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NEW OR RARE SPECIES OF THE GENERA *ACHNANTHIDIUM* AND *PSAMMOTHIDIUM* (BACILLARIOPHYCEAE) IN THE DIATOM FLORA OF POLAND

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Abstract: This paper concerns four small species of the genera *Achnanthidium* and *Psammothidium* recorded in calcium-rich waters of the Wyżyna Krakowsko-Częstochowska upland in Poland. Three species – *Achnanthidium straubianum* (Lange-Bert.) Lange-Bert., *Psammothidium grishunum* (Wuthrich) Bukht. & Round, and *P. lauenburgianum* (Hust.) Bukht. & Round – are reported and documented from Poland for the first time. The distribution of *Psammothidium bioretii* (Germ.) Bukht. & Round is given. The morphological characteristics, ecological requirements, and distribution of the species are briefly discussed, and photographic documentation is provided.

Key words: Bacillariophyceae, *Achnanthidium*, *Psammothidium*, taxonomy, ecology, distribution

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INTRODUCTION

Floristic aspects of the algae of the Wyżyna Krakowsko-Częstochowska upland have been the subject of investigations for many years (e.g., Cabejszekówna 1935; Siemińska 1947; Skalska 1966a, b; Skalna 1969; Hojda 1971) making it one of the better-known diatom floras of Poland. During almost 120 years of floristic studies in the Wyżyna Krakowsko-Częstochowska upland, 39 taxa of the family Achnanthaceae have been reported (Wojtal 1994). Most of the records are of species that dominated or were at least common in the material studied. The distribution of species, which usually occur in small numbers in the region and in Poland as a whole, is poorly known and still requires further studies.

This paper presents the results of a floristic study focused on small taxa of the genera *Achnanthidium* Kützing and *Psammothidium* Bukhtiyarova & Round, genera which until recently were included in the genus *Achnanthes* Bory.

The taxonomy of the genus *Achnanthes* has undergone many changes, particularly in the last 14 years. The most striking changes concern the genus *Achnanthidium*, redefined by Round *et al*. in 1990, based on *Achnanthes minutissima* Kützing. This genus comprises a large number of monoraphid diatoms common in freshwater. In 1996 the genus *Achnanthidium* was split into a few new genera, including *Planothidium* Round & Bukht., *Psammothidium* Bukht. & Round, *Rossitidium* Round & Bukht., *Karayevia* Round & Bukht., *Kolbesia* Round & Bukht. and others (Bukhtiyarova & Round 1996; Round & Bukhtiyarova 1996), but a number of taxa of the genus *Achnanthidium* are still being investigated and transferred to new genera.

Even though many species of the genus *Psammothidium* and some of the species belonging to the genus *Achnanthidium* prefer acid waters, other species also form an important component of diatom associations in circumneutral and more alkaline waters. They are very abundant in periphytic communities. Many representatives of these genera are good indicators of water quality and its physicochemical characteristics (Lange Bertalot & Krammer 1989; Krammer & Lange-Bertalot 1991; Van Dam *et al*. 1994).

The main difficulties in recording specimens of the genera *Achnanthidium* and *Psammothidium* are their small size, morphological variability, and small population size. Valve outline is a feature that can change during successive generations of vegetatively dividing diatoms, and smaller cells are not necessarily geometrically identical to larger ones (Cox 1984). In the case of species occurring in small populations, gradual changes in shape usually cannot be observed, and the recorded specimens represent particular stages of the vegetative continuum. Moreover, such environmental factors as season or habitat can also modify the ornamentation and shape of the diatom's frustules. Lastly, in SEM studies of diatom valve ultrastructure the morphological details are important for precise identification of certain species, but such examinations are not always feasible, especially when the studied taxa possess small, finely ornamented frustules and occur in low numbers.

Study area, material and methods

The material was collected mainly during extensive studies of the diatom flora of Kobylanka stream and its springs, and some another springs situated in the Wyżyna Krakowsko-Częstochowska upland (1–4 in Fig. 1) (see also Wojtal 2003a, b, 2004). During the study period the water temperature of the springs and stream was 6.2°C–10.0°C, conductivity was moderate, ranging from 312 to 480 μS/cm^{-1}, and pH varied from 6.1 to 8.0. Samples for detailed taxonomical investigation were prepared and cleaned by standard techniques (Krammer & Lange-Bertalot 1986). Observations were performed with a Nikon Optiphot microscope equipped with a Plan x 100 oil-immersion lens (numerical aperture 1.25) and a Nikon FX-35 photomicroscopy unit. SEM observations were made on cleaned, gold-coated material, with a Philips SEM microscope. SEM micrographs were taken at the Institute of Metallurgy and Materials Science, Polish Academy of Sciences, and at the Laboratory of Field Emission Microscopy, Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University.

