

***Gomphonema marriae* sp. nov. (Gomphonemataceae, Bacillariophyceae) from South Carolina (USA) streams**

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During sampling of a biodiverse site, Upper Three Runs Creek (UTRC) in South Carolina, a new *Gomphonema* taxon was encountered (Johnson & al. 2023). UTRC is known to have the highest species richness of insects in streams in the Western Hemisphere (Voelz & McArthur 2000). This creek is a tributary to the Savannah River and is partially located within the U.S. Department of Energy's Savannah River Site (SRS). The SRS is approximately 803 square kilometres, which encompasses Aiken, Allendale, and Barnwell counties and a variety of habitats (wetlands, hardwood stands, and riparian ecosystems). In the 1950s, the SRS was constructed around a plant producing plutonium and tritium for nuclear weapons in support of the USA's defence programs (<https://www.srs.gov>). Today, the SRS is a National Environmental Research Park owned by the Department of Energy, which is responsible for environmental clean-up, disposing of nuclear waste, and developing energy and defence technologies. UTRC is in an area that is considered a high-quality habitat which is protected by the Department of Energy and has been used as a reference site to monitor site operation impacts. The new *Gomphonema* taxon was found upstream of SRS control sites. Using cytological and growth characteristics paired with light and scanning electron microscopy of its morphology, we conclude that this species is new to science and describe it with comparison to known allied taxa, notably by differentiating it from the confusing *Gomphonema gracile* Ehrenberg complex.

***Gomphonema marriae* K.M.Johnson, Manoylov & Edlund, sp. nov. (Figs 1–18)**

Description: Living specimens (Figs 17, 18) with a single H-shaped or rhombic H-shaped chloroplast. Girdle view of live material wedge-shaped with narrower footpole (Fig. 18). Frustules not observed in girdle view in cleaned material. Valves heteropolar, rhombic, widest around the centre. Valve margins slightly undulate near headpole. Headpole distinctly apiculate. Footpole slightly cuneate to acutely rounded. Valve length 41–62 µm, width: 8–10 µm (n=32). Axial area moderate to small, almost linear, but widest around centre and narrowing near apices. Central area variable, small to moderate, slightly rectangular, wider on side opposite isolated punctum. Isolated punctum located near the end and slightly “off-centre” of shortened median stria. In SEM (Figs 13, 14), isolated punctum opening round, small. Raphe lateral to undulate, simple. Central raphe endings slightly expanded and weakly deflected away from isolated punctum. Terminal raphe fissures long, bent away from isolated punctum. At footpole, raphe bisecting apical porefield, is the latter made up of porelli. Striae slightly radiate towards apices and parallel, but sometimes variable around central area, 10–12 in 10 µm. Striae are uniseriate with large areolae. Areolae barely distinct in LM. In SEM (Figs 14–16), areola density 3–5 in 2 µm, or 15–25 in 10 µm. Areolae round to elongated with variable and sometimes overlapping occlusions in the valve surface around areolae. Depressions round, externally located on the central and axial area.

