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The centric diatom Puncticulata balatonis (Pantocsek) Wojtal et Budzyńska, comb. nov., in the plankton of eutrophic-hypertrophic Rusałka Lake (Western Poland)

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With 24 figures and 3 tables

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Abstract: *Cyclotella balatonis* Pantocsek is probably a common and widely distributed component of the phytoplankton in mesotrophic to eutrophic European lakes and rivers. However, the distribution and ecology of the species are still unclear, since the species remained hidden in the broad *C. radiosa* (Grunow) Lemmermann - concept throughout most of the 20th century. *Cyclotella balatonis* was found to form quite a large population in the plankton of a small and shallow, urban, eutrophic to hypereutrophic lake (Rusałka Lake, Western Poland). The species occurred in the lake throughout the study period, from February till December 2007, with its highest number in the winter - spring period. The morphology and fine valve structure of the species are described in the paper, documented with light microscope (LM) and scanning electron microscope (SEM) micrographs, and discussed along with the species ecology. Additionally, *Cyclotella balatonis* is formally transferred into the genus *Puncticulata* [*P. balatonis* (Pant.) Wojtal et Budzyńska, comb nov.], and compared with the morphologically similar taxa – *P. radiosa* (Lemmermann) Håkansson, *P. comta* (Ehrenberg) Håkansson and *P. praetermissa* (Lund) Håkansson.

Key words: Bacillariophyta, *Puncticulata,* ecology, morphology, Poland .

Introduction

Centric diatoms are an important component of freshwater ecosystems throughout the world. They often reach high numbers in eutrophic lakes and rivers (Genkal & Kiss 1993). As their occurrence is usually related to the trophic status of inhabited water bodies, they are particularly useful bio-indicators in monitoring works and paleolimnological studies (Wunsam et al. 1995, Siver 1999, Wojtal & Kwandrans 2006, Rimet et al. 2009, Houk et al. 2010).

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Despite some of the members of *Cyclotella* genus are known for up to 170 years, the ecology of many species still remains uncertain. Moreover, there are also many uncertainties within the genus concerning taxonomy and nomenclature (Hausmann & Lotter 2001, Håkansson 2002, Houk et al. 2010). Recently, some species of the not-uniform genus were moved to several newly-established genera (short review in Houk et al. 2010). In 2002 the genus *Puncticulata* was established, comprising species characterised by concentrically undulated central part of valve face and numerous, scattered or radially arranged, areolae and fultoportulae (or only areolae, or only fultoportulae), with *P. comta* as the type (Håkansson 2002). The genus has been generally accepted (e.g., Tanaka 2007, Hayashi 2007, Kobayasi et al. 2006, Cremer & Koolmees 2010), though some uncertainties are still discussed (Houk et al. 2010).

One of the species sharing the above-mentioned characteristics of the genus *Puncticulata* (though not transferred to the genus till now), is *Cyclotella balatonis* and its variety *C. balatonis* var. *binotata*, described by Pantocsek (1901, p. 104, figs 319, 331, 332) from lake Balaton near Siófok in Hungary. Originally the species was illustrated by three drawings of valves, with scattered (Pantocsek 1901, Plate XV, figs 319, 332) and radially arranged (Pantocsek 1901, Plate XV, fig. 331) puncta in the middle part of valve face. After Pantocsek's description, *C. balatonis* remained practically forgotten, and was reported only a few times (e.g., Handmann 1913; Hindák & Hindáková 2008). It was generally considered a synonym of *Cyclotella radiosa* (e.g., Krammer & Lange-Bertalot 1991, fig. 62: 11, 12), following the broad species concept that was in use at that time. Thus, specimens of a broad morphological range, present in a variety of water bodies were identified as *C. radiosa*. *Cyclotella balatonis* might have also been misidentified as other species of the complex, such as *P. praetermissa* (syn. *Cyclotella praetermissa*) or *Puncticulata comta* (syn. *Cyclotella comta*). Recently, as a result of precise study by Houk et al. (2010) using SEM, *Cyclotella balatonis* has been resurrected and the morphological ranges of similar species were discussed. However, due to the proceeding long period of taxonomical confusion, the species is almost absent in the literature, and needs much attention, particularly in terms of distribution and autecology.

In this paper a population of *C. balatonis* in a small and shallow, urban, eutrophic to hypereutrophic lake (Rusałka Lake, Western Poland) is presented, with its quantitative characteristics along an annual cycle. Morphological features of the diatom are described in detail and documented with LM photographs of live specimens and cleaned frustules, as well as with the SEM micrographs. *Cyclotella balatonis* was also compared with morphologically similar species, namely *Puncticulata comta*, *P. praetermissa* and *P. radiosa*. Due to the great morphological similarity of *Cyclotella balatonis* to these and other *Puncticulata*-species, the transfer of *Cyclotella balatonis* to the genus *Puncticulata* has been proposed.

