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New European locality of *Gomphonema varians* E. Reichardt & Levkov and first record in Poland

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ABSTRACT

The aim of this work is to indicate a new locality of Gomphonema varians in Poland, in the Kisielina River, together with photographic documentation under LM and SEM, and to compare the species with similar taxa from the Gomphonema genus like G. parvulum, G. micropus, and G. sarcophagus. The species often coexisting and may be confused and, consequently, misidentified. The research was carried out in 2023 in April and September at seven sites designated along a rivercourse in SE Poland. Findings indicate that G. varians prefers stagnant waters, mesotrophic to meso-eutrophic conditions, alkaline to neutral pH, and low electrical conductivity.

Keywords: Bacillariophyta, morphology, diatoms, new record, Gomphonema, Kisielina River.

INTRODUCTION

Species belonging to the genus Gomphonema are very diverse in terms of morphological and ultrastructural characteristics and basically meet the morphological characteristics represented by *Gomphonema acuminatum* Ehrenberg 1832 (Bąk et al., 2012; Levkov et al., 2016, Lange-Bertalot et al., 2017). The cells are most often characterised by a more or less clublike shape in view from the valve side and are symmetrical about the apical axis. The valves are often arranged in preparations from the side of the peripheral band – then they have a wedge-shaped shape with a wide upper end and a narrow lower end and are never curved (Hofmann et al., 2011, Lange-Bertalot et al., 2017).

Since 1990, many new species of the genus Gomphonema have been described worldwide, and numerous taxonomic revisions have been carried out (Reichardt and Lange-Bertalot, 1991, Reichardt, 1997, 1999, 2001, 2012, 2015, 2018, Levkov et al., 2016, Jüttner et al., 2018, Kociolek et al., 2018, Radhakrishnan et al., 2020, Kulikovskiy et al., 2023, Yogeshwaran et al. 2023, Van de Vijver, 2024, Van de Vijver et al., 2024, and many others). Among the diatoms described in recent years as new for Poland, there are also species of the genus *Gomphonema* (Wojtal, 2003, 2009, Eliasz-Kowalska, 2017, Noga et al., 2018).

Gomphonema varians E. Reichardt & Levkov was described as new to science recently, that is, in 2018, from materials collected by Reichardt from ponds in Germany (Reichardt, 2018). Similar cells were also found in a population from Falaise, France (Van de Vijver et al., 2023). This species is very variable and similar to *Gomphonema micropus*, among others. It can be said that it has intermediate characters between *G. micropus* and *G. sarcophagus* (Reichardt, 2018) and therefore if diatomological materials are not subjected to detailed analysis under scanning electron microscope (SEM) this species may be incorrectly classified as *G. micropus.*

Gomphonema varians has also been recorded in southern Poland in the Kisielin River (a right-bank tributary of the Vistula), where it was

identified only after a thorough analysis of materials under SEM. This is the first locality of this species in Poland and the third in Europe.

The aim of this work is to indicate a new locality of *Gomphonema varians* in Poland, on the Kisielin River, together with photographic documentation from LM and SEM, and to compare the species with similar taxa from the Gomphonema genus, with which this species may be confused and, consequently, misidentified.

STUDY AREA AND METHODS

The Kisielina River is a right-bank tributary of the Vistula, over 40 km long, which flows out near the villages of Łysa Góra and Grabno, in a small forest (Wilkówka hill, over 340 m above sea level). Previously, the Kisielina flowed into the Dunajec River, but at the beginning of the twentieth century its course was changed, regulated, and directed to the Vistula (Przybysz-Ławnicka et al., 2008, 2010). A more detailed description of the study area was presented by Noga et al. (2025).

The research was carried out in 2023 in April and September at 7 designated sites along the Kisielina River. Materials were collected from stones, mud, and aquatic vegetation (depending on availability at the sites). The pH, electrolytic conductivity, and water temperature were measured directly in the field, while the chemical parameters of water in the range of basic anions and cations were measured in the laboratory. Analyses were performed using a Thermo scientific DIONEX ICS–5000+DC ion chromatograph. The diatomaceous materials were macerated in sulfuric acid and potassium dichromate according to the methods used by, among others: Kawecka (2012) and Noga et al. (2015).

