Oceanological and Hydrobiological Studies

International Journal of Oceanography and Hydrobiology

Volume 55, No. 2 June 2026
pages (118-132)

ISSN 1730-413X
eISSN 1897-3191

Rarely reported *Planothidium* Round et Bukhtiyarova (Bacillariophyceae) from flowing waters of southern Poland

by

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DOI: **https://doi.org/10.26881/oahs-2026.1.11**
Category: **Original research papers**
Received: **January 27, 2026**
Accepted: **April 02, 2026**

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Abstract

The aim of this study was to document new records for Poland of *Planothidium* species occurring in running waters of southern Poland and to characterise their morphology, ecology and distribution. The study material was collected during the spring (April–June) and autumn (September–October) seasons in years 2013, 2017, 2023 and 2024. Species identification was conducted using light microscopy and scanning electron microscopy. Environmental parameters were measured *in situ* and complemented by laboratory analyses of water chemistry. Ecological status was assessed using diatom indices (Specific Pollution Sensitivity Index, Generic Diatom Index). Five *Planothidium* species not previously reported from Poland were identified: *Planothidium cavilanceolatum, Planothidium daui, Planothidium gallicum, Planothidium hinzianum and Planothidium potapovae*. Most taxa occurred rarely and predominantly as individual valves, which limits the precise interpretation of their ecological preferences. In our study, *P. daui* exhibited a broad ecological amplitude, occurring under oligo- to eutrophic conditions, whereas *P. cavilanceolatum*, *P. gallicum* and *P. hinzianum* were restricted to specific habitats and showed low abundances. In contrast, *P. potapovae* reached dominant status in the upper course of the Szum River, where it was associated with oligotrophic conditions, sandy substrates and high calcium concentrations.

Key words: diatoms, *P. cavilanceolatum*, *P. daui*, *P. gallicum*, *P. hinzianum*, *P. potapovae*, morphology, ecology

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1. Introduction

The genus *Planothidium* was separated from the *Achnanthes lanceolata* (Brébisson) Grunow complex by Round and Bukhtiyarova (1996). The genus comprises species that fulfil the morphological criteria defined for *Planothidium lanceolatum* (Brébisson) Lange-Bertalot (Lange-Bertalot et al., 2017; Round & Bukhtiyarova, 1996). *Planothidium* includes monoraphid diatoms with predominantly elliptical, lanceolate or elliptic-lanceolate valves, sometimes with capitate or rostrate apices. The raphe is straight to slightly curved, and the raphe valve is concave in girdle view. Some species possess a characteristic horseshoe-shaped structure on the rapheless valve. The striae are composed of two or more rows of areolae, which are discernible only under scanning electron microscopy (SEM) (Lange-Bertalot et al., 2017; Round & Bukhtyarova, 1996; Wetzel et al., 2019).

Species of *Planothidium* are mainly epilithic or epipsammic and occur commonly, sometimes in high abundances, in running waters characterised by variable water quality. Due to their ecological sensitivity, taxa of this genus are considered to have significant potential as bioindicators for assessing ecological status and specific stressors, particularly eutrophication (Morales, 2006; Potapova & Charles, 2007; Wetzel et al., 2019).

In recent years, numerous new *Planothidium* species have been described from Europe (Alvarez-Blanco & Blanco, 2013; Bąk & Lange-Bertalot, 2014; Cantonati et al., 2021; Lai et al., 2021; Morales et al., 2021; Wetzel et al., 2019) as well as from other continents, including Asia (Jahn et al., 2017; Li et al., 2025; Tseplik et al., 2024; Wetzel et al., 2019), Africa (N'Guessan et al., 2014; Van de Vijver et al., 2023), North America (Stancheva et al., 2020), South America (Junqueira et al., 2024; Marquardt et al., 2021; Morais et al., 2020) and Antarctica (Juchem et al., 2023; Kopalová et al., 2016).

Diatomological investigations in south-eastern Poland began relatively late, in the late 1990s, following the massive reproduction of *Didymosphenia geminata* (Lyngbye) M. Schmidt in the upper reaches of the San River (Kawecka & Sanecki, 2003). Systematic studies on diatom community diversity have been conducted only since 2007, initially focusing on the Wisłok River and its tributaries and later extending to the San River and its tributaries. The results of these studies have been presented in numerous publications (e.g. Kochman-Kędziora et al., 2022; Noga, 2012; Noga et al., 2014b, 2014c, 2016b, 2016c; Pajączek et al., 2012; Peszek et al., 2015; Żelazna-Wieczorek, 2012). Numerous diatom taxa new to Poland or new to science have been recorded in this region (Noga, 2019; Noga et al., 2013, 2014a, 2014d, 2016a, 2017a, 2017b, 2017c, 2018; Rybak et al., 2020). More recent studies have included the Roztocze region, peatlands of south-eastern Poland and selected lowland rivers (Noga, 2019; Noga et al., 2014d; Skubisz & Noga, 2023). In 2023, diatom diversity in the Kisielina River was investigated (Bysiek et al., 2025; Noga et al., 2025). Nevertheless, none of the cited publications reported any of the five species described in this study.

The aim of this study was to confirm new records for Poland of *Planothidium* species occurring in the running waters of southern Poland and to characterise their morphology using light microscopy (LM) and scanning electron microscopy (SEM), as well as their ecology and distribution.

2. Study area

Diatom community studies were conducted in flowing waters of southern Poland, including the Kisielina and Szum rivers, as well as the cooling-water discharge channel of the Stalowa Wola Combined Heat and Power Plant.

The Kisielina River is a right-bank tributary of the Vistula in southern Poland, exceeding 40 km in length, flowing mainly through agricultural areas with sections of forested catchment in its middle section.

The Szum River, approximately 24 km long, is a tributary of the Tanew River originating in marshy areas within Roztocze National Park. Its upper course remains largely natural, whereas the middle and lower sections have been regulated and include a dam and a retention reservoir.

The Stalowa Wola Combined Heat and Power Plant is situated on the left bank of the San River. Cooling water is abstracted from the San River and, after use, discharged back into the river through a mixing chamber and a discharge canal approximately 900 m long. The system also receives saline effluents and treated stormwater-industrial wastewater (www1).

