



Observations on and typification of *Gomphonema naviculoides* W.Smith (*Gomphonemataceae*, *Bacillariophyta*)

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In 1856, William Smith described *Gomphonema naviculoides* W.Smith based on material he received from Robert K. Greville (1794–1866) who collected it in August 1853 from the *Victoria regia* Lindley [now *Victoria amazonica* (Poeppig) J.C.Sowerby] tank in the Botanical Garden, Edinburgh, Scotland (Smith 1856: 98). The species was described as “Stipes quite distinct and regularly dichotomous; F[rustule].V[iew]. nearly linear, truncate; valves lanceolate, acute; nodule central; extremities equal; striae 30 in 001” (25 µm). Length 0013” (33 µm) to 0025” (63 µm). v.v.” Illustrations were not provided. Grunow (in Van Heurck 1880, pl. 24: fig. 13) recombined the species as *Gomphonema gracile* var. *naviculoides* (W.Smith) Grunow. Cleve (1894, p. 183) erroneously listed the species as *Gomphonema gracile* var. *naviculacea* W.Smith.

There is, however, some confusion about the correct type material for *G. naviculoides*. Smith (1856) indicated August 1853 as the collection date for the original material on which he based his species. When Reichardt (2015) published his analysis of the *G. gracile* complex, he included *G. naviculoides* in this analysis by adding pictures taken from the presumed type of *G. naviculoides* kept in the Natural History Museum (**BM**), London. There are two slides in **BM** based on the material indicated in the catalogue made by Smith (1859). The first slide, **BM** 23911, labelled ‘*Gomphonema naviculoides* – Botanic Garden Edinburgh – August 1853’ with an indication that it was to be considered an isotype. Unfortunately, the slide was in a bad condition due to a degraded mounting medium and consequently only five valves could be photographed (Reichardt 2015, figs 18–22). Together with the fairly large population of *G. naviculoides*, Reichardt (2015) also listed several brackish diatoms such as *Ctenophora pulchella* (Kützing) D.M.Williams & Round, *Tabularia fasciculata* (C.Agardh) D.M.Williams & Round, *Navicula salinarum* Grunow, *N. peregrina* (Ehrenberg) Kützing and *Nitzschia sigma* (Kützing) W.Smith. Smith (1856), however, stated that *G. naviculoides* was to be considered a freshwater species, which seems to be at odds with the presence of these brackish species. A further examination of slide **BM** 23911 by one of us (DMW), however, confirmed the presence of *G. naviculoides* but not the brackish species.

A second slide, **BM** 23910 labelled ‘*Gomphonema naviculoides* – Botanic Garden Edinburgh W.S.’, is marked as isotype and is of better physical quality. The slide shows a diatom composition similar to what was observed on the material present in the Van Heurck diatom collection (Meise Botanic Garden, Belgium, **BR**), where the majority of the William Smith type collection is conserved (Hoover 1976). The latter collection contains all material used by Smith to make his *Synopsis of the British Diatoms* (Smith 1853, 1856). In 1943, Richard B. Hoover compiled a complete inventory of all unmounted material in the Smith collection at **BR** (Hoover 1976). Four samples, each containing raw diatom material dried onto mica sheets, are listed under *G. naviculoides*. The labels on the samples are handwritten by W. Smith. Three of them were collected by R.K. Greville from the *Victoria regia* tank in the Botanical Garden of Edinburgh. One sample was collected on 31 August 1853 whereas the other two samples were collected on 10 September 1853. The fourth sample was collected by “Mr. West” from an unknown locality. Given the

indication in the original description, the material collected on the 31 August should therefore be considered type material. In the Van Heurck slide collection (**BR**), one slide, prepared by Charles Coppock (1837–1900), a nephew of William Smith, was made from the August 1853 material of *G. naviculoides* according to the catalogue card of the Van Heurck collection. Comparison of a new slide made from the 31 August 1853 untreated material and the slide made by Coppock in the collection, however, revealed significant differences in the species composition, making it improbable that both originated from the same material. The 31 August 1853 slide in **BR** is entirely dominated by an *Achnanthidium* (*Achnanthes*) species, most likely *Achnanthes exilis* Kützinger [now *Achnanthidium exile* (Kützinger) Heiberg] as in Smith (1856: 29), *Achnanthes exilis* is only reported as “Parasitic [i.e. epiphytic] on the stipes of *Gomphonema naviculoides* in the tank of the Victoria regia, Botanical Garden, Edinburgh, Sept. 1853, Dr. Greville”. The sample further contains small populations of *G. naviculoides* together with an unknown *Brachysira* species and was sampled from thick *Oedogonium* growth. A slide made from the material collected on the 10 September 1853, however, has a similar species composition to that of the slide made by Coppock. This slide, made from dried sediment, is dominated by *Achnanthidium exile*, *Brachysira* sp., *Ulnaria* sp., *Gomphonema acuminatum* Ehrenberg and *Gomphonema naviculoides*. None of the samples, however, contain brackish species.

