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# Pogórze Przemyskie Landscape Park Complex as a Habitat for Rare and New to Poland Pinnularia Species

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## ABSTRACT

The peat bog areas in southeastern Poland are a habitat for many interesting, often endangered, and rare or even new diatom species for Poland. Research conducted in the years 2022–2023 in three landscape parks (Pogórze Przemyskie Landscape Park, Południoworoztoczański Landscape Park, and Janowskie Forests Landscape Park) has allowed the identification of numerous rare and endangered species from the Pinnularia genus, including some that are new to Poland. The paper provides a detailed morphological and ecological characterization of six rare or endangered Pinnularia species, among which two were found to be new for Poland (Pinnularia lokana and P. esoxiformangusta).

**Keywords:** morphology, ecology of diatom species, peat bogs, SE Poland.

## INTRODUCTION

Diatoms (Bacillariophyta) are distinguished by various adaptations to environmental conditions, which is why they occur in various geographical regions, mostly in aquatic and humid environments. Many of them have a specific range of ecological tolerance towards habitat conditions (sometimes very narrow), which results in a high correlation between community structure and physicochemical and hydromorphological parameters of water. Diatoms are excellent bioindicators because they are abundant and diverse in species, exhibit seasonal changes, however they develop throughout the year. They produce very durable cell walls that are well-preserved in sediment. Due to their high durability, their frustules are used in paleoecology for reconstructing ancient environments. Diatoms are sensitive to various environmental factors, such as temperature, humidity, light, oxygen content, salinity, water pH, nutrients, and more. Many taxa have a cosmopolitan distribution and similar ecology worldwide, making them excellent indicators of environmental changes, eutrophication, pollution, and climate change (Kawecka, Eloranta 1994, Rakowska 2001, Smol, Stroemer 2010). The pH of the water plays a significant role in diatom lifecycle, affecting diatom communities directly and indirectly (e.g., by altering the solubility of certain substances in water, mainly carbonate and bicarbonate ions, as well as the buffering capacity of water). Environments with low pH typically exhibit low species diversity (Stokes 1986), and diatoms inhabiting such environments mainly belong to genera like *Eunotia*, *Brachysira*, *Pinnularia*, *Frustulia*, and *Nitzschia*. Diatoms from these genera have been observed in abundance even at pH levels ranging from 2.2 to 3.0 (Yoshitake, Fukushima 1995).

The genus *Pinnularia* Ehrenberg 1843 belongs to the raphid pennate diatoms and is characterized by naviculoid valves with three isopolar main axes. Diatoms from this genus mainly

occur in freshwater, with the highest abundance in ponds, oligotrophic and dystrophic waters, often acidic and mesotrophic waters with very low to moderate electrolyte content, peatlands, and moist soil (Krammer, Lange-Bertalot 1986, Round et al. 1990, Krammer 2000, Rumrich et al. 2000).

According to Siemińska et al. (2006) and Wołowski (2003), the best known algae assemblages are found in southern Poland, the Masurian Lake District, the Masovian Lowland, the Szczecin Lowland and the Oder floodplain, the western part of the Baltic Sea, the Wielkopolska Lakes and the Pomeranian Lakes District, and the Lublin Upland. In recent years, monographic studies have appeared on diatom communities developing, among others, in central Poland (Rakowska 2001, Żelazna-Wieczorek 2011), Tatra streams (Kawecka 2012) and springs in southern Poland (Wojtal 2013). Siemińska and co-authors (2006) believe that many data come from old or insufficiently documented publications and studies, therefore they require in-depth and critical verification, also using modern research tools (including electron microscopy).

In the northeastern part of Podkarpacie in Poland, specifically in the Pogórze Przemyskie Landscape Park, Południoworoztoczański Landscape Park, and Lasy Janowskie Landscape Park, there are rised bogs and transitional mires with valuable raised bog communities and very rare vegetation. However, detailed research on diatoms has not been conducted in any of these parks. Only in the Pogórze Przemyskie Landscape Park, a one-time study was conducted on rare and endangered diatom species in one of the peat hollows (Noga et al. 2022). Research on diatoms in southern and southeastern Poland has been ongoing for several years (Noga 2012, 2019, Noga et al. 2014b, 2022), but there are few studies directly related to diatom communities in peat bog areas (Noga et al. 2014c, Pajączek et al. 2014, Noga, Rybak 2017, Rybak et al. 2018). The genus *Pinnularia* is identified at many sites, including cosmopolitan taxa present in most studied locations, as well as rare and endangered species, including those new to Poland (Noga et al. 2014a). Some *Pinnularia* species have only been observed in peat bog areas (Noga, Rybak 2017). The aim of this study is to present new records of six *Pinnularia* species in peat bog areas of three landscape parks in southeastern Poland, along with a detailed morphological and ecological characterization. Two of the six described species are new to Poland, and little is known about their ecology and global distribution.

