

## NEW OR RARE SPECIES OF THE GENUS *NAVICULA* (BACILLARIOPHYCEAE) IN THE DIATOM FLORA OF POLAND

AGATA WOJTAL

**Abstract:** Diatoms (Bacillariophyceae) inhabiting different kinds of substrate including stone surfaces, mud, filamentous algae and submerged vascular plants in Kobylanka stream (Kraków-Częstochowa Upland) were studied by means of light and electron microscopy. Among numerous common species belonging to the genus *Navicula* Bory s.l., taxa new to the Polish diatom flora were observed, including *N. aquaedurae* Lange-Bert., *N. bacilloides* Hust., *N. reichardtiana* Lange-Bert. var. *reichardtiana*, *N. tenelloides* Hust., *N. wiesneri* Lange-Bert., and one rarely reported from Poland, *N. joubaudii* H. Germ.

**Key words:** Bacillariophyceae, *Navicula*, taxonomy, stream ecology, Kraków-Częstochowa Upland, distribution

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### INTRODUCTION

Diatoms represent the most diverse group of algae in lotic environments of the Kraków-Częstochowa Upland. Information about diatom taxa occurring in springs, streams, rivers and ponds in nature reserves and areas affected by human impacts have been published in more than 50 papers. About 600 diatom taxa have been identified from this area during almost 120 years of phycological studies. The diatoms reported as predominant species are usually cosmopolitan and common. This paper contains observations on some species of the genus *Navicula* Bory new to the Polish diatom flora or so far rarely recorded.

None of the reported taxa were frequent in the studied material, but although they are probably of little ecological significance in populated environments they are important for floristic studies. Among them are species rarely reported anywhere (e.g., *Navicula bacilloides* Hust.), and taxa that are opportunists of human interference in nature (e.g., *N. reichardtiana* Lange-Bert. var. *reichardtiana*) and are becoming more and more common (Lange-Bertalot 1999).

### STUDY AREA

The Kraków-Częstochowa Upland extends from the Carpathian foothills in the vicinity of Kraków in the south to the town of Częstochowa in the north (Fig. 1). The diatom flora was studied between 1993–1997 in Kobylanka stream. It flows through a limestone area, is one of the numerous tributary streams of the Rudawa River in the Dolinki Krakowskie Landscape Park. The first section of the stream retains some of its natural character in the Dolina Kobyłańska valley, but beginning from Kobyłany village it becomes increasingly affected by human activity. The most characteristic features of the stream are these: karstic springs, bottom with limestone gravel on more rapid stream sections, or mud in places where water flow is slow, cold water during summer and relatively warm during winter. It is 7300 m long, 40–120 cm wide, 10–30 cm deep, and the velocity ranges from 10 to 18 cm/s<sup>-1</sup>. The water temperature was 6.2°–9.0°C (rarely higher – up to 16.0°C). Conductivity during the study was medium,

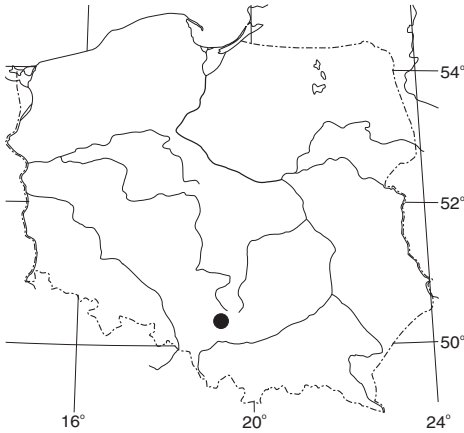


Fig. 1. Location of the study area in Poland.

generally 360–480  $\mu$ S, and pH values ranged from 6.1 to 8.0.