In **BM**, several other slides with *G. naviculoides* populations were found: **BM** 1159, No locality, “W.S.” and **BM** 4621, 4622, 4623, “Victoria tank, Bot. Gard.” – **BM** 4621 and 4622 are labelled as *Achnanthes exilis*. Each slide has a similar diatom composition as the material made from the **BR** Van Heurck collection.

It should be noted that *Gomphonema naviculoides* Skabitschevsky (Skabitschevsky 1987: 77, fig. 2: 7-10) from Lake Baikal is a later homonym and is thus illegitimate. The name does not appear to have been replaced.

In the present contribution, we present detailed observations on specimens of *G. naviculoides* from the 31 August 1853 sample using light and scanning electron microscopy. The slide made from this sample is therefore formally designated as lectotype for this species in accordance with ICN Art. 9.3 (Turland *et al.* 2018) since the above-mentioned isotypes of **BM** were never published.

Gomphonema naviculoides W.Smith (Figs 1–37)

Original description: *Gomphonema naviculoides* W.Smith, *A synopsis of the British Diatomaceae*, p. 98, no fig., 1856 (‘*Naviculoides*’).

Lectotype (here designated): **BR**-4597 (Meise Botanic Garden, Belgium).

Isolectotype (here designated): **BM** 23910 (Natural History Museum London, UK)

Type locality: Tank of Victoria Regia, Botanical Garden of Edinburgh, 31 August 1853, sample housed at **BR**.

Description: Frustules in girdle view almost rectangular to weakly clavate. Valvocopula bearing one row of rounded pores (Fig. 29). Valves lanceolate to rhombic-lanceolate, barely recognizable gomphonemoid-clavate but almost naviculoid-symmetrical, largest width at middle of valve. Head- and footpoles acutely rounded. Valves tapering gradually from mid-valve towards headpole or with slightly concave margins in large specimens. From valve middle to footpole margins more often weakly concave. Valve dimensions (n=30): valve length 28–65 µm, width 7.5–10.0 µm. Axial area moderately broad, linear. Central area unilaterally expanded, in general one stria shortened. Stria on opposite side only weakly shortened with one small, rounded, isolated pore (stigmatic) at its end. Raphe distinctly lateral. External raphe branches undulating (Fig. 32). Proximal raphe endings with small rounded, somewhat deflected central pores (Figs 32, 34). Terminal raphe fissures elongated, curved to one side, continuing onto valve mantle at

both poles (Figs 32, 33, 35). Apical pore field at footpole composed of small rounded areolae, for the most part restricted to polar mantle, bisected by terminal raphe fissure (Fig. 33). Striae uniseriate, parallel or slightly radiate, 11–12 in 10 μm , consisting of c-shaped (Figs 33, 35), but also less arched or slit-like (Fig. 34) areolae. Areolae often visible in LM (Fig. 16). Striae running without interruption onto the valve mantle where the foramina become smaller and finally dot-shaped or slightly elongated (Figs 30, 31). Internally, terminal raphe endings terminating onto well-developed helictoglossae (Fig. 20). Pseudosepta present at both poles (Fig. 36). Central raphe endings distinctly unilaterally bent with reversed ending. Internal isolated pore transversely elongated (Figs 36, 37). Viminis separating areolae interrupted (Fig. 37).

