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First record of *Prestauroneis tumida* Levkov and accompanying species in Poland

by

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Abstract

The paper presents morphological and ecological characteristics of *Prestauroneis tumida* Levkov recorded for the first time in Poland. The diatom *Prestauroneis tumida* Levkov was found in the microbenthos of the Czarna Staszowska River (left tributary of the Vistula River, south-eastern Poland). This diatom species was present in the upper section of the river (sampling sites: 1 – Drogowle, 2 – Raków) where saprobic state varied from oligosaprobic to beta-mesosaprobic. Dimensions of the valve were as follows: length 30-44 µm, width 8-11 µm and 13-16 striae in 10 µm. Our research updates the morphological diversity data such as measurements of valves in terms of width and the number of striae. The accompanying species of *Prestauroneis tumida* belonged to the group of good water quality indicators, from oligo- to mesosaprobic ones. Some of the identified species were indicators of alkaline, calcium-rich waters.

Key words: *Prestauroneis tumida*, new record, indicator species, SE Poland

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Introduction

A diatom species new to Poland was recorded during the study of benthic diatoms from the Czarna Staszowska River (south-eastern Poland) – *Prestauroneis tumida* Levkov (similar forms were identified as *Parlibellus protractus* (Grunow) Witkowski, Lange-Bertalot & Metzeltin sensu Levkov et al. 2007: Figs 64: 10-12). So far, the species has been recorded only in lakes Ohrid and Prespa in Macedonia, which are calcium-rich, oligotrophic and mesotrophic lakes (Levkov & Williams 2011), with slightly alkaline pH (Levkov et al. 2007).

Although forms similar to *Prestauroneis tumida* were identified in Poland, this particular species has not yet been observed. *P. tumida* could have been mistaken with *Navicula protracta* (Grunow) Cleve (syn. *Parlibellus protracta*) (Rakowska 1992; 2001a,b; Żelazna-Wieczorek, Mamińska 2006) and *Parlibellus protracta* (Grunow) Witkowski & Lange-Bertalot (Żelazna-Wieczorek 2011; Noga et al. 2013; 2014; Żelazna-Wieczorek et al. 2015). *Parlibellus protracta* is often accompanied by *Parlibellus protractoides* (Hustedt) Witkowski & Lange-Bertalot (Żelazna-Wieczorek 2011; Pajączek et al. 2012; Noga et al. 2013; 2014). *Prestauroneis integra* is the only taxon from the genus *Prestauroneis* occurring in running waters in Poland (Rakowska 2001; Żelazna-Wieczorek 2011; Noga 2012).

The genus *Prestauroneis* was described by Bruder & Medlin (2008). *Prestauroneis integra* (W. Smith) Bruder (syn. *Navicula integra* (W. Smith) Ralfs) is the type species of this genus. The valves of *Prestauroneis* are lanceolate or lanceolate-elliptical with subrostrate apices and pseudosepta located at the apices. The striae are radial at the center of the valve and become almost parallel at the apices. They are uniseriate and consist of small round or elliptical pores. In the middle of the valve, the striae are more distant from each other and the interstriae separating them are thickened. Proximal raphe endings are expanded and distal endings curve to the same side of the valve.

The genus *Parlibellus* was described by Cox (1988). *Navicula delognei* Van Heurck is the type species of this genus. The valves are more or less rhomboidal or lanceolate, often with a strongly convex face. The raphe is straight and its distal endings curve to one side. The central nodule contains a cuniculus. The pores of the central striae are slightly larger than elsewhere over the valve. Septa are lacking.

The aim of this study was taxonomical, morphological and ecological analysis of *Prestauroneis tumida*. The accompanying species were identified and their autecological characteristics were presented in this paper.