Study site

Rusałka Lake is situated in the city of Poznań, Western Poland (N52°25'E16°52'). It was formed in 1943 by damming the Bogdanka River and subsequent flooding of its valley. The lake covers the area

Table 1. Estimation of the trophic state of Rusałka Lake according to Carlson index (1977) and OECD (1982) criteria (acc. to Gołdyn et al. 2010)

	Carlson index		
TSI	Values in Rusałka lake	Boundary values for eutrophy	Trophic state
TSI (TP)	74.37	>70	Hypertrophy
TSI (ChL)	71.71	53–70	Hypertrophy
TSI (SD)	67.37	53–70	Eutrophy
	OECD		
Characteristic	Values in Rusałka lake	Boundary values for eutrophy	Trophic state
Mean TP (μg/l)	96	>100	Eutrophy
Mean chlorophyll-a (μg/l)	34.7	>25	Hypertrophy
Max. chlorophyll-a (μg/l)	80.2	>75	Hypertrophy
Mean Secchi depth (m)	0.8	<1.5	Hypertrophy
Min. Secchi depth (m)	0.6	<0.7	Hypertrophy

of 36.7 ha. Although its maximum depth is 9.0 meters, the average does not exceed 2 meters. As a result of the morphometry, the lake is mainly polymictic, with thermal stratification developing only in a small area around its deepest point in summer (Gołdyn et al. 2010).

The lake is strongly eutrophic or hypereutrophic, according to different criteria (Table 1). Cyanobacterial blooms occur in summer and autumn (Gołdyn et al. 2010). Due to its location and surrounding attractive areas (mainly forests), the lake is intensely used for recreation.

Materials and methods

Water samples for the phytoplankton analysis were taken at every meter depth at the deepest part of the lake in 2007, once a month from February till October and once in December. Quantitative samples were preserved with Lugol's solution and analysed with the use of inverted microscope PZO after sedimentation in cylindrical chambers, according to the Utermöhl method (Wetzel & Likens 1991).

All diatoms from the family *Stephanodiscaceae* were counted as one taxon. The relative frequency of *Puncticulata balatonis* and other species belonging to this family was then estimated by counting 100 frustules in hydrogene peroxide-treated samples using an Olympus BX-60 microscope. Measurements and the micrographs of live diatoms were done with the use of the same LM and AnalySIS programme.

A qualitative analysis of the diatom material was performed after removing carbonates (addition of 10% HCl to the samples, followed by boiling taking place after 24 h for 15 minutes) and organic matter (boiling in 30% H_2O_2 with small amounts of $KClO_3$). After air-drying the material was mounted in Naphrax®. Observations of the diatoms were performed with a Nikon Eclipse 80i light microscope equipped with Differential Interference Contrast. The micrographs were taken with a Nikon DS-Fi 1 camera. SEM analyses were performed on the material coated with gold using a Hitachi S-4700 scanning electron microscope. SEM micrographs were taken in the Laboratory of Electron and Confocal Microscopy at the Faculty of Biology, Adam Mickiewicz University in Poznań, and in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University in Kraków. Density of valve face structures (e.g., costae) in 10 μm in a line tangential to the radius was calculated based on the formula in Genkal (1977). Additionally, data on the morphology of *Cyclotella balatonis* were obtained from the type material (Balaton Lake, Siofok, samples 156, 157) hosted in the Natural History Museum in Budapest (Hungary).

Table 2. Physio-chemical parameters of water of Rusałka Lake in 2007.

	Temperature (°C)	**pH**	**Coductivity (µS/cm)**	**Transparency– Secchi depth (m)**
20 II	3.1–4.1	7.2–7.8	836–841	1.5
26 III	4.9–7.1	7.9–8.1	866–868	1.8
20 IV	13.4–10.3	7.9–8.0	no data	1.0
18 V	11.0–15.6	7.7–8.2	820–840	0.8
19 VI	11.2–23.2	7.3–8.4	760–878	0.9
18 VII	12.6–24.0	7.5–8.3	697–754	0.85
20 VIII	14.5–22.0	7.5–9.1	627–739	0.6
12 IX	14.4–14.8	8.3–8.5	646–652	0.8
22 X	8.5–8.9	8.0–8.3	668–680	1.05
03 XII	3.5–3.8	8.1–8.2	740–744	1.35

Water temperature, pH and conductivity were measured in situ, using YSI 610-DM-meter. Water transparency was expressed as the visibility of the Secchi disc. For the statistical graphs Statistica 8.0 software was used.