## STUDY AREA

The research was conducted in three nature reserves: 1) "Imielty Ług," 2) "Broduszurki," and 3) "Źródła Tanwi" located within three landscape parks: the "Lasy Janowskie Landscape Park," the "Pogórze Przemyskie Landscape Park," and the "Południoworoztoczański Landscape Park" (Fig. 1A). A detailed description of these landscape parks and reserves, along with a literature review, can be found in works such as Skubisz (2021, 2022), Noga et al. (2022), and Skubisz, Noga (2023). The "Imielty Ług" Nature Reserve (Fig. 1B) was established in 1988. It is located on the border of two voivodeships: Podkarpackie (a small, southwest part covering 72.22 ha) and Lubelskie (the remaining part). The reserve is part of a continuous forest complex covering the Sandomierz Basin, with predominant forestry activities in its vicinity. The conservation goal of the reserve is "preserving extensive marsh areas, overgrowing water reservoirs with rare and protected vegetation, serving as a habitat for birds".

The "Broduszurki" Nature Reserve (Fig. 1c) was established in 1995. It is located in the central part of the Podkarpacie Voivodeship, in the Przemyśl County, Dubiecko commune, encompassing an area of 25.57 ha. The reserve is surrounded by agricultural and built-up areas, with human settlements situated at a greater distance from its boundaries. The valley within the reserve (swampy and wet) lacks buildings, and its main land use forms are meadows and pastures, intensively overgrown with trees and shrubs in recent years. The conservation goal is "preserving well-developed peat bog communities with a large number of protected plant species for scientific, educational, and landscape reasons". The "Źródła Tanwi" Nature Reserve (Fig. 1D) was established in 1998. It is located in the northeastern part of the Podkarpacie Voivodeship, in the Lubaczów County, Narol commune, in the Huta Złomy village, covering an area of 185.94 ha. The reserve is situated on the northern edge of a large forest complex, in the immediate vicinity of agricultural and built-up areas in Huta Złomy. The conservation goal is "preserving, for scientific and educational reasons, natural

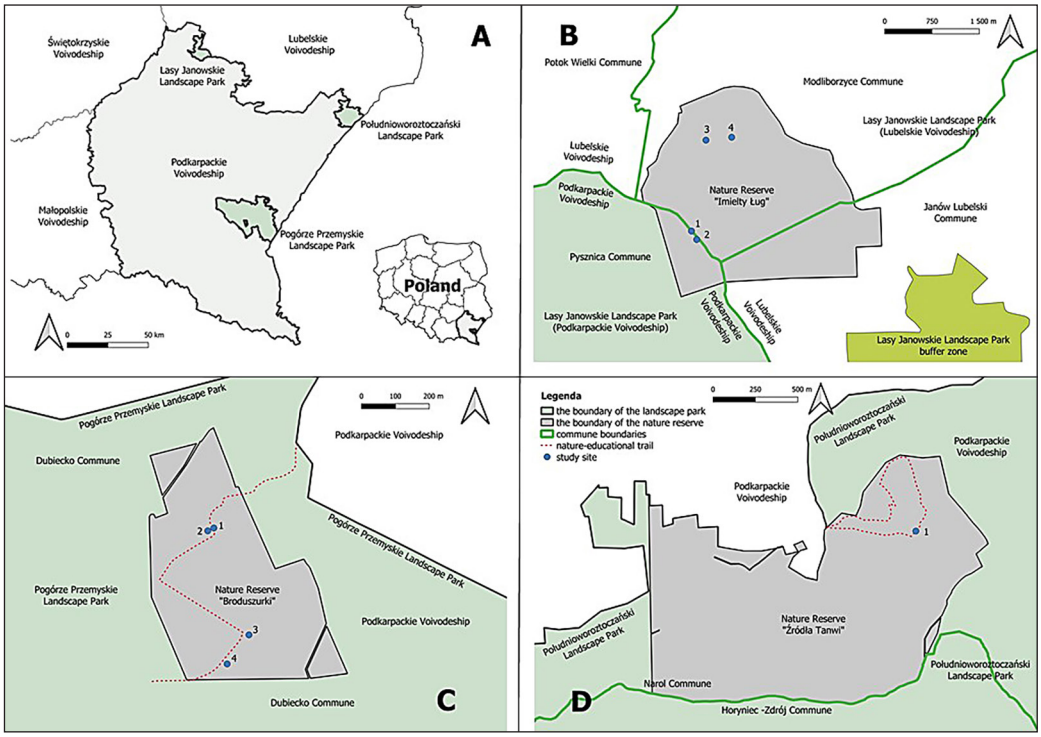


**Fig. 1.** The location of study area (a) along with sites distribution at reserves: „Imielty Ług" (b), „Broduszurki" (c) „Źródła Tanwi" (d)

communities of peat bogs, swampy and moist coniferous forests with numerous species of protected herbaceous plants".