Study area

The Czarna Staszowska River is a left tributary of the Vistula River and it flows in south-eastern Poland through the physiographical region referred to as Połaniec Basin, which is part of the Nida Basin (Fig. 1). Its length is 61 km, catchment area 1358.6 km^2, mean discharge 5 m^3 s^{-1} and mean slope 0.2% (Zieliński 2013). Its sources are in the Świętokrzyskie Mountains at 302-408 m a.s.l. Its headwater streamlets join together in the vicinity of the Smyków Village at 250 m a.s.l., and then the Czarna Staszowska River flows through the villages of Drogowle, Raków, Kurozwęki, Staszów, Rudniki, and finally enters the Vistula River (at 154 m a.s.l.) at the Połaniec Town.

The river bottom is gravelly and stony, occasionally sandy, and muddy at the river mouth. The substrate of the headwater section is composed of the Paleozoic rocks of the Świętokrzyskie Mountains (the highest peak at 612 m a.s.l.) and the Mesozoic (mostly carbonate) rocks. Karst phenomena are common in the valley of the river, which resulted in the development of numerous lakes and peat bogs. The geologic structure of the river valley is characterized by the occurrence of carbonate and sulfate rocks. This specific structure of the area has affected the development of diatom communities in the river, which are typical of calcium-rich waters.

The natural course of the river changes after 34 km due to the presence of the Chańcza Dam Reservoir (400 ha). Between its sources in the Świętokrzyskie Mountains and the Chańcza Reservoir, the water in the river complies with the standards of Water Quality Classes I-II as regards physicochemical parameters (unpublished data from 2014 made available by Voivodeship Inspectorate of Environmental Protection in Kielce; water quality classes according to Polish standards compatible with OJ pos. 1482 from 2014; Table 1).

Materials and methods

Samples were collected in August 2013 and August 2014 in the upper section of the Czarna Staszowska River (sandy and muddy substrates). Twelve samples were collected from the Czarna Staszowska River, four of which were included in morphological analysis of *Prestauroneis tumida*. The diatom material was collected from the river bottom into 100 ml containers using a glass pipette, and then preserved with 4% formalin (PN-EN ISO 5667-6: 2003). The collected epipsammon was treated with a mixture of sulfuric and chromic acids, which destroys the protoplasm of cells.

