurck 1880: pl. 24: figs 49–50) illustrated two valves as *G. angustatum* adding *G. commune* as one of the synonyms together with *Sphenella angustata* Kützing (1844: 83), *Sphenella naviculoides* Hantzsch (in Rabenhorst 1864: 1322) and *Navicula parmula* Brébisson ex Kützing (1846: 246). Both De Toni (1892: 429) and Cleve (1894: 181) also regarded *G. commune* as synonym of *G. angustatum*.

Gomphonema commune was based by Rabenhorst (1864) on material sent to him by Carl A. Hantzsch (1825–1886) from one of his samples (*Hantzsch 1021*) collected at Strehlen (Dresden, Germany) in March 1862. Based on the handwritten catalogue of the Hantzsch collection, kept in **BR**, sample *Hantzsch 1021* is identical to sample *Rabenhorst 1322*. Rabenhorst had originally included the sample in his set of exsiccatae *Die Algen Europa's* as n°1322 ("*Strehlen bei Dresden, in einem Graben*") under the name *Sphenella naviculoides* Hantzsch. A short description was added on the sample label: '*Hauptseite lanzettförmig, nach unten wenig konisch, Länge 0,027–0,034 m. M., Breite 0,008–0,010. Enden schwach kopfförmig; Streifung sehr deutlich, wenig radial; Centralknoten fast mittelständig, ein wenig mehr nach oben liegend. Nebenseite linearisch, schwach konisch, beiderseits gerade abgestutzt. – Nach der Theilung bleiben meist 2–4 Exemplare längere Zeit fest mit einander verbunden. – Panzer sehr robust.*' [Valve lanceolate, at the footpole weakly conical, length 27–34 µm, width 8–10. Apices weakly capitate. Striation very distinct, weakly radiate. Central raphe endings almost in the middle, located slightly closer towards the head pole. Girdle view linear, weakly clavate, at both apices truncated. After the cell division 2–4 cells stay firmly connected to each other for some time. Frustule very robust.]. Rabenhorst (1864) renamed the species as *Gomphonema commune* and added the following description: '*G. valvis lanceolatis, deorsum subconico-attentuatis, apicibus subcapitate-obtusis, nodulo medio distincto rotundato, striis subradiantibus, circ. 35 in 0,001´´. Long. 0,0010–0,0017´´.*' [*Gomphonema* with lanceolate valves, rarely subclavate, with subcapitate, obtuse apices. Central area distinctly rounded. Striae subradiate, ca. 35 in 25 µm (14 in 10 µm). Length 25–43 µm.]. Rabenhorst specified that after cell division, frustules regularly stayed connected to each other. The new name, *G. commune* was necessary to avoid homonymy with *Gomphonema naviculoides* W.Smith, described in 1856 (Smith 1856: 98) from the Royal Botanic Garden Edinburgh, Scotland (Van de Vijver & al. 2020).

In the Van Heurck collection, part of the general herbarium of Meise Botanic Garden (**BR**, Belgium), unmounted materials for the samples *Kützing 370*, *Hantzsch 1021* and *Rabenhorst 1322* were retrieved. The diatom composition in the latter two samples were identical, confirming that they originated from the same material. The record in the handwritten catalogue of the Hantzsch samples conserved in **BR** also confirms that *Hantzsch 1021* formed the basis for Rabenhorst's sample *1322*. As the former contained more valves, it was used for further analysis and lectotypification of *Sphenella naviculoides* Hantzsch (currently *Gomphonema commune*).

In this contribution, we provide a detailed morphological description of specimens belonging to *Gomphonema micropus* (*Kützing 209*) and *G. commune* (*Rabenhorst 1322 = Hantzsch 1021*) and compare them with a *Gomphonema* population erroneously identified by Lange-Bertalot (1993) as *G. micropus* (*Kützing 370*) using light and scanning electron microscopy. Kützing sample 209 is designated as lectotype for *G. micropus* whereas *Rabenhorst 1322* (*=Hantzsch 1021*) is designated as lectotype for *S. naviculoides* (syn. *G. commune*). Our observations show that the lectotype population of *Gomphonema micropus* and *G. commune* seem to be conspecific making *G. commune* a younger synonym of *G. micropus*.