## METHODS

Materials to studies were collected in 2022–2023 from designated sites in three landscape parks: 1) Pogórze Przemyskie Landscape Park (4 sites, samples colletion: October 2022), 2) Południoworoztoczański Landscape Park (3 sites, samples colletion: June and September 2022) and 3) Lasy Janowskie Landscape Park (4 sites, samples colletion: June 2023) – Fig. 1A–D. Individual samples were taken at all sites due to the uniformity of the habitats. Materials were collected from the following habitats:

- small depressions filled with water,
- squeeze from the moss growing on peat bogs, the edges of peat hollows and the edges of ponds,
- sediments at the bottom of a small stream flowing from the pond.

In the field, water temperature, pH, and electrolytic conductivity were directly measured. Other chemical parameters (anions and cations) were analyzed in the laboratory at the University of Rzeszów using a Thermo Scientific DIONEX ICS-5000+DC ion chromatograph.

To obtain cleaned frustules of diatoms, necessary for correct species identification, the collected materials were first subjected to acid maceration in the field, followed by appropriate purification. A detailed description of the methodology can be found in publications such as Kawecka (2012) and Noga et al. (2022). The purified material was used to prepare permanent microscope slides, on which diatoms were identified under a light microscope at a magnification of 1000x, using relevant specialized literature (e.g., Krammer 2000, Lange-Bertalot et al. 2011, 2017). Photographs of diatoms were taken using a light microscope (Carl Zeiss Axio Imager A2). During the microscopic examination, all frustules in randomly selected microscope fields were counted until a total of about 300 were counted to distinguish dominant species (≥5%). Threat categories for individual taxa were applied according to Siemińska et al. (2006).

## RESULTS AND DISCUSSION

The physicochemical analysis of water in peat bog areas located within the three landscape parks showed that the studied sites are characterized by

acidic to slightly acidic conditions (most commonly with a pH<6) and low to moderate electrolytic conductivity values. During the research conducted in the years 2022–2023, over 160 diatom taxa were identified, with 37 of them belonging to the genus *Pinnularia*. Among the identified taxa, there were both endangered, rare, and new to Poland diatoms.

***Pinnularia esoxiformis*** Fusey (Fig. 2: a–i)

Dimensions: length: 59.5–112.5, width: 10.7–14.8, number of striae in 10 μm: 8–9.

[based on literature: length: 62–135, width: 13–17, number of striae in 10 μm: 7–9 (Krammer 2000)]

Type of substrate: Between *Sphagnum* mosses, near the edge of the peat hollow.

Coexistence with other species: numerous (<30%) species from genus *Eunotia*: *E. sphagnicola* Van de Vijver, A. Mertens & Lange-Bertalot and *E. nymanniana* Grunow.

Distribution in Poland: a very rare species in Poland, known only from central Poland (Żelazna-Wieczorek 2011) and singularly observed in the Jagielnia stream in southeastern Poland (Noga et al. 2014b, Peszek et al. 2015).

Ecology and distribution worldwide: The species is likely cosmopolitan, observed in oligotrophic waters with low to moderate electrolyte content (Krammer 2000). *Pinnularia esoxiformis* is known from only a few sites, primarily in Europe, including France (Germain 1981), Germany (Ludwig, Schnittler 1996, Mauch, Schmedtje 2003, Hofmann et al. 2018, Reichardt 2018, Täuscher 2020,