3. Materials and methods

The study material was collected during spring (April–June) and autumn (September–October) seasons at the following sites:

Kisielina River – 7 sampling sites [**1:** N 49°92′76.7″; S 20°75′75.9″, **2:** N 49°96′46.2″; S 20°75′35.5″, **3:** N 50°00′47.3″; S 20°75′95.5″, **4:** N 50°07′74″; S 20°79′75.6″, **5:** N 50°11′13.8″; S 20°80′25″, **6:** N 50°17′36.5″; S

20°74′18.7″, **7:** N 50°22′60.7″; S 20°72′29.3″] designated along the river course from the source to the mouth (sampling periods: April 2023 and September 2023).

Szum River – 3 sites designated in the upper [N 50°31′44.7″; E 23°0′40.1″], middle [N 50°29′21.4″; E 22°57′26″] and lower river reaches [N 50°24′49,1″; E 22°55′28″]; (sampling periods: September 2013, May 2017, September 2017 and October 2024).

Cooling-water channel of the Stalowa Wola Power Plant – 3 sites located along an approximately 300 m section of the channel [**1:** N 50°33′27.5″; E 22°04′49.5″**, 2:** N 50°33′31.1″; E 22°04′51.8″, **3:** N 50°33′34.8″; E 22°04′57.7″]**;** (sampling period: June 2023).

At the designated sampling sites, material for analysis was collected from all available substrates, including stones, mud and submerged macrophytes in the Kisielina River; mud and sand in the Szum River; and stones covered with silt in the cooling-water discharge channel of the Stalowa Wola Combined Heat and Power Plant.

At all sites, water temperature, pH and electrical conductivity were measured *in situ* using specific tools such as pH meter MARTINI pH56 and conductivity meter MARTINI EC59.

Chemical analyses of water samples were conducted in the laboratory of the University of Rzeszów using an ion chromatograph (Thermo Scientific DIONEX ICS-5000 + DC).

Collected samples were preserved in a 4% formalin solution. To remove protoplasts and organic contaminants, the material was subjected to laboratory treatment following standard procedures according to Kawecka (1980). A portion of each sample was treated with a mixture of sulfuric acid and potassium dichromate (3:1) and left for several days. The material was subsequently cleaned by centrifugation (2500 rpm) and, when necessary, sedimentation. Cleaned material was used to prepare permanent microscope slides mounted in synthetic resin (Pleurax).

Diatoms were identified using a Carl Zeiss Axio Imager A2 light microscope equipped with differential interference contrast (Nomarski DIC) optics and a Plan-Apochromat 1.4 oil immersion objective at 1000 × magnification and also using a scanning electron microscope (SEM; HITACHI SU 8010). The material was sputter-coated with a 20 nm layer of gold using Quorum Q150OT ES sputter coater and examined at an accelerating voltage of 5 kV. Diatom microphotographs were taken using Carl Zeiss AxioCam ICc 5 camera. Diatoms were identified using the following literature: Krammer and Lange-Bertalot (1991); Morales (2006); Lange-Bertalot et al. (2017) and Wetzel et al. (2019).

Diatom counts were obtained by counting all valves in randomly selected fields of view under the microscope until a total of approximately 300 valves was obtained. Taxa with a relative abundance exceeding 5% were considered dominant.

Ecological preferences of identified taxa were assessed based on the indicator values proposed by Van Dam et al. (1994) and revised by Mertens et al. (2025). Ecological status was evaluated using diatom indices**,** such as Specific Pollution Sensitivity Index (IPS) and Generic Diatom Index (GDI), calculated with the OMNIDIA software (version 4.2; Lecointe et al., 1993).

4. Results

Flowing waters in southern Poland where *Planothidium* species were identified were typically characterised by alkaline or near-neutral pH. Electrolytic conductivity ranged from 115 to 511 μS · cm^{-1}. The highest pH values (>8) and conductivity values (>500 μS · cm^{-1}) were recorded at sites located in the cooling-water channel of the Stalowa Wola Power Plant.

Concentrations of most chemical parameters were low. In particular, phosphate and ammonium nitrogen were often below detection limits. In contrast, nitrate concentrations were relatively high compared with the thresholds for the first-class water quality. The highest nitrate levels (6–8 mg L^{-1}) were recorded in the upper

Table 1

Physico-chemical parameters measured in the Kisielina and Szum rivers and in the cooling-water discharge channel of the Stalowa Wola Combined Heat and Power Plant (southern Poland)

Parameter	Kisielina	Szum	Cooling-water channel
T[°C]	2.6–16.0	6.7–16.3	19.7–21.2
pH	6.2–7.2	6.6–8.0	8.3–8.6
EC [μS · cm^{-1}]	115–320	133.5–331	503–511
Cl^- [mg · L^{-1}]	10.55–28.94	0.07–9.17	10.67–13.58
SO_4^{2-} [mg · L^{-1}]	20.33–45.63	10.72–20.54	22.03–31.27
PO_4^{3-} [mg · L^{-1}]	<0.001	<0.001–0.15	<0.001
NO_2^- [mg · L^{-1}]	<0.001	<0.001–0.02	<0.001
NO_3^- [mg · L^{-1}]	2.31–8.09	0.13–6.60	2.55–2.79
NH_4^+ [mg · L^{-1}]	0.02–0.20	<0.001–0.55	0.02–0.05
Mg^{2+} [mg · L^{-1}]	3.22–11.86	1.28–3.73	4.13–5.76
Ca^{2+} [mg · L^{-1}]	16.36–47.30	26.48–50.27	21.92–30.40

EC, electrolytic conductivity; T, temperature.

and middle reaches of the Kisielina River and in the middle and lower reaches of the Szum River (Table 1).

Five *Planothidium* species not previously reported from Poland were identified at the investigated sites: *P. cavilanceolatum, P. daui, P. gallicum, P. hinzianum* and *P. potapovae*.

Planothidium cavilanceolatum C.E. Wetzel, M.G. Kelly & Van de Vijver (Figs. 1A–Z).

Dimensions: length 11.5–27.2 µm; width 4.4–6.3 µm; 11–14 striae in 10 µm.

Ecology and distribution: It was originally described from the Kleine Beek stream in Belgium and the River Poulter in the United Kingdom (Wetzel et al., 2019). It has also been reported from Spain, previously misidentified as *Planothidium frequentissimum* (Lange-Bertalot) Lange-Bertalot (Blanco et al., 2010).