Results

Morphology of *Puncticulata balatonis* in Rusałka Lake

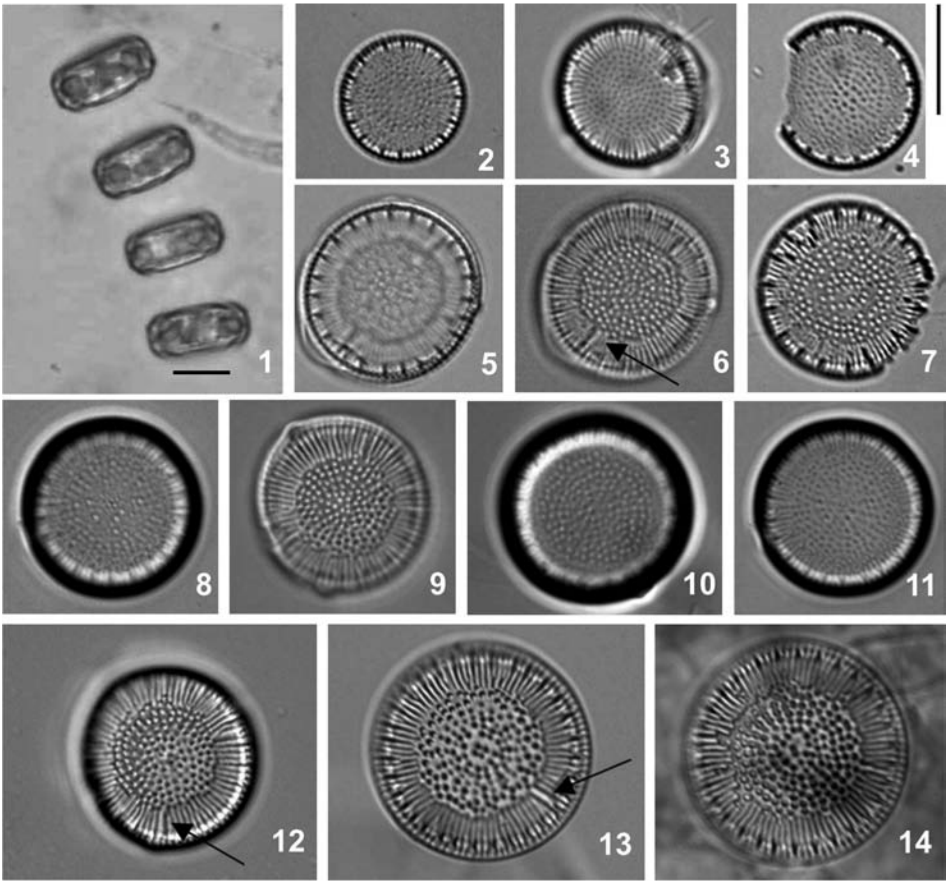
Puncticulata balatonis (Pantocsek) Wojtal et Budzyńska **comb. nov.**

Figs 1–12 & 15–22

BASIONYM: *Cyclotella balatonis* Pantocsek, Die Kieselalgen oder Bacillarien des Balaton, p. 104, Plate XV, figs 319, 332, 1901.

TYPE LOCALITY: Balaton Lake near Siófok, Hungary.

Cells solitary or in short, 2–7-cell chains (Fig. 1), containing multiple discoid chloroplasts. The valve diameter ranges between 8.7 and 21.0 µm. Stria density is 15–18.5 in 10 µm with 3.5–4.7 costae (thickened ribs) in 10 µm. Striae are of unequal length, with inserted shorter (Figs 15–17) or divided striae (Fig. 19), forming an irregularly circular central area (Figs 6, 9, 12, 17). The central area is concentrically slightly elevated (Figs 15, 17), with numerous scattered openings of valve face fultoportulae (externally visible as minor puncta, Fig. 16) and areolae (externally visible as bigger puncta, Figs 15–17). External openings of the rimopor-tulae are present at the end of the shortened striae (Figs 15, 16). The internal opening of the sessile rimoportulae has a radially or slightly obliquely positioned slit (Figs 18, 20), situated close to internal alveolar openings (towards the valve face margin). Marginal fultoportula openings, with two satellite pores, are situated (internally) on the thickened costae (shadow lines), separated by 3–5 thinner costae. Valve face fultoportula openings are internally covered with domed cribra and surrounded by three satellite pores (Figs 19, 20). The morphology of the valve face, internal alveolar openings and the location of internal rimoportula openings, correspond well with the morphology of the specimens from the type material of *Cyclotella balatonis* (Figs 13, 14 & 21, 22; Table 3).