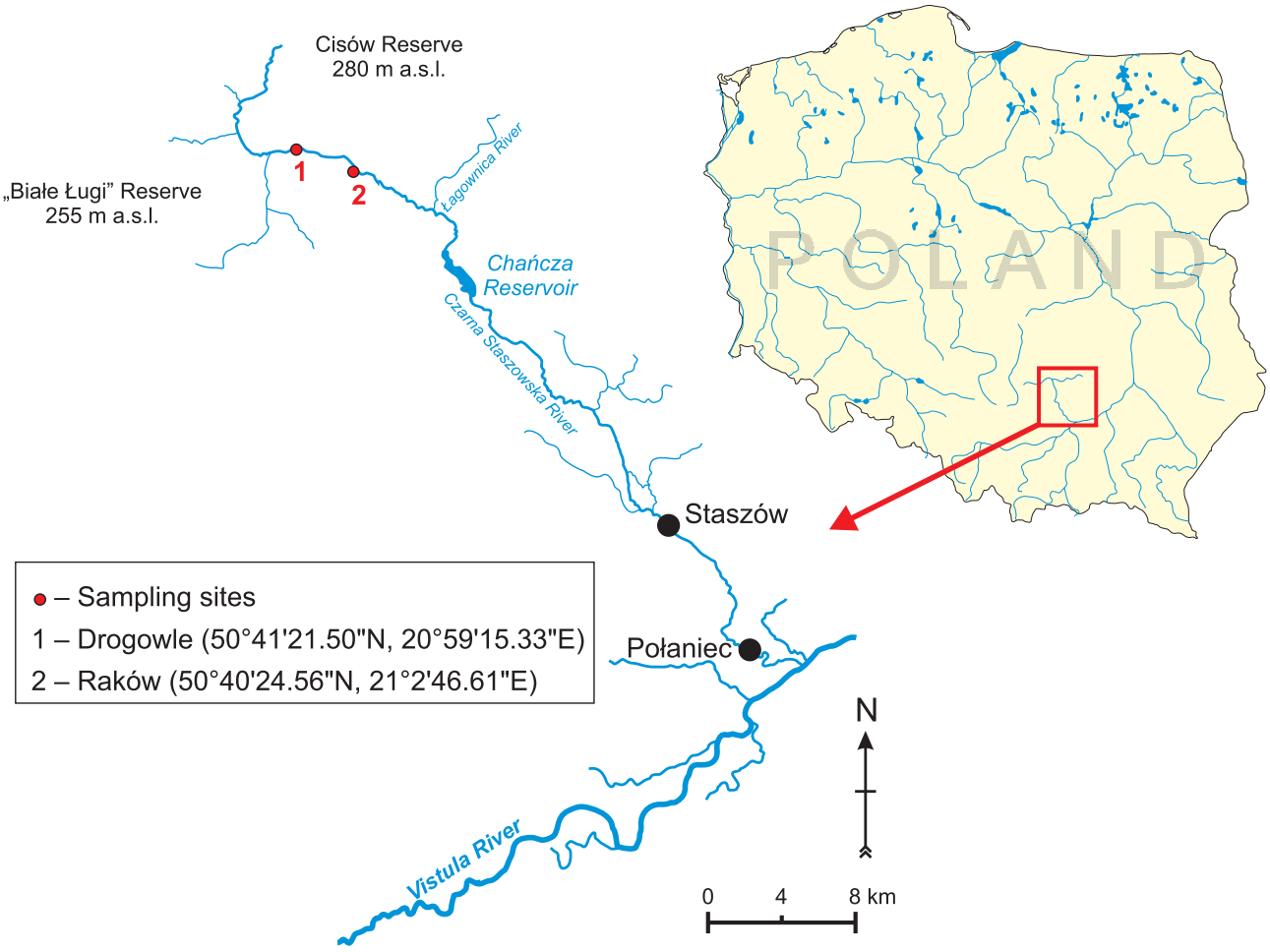

Figure 1

Map of sampling sites on the Czarna Staszowska River

Permanent slides were prepared from empty diatom frustules fixed in Naphrax®. A total of 400 valves were counted on the slides, based on which the percentage contribution of each taxon was calculated (Cholnoky 1968). Species that occurred with 5% or higher abundance were indicated as dominants, species with 2-5% abundance – as subdominants and those with 1-2% abundance – as influents.

The morphological analysis of the taxon *Prestauroneis tumida* Levkov involved the length and width of frustules, the number of striae in 10 µm, shapes of central and axial areas, the shape of raphe, the presence of stigmata and arrangement and structure of striae. These parameters were analyzed in 32 specimens. LM (light microscope) photographic documentation using a Nikon Eclipse 50i microscope and a photographic camera Canon EOS, as well as SEM (scanning electron microscope) analysis and photographic documentation using a Phenom Pro X (with 8 nm gold layer, at 10 kv) microscope were conducted in the Laboratory of Microscopy Imaging

Table 1

Values of physical and chemical water parameters in the spring section of the Czarna Staszowska River from 2014 and the water quality class according to Polish standards compatible with OJ pos. 1482 from 2014

Water parameters	Spring section (sites 1, 2)	Water Quality Class
Temperature (°C)	10.5	I
pH	7.6-7.9	I
Conductivity 20°C (µS cm^{-1})	405	I
Dissolved oxygen (DO) (mg O_2 dm^{-3})	10.0	I
BOD_5 (mg O_2 dm^{-3})	1.9	I
N-NH_4 (mg dm^{-3})	0.23	I
N-NO_3 (mg dm^{-3})	2.0	I
Total N (mg dm^{-3})	2.783	I
P-PO_4 (mg dm^{-3})	0.1	I
Total P (mg P dm^{-3})	0.13	I
Calcium (mg Ca dm^{-3})	64	I
Magnesium (mg Mg dm^{-3})	10	I
Total hardness (mg $CaCO_3$ dm^{-3})	202	I

& Specialist Biological Techniques at the Faculty of Biology & Environmental Protection. Diatom species were identified based the taxonomic keys published by Levkov et al. (2007) and Levkov & Williams (2011).