Data on the distribution of species were obtained from the literature and from the Iconotheca of Algae of the Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków. Data on the distribution of the species in Poland up to 1990 were obtained from references gathered in the *Catalogue of Polish Procariotic and Eucariotic Algae* (Siemińska & Wołowski 2003). The material studied is deposited in the collection of the Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

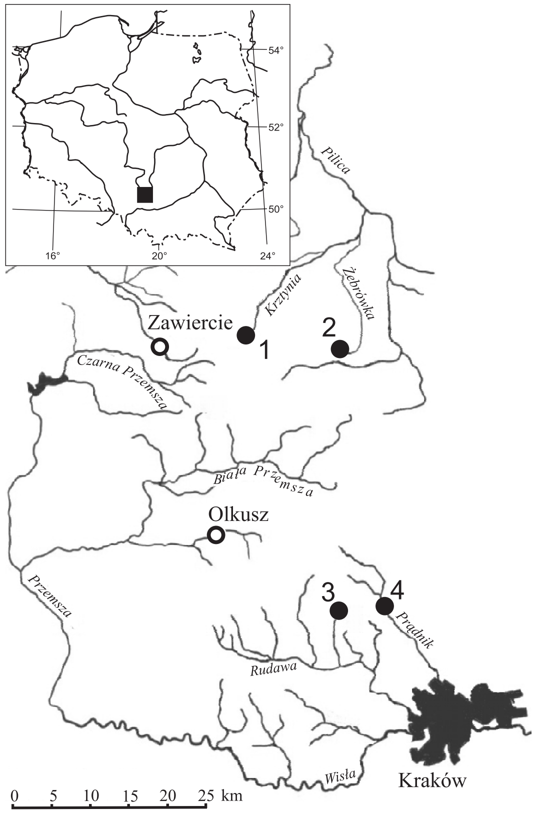


Fig. 1. Distribution of the studied springs (Wyżyna Krakowsko-Częstochowska Upland). 1 – spring of Żebrówka stream, 2 – spring of Krztynia stream, 3 – springs of Prądnik River in Ojców National Park, 4 – Kobylanka stream and its springs.