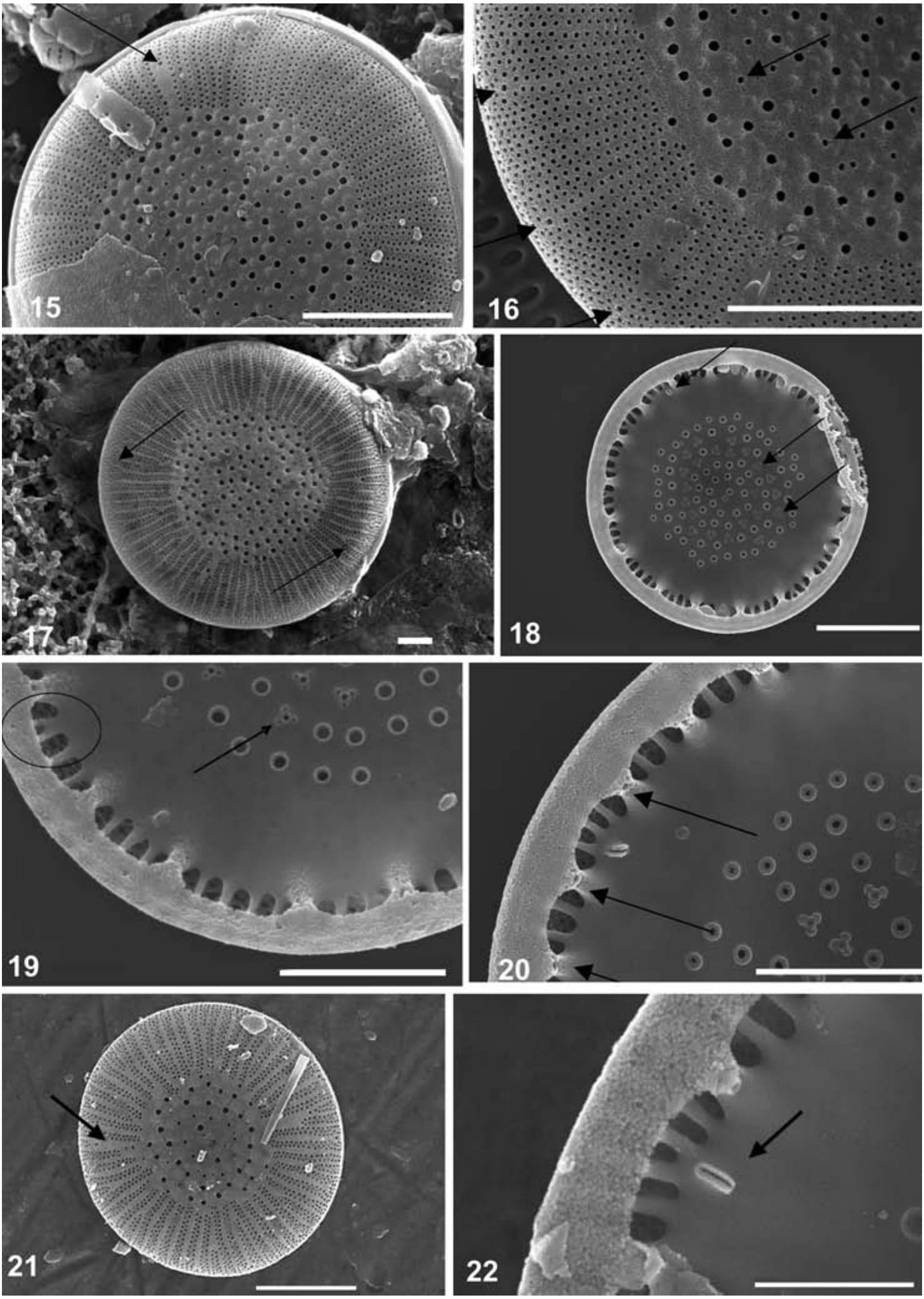


Figs 1–14. *Puncticulata balatonis* (Pantocsek) Wojtal et Budzyńska. Light microscopy. Figs 1–12. Specimens from the Rusałka Lake. Figs 13–14. *P. balatonis*, type material, sample no 152. Fig. 1. Short chain of alive cells, in girdle view. Figs 5–6. The same valve at different focus levels. On Figs 6, 12–13, the characteristic gaps (notae) are marked with an arrow. Scale bar represents 10 μm.

Ecological data

The water of Rusałka Lake was alkaline throughout the study period, showing high conductivity. Water transparency was relatively low, ranging from 0.6 to 1.8 m of Secchi depth (Table 2).

Puncticulata balatonis was present in the lake in all the seasons of 2007. It was found to form chains only in February, March and April. The diatom valve size distribution pattern varied in subsequent months, with the largest average valve size in February (Fig. 23). Its abundance in the lake was also higher in the winter-spring period (from February till May, fig. 24), with the maximum value of 3.5×10^3 cells ml^{-1} and a biomass of 2.98 mg l^{-1} (19% of the total phytoplankton cell number and 52.5% of the total biomass at 6 m depth in March). In other spring samples,



Figs 15–22. *Puncticulata balatonis* (Pantocsek) Wojtal et Budzyńska. Scanning electron microscopy. Figs 15–20. specimens from the Rusałka Lake, Figs 21–22. *P. balatonis*, type material, samples no 152 & 156. Fig. 15. external view of the rimoportula opening at the end of shortened striae – notae

P. balatonis contributed between 6.3% and 18.7% to the total phytoplankton numbers and between 21% and 47% to the total biomass. From June until October the number of the diatom did not exceed 300 frustules per 1 ml (Fig. 24), and no valve was found in September. At the beginning of December *P. balatonis* number increased slightly again.