The Pleurax synthetic resin was used to prepare microscopic slides. The diatoms were identified under a Carl Zeiss Axio Imager A2 light microscope, using Nomarski differential interference contrast (DIC) and a 1.4 planapochromatic objective, using the following literature: Reichardt (1999, 2018) and Levkov et al. (2016). In randomly selected fields of view of the microscope, all diatom valves were counted until a total of about 300 was obtained. Taxa that reached a 5% share in the community or more were considered to dominant. Detailed identification of taxa was verified using a scanning electron microscope (SEM). The materials were sputtered with a 20-nm gold layer in a Quorum Q 150OT ES Turbo-Pumped Sputter Coater and then viewed under a Hitachi SU 8010 microscope.

RESULTS AND DISCUSSION

The chemical parameters of the water measured in the Kisielin River were presented in detail in the work of Noga et al. (2025). The water at the sites in the middle course of the river (4 and 5), where *Gomphonema varians* occurred most abundantly, was characterized by a reaction close to neutral (pH: 6.6–7.2) and relatively low conductivity values (115–170 $\mu S \cdot cm^{-1}$). The content of NO_3^- anions was 2.69–4.25 $mg \cdot l^{-1}$, SO_4^{2-} 22.47–40.32 $mg \cdot l^{-1}$, Cl^-: 11.56–18.52 $mg \cdot l^{-1}$, while the content of Ca^{2+} cations: 16.36–25.24 $mg \cdot l^{-1}$.

Gomphonema varians was recorded in the Kisielina River in the middle (sites 4 and 5) and lower (sites 6 and 7) course. It was most abundant at site 4, which was designated in Brzeźnica, in the Radłowsko-Wierzchosławicki Protected Landscape Area. The site was located below the Radłowskie Forests reserve, in the area of a large forest complex called the Radłowski Forest. There are two ponds in the forest, Stradowski and Maruszka, and the Kisielina River flows in their immediate vicinity. At a distance of about 20 m above the designated site 4 there was a beaver dam, slowing down and limiting the flow of water.

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LM observations – the valves of *Gomphonema varians* are highly variable and very similar to *G. micropus*, but the former are more narrowly lanceolate. The apices of *G. varians* are slighly rounded (similar to *G. parvulum*, but less distinctly capitate), while the upper apices of *G. micropus* are more widely extended (similar to *G. sarcophagus*) – Table 1, Figure 1.

SEM observations – comparing the details of the structure in the SEM (Figure 2, 3), there are clear differences in the shape and appearance of the areoles between *G. varians* and *G. micropus*. *Gomphonema varians* has areoles in the shape of the letter C (sometimes they even look like number 3) and most often an elongated stigma. The shape of the areoles (C or 3) is also clearly visible from the inside of the valve (Figure 3). *Gomphonema parvulum* has similar-looking areoles

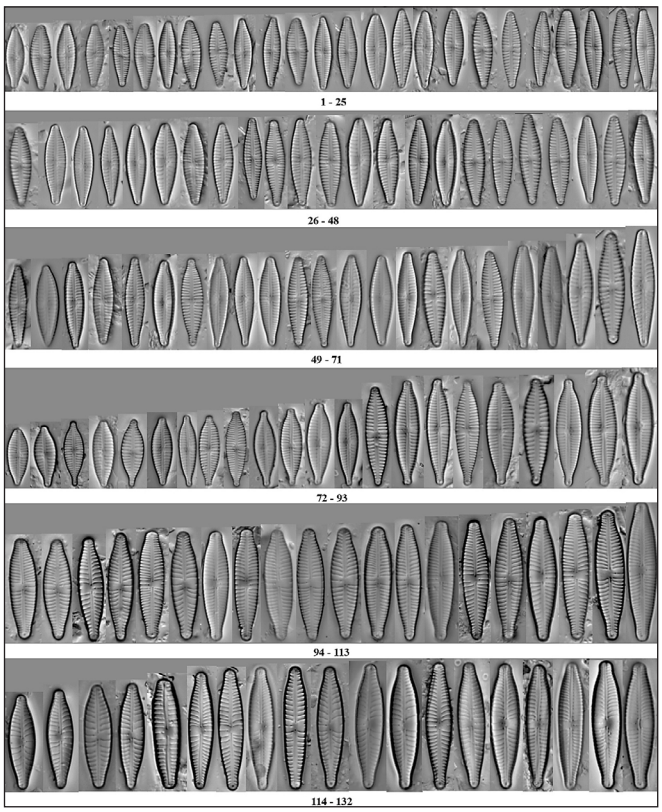

Figure 1. Examples of morphological variation in LM: *G. varians* (1–71), *G. parvulum* (72–93), *G. micropus* (94–113) and *G. sarcophagus* (114–132)