#### MATERIAL AND METHODS

The investigated material included epilithon, epiphyton and epipelon. The epilithic diatoms were scraped from stony surfaces with a scalpel blade. The epiphyton was taken from *Vaucheria* sp. with filaments and from submerged macrophytes with stems or leaves. The epipelon was taken by means of a slime aspirator. The collected material was preserved in 4% formaldehyde and then samples were chosen. The samples were treated with HCl, washed several times with distilled water, and boiled in concentrated  $H_2O_2$  with a small amount of  $KClO_3$  in order to remove organic matter. After several washings with distilled water the material was air-dried on cover glasses and mounted in Naphrax resin. Observations were made with a Nikon microscope equipped with an oil-immersion objective (100 $\times$ ). SEM observations of cleaned, gold-coated material were made with Philips and Hitachi S 4500 microscopes.

#### LIST OF TAXA

*N. aquaeduræ* Lange-Bert. (Figs 2 & 3)

*Navicula cryptocephala* sensu auct. nonul.

Ref. Krammer & Lange-Bertalot 1991 (Figs 69: 1–10); Lange-Bertalot 1993 (Figs 46: 14–19 & 47: 1–2).

Valves lanceolate with moderately rounded apices 14.4–18.2  $\mu$ m long and 4.6–5.8  $\mu$ m wide. Axial area linear, narrow, central area relatively small, elliptic to lanceolate. Raphe filiform, straight. Transapical striae radiate at middle, becoming convergent towards apices, 15–16 per 10  $\mu$ m. Striae composed of distinct lineolae, visible also by LM. External central raphe endings slightly expanded, rounded.

Single specimens were noticed in the spring and the unpolluted part of the stream on mud and stones in January, April and October 1993. More frequently they occurred among filamentous thalli of *Vaucheria* sp. and *Cladophora* sp. just upstream from Kobylany village, where domestic birds eutrophicated the water, in April 1993 and November 1995.

According to Lange-Bertalot (1993) the species is known from alkaline waters with medium electrolyte content, inhabiting oligosaprobic waters up to the mesosaprobic zone. Rumrich *et al.* (2000) determined this species as an inhabitant of oligosaprobic, predominantly carbonate-buffered waters, currently not endangered.

Noted in central, western and southern parts of Europe (Lange-Bertalot 1993). New to the Polish flora.