At the time of the bloom of *P. balatonis*, chrysoflagellates (*Erkenia subaequiciliata* Skuja*, Chrysococcus triporus* Matvienko), pennate diatoms (*Fragilaria* sp.) and/or coenobia-forming Chlorococcales (*Didymocystis inconspicua* Koršikov**,** *Tetastrum* sp. div. *Scenedesmus* sp. div., *Coelastrum microporum* Nägeli, *Crucigenia tetrapedia* Kirchner) were also abundant. Other diatoms such as *Aulacoseira ambigua* (Grunow) Simonsen, *Cyclotella meneghiniana* Kützing, *C. ocellata* Pantocsek, *Cyclostephanos delicatus* (Genkal) Casper, *C. dubius* (Fricke) Round, *Stephanodiscus parvus* Stoermer & Håkansson, *Asterionella formosa* Hassal and *Navicula* sp. were also observed.

Discussion

Morphology of *Puncticulata balatonis* (Pant.) Wojtal et Budzyńska

Puncticulata balatonis shares important morphological characters assigned to the genus justifying its formal transfer to this genus: a slightly concentrically undulate middle part of the valve face, with scattered or radially arranged numerous areolae with internally domed cribra and numerous fultoportulae. Additionally, valves of *P. balatonis* have internal alveolar openings with marginal fultoportulae located on thicker costae, rimoportulae located externally at the top of shortened striae, and internally in the marginal part of the valve face.

The morphology of *P. balatonis* valves from Rusałka Lake corresponds well with the morphology of the specimens from the Pantocsek's type material (Figs 13, 14, 21, 22, Table 3), though the diameter range and the number of striae in 10 µm were found to be different. Pantocsek (1901) stated in his diagnosis (p. 104) that the valves of *Cyclotella balatonis* are 16–20 µm in diameter, but we have found both smaller and larger specimens (Table 3). The wider diameter range in our observation could be related to a more complete morphological range of the species, since the diatom population in Rusałka Lake was abundant. However, the time of sampling may have also been of importance, as the medium valve size of the species in our

(arrowed) at concentrically elevated valve face. Fig. 16. external view of the openings of central (right) and marginal (left) fultoportulae (arrowed). Fig. 17. external view of the short and long striae of the marginal area. Fig.18. internal view of the rimoportula opening (arrowed), located close to the valve margin and internal alveolar opening, and central openings of numerous areolae and fultoportulae (arrowed). Fig. 19. internal view of the divided thinner costa (marked) and internal opening of central fultoportula (arrowed). Fig. 20. internal view of the marginal fultoportulae located on the thicker costae (arrowed). Fig. 21. external view of the valve face with marked notae. Fig. 22. internal view of the alveolar openings with thicker costa bearing marginal fultoportulae, and internal rimoportula opening located near the margin (arrowed). Scale bar represents 5 µm for Figs 15, 18 & 21, 4 µm for Fig. 16, 3 µm for Figs 19 & 20 and 2 µm for Figs 17 & 22.

Table 3. Comparison of *Puncticulata balatonis* and morphologically similar species. CF – central fultoportulae, MF – marginal fultoportulae. * our observation, type material Siofók, sample no 152; ** our observation based on the fig. 62: 11, 12 in Krammer & Lange-Bertalot 1991, which shows specimens from the type material of *Cyclotella balatonis* Pantocsek (as *C. radiosa*).

	Cyclotella balatonis Pantocsek	*Puncticulata balatonis* (Pantocsek) Wojtal et Budzyńska as *Cyclotella balatonis* Pantocsek	*Puncticulata balatonis* (Pantocsek) Wojtal et Budzyńska our observation	*Cyclotella praetermissa* Lund	*Puncticulata praetermissa* (Lund) Håkansson	*Puncticulata praetermissa* (Lund) Håkansson as *Cyclotella praetermissa* Lund	*Puncticulata radiosa* (Lemmer-mann) Håkansson	*Puncticulata radiosa* (Lemmer-mann) Håkansson, as *Cyclotella radiosa* (Grunow) Lemmermann	*Puncticulata comta* (Ehrenberg) Håkansson	*Puncticulata comta* (Ehrenberg) Håkansson as *Cyclotella comta* (Ehrenberg) Kützing
References	Pantocsek 1901, p. 104, Plate XV, Figs 319, 332.	Houk et al. 2010, p. 39, Plates 269: 1–11; 270: 1–6; 271: 1–6.		Lund 1951, p. 98, Figs 1, 2	Håkansson, 2002, p.116, Figs 422–426	Houk et al. 2010, p. 41, Plates 280: 1–11; 281: 1–6	Håkansson, 2002, p.114, Figs 415–421	Houk et al. 2010, p. 37, Plates 261: 1–11; 262: 1–12; 263: 1–5; 264: 1–6	Håkansson, 2002, p.113, Figs 410–414	Houk et al. 2010, p. 36, Plates 257: 1–23, 258: 1–11; 259: 1–12; 260: 1–8
Colonies	no data	2–8	2–7 cells loosely united	2–8 cells, loosely united	short, loosely united chains	Cells solitary or in short loosely united chains 2(8) cells	no data	"mostly solitary"	cells solitary rarely in short chains	no data
Diameter (µm)	16–20	16–22	8.7–21.0	8–25	8–25	8–30	7–35	7–25	8–50	5–32
Striae	20 per 10 µm	c.a., 16 per 10 µm, of nearly equal length, occupy 1/3–1/2 of valve face diameter	15–18.5 per 10 µm	13–19 per 10 µm	13–15 per 10 µm	15–18 per 10 µm, of nearly equal length; occupy 1/2–1/4 of the valvae diameter	no data	15–18 per 10 µm, of nearly equal length, taking about 1/2 of the valve face diameter	no data	14–18 per 10 µm