Gomphonema micropus Kützing (Figs 1–12)

Original description: *Gomphonema micropus* Kützing, *Die Kieselschaligen Bacillarien oder Diatomeen*, p. 84, pl. 8: fig. 12, 1844.

Lectotype (here designated): **BR**-4754, *Kützing 209* (Nordhausen, Germany) Fig. 5 illustrates the lectotype.

Registration: http://phycobank.org/102717

Etymology: *micropus* (Greek, noun), a small foot. The epithet is a noun in apposition and retains its gender.

Description: Frustules in girdle view not observed. Valves elliptic-lanceolate with distinctly convex margins. Head pole weakly protracted, truncated, short rostrate, more distinctly rostrate in longer specimens. Foot pole weakly protracted, more or less acutely rounded. Valve dimensions (n=10): length 24–36 µm, width 7.5–8 µm, the largest width slightly above the middle of the valve. Axial area slightly broadened (up to 1/5 of the total valve width), linear, not widening towards the central area. Central area small, rectangular, with one moderately shortened stria on one side and one slightly shortened stria on the opposite side. One isolated pore present at the end of the slightly shortened striae, separated from the stria. Central striae slightly more distant from adjacent striae, the striae bordering the central area slightly curved. Raphe branches straight to undulating, almost filiform. Central raphe endings distinct, tear-drop-shaped, well separated from each other. Terminal raphe fissures not discernible in LM. Striae regularly spaced with broad virgae, radiate, usually straight but occasionally becoming curved towards the apices, and more strongly radiate towards the foot pole, 12–14 in 10 µm. Areolae not discernible in LM, small rounded in SEM.

Comment on typification: Previously published typifications and illustrated types were helpful with respect to the identification of Kützing's taxon but have no standing under the ICN (Art. 9, Turland & al. 2018). The first attempted typification was published by Krammer & Lange-Bertalot (1986: 752). The caption reads "Fig 1: *Gomphonema micropus* Kützing, Lectotypus, Herbar *Kützing 370* […]." This sample originates from Falaise, France, but this gathering was not mentioned by Kützing (1849: 63) until five years after the name was introduced for Nordhausen, Germany material by Kützing (1844: 84). The Falaise material was clearly not from the type locality and cannot therefore be designated as lectotype (ICN Art. 9.3). Later, Lange-Bertalot (1993: 310) corrected and expanded the type information: "Fig. 2-4: *Gomphonema micropus* Kützing, (Lectotypus)/Neotypus, Herbar *Kützing 370* = BM 18607." Again, the supposed lectotype was not from original material; additionally, a neotype can only be designated if no original material is extant (ICN Art. 9.8).

The population in *Kützing 370* (Falaise, France) was also analysed and compared with the here designated lectotype population from Nordhausen (*Kützing 209*). Figures 13–30 show the Falaise population, pointing out several important morphological differences. The areolae are e-to c-shaped in the Falaise population, contrary to the lectotype that has small, rounded areolae. The stria density is only 11–12 in 10 µm, versus 12–14 in the lectotype population. The Falaise population thus represents a different species. Reichardt & Levkov (in Reichardt 2018: 161) described *Gomphonema varians* E.Reichardt & Levkov, as a species with a similar valve outline as *G. micropus* but with c-shaped areolae. A comparison between the *Gomphonema* population in sample *370* and *G. varians* showed that they are indeed conspecific (Reichardt 2018, pl. 447: figs 1–37).

Gomphonema commune Rabenhorst (Figs 31–62)

Original publication: *Gomphonema commune* Rabenhorst, *Flora Europaea Algarum aquae dulcis et submarinae. Sectio I. Algas diatomaceas complectens, cum figuris generum omnium xylographice impressis*. Apud Eduardum Kummerum, Lipsiae, p. 283, 1864.

Replaced synonym: *Sphenella naviculoides* Hantzsch in Rabenhorst, *Die Algen Europa's* no. 1322, 1862.

Lectotype (here designated): **BR**-4647 (Meise Botanic Garden, Belgium). *Die Algen Europa's* no. 1322, leg. C.A. Hantzsch (*Hantzsch 1021*), March 1862.