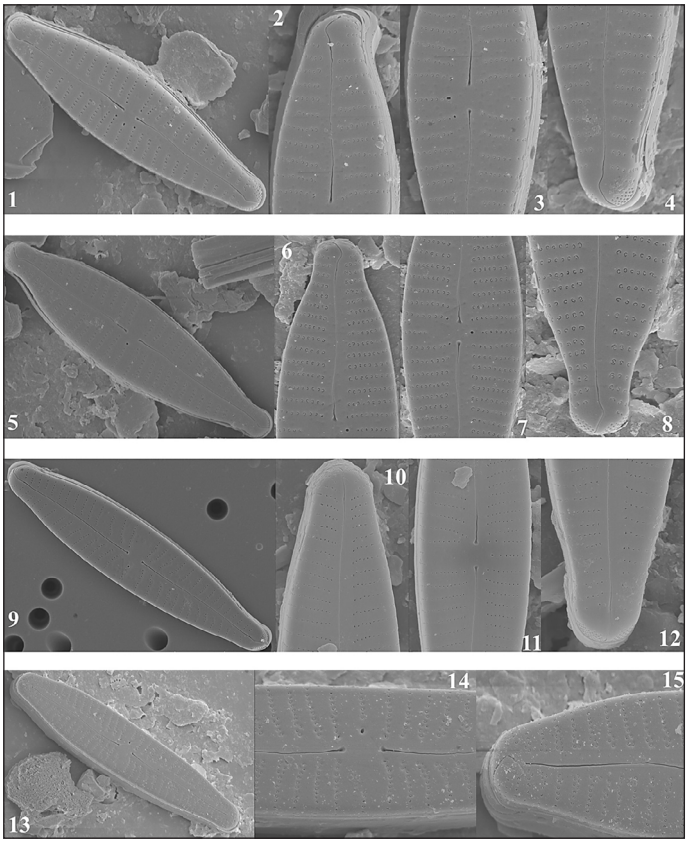

Figure 2. Gomphonema external view of valve: *G. varians* (1–4), *G. parvulum* (5–8), *G. micropus* (9–12) and *G. sarcophagus* (13–15)