Central area	* flat to slightly concentrically undulate, with numerous CF and areolae openings scattered or arranged in radial pattern	flat to slightly concentrically undulate, with CF and areolae arranged in more or less radial rows	flat to slightly concentrically undulate, with numerous CF and areolae openings scattered or occasionally arranged in radial pattern (Figs 8 & 9)	central area with more or less regularly arranged radial puncta	concentrically undulate, with scattered or radially arranged CF and areolae	flat or slightly concentrically undulate; central areolae and CF scattered or arranged in radial rows	slightly concentrically undulate, radially wrinkled, CF and areolae arranged in radial pattern	distinctly concentrically undulate and radially wrinkled; CF and areolae always arranged in radial rows	flat to concentrically undulate, smooth	flat to concentrically undulate, smooth; CF and areolae scattered or arranged in radial rows
Rimoportulae	*2–3 in the marginal area near the valve margin. External openings at the end of shortened stria. Internally a small sessile labium close to internal alveolar openings, with radially or obliquely positioned slit	(1)2–5 in the marginal area near the valve margin. External openings at the end of shortened stria. Internally a sessile labium very close to internal alveolar openings, with radially or obliquely positioned slit	1–2(3) in the marginal area near the valve margin. External openings at the end of shortened stria. Internally a small sessile labium close to internal alveolar openings, with radially or obliquely positioned slit	no data ** Internally a sessile labium in oblique position, located between alveolar openings and central area	at least one, on the valvae face, at the end of shortened stria. Internally a sessile labium in radial position, located midway between alveolar openings and central area	1–5 in the marginal area close to limit of the central area. External openings on a hyaline area at the end of a slightly shortened stria. Internally a sessile labium in oblique to circumferential slit position	at least one, on the valve face at the end of shortened stria. Internally a relatively large sessile labium in slit position, located between alveolar openings and central area	at least one, in the marginal area close to limit of the central area. External openings on a hyaline area at the end of a slightly shortened stria. Internally a sessile labium with a slit oriented obliquely to nearly circumferentially	at least one, on the valvae face, at the end of shortened stria. Internally a large sessile labium in oblique position, located between alveolar openings and central area	at least one, on the valvae face, at the end of slightly shortened stria. Internally a large sessile labium in oblique or circumferential position, located in the marginal area near to the central area
Internal alveolar openings	small; costae bearing MF clearly larger than thin ribs	small; costae bearing MF clearly larger than thin ribs	small; costae bearing MF clearly larger than thin ribs	** radially elongated, costae bearing MF clearly larger than thin ribs	radially elongated, costae bearing MF clearly larger than thin ribs	radially elongated, costae bearing MF slightly larger than thin ribs	small; costae bearing MF clearly larger than thin ribs	small; costae bearing MF clearly larger than thin ribs	small; costae bearing MF clearly larger than thin ribs	small; costae bearing MF clearly larger than thin ribs

Table 3 continued.

	Cyclotella balatonis Pantocsek	*Puncticulata balatonis* (Pantocsek) Wojtal et Budzyńska as *Cyclotella balatonis* Pantocsek	*Puncticulata balatonis* (Pantocsek) Wojtal et Budzyńska our observation	*Cyclotella praetermissa* Lund	*Puncticulata praetermissa* (Lund) Håkansson	*Puncticulata praetermissa* (Lund) Håkansson as *Cyclotella praetermissa* Lund	*Puncticulata radiosa* (Lemmer-mann) Håkansson	*Puncticulata radiosa* (Lemmer-mann) Håkansson, as *Cyclotella radiosa* (Grunow) Lemmermann	*Puncticulata comta* (Ehrenberg) Håkansson	*Puncticulata comta* (Ehrenberg) Håkansson as *Cyclotella comta* (Ehrenberg) Kützing
	Lake Balaton near Siófok	Mesotrophic/eutrophic lakes, reser., slowly run-ning waters. One of the most common European species of the C-radiosa complex	Eutrophic/hypereutro-phic reservoir	Plankton of a number of lakes poor in organic matter and some quarry pools in English Lake District	no data	Plankton or littoral oligo/mesotrophic lakes	no data	Plankton of oligo/meso-trophic mainly sub-alpine lakes	no data	fossil diatom