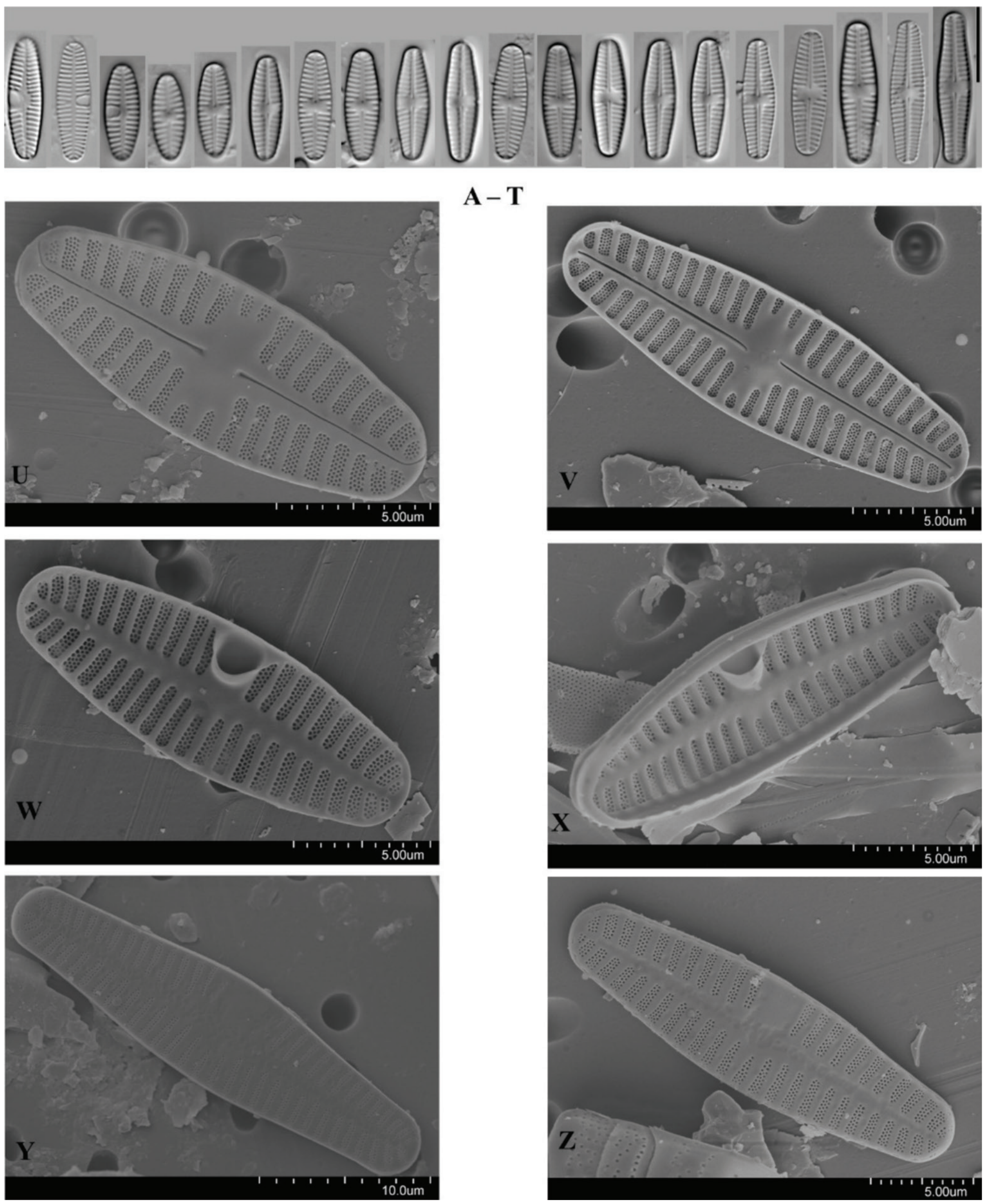

Figure 1

Planothidium cavilanceolatum: **A–T** – light micrographs (scale bars: 10 µm); **U–Z** – scanning electron microscope micrographs **(U** – external view of the raphe valve, **V** – internal view of the raphe valve, **W & X** – internal view of the rapheless valve, **Y & Z** – external view of the rapheless valve).

The ecological preferences of this species remain poorly defined, and indicator values were assigned only recently by Mertens et al. (2025).

Distribution in southern Poland: Observed exclusively in the lower reach of the Kisielina River.

Substrate: Mud and aquatic plants, primarily grasses.

Dominant species: *Cocconeis euglypta* (up to 87%), *Achnanthidium minutissimum* (Kützing) Czarnecki (up to 60%), *Meridion circulare* (Greville) Agardh (up to 9%), at times in particular seasons, the following species also dominated: *Lemnicola hungarica* (Grunow) Round & Basson (13%), *Melosira varians* C. Agardh (about 15%), *Cocconeis lineata* Ehrenberg (11%), *Gomphonema parvulum* Kützing (10%), *Gompphonema micropus* Kützing (9%), *Gomphonema innocens* Reichardt (9%), *Humidophila contenta* (Grunow) R.L. Lowe, Kociolek, Johansen, Van de Vijver, Lange-Bertalot & Kopalová and *Cocconeis pediculus* Ehrenberg (over 6%), *Fragilaria famelica* (Kützing) Lange-Bertalot, *Fragilaria gracilis* Østrup and *Navicula cryptotenella* Lange-Bertalot (over 5%).

Remarks: The species usually occurred as individual valves and was most abundant in autumn, particularly in the near-mouth section of the river (2%), in materials collected from macrophytes. At these sites, the river was characterised by a slow current and was densely overgrown with vegetation, predominantly grasses. The sites were well insolated, and the water was turbid. Water reaction was neutral or close to neutral (pH 6.8–7.0), while electrical conductivity ranged from 140 to 180 μS · cm^{-1}. The analysed chemical parameters of the water were generally low, with only nitrate concentrations slightly elevated (2.75–2.95 mg · L^{-1}), indicating a good chemical status of the waters in accordance with national regulations (Journal of Laws, 2021, item 1475). Calcium concentrations ranged from 17.01 to 26.51 mg · L^{-1}.

Planothidium daui (Foged) Lange-Bertalot (Figs 2A–AI)

Dimensions: length 6.8–11.6 μm; width 3.6–4.5 μm; 13–18 striae in 10 μm.