Type locality: Strehlen, Dresden (Germany).

Registration (of above lectotypification): http://phycobank.org/103207

Description: Frustules in girdle view almost rectangular to very weakly clavate. Valves broadly lanceolate (larger valves) to elliptic-lanceolate (smaller valves) with distinctly convex margins. Head pole short protracted, truncated, rostrate. Foot pole clearly protracted, more or less broadly rounded. Valve dimensions (n=40): length 23–35 µm, width 7.0–8.5 µm, the largest width slightly above or in the middle of the valve. Axial area slightly broadened (up to 1/6 of the total valve width), linear, not widening towards the central area. Central area distinct, rectangular and asymmetric, with one very short stria on one side and a moderately shortened stria on the opposite side. Central striae slightly distantly placed from the adjacent striae, occasionally two slightly shortened striae in the central area. Several isolated, irregularly scattered areolae present in the central area, slightly larger than the areolae of the striae. One (rarely two) rounded isolated pores present at the end of, but clearly separated from, the moderately shortened central stria,. Internally, isolated pore opening visible as a long transapically elongated slit. Externally, raphe branches straight to very weakly undulating, almost filiform. Central raphe endings distinct, expanded and tear-drop-shaped, well separated from each other. Terminal raphe fissures elongated, unilaterally hooked, bisecting the apical pore field at the foot pole in two almost equally large parts. Apical pore field at foot pole composed of several dense rows of small porelli. Striae regularly spaced with broad virgae, radiate, becoming less radiate towards the apices in some valves, 12–13 in 10 µm. Striae uniseriate, composed of small, rounded areolae near the axial area and short slit-like, transapically elongated, areolae towards the valve margins, continuing onto the valve mantle. Internally, central raphe endings hooked and slightly recurved. Striae located in shallow grooves; areolae not separated by siliceous struts. Small pseudoseptum present at foot pole. Terminal raphe endings terminating in well-developed helictoglossae.

It is not clear how *Gomphonema varians* E.Reichardt & Levkov and *G. micropus* differ ecologically but accompanying taxa in sample *Kützing 370* compared to sample *Hantzsch 1021* = *Rabenhorst 1322* suggest that the former might be more typical of more meso-eutrophic waters. Sample *Hantzsch 1021* (or *Rabenhorst 1322*) is dominated by *G. commune* and *Meridion circulare* (Greville) C.Agardh with minor abundances for *Planothidium lanceolatum* (Brébisson) Lange-Bertalot, *Surirella minuta* Brébisson ex Kützing and *S. angusta* Kützing. Based upon Lange-Bertalot & al. (2017), this flora indicates moderate to higher trophic levels. On the other hand, sample *Kützing 370* has very high abundances of the same two *Surirella* species, together with *Navicula gregaria* Donkin, *Planothidium frequentissimum* (Brébisson ex Kützing) Lange-Bertalot, *Nitzschia linearis* W.Smith and *Cymatopleura solea* (Brébisson) W.Smith, according to Lange-Bertalot & al. (2017) are tolerant of eu- to even polytrophic environments.

Cleve, P.T. (1894). Synopsis of the naviculoid diatoms. Part I. *Kongliga Svenska Vetenskapsakademiens Handlingar Series* 4 26(2): 1–194, 5 pls.

De Toni, G.B. (1892). *Sylloge algarum omnium hucusque cognitarum*. Vol. II. Sylloge Bacillariearum. Sectio II. Pseudoraphideae. pp. [i-v], 491-817. Padova [Padua]: Sumptibus auctoris.

Krammer, K. & Lange-Bertalot, H. (1986). Bacillariophyceae. 1 Teil. Naviculaceae.- Die Süsswasserflora von Mitteleuropa 2/1. pp. 876, 206 pl., 2976 fig. Jena: Gustav Fischer Verlag.

Krammer, K. & Lange-Bertalot, H. (1991). Bacillariophyceae. 4 Teil. Achnanthaceae. Kritische Ergänzungen zu *Navicula* (Lineolatae) und Gomphonema.- Die Süsswasserflora von Mitteleuropa 2/4. pp. 437, 88 pl., 2048 fig. Jena: Gustav Fischer Verlag.