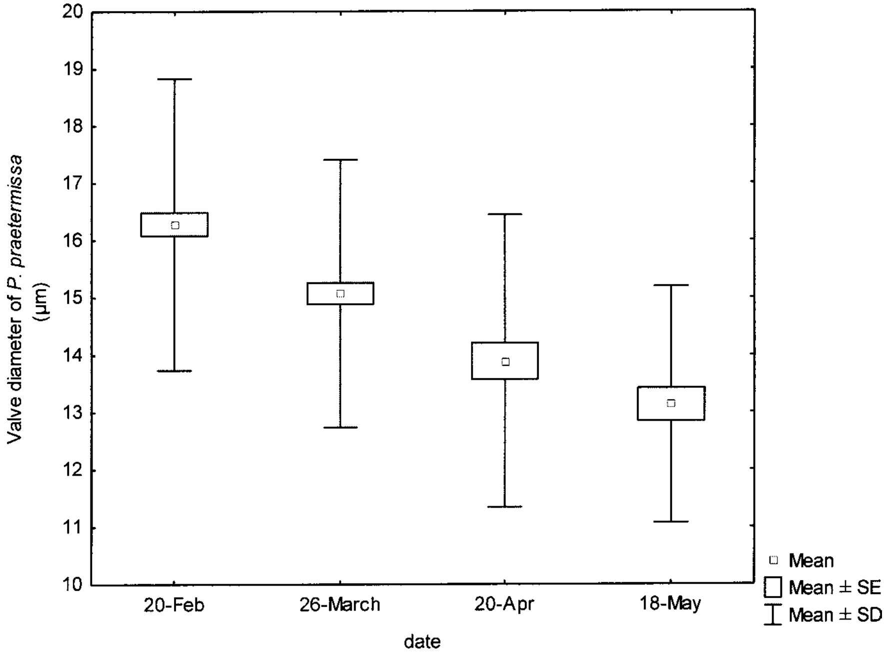


Fig. 23. The variation in *Puncticulata balatonis* valve size in Rusałka Lake in subsequent months in 2007.

samples declined in subsequent winter-spring months, which is a typical consequence of diatom cell division. The number of striae in 10 µm was found to be lower (11 to 17 striae in 10 µm) in some specimens from Rusałka Lake than has been originally stated by Pantocsek (1901). It might be related to the striae counting method, because even at original Pantocsek's drawings (Plate XV, figs 319, 332) number of striae in 10 µm is lower, when the Genkal's method (1977) is applied. It also remains in accordance with our observations of the type material (Table 3) and the observations in Houk et al. (2010).

Puncticulata balatonis is morphologically similar to several species of the complex, making it difficult for a non-specialist to distinguish them. The species resembles *P. radiosa*, but differs from it in valve face ultrastructure, such as the location of the internal rimoportula openings. The valves of *P. radiosa* have a more coarse and radially wrinkled central area in the valve face, whereas *P. balatonis* has a smoother and finely silicified valve face. Additionally, the radial pattern of the valve face fultoportulae and areolae is very distinct in *P. radiosa*. The external rimoportula openings of *P. balatonis* are situated at the end of shortened stria, well discernible in LM as gaps (notae), whereas according to Houk et al. (2010), the external openings of *P. radiosa* are situated at the end of only slightly shortened striae. The differences are clearly visible from the internal valvae view, because *P. balatonis* has valve face rimoportula openings located close to the internal alveolar openings, whereas the

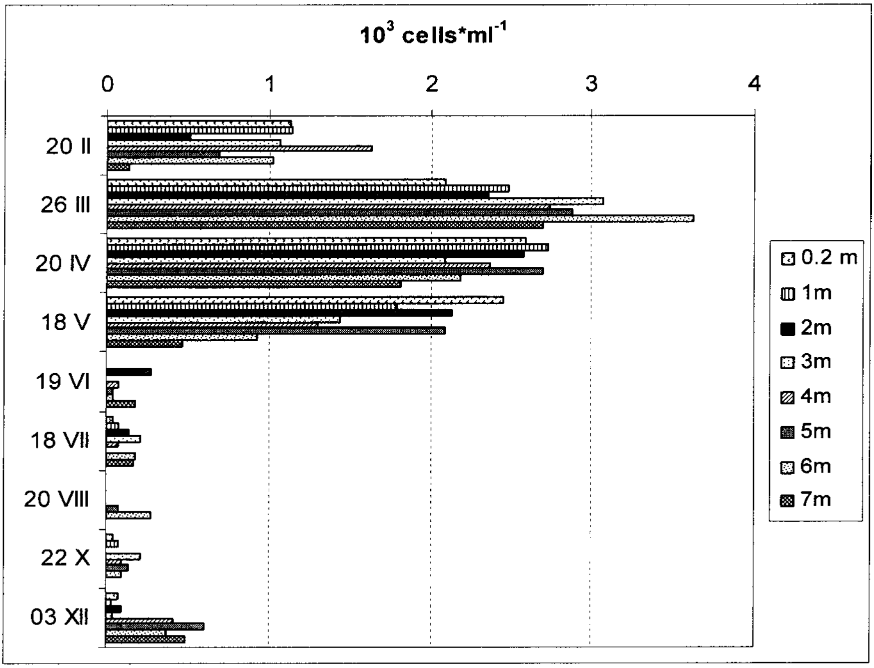


Fig. 24. The number of *Puncticulata balatonis* frustules in the water column of Rusałka Lake in 2007.

rimoportula openings in *P. radiosa* are located more close to the central area of the valves. Such a close location of the internal rimoportula openings to the valve margin is typical only for *P. balatonis* within the discussed group (Table 3).