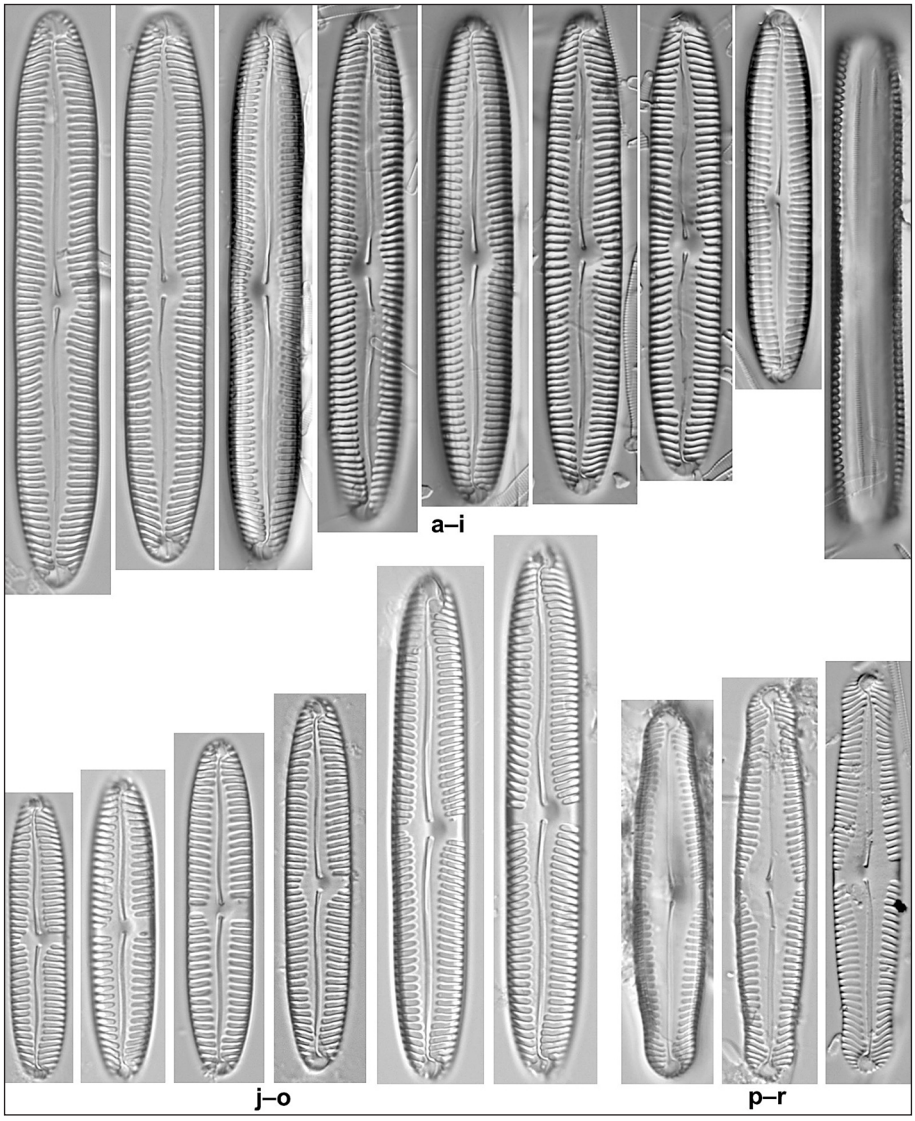


**Fig. 2.** *Pinnularia esoxiformis* (a–i), *Pinnularia eifelana* (j–o), *Pinnularia parvulissima* (p–r)

Doege et al. 2022), the Netherlands (Veen et al. 2015), Scandinavia (Karlason et al. 2018), Ukraine (Barinova et al. 2019). There are also individual records from North America, such as the United States of America (Kociolek 2005), South America, like Argentina (Vouilloud 2003), and Asia, including China (Li, Qi 2014).

Remarks: the species was one of the three dominant ones at site 2 in the "Broduszurki" Reserve (33%). It developed among *Sphagnum* moss, which densely covered the edge of the peat hollow in the form of a green belt about 1 meter wide. The water at the site was characterized by an acidic pH (4.9) and low conductivity (51 µS/cm). Nitrate content was 1.87 mg/l, and the values of other ions were very low. Among the numerous cells in the examined material, frustules were slightly shorter and narrower compared to the literature data (Krammer 2000).

***Pinnularia eifeliana*** (Krammer) Krammer
(Fig. 2: j–o)

*Basionym: Pinnularia esoxiformis var. eifeliana Krammer*

Dimensions: length: 41.8–80.1, width: 8.3–11.4, number of striae in 10 µm: 8–10.
[based on literature: length: 38–75, width: 8–11, number of striae in 10 µm: 7–10 (Krammer 2000)]

Threat category: E – endangered (Siemińska et al. 2006).

Type of substrate: among mosses and tussocks of grass and sedges, near the edge of the peat hollow.

Coexistence with other species: numerous (10–20%) species from genus *Eunotia*: *E. minor* (Kützing) Grunow and *E. bilunaris* (Ehrenberg) Schaarschmidt oraz less numerous (5–10%): *Stauroneis kriegerii* Patrick, *Nitzschia nana* Grunow, *Encyonema vulgare* Krammer and *Gomphonema exilissimum* (Grunow) Lange-Bertalot & Reichardt.

Distribution in Poland: The species is very rarely reported from Poland, listed in the Red List of Algae in Poland as endangered (Siemińska et al. 2006). It was last observed in research conducted by Bogusz et al. (2022), where diatoms were studied at sites designated in a fish pond, drainage ditch, marshy area, and the Bug River.