Kützing, F.T. (1844). *Die Kieselschaligen Bacillarien oder Diatomeen*. pp. [i–vii], [1]–152, pls 1–30. Nordhausen: zu finden bei W. Köhne.

Kützing, F.T. (1846). Kurze Mittheilung über einige kieselschalige Diatomeen. *Botanische Zeitung* 4(14): 247-248.

Kützing, F.T. (1849). *Species algarum*. pp. [i]-vi, [1]–922. Lipsiae [Leipzig]: F.A. Brockhaus.

Lange-Bertalot, H. (1993). 85 neue Taxa und über 100 weitere neu definierte Taxa ergänzend zur Süsswasserflora von Mitteleuropa, Vol. 2/1-4. *Bibliotheca Diatomologica* 27: 1–164, 134 pl.

Lange-Bertalot, H., Hofmann, G., Werum, M. & Cantonati, M. (2017). *Freshwater benthic diatoms of Central Europe: over 800 common species used in ecological assessments.* English edition with updated taxonomy and added species (Cantonati, M. & al. eds). pp. [1]–942, 135 pls. Schmitten-Oberreifenberg: Koeltz Botanical Books.

Rabenhorst, L. (1862). *Algen Europ''s, Fortsetzung der Algen Sachsens, Resp. Mittel-Europ''s.* Dec. 33–34. Nos 1321–1340. Dresden.

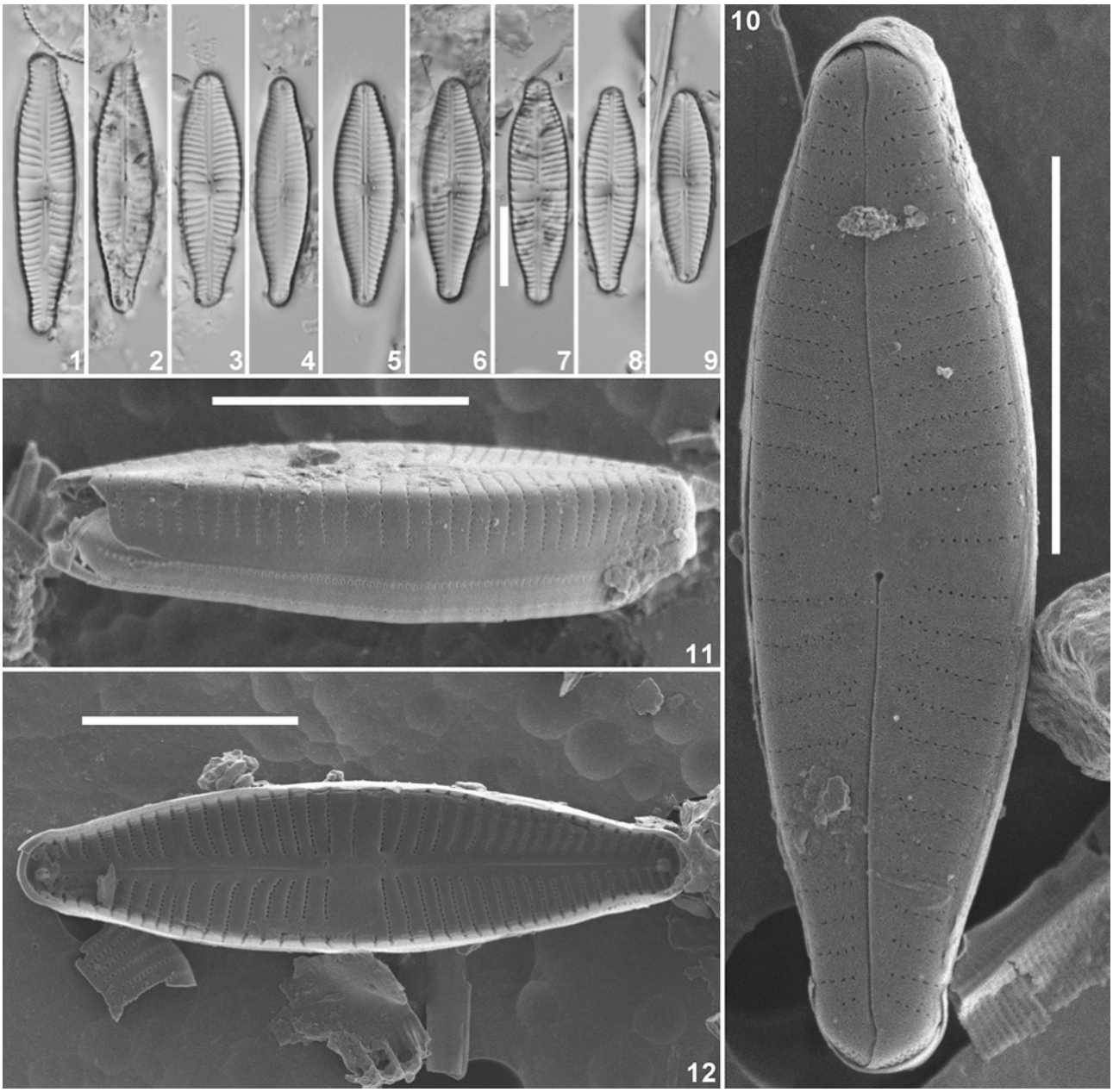
Rabenhorst, L. (1864). *Flora europaea algarum aquae dulcis et submarinae. Sectio I. Algas diatomaceas complectens, cum figuris generum xylographice impressis.* pp. 1–359. Lipsiae [Leipzig]: Apud Eduardum Kummerum.