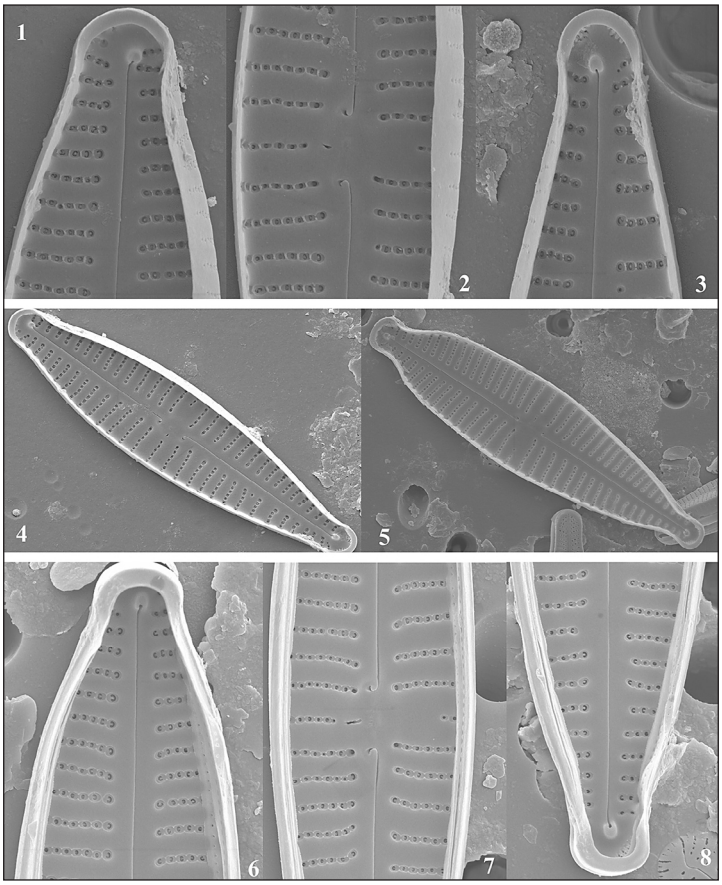

Figure 3. Gomphonema internal view of valve: *G. varians* (1–4) and *G. parvulum* (5–8)

(more often, however, they take the shape of number 3), while the stigma is round. *Gomphonema sarcophagus* also has a similar appearance to the areoles, but the areoles often split near the raphe and the stigma is more rounded compared to *G. varians*. *Gomphonema micropus* is distinguished by a completely different shape of areoles, which are most often punctate or densely arranged closer to the poles, while the stigma is more rounded or only slightly elongated (Figure 2, Table 1).

Co-existence with other species: In the middle and lower reaches of the Kisielina River, the dominant species were the following: *Navicula lanceolata* (1–33%), *N. gregaria* (< 1–11.3%), *Achnanthidium minutissimum* (1.8–9.5%), *Fragilaria gracilis* (7–14%) and less numerous (< 10%): *Gomphonema micropus*, *G. parvulum*, *G. inocens*, *Cyclostephanos invistatus*, and *Melosira varians*. In the lower reaches, the most numerous populations were: *Achnanthidium minutissimum* (3–60%), *Cocconeis euglypta* (< 1–87.7%), *Navicula lanceolata* (0–30.5%) and *N. gregaria* (2–20%).

Distribution worldwide – the species was first described in Germany (Reichardt 2018), and similar cells were later identified in material from Falaise, France (Van de Vijver et al., 2023). To date, these are the only locations where this species is found. Habitat and ecology: *Gomphonema varian*s was described in ponds near Althmühl (Germany). It is probably an eutrophic species, more common in stagnant waters (Reichardt 2018). Similar observations were made by Van de Vijver et al. (2023), as the cells isolated in the material from France cooccurred with eutrophic water species such as *Navicula gregaria*, *Planothidium frequentissimum*, *Nitzschia linearis*, *Cymatopleura solea*, and species of the genus *Surirella*.

Comments – *Gomphonema varians* was most abundant in the middle course of the Kisielina River (approx. 3%), while only single cells were found in the lower course of the river. Site 4, where it developed most abundantly, was shaded and characterised by a stony bottom with a small amount of sand and mud and rusty-brown water. The bottom was covered with organic matter in the form of fallen leaves and small branches. *Gomphonema varians* developed on stones as well as on sand and mud, but the most abundant

Table 1. Morphological characteristics and comparison of valve structures of *Gomphonema varians*, *G. micropus*, *G. sarcophagus* and *G. parvulum*

Parameter	*Gomphonema varians*	*Gomphonema micropus*	*Gomphonema sarcophagus*	*Gomphonema parvulum*
Length [µm]	18.9–29.1	18.1–39.8	25.6–40.3	13.6–28.5
Width [µm]	5.6–6.9	5.0–7.9	6.1–7.2	4.9–6.8
Striae [in 10 µm]	9–14	8–13	7–11	12–17
Valve outline	Lanceolate, club-shaped valves,	Valves of variable shape, lanceolate to linear-elliptical	Linear-club-shaped valves	Shape of valves very variable, most often weakly Club-lanceolate To oval
Valve apices	Apices slightly rounded And elongated, Slightly narrower at the base	Capitate apices, upper ones more broadly extended than In *g. Varians*, Usually slightly narrower at the base	Upper apices short and broadly-elongated, wide at the base	Apices often short elongated, sometimes more elongated And capitate, less frequently bluntly or pointedly rounded
Raphe structure	Raphe slightly curved, Almost filiform	Filiform raphe, almost straight with distinctly defined central pores (droplet-shaped)	Raphe relatively broad and strongly undulate with distinctly marked central pores (droplet-shaped)	Raphe weakly curved, in small specimens filiform
Striae and areolae	Slightly radial striations, sometimes almost parallel, areoles almost invisible, In sem they have the shape of letters c, s or in some places the number 3	Slightly radial striations at fairly even intervals, usually straight, sometimes curved towards the center of the cell, areoles not visible in lm, areoles small and rounded in sem	Radiate-arcuate striae, areoles sometimes visible Under lm, under sem areoles are c- or s-shaped (similar to those In *g. Varians*), along the longitudinal field often double rows of areoles	Striae slightly radiate To parallel, indistinctly Punctate, under sem they most often have the number 3 or the letter c-shapes
Axial area	Narrow and linear	Narrow and linear	Moderately narrow, slightly curved as a raphe	Narrow and linear
Central area	Small, broadened on one side, with the raphe opposite the stigma more or less shortened	Small, rectangular, and unilateral, with the raphe opposite the stigma clearly shortened.	Central area fairly large, resulting from the severe shortening of one raphe (rarely two)	Central area typically weakly developed, one-sided, with only one shortened strie.
Stigma	Punctate or, more often, elongated, located close to the central strie	Punctate, a bit far away from the striae	Stigma very distinct, elongated, slightly separated from the striae	Punctate stigma located near the unshortened central striae