Ecology and distribution worldwide: The species is generally rare, although in some places, it can form numerous populations. It prefers oligotrophic waters with moderate electrolyte content (Krammer 2000). Until recently, it was known only from Germany (Ludwig, Schnittler 1996, Mauch, Schmedtje 2003) and the Netherlands (Veen et al. 2015), and it was described as *Pinnularia esoxiformis* var. *eifeliana*. It has been identified as *Pinnularia eifeliana* in various regions, including Germany (Krammer 2000, Reichardt 2018), Bulgaria (Stoyneva-Gärtner et al. 2015), Romania (Caraus 2017), Scandinavia (Karlason et al. 2018), Serbia (Vidaković et al. 2020), as well as in various parts of Asia, including China (Fan, Liu 2016), Korea (Joh 2012), and the Russian Arctic (Barinova et al. 2023).

Remarks: The species occurred infrequently (<1%) at only one site (site 4) in the "Broduszurki" Reserve within the Pogórze Przemyskie Landscape Park. At this site, the water had a dark brown color and low nutrient content, with only elevated nitrate levels (1.85 mg/l) and a pH of 6.1, along with a conductivity of 169 µS/cm. This site had the highest sulfate content (20.40 mg/l), and the calcium content was 14.30 mg/l. The observed cells in the examined material were slightly longer and wider compared to the dimensions provided by Krammer (2000).

***Pinnularia parvulissima*** Krammer (Fig. 2: p–r)

Dimensions: length: 54.6–66.8, width: 10.6–11.2, number of striae in 10 µm: 9–10.
[based on literature: length: 34–70, width: 10–12, number of striae in 10 µm: 8–10 (Krammer 2000)]

Type of substrate: Among mosses, in stagnant water, and on mud with a high organic matter content.

Coexistence with other species: numerously (>10%–23%): *Eunotia meisterioides* Lange-Bertalot, *Nitzschia gracilis* Hantzsch, *Pinnularia subcapitata* var. *elongata* Krammer and *Tabellaria flocculosa* (Roth) Kützing, and also less numerous (5%–6.5%): *Pinnularia lokana* Krammer, *Eunotia rhomboidea* Hustedt, *Staurosira venter* (Ehrenberg) Cleve & J.D. Möller and *Aulacoseira* cf. *alpigena* (Grunow) Krammer.

Distribution in Poland: single specimens, identified as *Pinnularia* cf. *parvulissima*, Krammer stated only in Żołynianka stream in southeastern Poland (Noga et al. 2014b, Peszek et al. 2015).

Ecology and distribution worldwide: The species is widely distributed but not very common in waters with a moderate electrolyte content (Krammer 2000). It has been reported from several locations in Europe, including Germany (Hofmann et al. 2018, Doege et al. 2022), Netherlands (Veen et al. 2015), Spain (Leira et al. 2017), Ukraine (Malakhov et al. 2017), and the Russian Arctic (Barinova et al. 2023). *Pinnularia parvulissima* is also known from other continents, including North America (Mexico – Mora et al. 2017), South America (Brazil – Eskinazi-Leça et al. 2010, Colombia – Heinrich et al. 2019), and Asia (China – Fan, Liu 2016, Korea – Lee et al. 2020, Mongolia – Kulikovskiy et al. 2010, Russia – Kulikovskiy et al. 2016, Genkal, Eremkina 2023).

Remarks: The species is very rare, with only two specimens found in the Źródła Tanwi Reserve in June 2022 (water temperature was 18.9°C). The species developed in water with a pH of 5.5 and low conductivity (24 µS/cm). One specimen was also identified in a small stream flowing out of the "Imielty Ług" Pond in June 2023 in material collected from organic mud (the stream's bottom had a large amount of decomposing leaves, branches, etc.). The water, like the site described above, was slightly acidic (pH=5.6) with low electrolyte content (21 µS/cm). The nitrate content at both sites was the same at 1.85 mg/l, and other parameters were very low, except for phosphates in the pond (3.45 mg/l).

***Pinnularia esoxiformangusta*** Reichardt
(Fig. 3: a–g)

Synonym: *Pinnularia esoxiformis var. angusta* Krammer

Dimensions: length: 54.5–100, width: 9.7–13, number of striae in 10 µm: 9–10.

[based on literature: length: 62–73, width: 11.4–12.2, number of striae in 10 µm: 8–10 (Krammer 2000), length: 49.8–88, width: 10–13, number of striae in 10 µm: 8–10 (Reichardt 2018)]

Type of substrate: among mosses and tussocks of grass and sedges, near the edge of the peat hollow and among *Sphagnum* mosses at the edge of the pond.