Ecology and distribution: The occurrence and ecological requirements of *P. daui* remain difficult to determine precisely, as the species is frequently confused with *P. granum* (Hohn) Lange-Bertalot, particularly in the case of small valves (Bąk et al., 2012; Hofmann et al., 2011; Lange-Bertalot et al., 2017). *Planothidium daui* was first described by Foged (1962) from the eastern part of the Jutland Peninsula under the name *Achnanthes daui*, while Lange-Bertalot (1999) subsequently transferred *A. daui* to the newly established genus *Planothidium*. Morales (2006) provided a detailed description of the species, including SEM documentation and a comparison with other similar and small species of the genus *Planothidium* from the United States. *Planothidium daui* has been reported from most continents, although it's most frequently recorded in Europe, including Germany (Doege et al., 2022; Hofmann et al., 2018; Ludwig & Schnittler, 1996; Mauch & Schmedtje, 2003; Täuscher, 2016), France (Peeters & Ector, 2018), Great Britain and Ireland (Whitton et al., 2003), Spain (Leira et al., 2017), the Netherlands (Mertens et al., 2025; Veen et al., 2015), Sweden (Karlson et al., 2018) and Romania (Caraus, 2017). The species is also known from North America, mainly from the United States (Bahls, 2009; Kociolek, 2005; Morales, 2006; Potapova & Charles, 2003; Reavie, 2020; Stancheva et al., 2020), as well as Alaska (Foged, 1981). It has also been reported from Asia (Joh, 2012; Medvedeva & Nikulina, 2014), Africa (Stoyneva-Gärtner & Descy, 2020) and Australia (John, 2020). *Planothidium daui* was included by Bąk et al. (2012) in the identification literature for phytobenthic diatoms in Poland; however, its occurrence has not yet been confirmed in Poland.

Distribution in southern Poland: Occurred sporadically in the middle and lower reaches of the Kisielina River and throughout the Szum River.

Substrate: Sandy–silty habitats in the Szum River and predominantly silty, less frequently stony-sandy substrates in the Kisielina River.

Dominant species: In the Kisielina River, the assemblage was dominated by *Achnanthidium minutissimum* (up to 46%), *Navicula lanceolata* (Agardh) Ehrenberg (up to 30%), *Melosira varians* Agardh (up to 24%), *Navicula gregaria* Donkin (up to 20%), *Cocconeis euglypta* (up to 11.5%), *Prestauroneis protractoides* (Hustedt) Q. Liu & Kociolek (up to 10%), *Meridion circulare* (up to 9%) and *Cyclostephanos invisitatus* (M.H. Hohn & Hellerman) E.C. Theriot, Stoermer & Håkanasson (up to 9%), and in the Szum River, the most abundant taxa included *Psammothidium subatomoides* (Hustedt) Bukhtiyarova & Round (up to 35%), *Punctastriata* sp. D.M. Williams & Round (up to 27%), *Achnanthidium minutissimum* (up to 19%), *Platesa conspicua* (A. Mayer) Lange-Bertalot (up to 18%), *Staurosira venter* (Ehrenberg) Cleve & J.D. Möller (up to 14%), *Cocconeis pseudothumensis* Reichardt (up to 13%), *Planothidium potapovae* (up to 12%) and *P. lanceolatum* (Brébisson) Lange-Bertalot (up to 8%).

Remarks: At all sampling sites, the species was consistently identified only as individual valves; however, it was more frequently observed in the Szum River within the Roztocze region, reaching its highest relative abundance in the upper course (approximately 1.5%). The upper reach of the Szum River was characterised by a good ecological status, with a