Taxonomic identification of species accompanying *Prestauroneis tumida* was carried out using references published by Hofmann et al. (2011), Krammer (2002, 2003), Lange-Bertalot (2001), Werum, Lange-Bertalot (2004).

The microbenthos samples and permanent slides are deposited at the Laboratory of Algology and Mycology of the University of Łódź, Poland (numbers of samples: 00423; 00424; 00425; 00426).

Results and Discussion

Prestauroneis tumida was present in the upper section of the river (sampling sites: 1 – Drogowle, 2 – Raków) where water quality varied from oligosaprobic to beta-mesosaprobic.

Live individuals of *Prestauroneis tumida* were noted in the studied samples. *Prestauroneis tumida* occurred on permanent slides with a relative abundance ranging from 1% do 2%. The species has been identified as an influent.

Taxonomy

Division: *Bacillariophyta*
Family: *Stauroneidaceae* Greville (1833)
Genus: *Prestauroneis* K. Bruder in Bruder & Medlin (2008)
Species: *Prestauroneis tumida* Levkov (2011)
Synonym: *Parlibellus protractus* (Grunow) Witkowski, Lange-Bertalot & Metzeltin (2000)

LM morphological observations – Cells solitary, valves linear-lanceolate, with shortly protracted and broadly rounded ends. Length 30-44 µm, 8-11 µm, 13-16 striae in 10 µm in the middle (based on 32 valves) (Fig. 2).

SEM observations – Distinct structures of the valve and the number of areolae amounting to 45 in 10 µm were observed. Raphe branches straight with slightly widened and unilaterally deflected central pores. Distal raphe fissures prolonged, extending over the valve mantle and unilaterally curved in the opposite direction to the proximal ends (Fig. 2).

Ecology – So far *Prestauroneis tumida* Levkov was recorded in oligotrophic and mesotrophic lakes: Ohrid and Prespa (Levkov, Williams 2011). Based on our research, the distribution area of this species can be extended by lotic ecosystems. The taxon is an indicator of oligotrophic and oligosaprobic to beta-mesosaprobic flowing waters with a calcium content of about 60 mg Ca dm^{-3}. In the currently studied river, *Prestauroneis tumida* was noted with 1.5% abundance at sampling site 1 (Drogowle) and with 1.75% abundance at sampling site 2 (Raków) (Fig. 1). The water quality of this river section was described as between oligo- and beta-mesosaprobic status; pH was 7.7. This is the first record of this species in Poland.

The upper course of the Czarna Staszowska River (where *Prestauroneis tumida* was recorded) is located in areas covered by Mesozoic, mostly carbonate rocks (Zieliński 2013). It seems that the described species may be considered an indicator of calcium-rich waters with a good ecological status. It occurs both in lentic (springs, lakes) and rarely in lotic (streams, rivers) waters.

Our research confirmed that *Prestauroneis tumida* is an indicator of good water quality (oligotrophic and from oligosaprobic to beta-mesosaprobic) and waters with high concentration of calcium (Levkov, Williams 2011).

So far, *Prestauroneis tumida* was noted only in lentic, calcium-rich water of good quality (Levkov et al. 2007; Levkov, Williams 2011). Our research provides new data on the autecology of this species by reporting its occurrence in lotic waters.

Morphological forms similar to *Prestauroneis tumida* have been identified and described in the literature (Table 2). *Navicula crucicula* var. *obtusata* (Hustedt 1930) is a form similar to *P. tumida*. However, the former species occurs in saline waters, rarely in fresh waters. Simonsen (1987) described a similar species, named *Navicula protracta* f. *elliptica*, and Cleve-Euler (1953) noted *Navicula crucicula* var. *obtusata* or *Navicula crucicula* var. *minor*. The morphology of the *P. tumida* valve – its width and length and the number of striae in 10 µm – is similar to that of *Navicula protracta* described in Grand-Lieu Lake and the Main and Anger Rivers (France) by Germain (1981). Krammer & Lange-Bertalot (1986) described two similar species: *Navicula crucicula* var. *crucicula* (W. Smith) Donkin occurring in saline waters and *Navicula protracta* (Grunov) Cleve, which occurs mainly in saline waters, but also in fresh waters with high concentrations of minerals.