Reichardt, E. (1999). Zur Revision der Gattung *Gomphonema*. Die Arten um *G. affine/insigne*, *G. angustatum/micropus*, *G. acuminatum* sowie gomphonemoide Diatomeen aus dem Oberoligozän in Böhmen. *Iconographia Diatomologica* 8: 1–203.

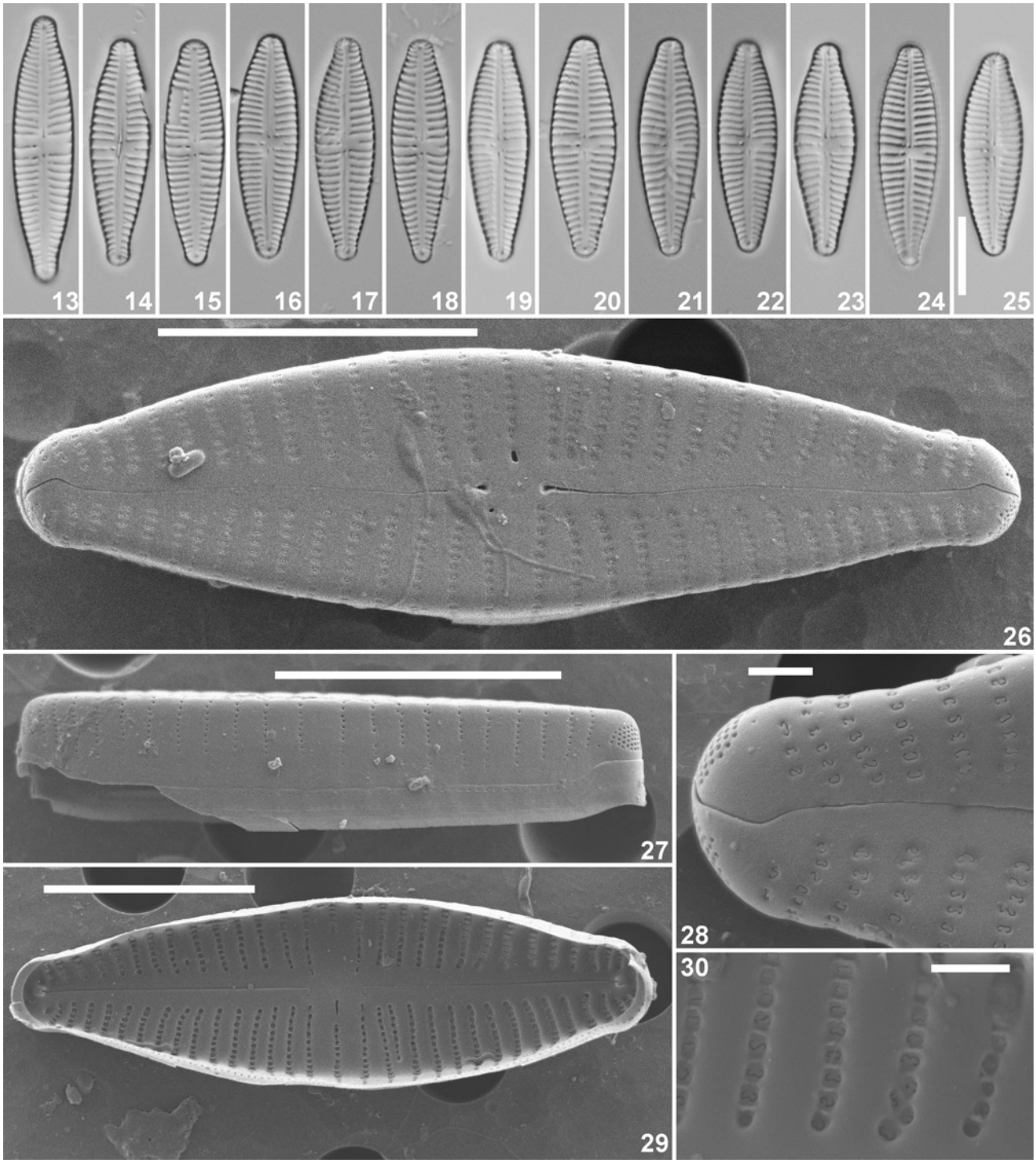
Reichardt, E. (2018). Die Diatomeen im Gebiet der Stadt Treuchtlingen. pp. [1]–576 (Band 1); 579–1184 (Band 2), incl. 451 pls. München: Bayerische Botanische Gesellschaft.