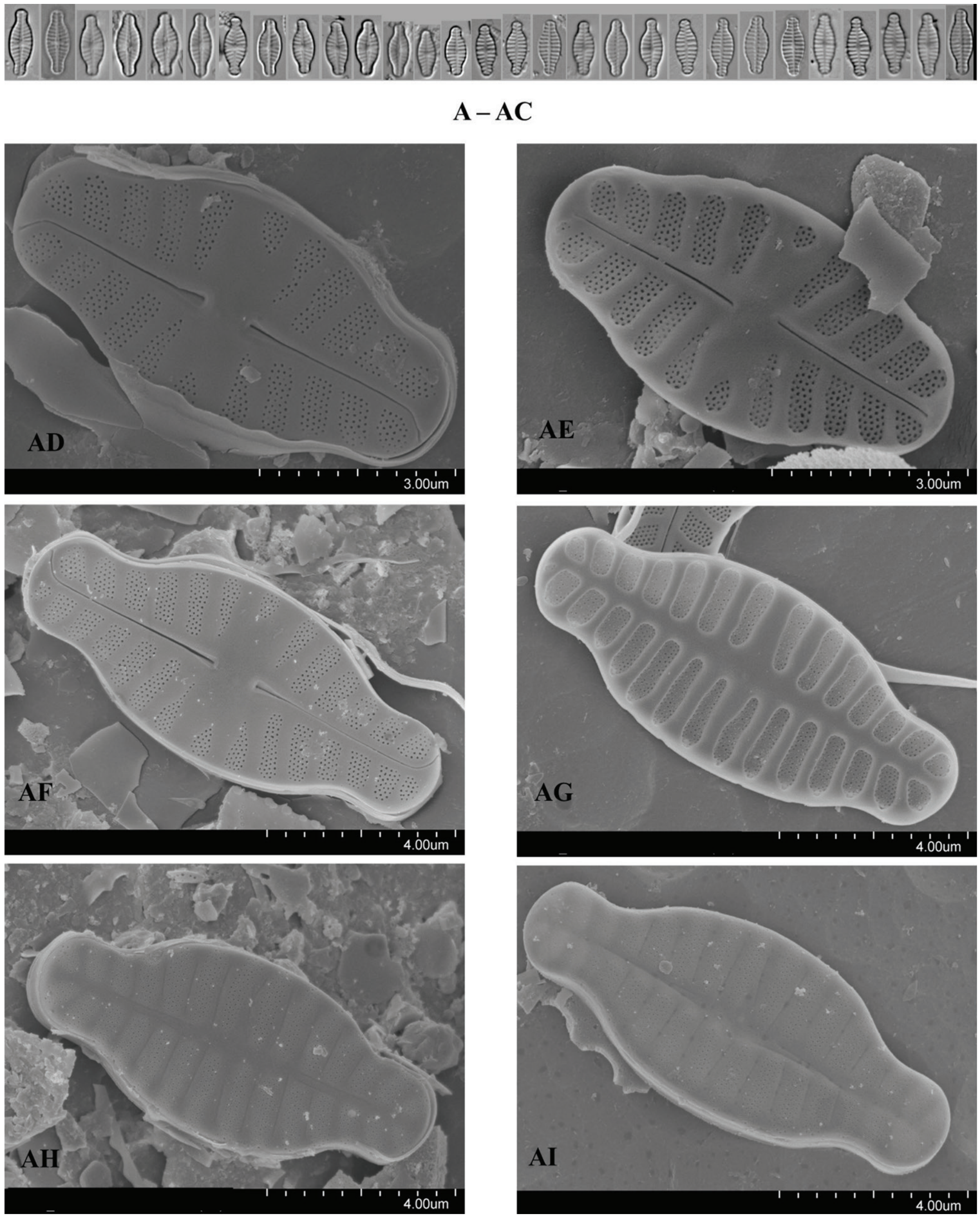

Figure 2

P. daui: **(A–AC)** light micrographs (scale bars: 10 µm); **(AD–AI)** scanning electron microscope micrographs **(AD & AF)** external view of the raphe valve, **(AE)** internal view of the raphe valve, **(AG)** internal view of the rapheless valve, **(AH & AI)** external view of the rapheless valve).

dominance of oligosaprobic diatoms. Depending on the sampling season, pH values were alkaline or close to neutral (6.6–7.9), while electrical conductivity ranged from 133.5 to 331 µS · cm^{-1}.

Planothidium gallicum C.E. Wetzel & Ector (Figs 3A–AA)

Dimensions: length 12.8–17.3 µm; width 4.3–5.6 µm; 13–17 striae in 10 µm.

Ecology and distribution: A poorly known species, originally described from the Saunus River in France (Wetzel et al., 2019) and later recorded in the Netherlands (Mertens et al., 2025).

Distribution in southern Poland: Very rare, recorded mainly in the middle reach of the Kisielina River and sporadically in the upper and middle reaches of the Szum River.

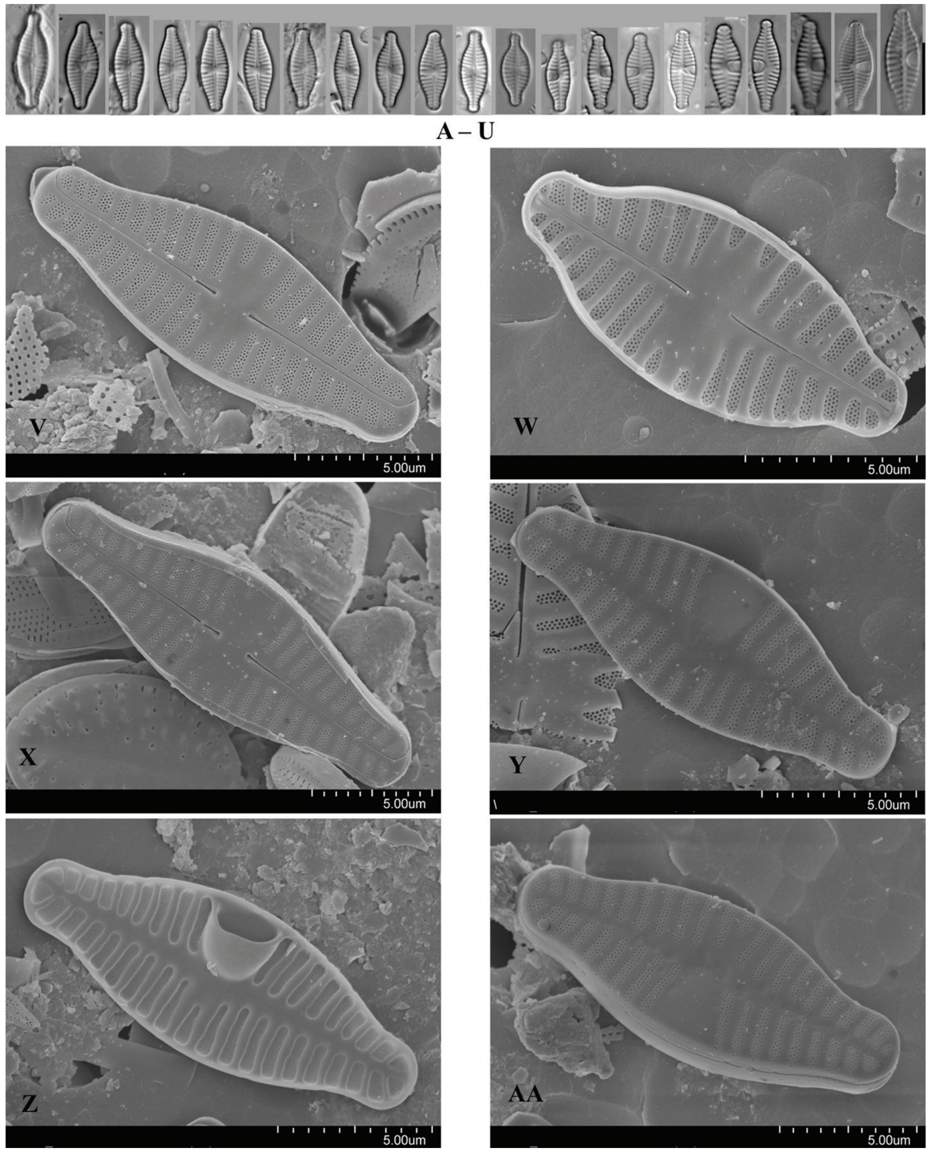

Figure 3

Planothidium. gallicum: **(A–U)** light micrographs (scale bars: 10 μm); **(V–AA)** scanning electron microscope micrographs **(V & X)** external view of the raphe valve, **(W)** internal view of the raphe valve, **(Y & AA)** external view of the rapheless valve, **(Z)** internal view of the rapheless valve).

Substrate: Sandy–silty in the Szum River, and predominantly silty, rarely stony–sandy substrates in the Kisielina River.

Dominant species: In the Kisielina River, the assemblage was dominated by *Navicula lanceolata* (up to 30%) and *N. gregaria* (up to 20%), *Achnanthidium minutissimum* (up to 24%), *Fragilaria gracilis* Østrup (up to 14%), *Gomphonema parvulum* (up to 10%) and *Meridion circulare* (up to 9%). In the Szum River, the most abundant taxa included *Psammothidium subatomoides* (up to 35%), *Punctastriata* sp. (up to 27%), *Platesa conspicua* (up to 18%), *Cocconeis pseudothumensis* (up to 13%), *Psammothidium potapovae* (up to 12%) and *Planothidium lanceolatum* (up to 8%).