Coexistence with other species: Numerous *Eunotia minor* (Kützing) Grunow and *E. bilunaris* (Ehrenberg) Schaarschmidt (similar to the description of *Pinnularia eifeliana*), along with *Tabellaria flocculosa* (Roth) Kützing (34%), *Tabellaria fenestrata* (Lyngbye) Kützing (around 11%), and *Fragilaria gracilis* Østrup (approximately 20%), were dominant in the pond.

Distribution in Poland: The species new to Poland.

Ecology and distribution worldwide: Little is known about the distribution and ecology of this species. Krammer (2000) first described this species from Germany as *Pinnularia esoxiformis* var. *angusta* and noted its occurrence in oligotrophic waters with low to moderate electrolyte content, similar to *P. esoxiformis* var. *esoxiformis*. Reichardt (2018) also reported the presence of this species in Germany, although in drier areas and around ponds. This species has also been identified in the benthos of flowing and standing waters in Mongolia (Metzeltin et al. 2009, Dorofeyuk, Kulikovskiy 2012).

Remarks: The species occurred rarely (approximately 1%) at only one site (site 4) in the "Broduszurki" Reserve (Pogórze Przemyskie Landscape Park), in the same environmental conditions as *P. eifelana*. Single specimens were also identified in the "Imielty Ług" Pond (Lasy Janowskie Landscape Park), among *Sphagnum* mosses. The water at this site had a slightly brown color, low conductivity (48 µS/cm), and a low pH (5.8), along with relatively high nutrient content (nitrate: 1.94 mg/l, phosphate: 3.45 mg/l). The identicated *Pinnularia esoxiformangusta* cells were both slightly narrower and significantly longer compared to the literature data (Krammer 2000, Reichardt 2018).

***Pinnularia polyonca*** (Brébisson) W. Smith var. ***polyonca*** (Fig. 3: h–n)

Dimensions: length: 67.2–77.2, width: 8.6–9.9, number of striae in 10 µm: 10–11.

[based on literature: length: 50–90, width: 8–12, number of striae in 10 µm: 10–12 (Siemińska 1964, Krammer 2000)].

Threat category: E – endangered (Siemińska et al. 2006).

Type of substrate: among *Sphagnum* mosses growing on the edge of the pond and on mud with a high amount of organic matter in a small stream flowing out of that pond.

Coexistence with other species: the dominant species are the same as those mentioned