A species that is most morphologically similar to *Prestauroneis tumida* is *Parlibellus protracta*. The correct identification of these two species may be the most troublesome. A feature differentiating these species is primarily the shape of valves, which are more globosely terminated in *Parlibellus protracta*,

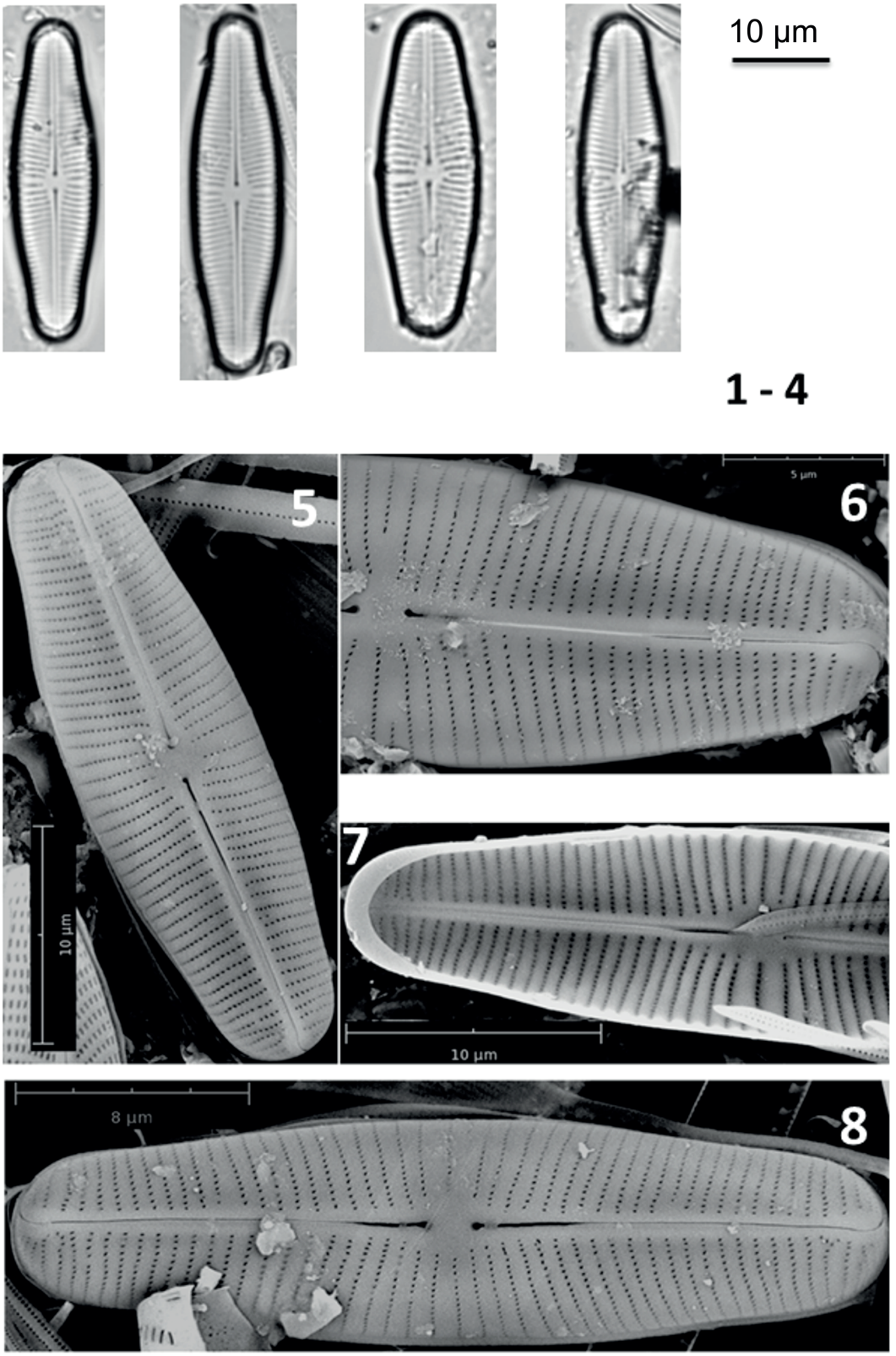

Figure 2

LM photomicrographs of *Prestauroneis tumida* Levkov (1-4); SEM images of external view (5-7); SEM image of internal view (8)