Remarks**:** Given that *Planothidium gallicum* occurred very rarely in our study and was always observed as individual valves, it is difficult to draw any conclusions regarding the ecological preferences of this species. In both the middle course of the Kisielina River and the upper and middle courses of the Szum River, the water had a brown or light-brown colour. In its middle reach, the Kisielina River flows through a large forest complex (the so-called Radłowska Forest), within which waterlogged areas and wetlands are present. Similarly, the Szum River originates in forested areas characterised by wet and marshy habitats. In addition, the Szum River is regulated by a water dam and a retention reservoir, while within the Radłowska Forest, the Kisielina River flows in close proximity to ponds. A beaver dam is also present in the middle course of the river, further reducing water flow velocity. Further detailed studies and long-term observations are required to determine whether the presence of wetlands, marshes, or standing-water bodies has any influence on the occurrence of *P. gallicum*.

Planothidium hinzianum C.E. Wetzel, Van de Vijver & Ector (Figs 4A–AA)

Dimensions: length 7.6–22.0 µm; width 4.7–7.5 µm; 13–16 striae in 10 µm.

Ecology and distribution: Little is known about the ecology of this species. It was originally described from the Wümme River in Germany as an epiphyte on mosses of the genus *Hypnum* (material from the Hustedt Collection). Similar cells have been observed in Portugal, Spain and France, where they were often identified only to the genus level (*Planothidium* sp.) (Blanco et al., 2010; Peeters & Ector, 2018; Wetzel et al., 2019).

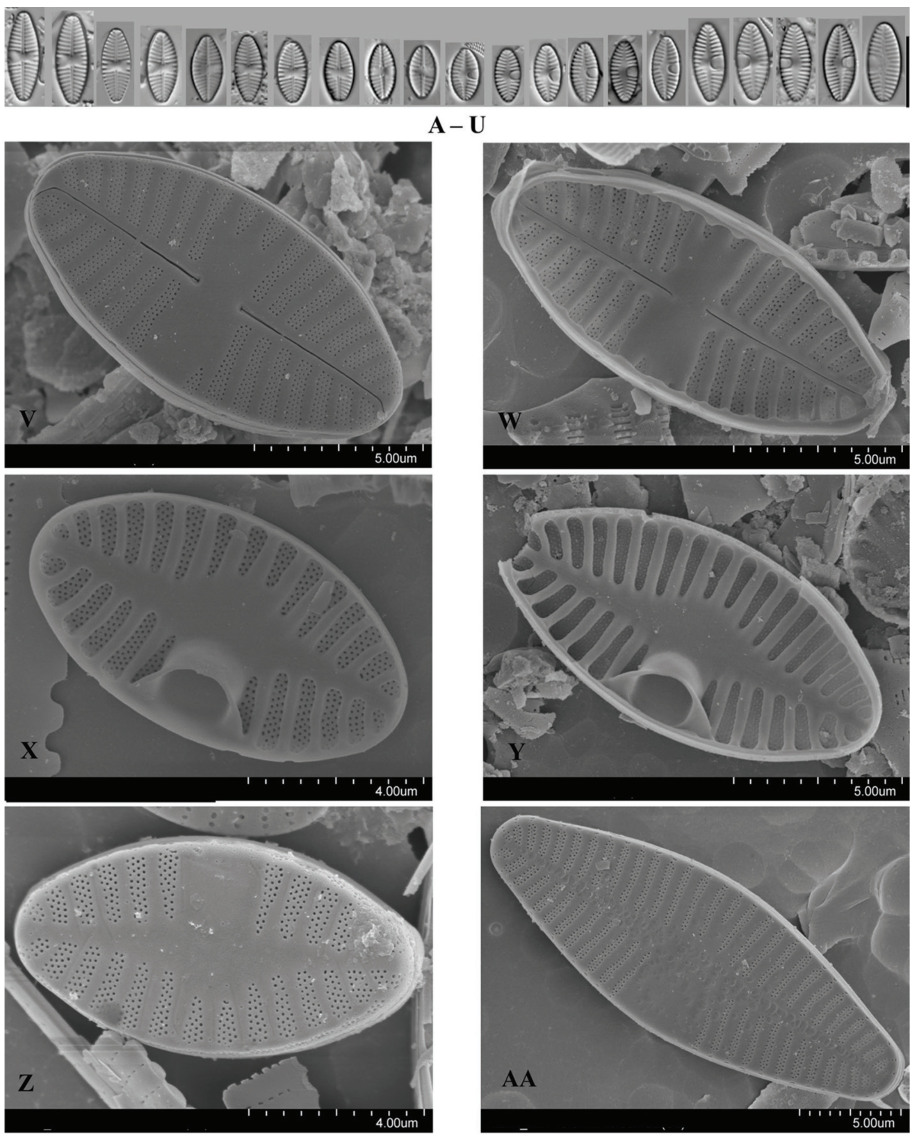

Figure 4

Planothidium. hinzianum: **(A–U)** light micrographs (scale bars: 10 µm); **(V–AA)** scanning electron microscope micrographs **(V)** external view of the raphe valve, **(W)** internal view of the raphe valve, **(X & Y)** internal view of the rapheless valve, **(Z & AA)** external view of the rapheless valve).

Distribution in southern Poland: The species occurred very rarely in the lower course of the Kisielina River, with single valves also recorded in the middle section. It was more frequently observed in the Szum River, where it reached its highest relative abundance in the upper course (up to 2%). Individual valves were also identified in the cooling-water channel discharging effluents from the Stalowa Wola Combined Heat and Power Plant into the San River.

Substrate: Sandy–silty habitats in the Szum River, silty substrates in the Kisielina River and silt-covered stone substrates in the cooling-water channel of the Stalowa Wola Combined Heat and Power Plant, discharging into the San River.