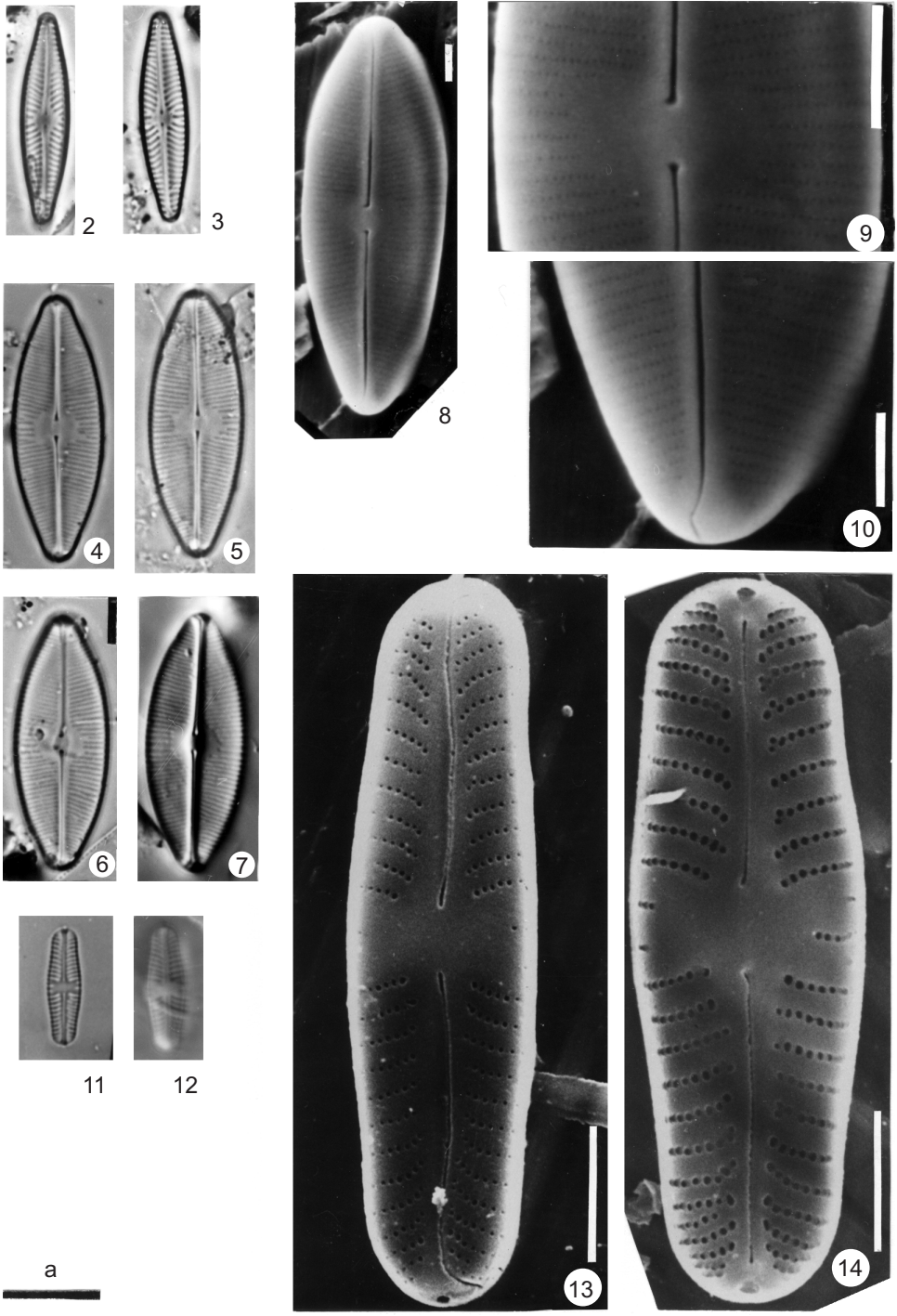
*N. bacilloides* Hust. (Figs 4–10)

Ref. Hustedt 1945 (Fig. 42: 29); Krammer & Lange-Bertalot 1986 (Fig. 67: 5).

Valves linear-elliptic with broadly rounded apices, 24.0–28.5  $\mu$ m long and 8.5–9.7  $\mu$ m wide. Axial area very narrow, central area circular. Raphe straight. Terminal raphe fissures curved to the same side. Shallow depressions along raphe sternum. Transapical striae radiate, 22–24 per 10  $\mu$ m, composed of single rows of areolae up to 50 per 10  $\mu$ m visible only by SEM.

It was rarely observed in material from the surface of mud in September 1993 in the unpolluted section of the stream and among filamentous thalli of *Vaucheria* sp. just upstream from Kobylany village, where the water was eutrophicated by domestic birds, in October 1993.

According to Krammer and Lange-Bertalot



**Figs 2–14.** 2–3 – *Navicula aquaedurae* Lange-Bert.; 4–10 – *N. bacilloides* Hust.; 11–14 – *N. joubaudii* H. Germ. Scale bars: a – 10  $\mu$ m (2–7, 11, 12); 2  $\mu$ m (8–10, 13–14).

(1986) it is a very rare species, known from Scandinavia, Yugoslavia, France and the U.S.A.; recently it was reported from the Andes (Rumrich *et al.* 2000) (Fig. 26). Its ecological preferences are unknown so far, but usually noted from springs. New to the Polish flora.

***N. joubaudii*** H. Germ. (Figs 11–15)

*Navicula seminulum* Grunow var. *radiosa* Hust.

Ref. Germain 1982 (Figs II: 12–24); Krammer & Lange-Bertalot 1986 (Figs 76: 37 & 38).

Valves linear, lanceolate, 13.6–14.0  $\mu\text{m}$  long and 3.7–4.0  $\mu\text{m}$  wide, with weakly capitate, broadly rounded apices. Axial area narrow, linear, central area rectangular. External central raphe endings distinctly expanded. Transapical striae radiate, 17.5–19.0 per 10  $\mu\text{m}$  at middle of valve, in the apical part slightly curved, becoming 22 per 10  $\mu\text{m}$ .