Table 2

Comparison of morphological features of species similar to *Prestauroneis tumida*, in chronological order

	Length	Width	Number of striae in 10 µm	Number of areolae in 10 µm	Plate/Figure
Hustedt (1930) *Navicula crucicula* var. *obtusata* Grunow	25-50	10-16	-	-	-
Cleve-Euler (1953) *Navicula crucicula* β *obtusata* Grunow *Navicula crucicula* var. *minor* Agardh Cleve	 25-50 30-50	 10-16 10-13	 19 -	 - -	Fig. 884 c d
Germain (1981) *Navicula protracta* (Grunow) Cleve	30-35	8-10	14-17	-	Plate 83, Fig. 6
Krammer & Lange Bertalot (1986) *Navicula crucicula* var. *crucicula* (W. Smith) Donkin *Navicula protracta* (Grunow) Cleve	 35-100 17-60	 8-23 5-10	 14-18 14-20	 - -	 Fig. 54: 1 Fig. 55: 5, 6
Simonsen (1987) *Navicula protracta* f. *elliptica* Hustedt	-	-	-	-	Plate 659, Fig. 1, 2
Levkov et al. (2007) *Parlibellus protractus* (Grunow) Witkowski, Lange-Bertalot & Metzeltin	32-44	9-11	14-16	-	Plate 64, Fig. 12
Levkov & Williams (2011) *Prestauroneis tumida* Levkov	22-44	9-11	14-17	45	Fig. 69-82

while rounded in *Prestauroneis tumida* (Fig. 3). Another important element characteristic of this species is the presence of pseudosepta in *Prestauroneis tumida* (Fig. 3A). Pseudosepta are absent in *Parlibellus protracta*. As regards the autecology, *Parlibellus protracta* has so far been recorded in fresh and brackish waters (Żelazna-Wieczorek 2011; Bąk et al. 2012; Żelazna-Wieczorek et al. 2015). According to Levkov & Williams (2011) and our study, *Prestauroneis tumida* is a species typical of waters with a good ecological status (oligotrophic and from oligosaprobic to beta-mesosaprobic) and alkaline waters.

Parlibellus protractus (Grunow) Witkowski, Lange-Bertalot & Metzeltin was recorded for the first time in Lake Prespa by Levkov et al. in 2007. However, the above authors presented only three photographs without any descriptions of the species. Later on, Levkov & Williams (2011) defined *Parlibellus protractus* as a new genus called *Prestauroneis* and described the species as *Prestauroneis tumida* Levkov.

Accompanying species of *Prestauroneis tumida* belonged to the group of good water quality indicators, from oligo- to mesosaprobic. Ecological characterization was carried out on the basis of