Dominant species: In the Kisielina River, *Navicula lanceolata* (up to 30%), *Achnanthidium minutissimum* (up to 24%), *Navicula gregaria* (up to 20%), *Fragilaria gracilis* (up to 14%), *Gomphonema parvulum* (up to 10%) and *Meridion circulare* (up to 9%), and in the Szum River, *P. subatomoides* (Hustedt) Bukhtiyarova & Round (up to 35%), *Punctastriata* sp. (up to 27%); *Platesa conspicua* (up 18%), *Cocconeis psudothumensis* (up to 13%), *Planothidium lanceolatum* (up to 8%) and *P. potapovae* (up to 12%), and in the cooling-water channel, *Discostella pseudostelligera* (Hustedt) Houk & Klee (30%–78.7%), *Cyclostephanos invistatus* (3.6%–10.6%), *Stephanocyclus meneghinianus* (Kützing) Kulikovskiy, Genkal & Kociolek (2%–6.2%), *Amphora pediculus* (Kützing) Grunow (<1%–14.3%) and *Navicula cryptotenella* (<1%–9.1%).

Remarks: At all sampling sites, the species occurred exclusively as individual valves; however, it was most abundant (approximately 2%) in the upper course of the Szum River within the Roztocze region, where it was recorded on sandy substrates. At this site, the water exhibited a very good ecological status in all sampling seasons. Values of most analysed parameters were low or below the detection limit; only nitrate concentrations (NO_3^-) were generally slightly elevated (0.06–3.78 mg · L^{-1}). Water reaction was alkaline or close to neutral (6.6–7.9), while electrical conductivity ranged from 133.5 to 331 µS · cm^{-1}.

In the Kisielina River, *Planothidium hinzianum* occurred only in the lower course, exclusively as individual valves, mainly at sites with a silted bottom and only rarely at sites overgrown with aquatic vegetation. The water was characterised by a neutral or near-neutral reaction (pH 6.6–7.0) and relatively low conductivity values (140–180 µS · cm^{-1}), while nitrate concentrations ranged from 2.69 to 3.80 mg · L^{-1}. Higher values of conductivity, nitrates and most other analysed parameters were recorded in the upper and middle reaches of the river.

Sites designated in the cooling-water discharge channel of the Stalowa Wola Combined Heat and Power Plant exhibited physical parameters similar to those observed in the Kisielina River. These sites were also characterised by a silted bottom, with channel banks overgrown by grasses and emergent vegetation. However, the chemical parameters of the water differed markedly: water reaction was distinctly alkaline (pH consistently >8), and conductivity values exceeded 500 µS · cm^{-1} at all sites (Table 1).

It is noteworthy that the individual valves of *Planothidium hinzianum* identified both in the Kisielina River and in the cooling-water channel were distinctly smaller (up to 17 µm in the Kisielina River and up to 11.5 µm in the cooling-water channel) compared with those recorded from the Szum River (up to 22 µm).

Planothidium potapovae C.E. Wetzel & Ector (Figs 5A–Y)

Dimensions: length 9.4–15.5 µm; width 4.7–6.1 µm; 12–14 striae in 10 µm.

Ecology and distribution: Little is known about the ecology of this species. It was previously included in the *Planothidium rostratum* complex (Krammer & Lange-Bertalot, 1991; Wetzel et al., 2019). *Planothidium potapovae* has since been distinguished from *Planothidium rostratocholarcticum*, and *P. rostratum* and has been reported from Europe, including France (Peeters & Ector, 2019; Wetzel et al., 2019) and the Netherlands (Mertens et al., 2025), as well as from North America (Bahls, 2021; Stancheva et al., 2020).

Distribution in southern Poland: Recorded exclusively in the Szum River, where it was dominant (6%–12%) in the upper reach.

Substrate: Sandy and sandy–silty.

Dominant species: *Psammothidium subatomoides* (16–35%), *Platesa conspicua* (6%–18%), *Cocconeis psudothumensis* (5%–13%), *Planothidium lanceolatum* (8%), *Staurosirella pinnata* (Ehrenberg) D.M. Williams & Round (up to 7%); on a single occasion, in autumn 2017, the assemblage was dominated by *Karayevia laterostrata* (Hustedt) Bukhtiyarova, *Placoneis clementispronina* Lange-Bertalot & Wojtal, *Reimeria sinuata* (Gregory) Kociolek and *Skabitschewskia peragalloi* (Brun) Kulikovskiy (5%–7%).

Remarks: The present study demonstrates that *Planothidium potapovae* finds favourable conditions for development in the upper course of the Szum River, as only there did it form numerous populations and occur as a dominant species. The taxon was recorded on sandy substrates, in shaded habitats, locally overgrown with vegetation (*Berula* sp. Besser & W.D.J. Koch). Water reaction was alkaline or close to neutral (pH 6.6–7.9), and electrical conductivity ranged from

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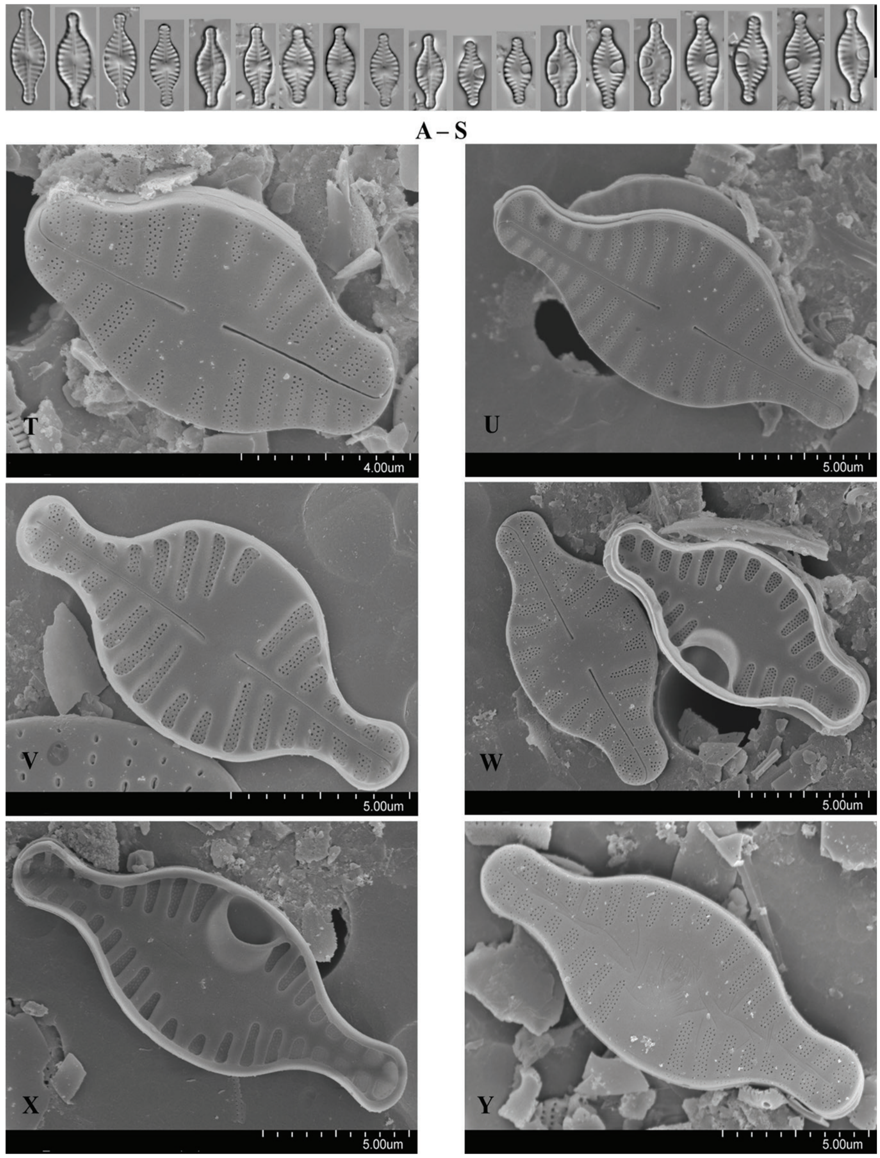