It occurred rarely on mud of the spring in April 1994 and among filamentous thalli of *Cladophora* sp. in the polluted part of the stream in July and August 1995 and in May 1997.

In Poland known until now only from fossil material from Imbramowice (Kaczmarek 1976, 1977). In Europe known from many localities such as Andorra (Carter 1970), Switzerland (Wuthrich 1971), Germany (Schimanski 1973), France (Germain 1982) and Austria (Maier & Rott 1990). Recently it was reported from the Andes (Rumrich *et al.* 2000) (Fig. 26).

Its ecological preferences are unknown so far, but according to Germain (1982) and Krammer and Lange-Bertalot (1986) it is reported from aerial habitats; not currently endangered (Rumrich *et al.* 2000).

***N. reichardtiana*** Lange-Bert. var. *reichardtiana*  
(Figs 16–17)

*Navicula* species 2 in Krammer & Lange-Bertalot 1986  
Ref. Krammer & Lange-Bertalot 1986 (Fig. 33: 23–25);  
Krammer & Lange-Bertalot 1991 (Fig. 68: 10–15).

Valves lanceolate with protracted, rostrate apices, 18.5–22.6  $\mu\text{m}$  long and 5.5–6.4  $\mu\text{m}$  wide. Axial area linear, narrow, central area relatively small, irregular. Transapical striae radiate, slightly

curved in middle of valve, becoming slightly convergent towards apices, 14.5–16.0 per 10  $\mu\text{m}$ .

It occurred rarely on mud and stones in the unpolluted part of the stream in April 1993, and among filamentous thalli of *Vaucheria* sp. just upstream from Kobylany village in January and April 1993.

It is probably a cosmopolitan species, often reported from waters with higher electrolyte content, especially carbonate-rich waters, and it is pollution-resistant (Krammer & Lange-Bertalot 1986). According to Hofmann (1994) it occurs in the epilithon mainly under  $\alpha$ -mezosaprobic conditions. According to Rumrich *et al.* (2000) the highest vitality of the species is reported from mesotrophic to eutrophic waters, and it is certainly not endangered or is even in progression and stimulated by human activity. New to the Polish flora.