populations formed on stones in the spring season. This site was designated at a distance of approx. 20 m below the beaver dam.

CONCLUSIONS

Gomphonema varians was the most abundant in the middle course of the Kisielina River (approx. 3%), while only single cells were found in the lower course of the river. Site 4, where it developed most abundantly, was shaded and known by a stony bottom with a small amount of sand and mud and rusty brown water. The bottom was covered with organic matter in the form of fallen leaves and small branches. *Gomphonema varians* developed on stones, as well as on sand and mud, but the most abundant populations formed on stones in the spring season. This site was designated at a distance of approx. 20 m below the beaver dam. The studies conducted clearly indicate how difficult it is to identify this diatom as a species. On the one hand, it is a very variable morphological species, on the other hand, it cooccurs with other species of the Gomphonema genus, including *G. micropus*, *G. sarcophagus* and *G. parvulum*, and is more or less similar to them. *Gomphonema varians* was initially identified in the middle course of the river only because this species occurred relatively abundantly in a population in which one of the dominants was *G. micropus*.

When reviewing the materials under a light microscope (LM), individual specimens appeared smaller and had more narrowly rounded upper apices compared to typical *G. micropus* cells. For this reason, the material was analysed by SEM and it was possible to find cells that morphologically resembled smaller *G. miropus* specimens, but had a completely different areole shape. It should also be noted that additional difficulties in identification were caused by *G. sarcophagus* and *G. parvulum*, also morphologically variable and sometimes very similar to *G. varians*, which is why identification of individual species required particularly detailed observations. The authors emphasise that the occurrence of *G. varians* in the form of single specimens (additionally with other similar species from this genus) can cause many difficulties during identification. This species can be incorrectly identified, e.g. as *G. micropus* (especially when the latter occurs in large numbers in the material). Often, only a thorough SEM analysis will allow the identification of *Gomphonema varians* and confirm the correctness of the determinations made in LM. This species probably occurs much more frequently, both in Poland and in Europe, but due to its similarity to other species of the *Gomphonema* genus, it may be confused with them. Habitat conditions in which *G. varians* developed in Kisielin indicate mesotrophy or meso-eutrophy, most often slightly alkaline or neutral water pH and conductivity values < 200 $\mu S \cdot cm^{-1}$. The ecological status of the waters in the middle reaches was determined as moderate or poor (based on IPS and GDI indices), depending on the research season. The dominant diatom species also indicate the mesotrophic or eutrophic nature of the waters studied waters. In the lower reaches, the share of taxa with a wide tolerance to the trophy parameter (oligo-eutraphentic) increases, while in the middle reaches, where *G. varians* was observed most abundantly, the largest share (about 20%) of oligotraphentic taxa was found at the same time. It is also significant that the site where *G. varians* developed the most abundantly was located below a beaver dam and the river in the "Lasy Radłowskie" forest complex flows in close proximity to the ponds. All this together makes the authors agree with earlier observations in the literature, based on which *G. varians* was recognised as a species that prefers standing waters.

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