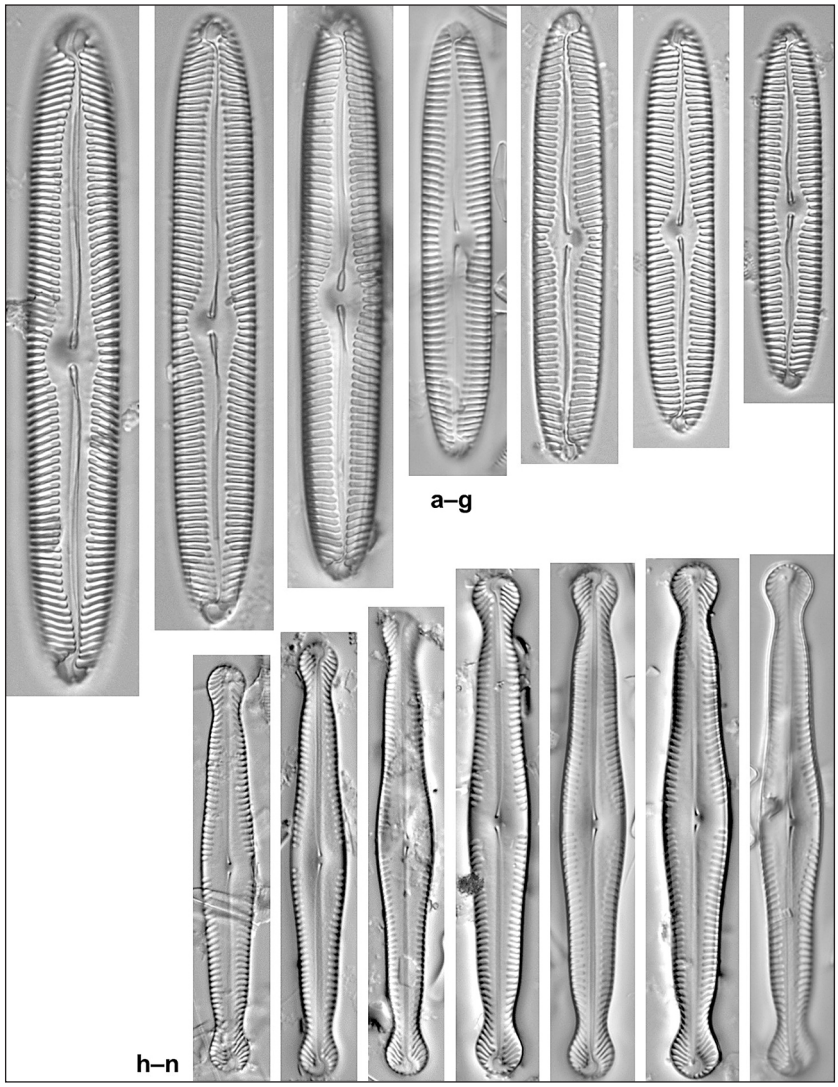


**Fig. 3.** *Pinnularia esoxiformangusta* (a–g), *Pinnularia polyonca* var. *polyonca* (h–n)

in the previous description of *Pinnularia parvulissima*.

Distribution in Poland: the species is rare in Poland (Siemińska 1964, Siemińska, Wołowski 2003), reported from various locations including a now-extinct peat bog near Krakow (Rumek 1946), the Widawka River (Ligowski 1988), the Kryniczanka Stream (Starmach 1989), and a peat bog in Magdalenowo (Lesiak, Sitkowska 1981). In recent years, the species has only been identified in Holocene sediments from the Mały Staw in the Karkonosze Mountains (Sienkiewicz 2005, 2016).

Ecology and distribution worldwide: The species is rare and occurs zonally as a zonal element in the Palaearctic region, often in isolated locations. It prefers waters with low electrolyte content (Krammer 2000). According to Siemińska (1964), it is a rare freshwater species typically found in mountainous waters, usually in small numbers. *Pinnularia polyonca* is known from various places in Europe, including Britain and Ireland (Sims 1996, Whitton et al. 2003, Pentecost, Haworth 2021), France (Germain 1981), Spain (Álvarez Cobela, Estévez García 1982), Germany (Ludwig, Schnittler 1996, Mauch, Schmedtje 2003, Hofmann et al. 2018, Doege et al. 2022), the Netherlands (Veen et al. 2015), Slovakia (Hindák, Hindáková 2016), Romania (Caraus 2017), Scandinavia (Karlason et al. 2018), Ukraine (Bukhtiyarova 1999, Malakhov et al. 2017, Barinova et al. 2019). It has also been recorded in the Arctic (Cremer 1998) and Iceland (Foged 1974). The species has been identified on other continents as well, including North America (Patrick, Reimer 1966, Foged 1981, Kociolek 2005, Bahls

2009), South America (Bicudo et al. 1975, Rivera Ramírez 1983, Vouilloud 2003), Africa (Smith et al. 2015), and Asia (Li, Qi 2014, Gupta, Das 2020).

Remarks: The species is very rare, with only two specimens found in "Imielty Ług" Pond. A few more specimens were observed in the stream flowing from this pond. Both sites had slightly acidic pH (5.6–5.8) and low conductivity values (48 µS/cm in the pond and 21 µS/cm in the stream). Nitrate content was similar at both sites (1.8–1.9 mg/l), with differences primarily in phosphate levels (3.45 mg/l in the pond and below the detection limit in the stream flowing from the pond). Since *Pinnularia polyonca* var. *polyonca* was more abundant in the stream, which had very low or nearly undetectable values for most of the measured parameters, it is reasonable to assume that this species prefers strongly oligotrophic conditions with very low electrolyte content and a pH below 5.

***Pinnularia lokana*** Krammer (Fig. 4: a–g)

Dimensions: length: 75–107.7, width: 11.8–13.3, number of striae in 10 µm: 9–10.

[based on literature: length: 56–107, width: 12–15, number of striae in 10 µm: 9–10 (Krammer 2000)]

Type of substrate: among mosses, mainly from genus *Sphagnum*.

Coexistence with other species: very often *Eunotia meisterioides* Lange-Bertalot (more than 35%) and also less numerous *Pinnularia subcapitata* var. *elongata* Krammer (>13%), *Eunotia rhomboidea* Hustedt (>10%) and *Tabellaria flocculosa* (Roth) Kützing (7%).

Distribution in Poland: new to Poland.

Ecology and distribution worldwide: The species was first described from Sweden in 2000, and little is known about its distribution and ecology (Krammer 2000). So far, the species has been reported from a limited number of sites, not only in Scandinavia (Krammer 2000, Karlason et al. 2018) but also from North America (Bahls et al. 2018, Aycock 2022), and Asia, including peat bogs in Mongolia (Kulikovskiy et al. 2010), China (Fan, Liu 2016), and Russia (Kulikovskiy et al. 2016).