Taxonomic remarks: The new taxon falls within the highly variable *Gomphonema gracile* species complex based on valve shape and morphometrics (Krammer & Lange-Bertalot 2004); *G. marriae* was in fact reported as *Gomphonema gracile* Ehrenberg in Gaiser & Johansen (2000). This species complex has long challenged researchers on its identity and nomenclature (Van Heurck 1881, Patrick & Reimer 1975, Reichardt 2015). Foremost in this history was Reichardt's (2015) reanalysis of Ehrenberg's material, which showed that our modern concept of *Gomphonema gracile* (Patrick & Reimer 1975, Krammer & Lange-Bertalot 2004) did not conform with Ehrenberg's type, which was shown to be more closely allied with the *Gomphonema subtile* Ehrenberg, another species complex. As a result, many taxa originally referred to the *Gomphonema gracile* species complex have been characterized and separately described from the complex. In fact, if we compare original description illustrations (Fig. 19) of *G. gracile* Ehrenberg (1838, pl. XVIII: fig. III) with live images of *G. marriae* (Figs 17, 18), the valve shape, branching length, and chloroplast structure of *G. marriae* differ in appearance. We observed *G. marriae* valves to have a more elongated wedge shape, with a shorter branching length, and "H"-like chloroplasts. We also compare *G. marriae* with other taxa separated from the *G. gracile* complex, including *Gomphonema graciledictum* E.Reichardt (2015: 373) and *Gomphonema naviculoides* W.Smith (1856: 98). *Gomphonema graciledictum* is found in similar oligotrophic and slightly acidic habitats (Levkov & al. 2016). However, *G. marriae* is wider with a lower stria density than *G. graciledictum*. Valve apices of *G. graciledictum* are more rounded with an axial area that is much narrower than that of *G. marriae*. The raphe endings of both *G. graciledictum* and *G. naviculoides* are deflected towards the isolated pore whereas they are deflected away from isolated pore in *G. marriae*. *G. graciledictum* and *G. naviculoides* have more areolae in 10 µm than *G. marriae* and have "C-like" shaped areolae (Van de Vijver & al. 2020). The areolae of *G. marriae* are not C-shaped. *Gomphonema marriae* overlaps in length, width, and striae count in 10 µm with *Gomphonema gracile* var. *subcapitatum* H.P.Gandhi (1960: 116). However, *G. marriae* has a larger axial area and a distinctly apiculate headpole. The headpole of *G. gracile* var. *subcapitatum* is much more subcapitate. Although both are freshwater species, *G. gracile* var. *subcapitatum* was collected in pools and ponds in India, whereas *G. marriae* was collected in a flowing stream in the south-eastern United States.

Holotype: United States. South Carolina, Upper Three Runs Creek, samples collected from diatometers and epiphytic mats of filamentous green algae, Lat. 33.393067, Long. -81.610719, K.M. Johnson, 9 April 2018. Holotype illustrated as Fig. 10 (PH ANSP-GC58462). Isotypes illustrated as Figs 11 (PH ANSP-GC58462), 2 and 4 (PH ANSP-GC58463). Paratype illustrated as Fig. 6 (SMM MBE2595). Paratype preserved live material GCSU GCAM2302, same as type locality, composite epiphytic material collected 16 August 2018 (Figs 17, 18).

Type locality: epiphytic on mats of filamentous green algae growing on aquatic macrophytes in Upper Three Runs Creek, a headwater stream to the Savannah River, partially located on the Savannah River Site (SRS), near Aiken, Barnwell County, South Carolina, USA.

Registration: <http://phycobank.org/104269>

Etymology: This species is named in honour of Mrs Sharon M. Brown (née Marr), missionary, philanthropist, patron of the arts, family matriarch and KMJ's grandmother, who encouraged and supported KMJ's scientific endeavours.

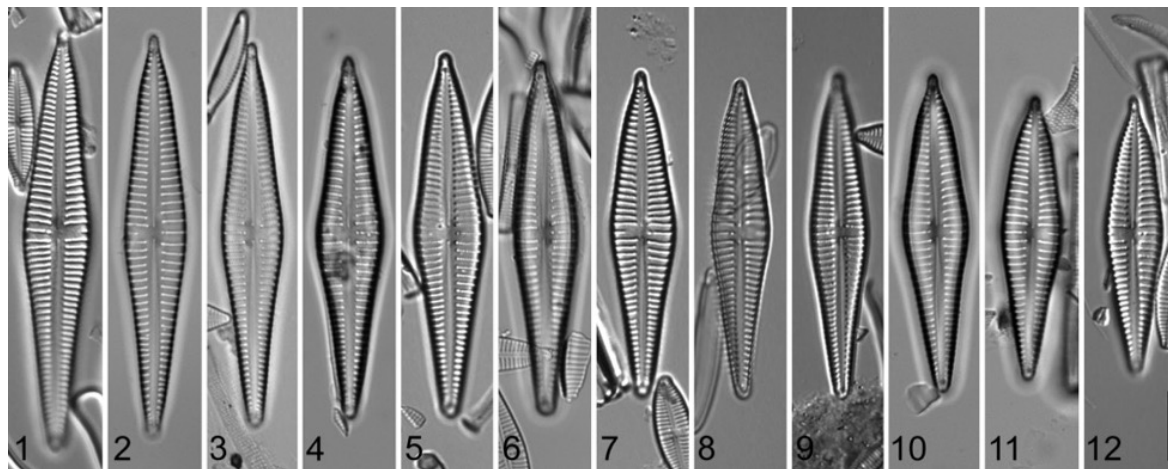
Distribution and ecology: The type population was found in a headwater stream, Upper Three Runs Creek, near Aiken, South Carolina. Upper Three Runs Creek has a slightly acidic to acidic environment (pH at type and paratype collection site = 5.3 and 4.2, respectively), is high in tannic acid, organic debris, and has a sandy and silty bottom. Live specimens of *G. marriae* were found growing together on mucilage stalks in epiphytic mats of filamentous green algae (*Stigeoclonium* sp.) growing on aquatic macrophytes at this location (Figs 17, 18). Frustules wedge-shaped in girdle view (Fig. 18). Upper Three Runs Creek is known for its high biodiversity and is partially located within the protected boundaries of the Savannah River Site