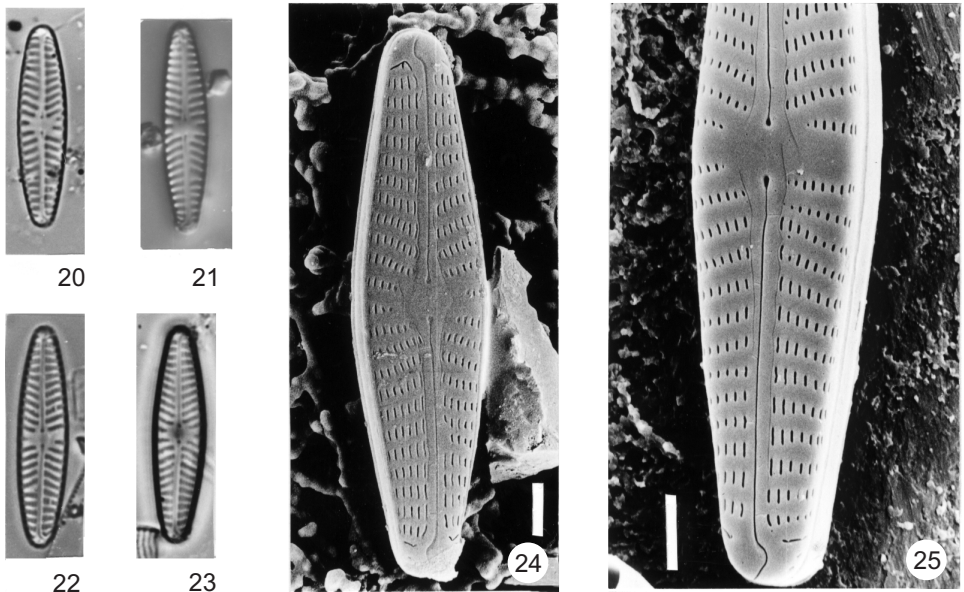
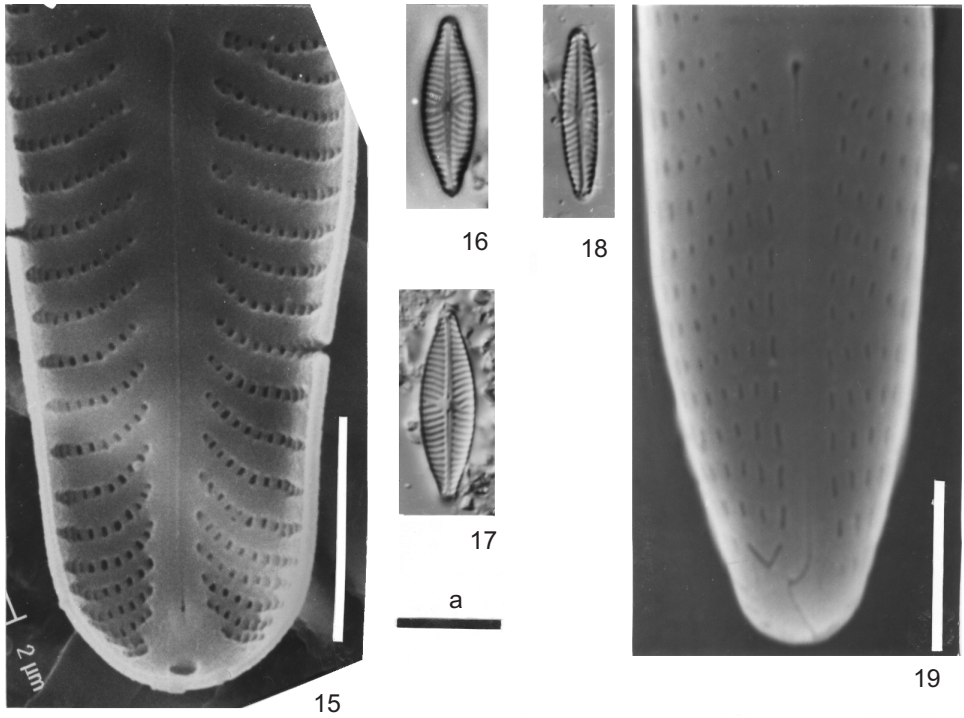
***N. tenelloides*** Hust. (Figs 18–19)

Ref. Lund 1946 (Fig. J-DD); Krammer & Lange-Bertalot 1986 (Fig. 38: 16–20).

Valves linear-lanceolate, 14.6–21.0  $\mu\text{m}$  long and 3.0–3.8  $\mu\text{m}$  wide with narrowly rounded or weakly rostrate apices. Raphe straight with terminal fissures curved to the same side. Axial area very narrow, central area circular. Transapical striae radiate in the middle part, becoming convergent towards apices, 15–16 per 10  $\mu\text{m}$ . Voigt's fault distinct.

It was rarely observed on the mud surface in July 1997 in the unpolluted section of the stream and among filamentous thalli of *Vaucheria* sp. just upstream from Kobylany village, where the water was eutrophicated by domestic birds, in July 1997.

According to Lund (1946) it is known from Java, Iceland, Great Britain and Germany (Fig. 26), common in soils. Widespread, recorded from water with various ion content, especially often from springs and small streams, from mosses or other aerial habitats (Krammer and Lange-Bertalot 1986). Patrick and Palavage (1994) determined this species as characteristic of natural water conditions (Patrick and Palavage 1994). New to the Polish flora.



**Figs 15–25.** 15 – *Navicula joubaudii* H. Germ. 16–17 – *N. reichardtiana* Lange-Bert. var. *reichardtiana*; 18–19 – *N. tenelloides* Hust.; 20–25 – *N. wiesneri* Lange-Bert. Scale bars: a – 10 μm (16–18, 20–23); 2 μm (15, 19, 24, 25).