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F., editors (2018). *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code)* adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. *Regnum Vegetabile*, Vol. 159. pp. [i]–xxxviii, 1–253. Glashütten: Koeltz Botanical Books.

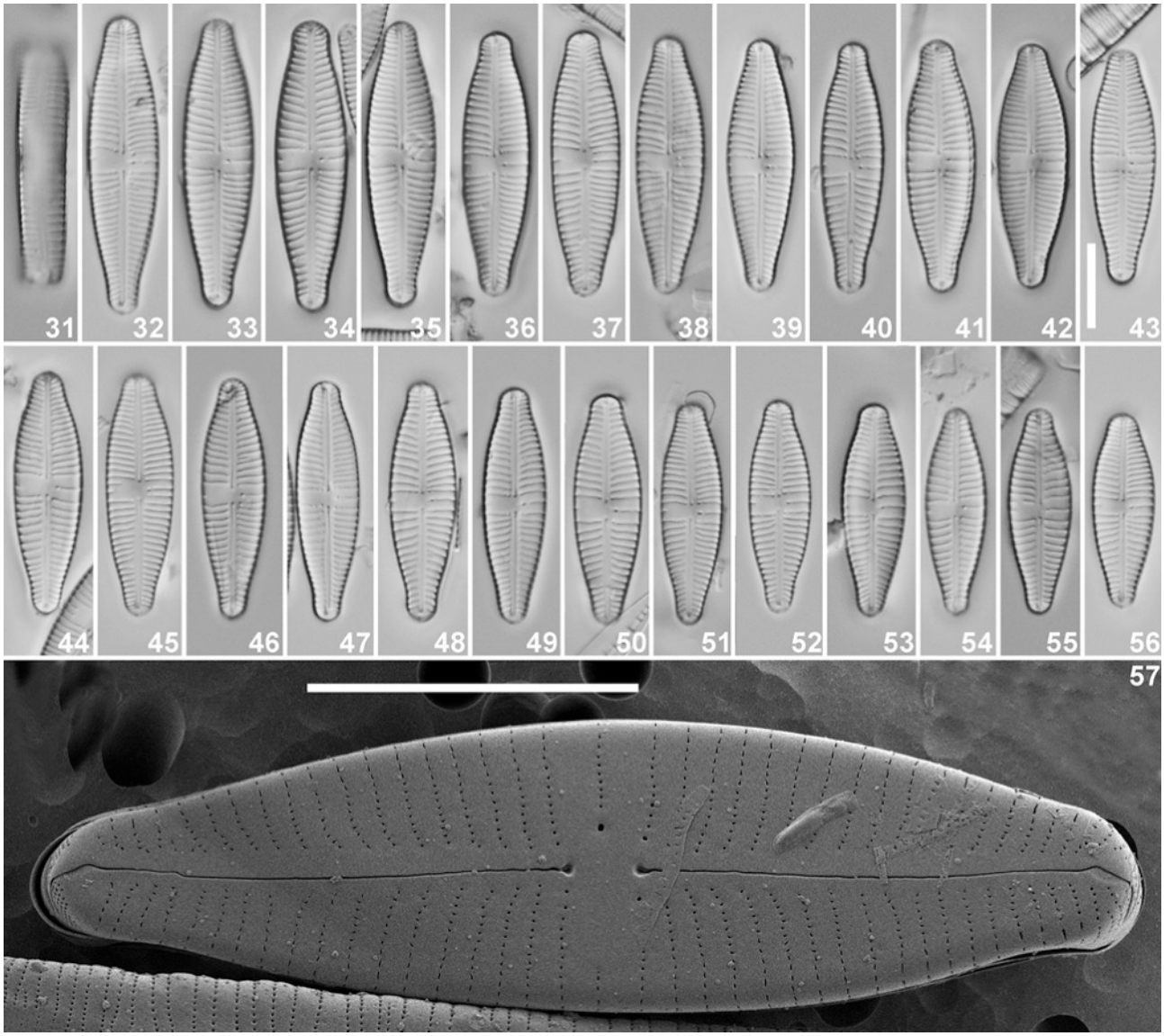
Van Heurck, H. (1880). *Synopsis des Diatomées de Belgique* Atlas. pls I-XXX [pls 1–30]. Anvers: Ducaju et Cie.