(Johnson & al. 2023). Reported as *Gomphonema gracile* from nearby freshwater ponds (Carolina “bays”), Gaiser & Johansen (2000) found it to be uncommon to rare and often associated with *Encyonema silesiacum* (Bleisch) D.G.Mann in macrophyte and littoral summer samples with an abundance-weighted mean water depth optimum of 28 cm and pH optimum of 5.2. Other biodiversity surveys from this region have not encountered this taxon (Siver & Hamilton 2011, Bishop & al. 2017).

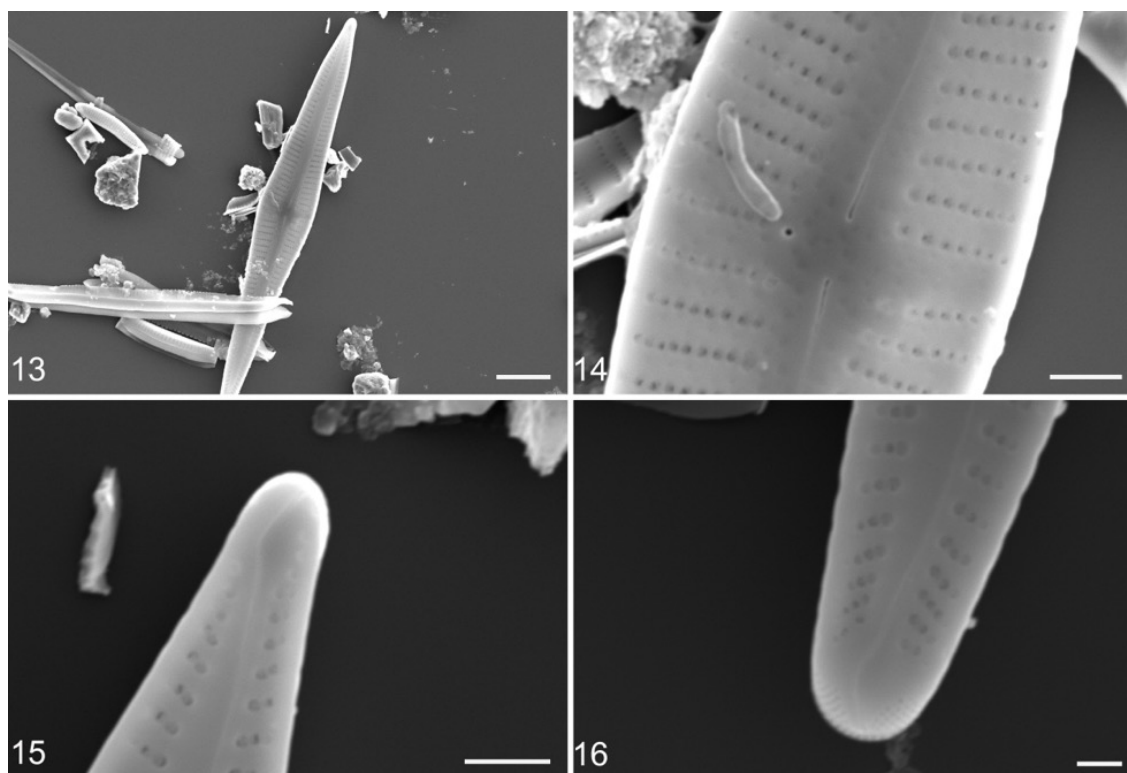
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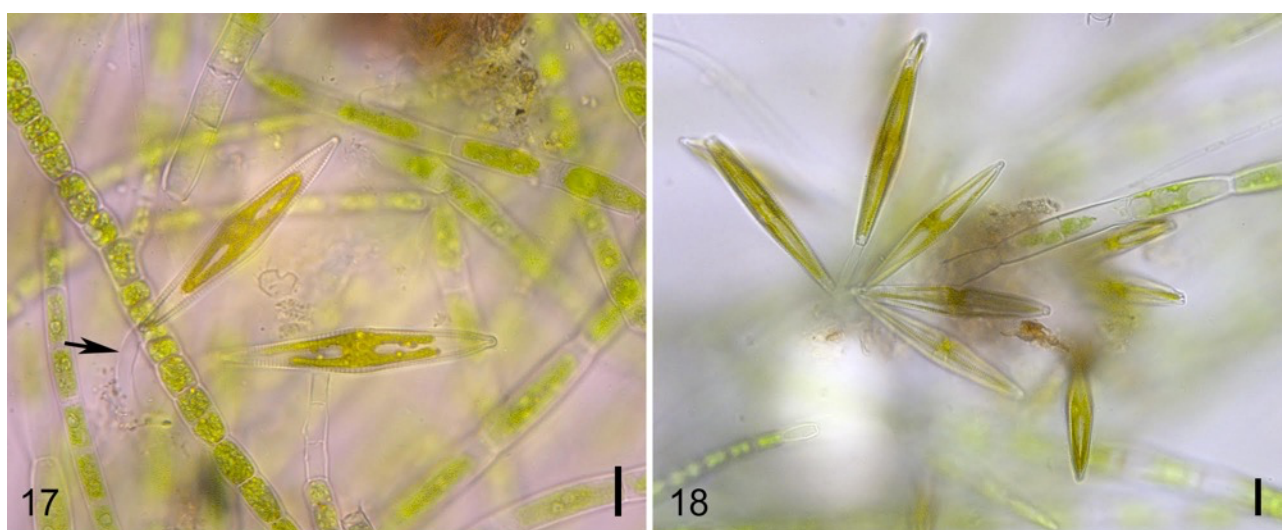
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Figs 1–12. Light microscopy images of *Gomphonema marriae*; valve view, size diminution series from the Upper Three Runs Creek, South Carolina. **Fig. 2.** Isotype 2 specimen, PH ANSP-GC58463. **Fig. 4.** Isotype 3 specimen, PH ANSP-GC58463, **Fig. 6.** Paratype specimen, SMM MBE2595 **Fig. 10.** Holotype specimen, PH ANSP-GC58462, **Fig. 11.** Isotype 1 specimen, PH ANSP-GC58462. Scale bar = 10 μ m.



Figs 13–16. Scanning electron microscope images of *Gomphonema marriae* found in Upper Three Runs Creek, type material PH ANSP-GCM6801. **Fig. 13.** Entire valve with moderate axial area, **Fig. 14.** Close up of external valve view central area with an isolated pore, external morphology of striae made of round areolae and proximal raphe endings drop like, **Fig. 15.** Close up of external valve view headpole, **Fig. 16.** Close up of external valve foot pole and apical porefield. Scale bars: 10 μ m, 2 μ m, 2 μ m, and 1 μ m, respectively.



Figs 17–18. Light microscopy images of live *Gomphonema marriae* frustules and mucilage stalks from composite material of epiphytic scrapings of Upper Three Runs Creek, 16 Aug 2018, paratype material, GCSU GCAM2302. **Fig. 17.** Frustules *G. marriae* attached with visible short stalk (arrow) surrounded by *Stigeoclonium* sp. (Chlorophyta) filaments, **Fig. 18.** Cluster of *G. marriae* frustules in valve and girdle view. Scale bars 10 μ m.



Fig. 19. Original illustrations of *Gomphonema gracile* Ehrenberg (1838, Pl. XVIII, Fig. III). Scale bar approximates 10 μ m.