*N. wiesneri* Lange-Bert.

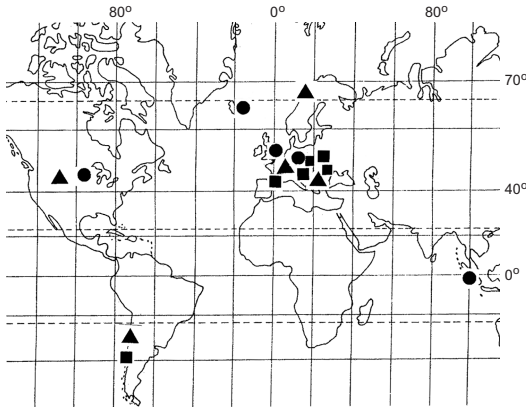
(Figs 20–25)

DISCUSSION

*Navicula heufleri* Grunow fo. *minuta* Grunow

Ref. Krammer & Lange-Bertalot 1991 (Figs. 59: 19–22); Lange-Bertalot 1993 (Figs 41: 23–37; & 42: 3–6).

Valves linear-lanceolate with broadly rounded apices, 21.0–26.5  $\mu\text{m}$  long and 4.9–5.0  $\mu\text{m}$  wide. Raphe straight. Axial area linear, narrow, central area relatively small, irregular. Transapical striae radiate in middle part, becoming parallel towards apices, 13.5–14.5 per 10  $\mu\text{m}$ .



**Fig. 26.** World distribution of some rare *Navicula* species. ▲ – *N. bacilloides* Hust., ■ – *N. joubaudii* H. Germ., ● – *N. tenelloides* Hust.

It occurred rarely in the epilithon in the unpolluted part of the stream in March and October 1993, but on mud in both unpolluted and polluted parts and among filamentous thalli of *Vaucheria* sp. just upstream from Kobylany village, where the water was eutrophicated by domestic birds, in February and November 1993.

Probably it is a cosmopolitan and halophilic species widely distributed in Europe, reported from waters with higher electrolyte content, in a wide range from oligo- to eutrophic waters without a discernible preference (Krammer & Lange-Bertalot 1986). According to Rumrich *et al.* (2000) it is not currently endangered. New to Polish flora.

The diatom flora of Kobylanka stream is dominated by widely distributed tolerant, common species, typical for streams on calcareous terrain, but interesting, rarely recorded diatom species representing *Navicula* were also found here. *Navicula* is one of the genera containing the greatest number of species in the studied diatom material. This genus includes a heterogeneous assemblage of taxa. Most of the taxa considered in this paper belong to *Navicula* Bory s. str., Section *Lineolatae* Cleve (*Navicula aquaedurae*, *N. tenelloides*, *N. reichardtiana* var. *reichardtiana* and *N. wiesneri*). The redefined genera *Navicula* s. str. includes species only from Section *Lineolatae* (Round *et al.* 1990), which according to Witkowski *et al.* (1998) possesses the following characteristics: boat-shaped valves, lineolate striae, central external raphe endings simple, apical endings hooked to one side, internal raphe slit running obliquely in raised ribs, without expanded central pores, and with two lateral plastids. Central external raphe endings are more or less expanded in some cases. The other taxa have been transferred to recently created genera such as *Geissleria* Lange-Bertalot & Metzeltin 1996, *Hippodonta* Lange-Bertalot, Metzeltin & Witkowski 1996 and *Eolimna* Lange-Bertalot in Schiller & Lange-Bertalot 1997, or resurrected genera such as *Placoneis* Mereshkovsky 1903 and *Sellaphora* Mereshkovsky 1902. So far *Navicula bacilloides* and *N. joubaudii* recorded in Kobylanka stream have been included in *Navicula* s.l. Because their characters are not typical for *Navicula* s. str., it is expected that the species will be separated from *Navicula* in the future.

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