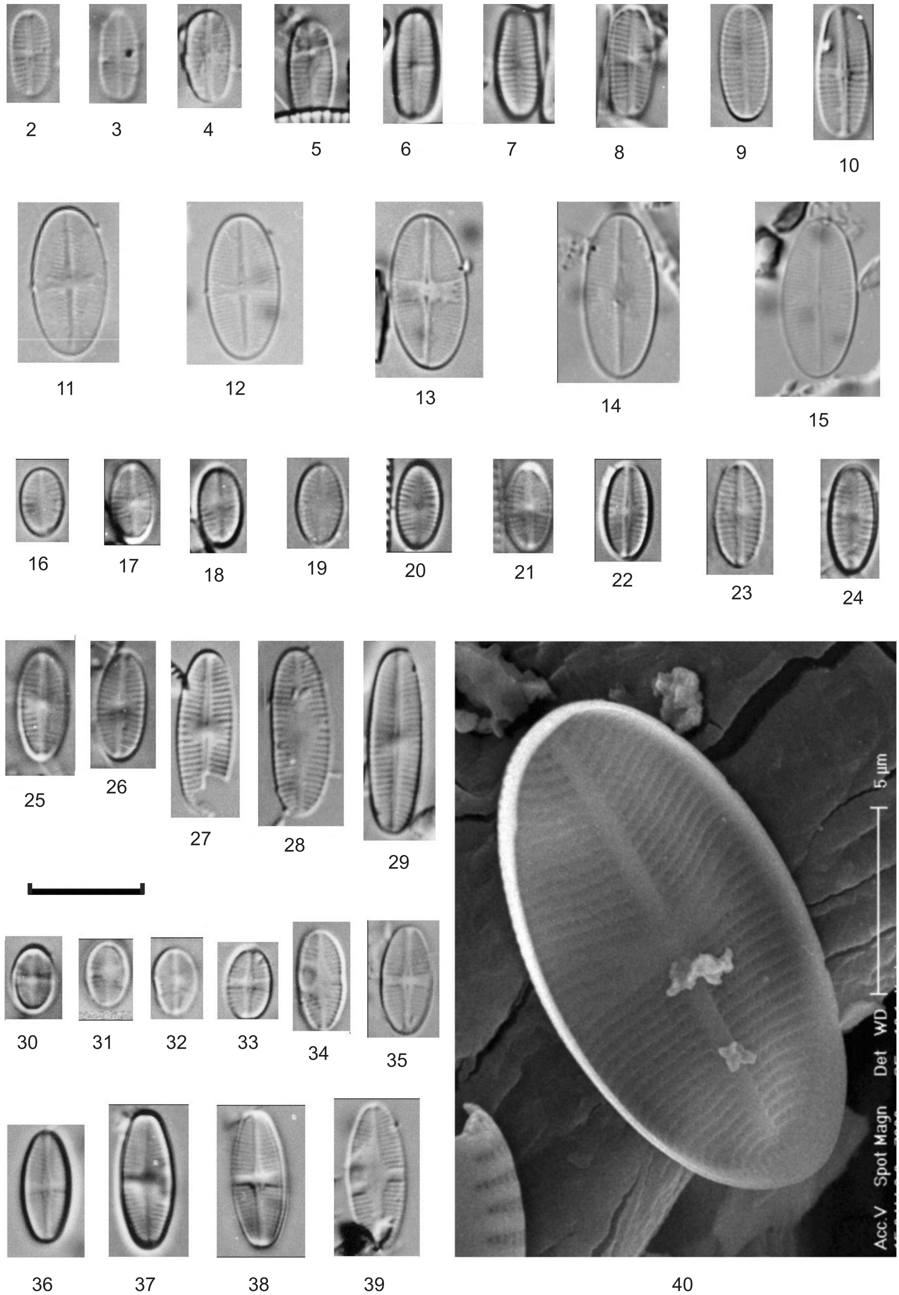
Results and discussion

Achnanthidium straubianum (Lange-Bert.) Lange-Bertalot 1999 (Figs 2–10)

Achnanthes straubiana Lange-Bert.

Achnanthes minutissima "Sippe mit breit elliptischen Schalen"

Ref. Lange-Bertalot & Metzeltin 1996 (Taf. 78: 21a–b); Krammer & Lange-Bertalot 1991 (Fig. 32: 53–56).



Figs 2–40. 2–10: *Achnanthidium straubianum* (Lange-Bert.) Lange-Bert.; 11–15, 40 – *Psammothidium bioretii* (Germ.) Bukht. & Round; 16–29 – *P. grischunum* (Wuthrich) Bukht. & Round; 30–39 – *P. lauenburgianum* (Hust.) Bukht. & Round. Scale bar 10 µm. (2–39: LM), 40 – SEM: rapheless valves in internal view.

Valves elliptical or linear-elliptical with broadly rounded apices, 7.5–11.5 µm long, 3.5–4.5 µm wide. Raphe valve with very narrow axial area. Central area very small, formed by more distinct and more distantly spaced transapical striae. Rapheless valve with linear sternum becoming narrower towards apices, central area lacking. Transapical striae parallel or slightly radiating throughout the raphe and rapheless valves, 24–30 in 10 μm.

ECOLOGY. The preferences of the species are still insufficiently known. So far it has been reported from calcium-rich, mesotrophic and eutrophic waters (Krammer & Lange-Bertalot 1991; Lange-Bertalot & Metzeltin 1996).

DISTRIBUTION. The general distribution of *A. straubianum* is still not precisely known. Most probably widespread, not rare but overlooked when it occurs in small numbers. Known from Lac de Locat in Switzerland, lake Mittersee in Austria (Lange-Bertalot & Metzeltin 1996), and springs in the limestone Alps (Cantonati 1998). In the material studied it occurred in samples collected from stones, *Vaucheria* sp. filaments and mud from springs (2, 3) and the Kobylanka stream (4), but its relative abundance has never exceeded 1%. New to the Polish flora.

Psammothidium bioretii (Germ.) Bukht. & Round 1996 (Figs 11–15, 40, 41)

Achnanthes bioretii Germ.

Navicula rotaeana var. *excentrica* Grun.

Ref. Germain 1957 (Fig. 21); Lange-Bertalot & Krammer 1989 (Figs 21: 23–35, 95: 14, 14', 96: 1–2'); Krammer & Lange-Bertalot 1991 (Fig. 12: 1–9); Bukhtiyarova & Round 1996 (Figs 26–31).

Valves oval to elliptical, 13–15 μm long, 6–7 μm wide. Raphe valve with narrow linear axial area, sigmoid near apices, with distinctive external raphe endings. Central area rectangular, formed by irregularly shortened transapical striae. Rapheless valve with narrow linear sternum, expanding in the central area. Transapical striae radiate throughout the raphe and rapheless valves.

The outline of the frustules, the curvature of the raphe valve, striation, and raphe fissures lying in channel are the characters that justified transferring the species to the genus *Psammothidium* (Bukhtiyarova & Round 1996).

ECOLOGY. Although *P. bioretii* is reported from waters of different types, its occurrence is often related to oligotrophic waters with a moderate concentration of electrolytes and a very wide range of pH (Krammer & Lange-Bertalot 1991). According to Van Dam *et al*. (1994) it is acidophilous, tolerating very small concentrations of organically bound nitrogen, and belongs to the group of diatoms requiring a continuously high concentration of dissolved oxygen.