Gomphonema naviculoides belongs to the group of species related to *G. graciledictum* E.Reichardt. Reichardt (2015) discussed the morphology of *G. gracile* and concluded, based on his observation of the original Ehrenberg material, that *G. gracile* is a species belonging to the *G. subclavatum* (Grunow) Grunow species complex, and that almost all populations formerly identified as *G. gracile* should now be called *G. graciledictum*, a newly described taxon. The latter can be distinguished from *G. naviculoides* by its less rhomboid, more lanceolate valve outline often with slightly convex margins unlike *G. naviculoides* which has a clearly rhomboid outline (see Reichardt 2015, figs 36–61). In the literature, long *Gomphonema* valves with a more or less rhombic to rhombic-lanceolate valve outline are often identified as *G. naviculoides* but it is highly likely that most of these valves represent other taxa.

Gomphonema naviculoides, often reported as *G. gracile* var. *naviculoides* (W.Smith) Grunow, occurs relatively frequently in literature from South America, unfortunately rarely with illustrations of the valves. Azevedo *et al.* (2018, figs 2i, j) illustrated two valves from Brazil that are narrow and with a more lanceolate valve outline showing a greater similarity to *G. graciledictum* than to *G. naviculoides*. Several other observations on material from Brazil show similar valves that most likely all belong to the same species, but different, however, from *G. naviculoides* due to the more lanceolate valve outline [Bartozek *et al.* (2018, figs 56–58); Laudares-Silva (1987, pl. 8: fig. 76); Marquardt & al. (2018, figs 94–96); Marra & al. (2016, figs 116–117); Medeiros & al. (2018, figs 50–52)]. Most of these records illustrate, however, a different, larger, more rhombic-lanceolate, *Gomphonema* species, *G. guaraniarum* Metzeltin & Lange-Bertalot, originally described from Brazil (Metzeltin & Lange-Bertalot 2007: 147–149, pl. 212: figs 9–14). The latter authors separated this species from *G. gracile* in having a more rhombic-lanceolate valve outline. It actually shows a great similarity to *G. naviculoides*, and possible conspecificity should be considered. Smith (1856: 99) stated that “*The species has not occurred to any other collector, and may probably be of foreign origin*”. As the type locality for *G. naviculoides* is the *Victoria regia* tank in the Edinburgh Botanical Garden, a giant waterlily found naturally only in tropical South America, it is likely that the diatom was introduced from tropical or subtropical South America. A report from Mexico (Mora Hernández 2017, fig. 90) more likely represent *G. graciledictum* rather than *G. naviculoides*. Records outside South America are scarce. Patrick & Reimer (1975, p. 131), in their monograph of the diatoms of the United States, considered *G. gracile* var. *naviculoides* to be a synonym for *G. gracile*, but no justification for this conclusion was presented and illustrations of valves were not shown. In Europe, Cleve-Euler (1932, fig. 247) presented a very small drawing of a valve identified as *G. gracile* var. *naviculoides* from Lake Tåkern in Sweden, but the drawing is so small and with so few details that it cannot be identified with any certainty. Also, her interpretation of *G. gracile* var. *naviculoides* in Cleve-Euler (1955, fig. 1281c) probably represents a different *Gomphonema* species since it lacks the typical rhombic-lanceolate outline. The valves shown by Mayer (1913, pl. 19: fig. 28 and 1928, pl. 4: fig. 6) are more lanceolate, lacking the rhombic margins, and are most likely referable to *G. graciledictum*.