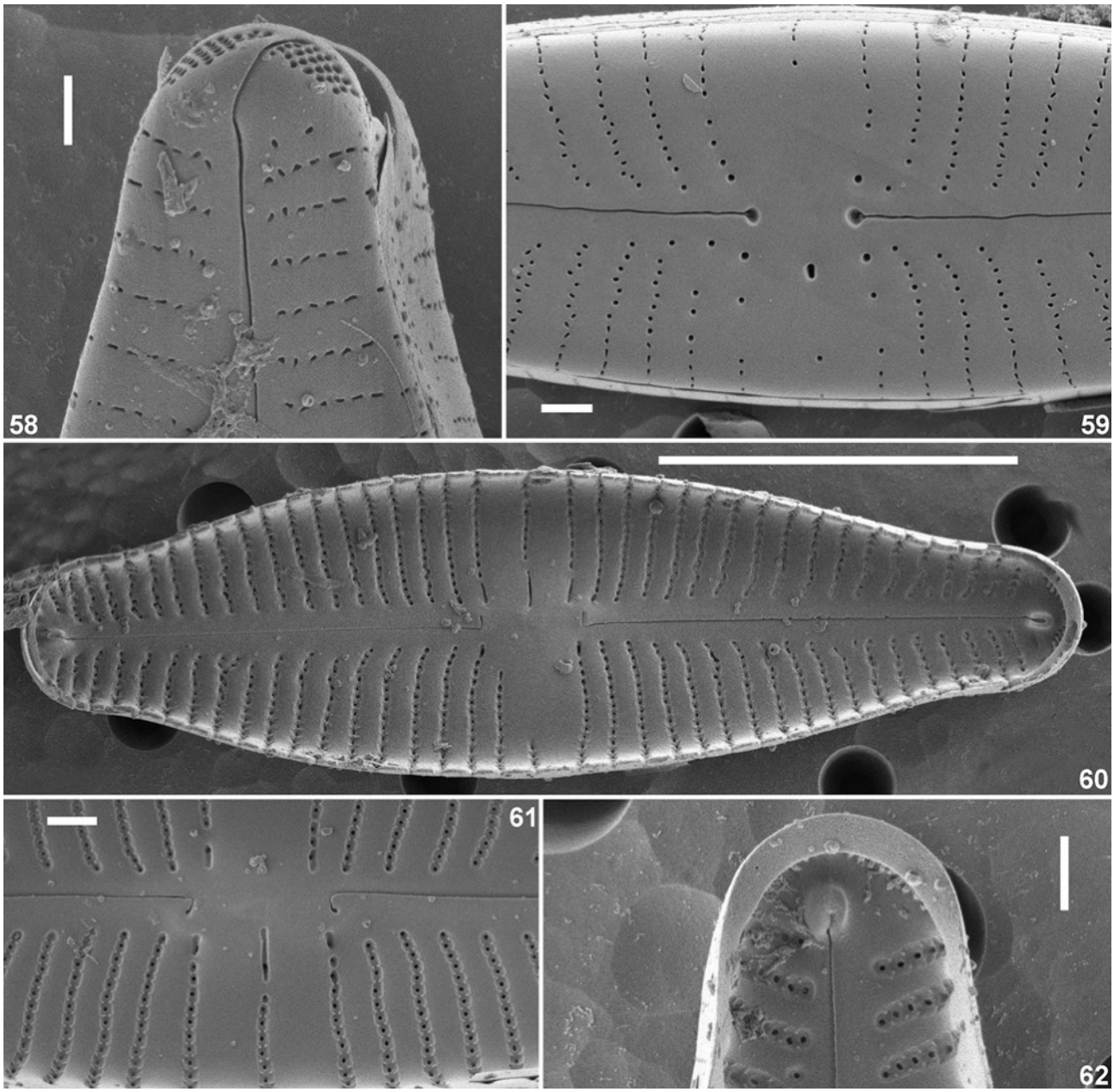
Figures 1–12. *Gomphonema micropus* Kützing. LM and SEM pictures taken from *Kützing 209* (Nordhausen, Germany, **BR**-4754) kept at **BR**. **Figs 1–9.** Cell diminution series cycle of *Gomphonema micropus* Kützing showing the Nordhausen material. **Fig. 10.** SEM external view of an entire valve. Note the rounded areolae. **Fig. 11.** SEM external view of an entire valve in girdle view. **Fig. 12.** SEM internal view of an entire valve. Scale bars = 10 µm.