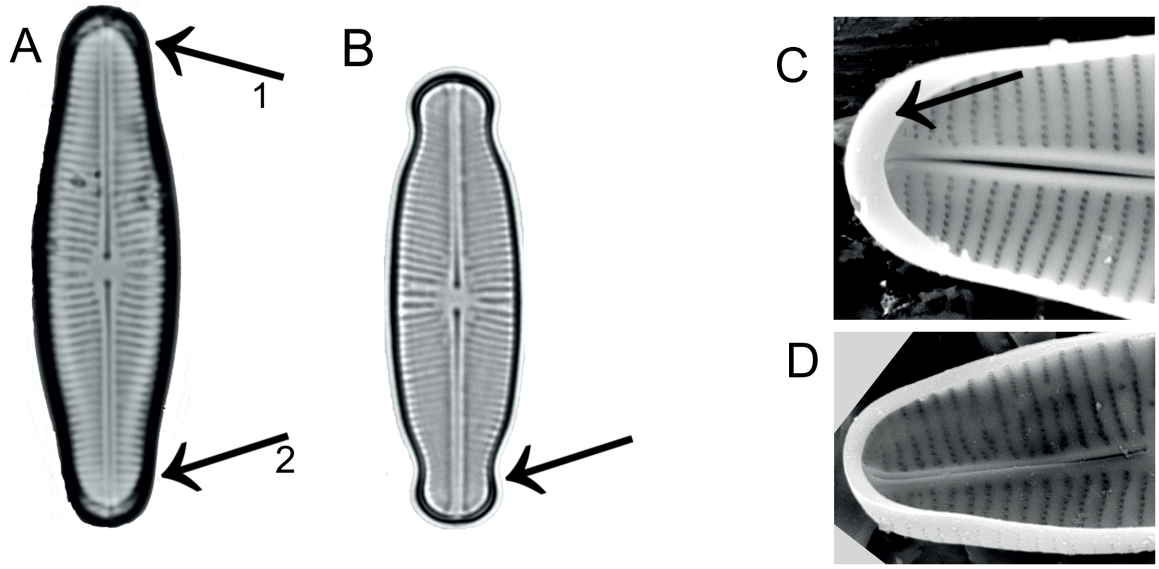

Figure 3

Comparison of valve morphology of *Prestauroneis tumida* and *Parlibellus protracta*. A. LM photomicrograph of *Prestauroneis tumida*; Arrow 1: rounded apices; Arrow 2: pseudosepta on apices. B. LM photomicrograph of *Parlibellus protracta*; Arrow: capitate apices. C. SEM image of *Prestauroneis tumida*, internal view; Arrow: presence of pseudosepta. D. SEM image of *Parlibellus protracta*, internal view: pseudosepta absent

publications by Bąk et al. (2012), Hofmann et al. (2011) and Lange-Bertalot (2001). Some of the identified species were indicators of alkaline, calcium-rich waters. The main dominants were: *Navicula concentrica* Carter (indicator of calcium-rich, oligotrophic waters), *N. novaesiberica* Lange-Bertalot, *N. rostellata* Kützing (alkaline water), *Nitzschia archibaldii* Lange-Bertalot (oligo- to mesosaprobic) and *Staurosirella pinnata* (Ehrenberg) D.M. Williams & Round.

Subdominants were represented by such species as: *Amphora copulata* (Kützing) Schoeman & Archibald, *Fragilaria brevistriata* Grunow in Van Heurck, *Geissleria declivis* (Hustedt) Lange-Bertalot & Metzeltin (alkaline water, oligosaprobic), *G. decussis* (Hustedt) Lange-Bertalot & Metzeltin (calcium-rich water), *Hippodonta capitata* (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski, *Navicula cryptocephala* Kützing, *Navicula gregaria* Donkin, *Nitzschia dissipata* (Kützing) Grunow, *Sellaphora pupula* (Kützing) Mereschkowsky, *Staurosira construens* Ehrenberg, *Rossithidium pussillum* (Grunow) Round & Bukhtiyarova (calcium-rich waters, oligotrophic, oligo- to beta-mesosaprobic).

The following species were recorded with a lower abundance: *Aneumastus stroesei* (Østrup) Mann & Stickle (chalk-rich waters, oligo- to mesotrophic), *Gomphonema extentum* Reichardt & Lange-Bertalot, *G. sphenovertex* Lange-Bertalot & Reichardt, *G. montanum* Schumann, *Navicula antonii* Lange-Bertalot, *N. lanceolata* (Agardh) Ehrenberg, *N. oppugnata* Hustedt, *N. reinchardtii* (Grunow) Grunow, *N. striolata* (Grunow) Lange-Bertalot, *Nitzschia fibulafissa* Lange-Bertalot, *Parlibellus protractoides* (Hustedt) Witkowski, Lange-Bertalot & Metzeltin, *Psammothidium subatomoides* (Hustedt) Bukhtiyarova & Round, *Planothidium peragalli* (Brun & Hèribaud) Round & Bukhtiyarova and *Sellaphora mutatoides* Lange-Bertalot & Metzeltin.

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