Remarks: *Pinnularia lokana* was one of the main dominants in the Źródła Tanwi Reserve (Południoworoztoczański Landscape Park), with the most numerous populations observed in September 2022 (close to 19%). It thrived at pH levels of 4.7–5.5 and had a conductivity ranging from 24 to 133 µS/cm. The nitrate content was approximately 1.8 mg/l, while

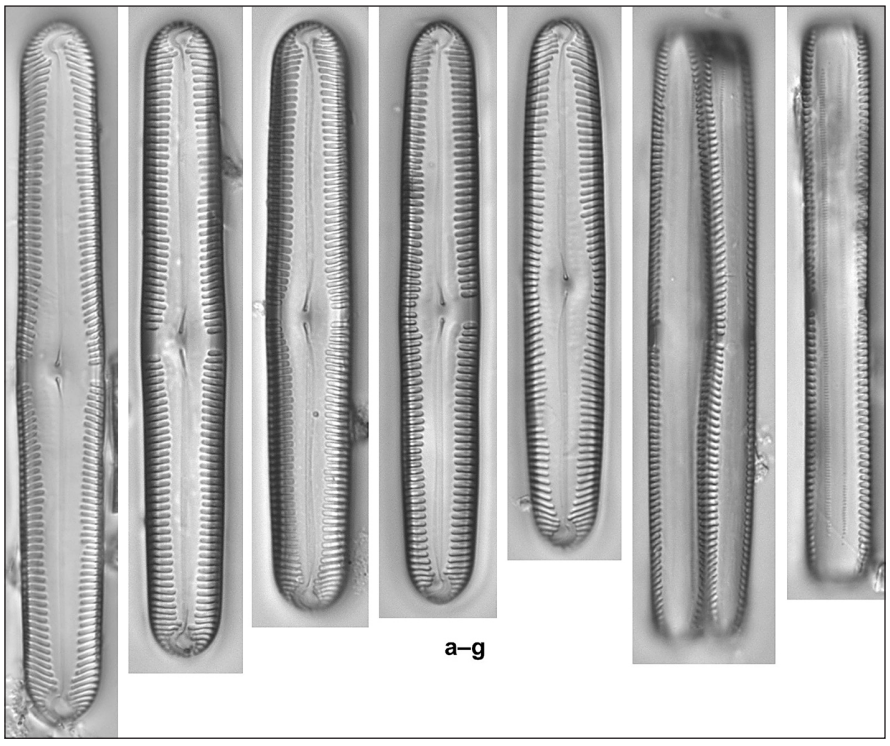


**Fig. 4.** *Pinnularia lokana* (a–g)

the values of other ions were very low, often below the detectable limit. The research indicates that *P. lokana* had favorable conditions for development in the Źródła Tanwi Reserve, where it formed numerous populations, and some specimens were slightly longer compared to the dimensions provided in the literature (Krammer 2000).

## CONCLUSIONS

The conducted research allowed for the identification of 32 diatom taxa (which constitutes 18.8% of all identified taxa) that are listed on the Red List of Algae of Poland (Siemińska et al. 2006). It is worth noting that among the diatoms listed on the mentoined list, 15 taxa fall into category E (endangered), all belonging to the genus *Pinnularia*, and 9 of them were found in the studied material. Particularly valuable is the confirmation of the presence of *Pinnularia polyonca* var. *polyonca*, a species known from only a few locations in Poland (Siemińska, Wołowski 2003). This species was found only in "Imielty Ług" Pond and a small stream flowing from it (Lasy Janowskie Landscape Park), in the form of single cells. In the neighboring Germany, it was initially listed as an extremely rare species (Lange-Bertalot, Steindorf 1996) and is still considered a very rare species with an unknown level of threat (Threat of Unknown Extent) (Hofmann et al. 2018). During the research, two diatom species new to Poland were also identified – *Pinnularia lokana* and *Pinnularia esoxiformangusta*. Little is known about their distribution and ecology, and they are known from only a few locations (Krammer 2000, Reichardt 2018). *Pinnularia lokana*, in particular, dominated in the community in the Źródła Tanwi Reserve (Południoworoztoczański Landscape Park), suggesting that this may be an area with favorable conditions for its development.

The research conducted in the three landscape parks in the Podkarpackie Voivodeship clearly showed that peatland areas are home to many interesting diatom species, often endangered, rare, or known from very few locations in Poland. These areas are still insufficiently studied from an algological perspective, often proving to be the habitat of diatoms not previously recorded in Poland. According to the authors, more detailed and long-term studies (for at least a few research seasons) will allow for the identification of additional diatom taxa new to Poland and expand our knowledge of the morphology and ecology of many diatom species that are still poorly known in science.

### Acknowlegments

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