Figure 5

Planothidium. potapovae: **(A–S)** light micrographs (scale bars: 10 µm); **(T–Y)** scanning electron microscope micrographs **(T & U)** external view of the raphe valve, **(V)** internal view of the raphe valve, **(W)** external view of the raphe valve and internal view of the rapheless valve, **(X)** internal view of the rapheless valve, **(Y)** external view of the rapheless valve).

133.5 to 331 µS · cm^{-1} (Table 1). The highest abundance of this species (12%) was observed in autumn 2024, at a pH of 7.5, conductivity of 331 · µS cm^{-1} and a high concentration of Ca^{2+} ions (exceeding 50 mg · L^{-1}). The remaining chemical parameters of the water were low, often below the detection limit; only nitrate concentrations (NO_3^-) reached 3.37 mg · L^{-1}. The water in the upper course of the Szum River exhibited a very good ecological potential in all sampling seasons, and the diatom assemblage was dominated by oligosaprobic and oligo-mesotrophic taxa.

5. Discussion

Most of the *Planothidium* species presented in this study were described only a few years ago (Wetzel et al., 2019) and therefore remain poorly understood. In particular, detailed information on their ecology and distribution is lacking. Only recently, Mertens et al. (2025) provided indicator values for some of them. *Planothidium daui* has been known for a long time (Foged, 1962); its small valve size makes it difficult to identify, and as a result, it may be confused with other morphologically similar species with which it often co-occurs (Lange-Bertalot et al., 2017). Morales (2006) emphasised that *P. daui* is morphologically similar to *P. lemmermannii* and *P. granum* and that, in particular, larger valves of *P. granum* are very similar to those of small specimens of *P. daui*. Consequently, the ecology and distribution of such taxa remain imprecise and insufficiently documented, with *P. daui* representing a good example of this problem. Van Dam et al. (1994) classified *P. daui* as circumneutral, oligotraphentic and oligosaprobous, developing in waters of quality classes I and I–II. Mertens et al. (2025) revised the trophic status to oligo-mesotraphentic. Studies conducted by Morales (2006) in rivers of the United States (Big Thompson River, Colorado, Larimer County) showed that the species was most abundant in oligotrophic waters but was also identified in waters with alkaline pH (8.2) and conductivity 668 μS · cm^{-1}, i.e. under conditions differing from those described by Van Dam et al. (1994). In rivers of southern Poland, *P. daui* generally developed in waters with neutral or near-neutral pH, although at some sites reactions were alkaline (pH up to 7.9). The species occurred mainly in the Szum River in the Roztocze region, under oligo- to mesotrophic conditions, while single valves were also recorded in the Kisielina River, in mesotrophic and eutrophic waters (Noga et al., 2025). The ecological conditions defined by Van Dam et al. (1994) and Mertens et al. (2025) undoubtedly represent optimal conditions for *P. daui*; however, the results of the present study indicate that the species exhibits a broader ecological amplitude, ranging from oligotrophic to even eutrophic conditions.

The species *Planothidium cavilanceolatum*, *P. gallicum* and *P. hinzianum* were described new to science only 5 years ago, and to date, none of them has a precisely defined ecology (Wetzel et al., 2019). All three taxa occurred rarely at the investigated sites, which makes it difficult to draw firm conclusions regarding their ecological preferences. *Planothidium cavilanceolatum* was most frequently identified in the lower course of the Kisielina River, in samples collected from silt-covered aquatic vegetation, where it reached nearly 2% of the diatom assemblage. This species appears to prefer silted, vegetation-rich habitats in slow-flowing and turbid waters.

A similar relative abundance (approximately 2%) was recorded for *Planothidium hinzianum* in the upper, oligotrophic section of the Szum River, whereas under eutrophic conditions in the Kisielina River and in the cooling-water channel of the Stalowa Wola Combined Heat and Power Plant, it was always recorded as single valves. The species probably prefers clean waters, where its valves were larger than those reported in the literature (Wetzel et al., 2019). In contrast, valves identified in eutrophic waters were often smaller and narrower than the dimensions reported by Wetzel et al. (2019).

Only one of the identified taxa in this article, *Planothidium potapovae*, achieved dominant status in the upper course of the Szum River. The species was most abundant in autumn 2024, during a period of low water level, coinciding with the highest calcium concentration (>50 mg · L^{-1}) recorded during the study. At the remaining sites, in the middle and lower courses of the river, only single valves were identified. These observations suggest that *P. potapovae* prefers oligotrophic conditions, clean waters and sandy substrates, which dominate in the upper course of the river. Recently, single cells of *P. potapovae* were also identified in the lower course of the San River, in material collected from silt-covered stones. Water at this site was characterised by alkaline pH (>8) and conductivity values ranging from 289 to 493 μS · cm^{-1} (Bąk, unpublished data).

Acknowledgements

The authors would like to thank the Roztocze National Park Directorate and the Management Board of the Stalowa Wola Combined Heat and Power Plant for allowing them to collect diatom materials for research.

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