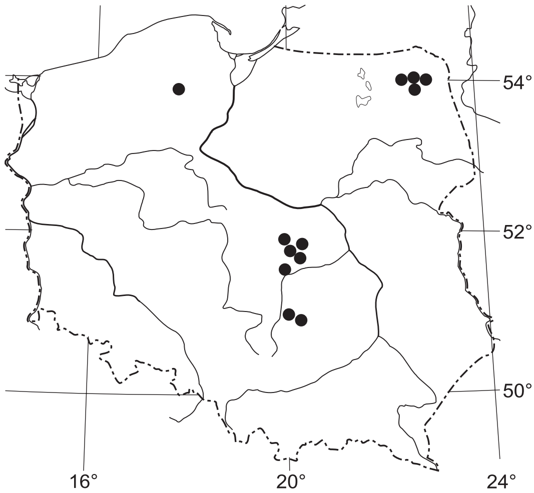


Fig. 41. Distribution of *Psammothidium bioretii* (Germ.) Bukht. & Round in Poland.

DISTRIBUTION. Most probably cosmopolitan. In Poland, *P. bioretii* was first recorded in material collected from springs in northern Poland (Wołoszyńska 1922). Known also from Wigry Lake (Wołoszyńska 1924), springs and other water bodies in central and northern Poland (Rakowska 2001), the Mylof reservoir dam (Sekulska-Nalewajko 1999) and from the Baltic Sea (Potapova 1995) (Fig. 41). Although its records come from several freshwater localities in Poland, it is not abundant at any of them. In the material studied it was identified only in samples collected from springs 1 and 2 in the northern part of the Wyżyna Krakowsko-Częstochowska upland (Fig. 1), and its relative abundance was always below 1%.

Psammothidium grischunum (Wuthrich) Bukht. & Round 1996 (Figs 16–29)

Achnanthes grishuna Wuthrich

Ref. Wuthrich 1975 (Fig. 7); Lange-Bertalot & Krammer

1989 (Fig. 26: 22–36; 62: 2–3, 96: 17, 18, 20); Krammer & Lange-Bertalot 1991 (Fig. 13: 24–40); Bukhtiyarova & Round 1996 (Figs 32–37).

Valves elliptical or linear-elliptical, with broadly rounded apices, 6–16 µm long, 4–5 µm wide. Raphe valve with very narrow axial area. Central area transversely expanded, irregular, occupying from 1/2 to 2/3 of the valve breath. Rapheless valve with sternum narrow towards apices, becoming broader (rhombic) at the centre. Transapical striae radiate slightly throughout the raphe and rapheless valves, 19–24 in 10 µm.

ECOLOGY. Oligosaprobic species known from circumneutral spring and stream waters with a wide range of electrolyte concentrations (Krammer & Lange-Bertalot 1991). According to Van Dam *et al.* (1994), *P. grischunum* belongs to the group of diatoms occurring in waters with very low Cl^- concentration (below 100 mg l^{-1}).

DISTRIBUTION. *P. grischunum* is a cosmopolitan species, and not rare (Krammer & Lange-Bertalot 1991). Most probably overlooked or not reported. It was recorded in material collected from submerged stones, *Vaucheria* sp. filaments and mud from springs 3, 4 and from Kobylanka stream (Fig. 1), but its relative abundance has never exceeded 1%. New to the Polish flora.

Psammothidium lauenburgianum (Hust.) Bukht. & Round 1996 (Figs 30–39)

Achnanthes lauenburgiana Hust.

Ref. Husted 1950 (Fig. 36: 3–9); Lange-Bertalot & Krammer 1989 (Figs 35: 1–10, 28: 3–7); Krammer & Lange-Bertalot 1991 (Fig. 14: 27–34); Bukhtiyarova & Round 1996 (Figs 62–65).

Valves elliptical with broadly rounded apices, 5.5–13.0 µm long, 3.5–5.0 µm wide. Raphe valve with very narrow axial area. Central area transversely expanded, reaching the valve margins. Rapheless valve with narrow, asymmetrical sternum, expanded in the centre to mantle. Transapical striae radiating slightly throughout the raphe and rapheless valve.

ECOLOGY. *Psammothidium lauenburgianum* is known from oligo- and mesotrophic waters with pH above 7 and with low to medium electrolyte concentrations (Krammer & Lange-Bertalot 1991). According to Van Dam *et al*. (1994) it is an oligo-mesotraphentic species, belonging to the group of diatoms typical for circumneutral waters with Cl^- concentration below 500 mg l^{-1}.

DISTRIBUTION. Its general distribution is still not precisely known. Probably widespread and not rare but overlooked when it occurs in small populations. It occurred in material collected from submerged stones from springs 3, 4 and from Kobylanka stream, but its relative abundance never exceeded 1%.

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