Figs 13–30. *Gomphonema varians* E.Reichardt & Levkov. LM and SEM pictures taken from *Kützing 370* (Falaise, France) kept at **BR**. **Figs 13–25.** Cell diminution series cycle of *Gomphonema varians.* **Fig. 26.** SEM external view of an entire valve. **Fig. 27.** SEM external view of a valve in girdle view. **Fig. 28.** SEM external detail of a footpole clearly showing the c- to e-shaped areolae. **Fig. 29.** SEM internal view of an entire valve. **Fig. 30.** SEM internal detail of the areolae. Scale bar = 10 µm except for figs 28 & 30 where scale bar = 1 µm.



Figs 31–57. *Gomphonema commune* Rabenhorst. LM and SEM pictures taken from the original lectotype material (**BR**-4647, Strehlen near Dresden, Germany). **Figs 31–56.** Cell diminution series cycle of *Gomphonema commune* Rabenhorst showing the lectotype material. Fig. 31 shows a frustule in girdle view. **Fig. 57.** SEM external view of an entire valve. Scale bar = 10 µm.



Figs 58–62. *Gomphonema commune* Rabenhorst. SEM pictures taken from the original lectotype material (**BR**-4647, Strehlen near Dresden, Germany). **Fig. 58.** External detail of the foot pole showing the bisection of the apical pore field by the terminal raphe fissure. **Fig. 59.** External detail of the central area showing the irregularly scattered areolae in the central area and the isolated pore. **Fig. 60.** Internal view of an entire valve. **Fig. 61.** Internal detail of the central area showing the transapically elongated isolate pore and the hooked central raphe endings. **Fig. 62.** Internal detail of the foot pole showing the small pseudoseptum and the large helictoglossa. Scale bar = 1 μm except for Fig. 29 where scale bar = 1 μm.