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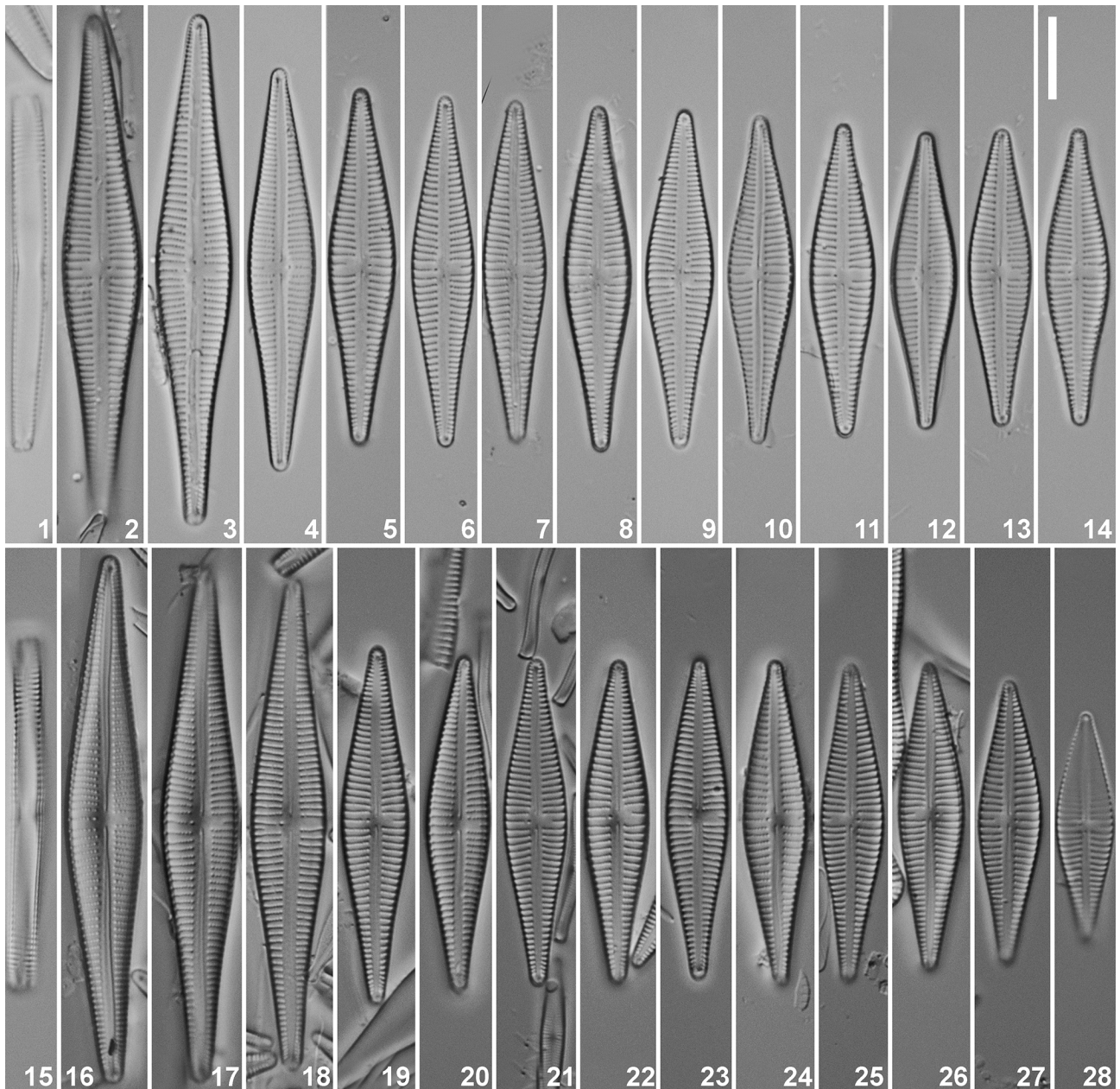
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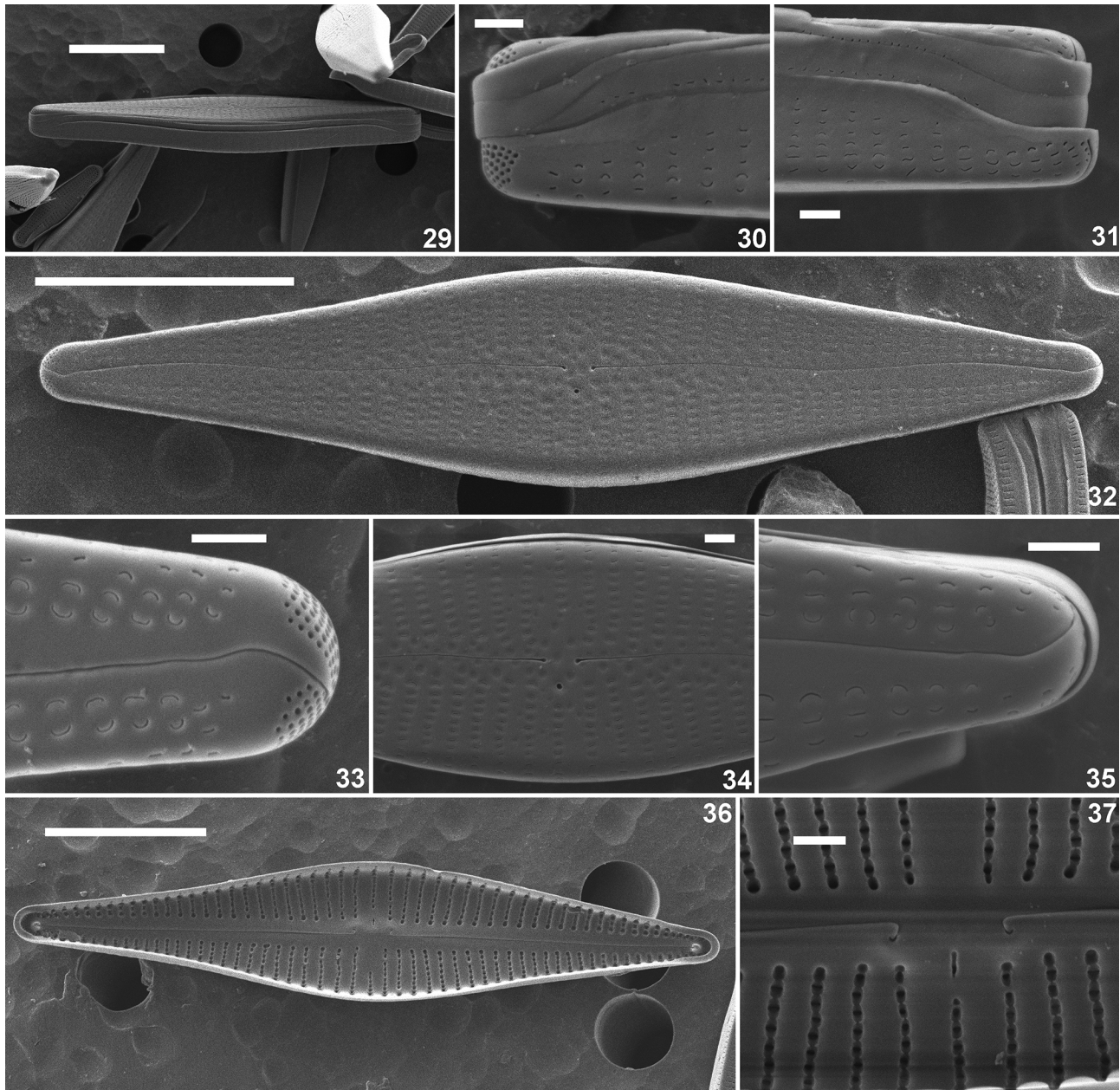
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Figs 1–28. *Gomphonema naviculoides* W.Smith. **Figs 1–14.** Cell cycle of *Gomphonema naviculoides* W.Smith based on lectotype material (Botanical Garden Edinburgh, W. Smith sample August 31st 1853). Fig. 1 shows a frustule in girdle view. **Figs 15–28.** Cell cycle of *Gomphonema naviculoides* W.Smith based on a second sample in the W. Smith collection (Botanical Garden Edinburgh, W. Smith sample 10.09.1853); Fig. 15 shows a frustule in girdle view. Scale bar represents 10 μ m.



Figs 48–55. *Gomphonema naviculoides* W.Smith. SEM micrographs of the lectotype specimens (Botanical Garden Edinburgh, W. Smith sample 31 August 1853) (Figs 32–37) and a second W. Smith sample (Botanical Garden Edinburgh, W. Smith sample August 10 September 1853) (Figs 29–31). **Fig. 29.** SEM external view of an entire frustule in girdle view. **Fig. 30.** SEM external detail of the foot pole in girdle view showing the perforated valvocopula and the apical porefield. **Fig. 31.** SEM external detail of the head pole in girdle view showing the mantle areolae. **Fig. 32.** SEM external view of an entire valve with the typical markings in the axial area. **Fig. 33.** SEM external detail of the footpole with the apical pore field bisected by the terminal raphe fissure. **Fig. 34.** SEM external detail of central area with the apical pore field. **Fig. 35.** SEM external detail of the head pole with the dense irregular striation resembling an apical pore field. **Fig. 36.** SEM internal view of an entire valve with the small pseudosepta and the helictoglossae. **Fig. 37.** SEM internal detail of the central area with the central raphe endings and the slit-like internal opening of the isolated pore. Note the interrupted vimines. Scale bars represent 1 μm except for Figs 32 & 36 where scale bar = 10 μm .