Another diatom showing a similar morphology to *Puncticulata balatonis* is *P. praetermissa* (Lund) Håkansson. Most of the morphological features are similar for both species (Table 3), but the later possesses radially elongated, relatively large internal alveolar openings. Moreover, the costae bearing marginal fultoportulae are only slightly thicker than the rest, and the internal rimoportula openings are closer to the central part of the valve face (Table 3). The last feature, as well as the marginal stria length, enable also the morphological distinction between *P. balatonis* and *P. comta.*

Ecology and distribution

The distinction between the species of the *Puncticulata radiosa*-complex, including *Puncticulata balatonis*, is not easy for a plankton ecologist or other researcher who is not a centric diatom specialist. The correct identification requires detailed morphological studies with SEM and/or specialized knowledge. That is why, apart from the long-lasting taxonomical confusion, the real distribution of the species from the complex is uncertain. According to Houk et al. (2010) *Puncticulata balatonis* (as *Cyclotella balatonis*) is one of the most common members of the *P. radiosa* (as

Cyclotella radiosa) complex in Europe, found in numerous mesotrophic and eutrophic lakes and slowly running waters in Hungary, Germany and Czech Republic. However, reports of the species are not numerous. Till now *P. balatonis* has also never been reported from Poland.

The limited number of reports on the occurrence of *P. balatonis* may be related to its misidentification/misinterpretation, as *Cyclotella comta* (Ehrenb.) Kütz. (Kiss & Pająk 1994, fig. 13), found in the plankton of the eutrophic Vistula River; as *Cyclotella praetermissa /quadrijuncta* (Wunsam et al. 1995) or as *Puncticulata radiosa* (Wojtal & Kwandrans 2006) found in the eutrophic Rudawa River. We are convinced that a part of other records of *P. comta*, the most commonly reported species of the complex in Poland (Siemińska & Wołowski 2003), in fact might concern *P. balatonis*. In Rusałka Lake, the species may have also been mistaken for *P. comta* (as *C. comta*), reported from the lake by Kotlińska (1976). It is also likely that *P. balatonis* in Poland may have been misidentified as *P. praetermissa*, although the latter species was only reported several times, including findings in the benthos of Czarne Lake and the Kamionka River, NE Poland (Rakowska 1996), in the plankton of several lakes of the Drawa National Park, NW Poland (Gołdyn & Szeląg-Wasielewska 2004), in a sand-pit lake in Kraków and a spring fed pond in Krztynia in S Poland (Wojtal, unpublished data).

Up to now, there has also been much confusion around the ecology of the species from the complex. For instance *P. praetermissa*, described by Lund (1951) from lakes with a low organic matter content, was later found both in the plankton and the benthos in a wide variety of natural and man-made lakes, including alpine and subalpine lakes (Wunsam et al. 1995; Lange-Bertalot & Metzeltin 1996, Güttinger & Straub 1998; Tolotti et al. 2004), as well as in more eutrophic habitats (e.g., Schmidt et al. 2002, Hindák & Hindáková 2003, Tanaka 2007). Houk et al. (2010) cleared up the ambiguities, ascribing *P. praetermissa* and *P. radiosa* to oligo-mesotrophic habitats. According to the authors, *P. comta* (as *Cyclotella comta*) is till now known only from fossil materials. *P. balatonis* (as *Cyclotella balatonis*), in turn, has been assigned to meso-eutrophic lakes and rivers, consistently with the trophic character of its type locality – lake Balaton. Our results correspond with the autecology of *P. balatonis* (as *Cyclotella balatonis*) proposed by Houk et al. (2010), widening even slightly the preferences of the species for the trophic conditions determined by Houk et al. (2010), as it was also able to develop a large population in an eutrophic to hypereutrophic water body.

The highest numbers of *P. balatonis* in Rusałka Lake were observed in the winter-spring period. The diatom bloom in the spring plankton is a well-known phenomenon (Sommer et al. 1986) – sometimes also occurring during the winter period (Kiss & Genkal 1993) – and is usually associated with a changing silica and/or phosphorus availability during that period (Lampert & Sommer 2001). Sinking was also proved to be an essential factor hampering diatom success during the thermal stratification period (Jewson et al 1981; Ferris & Lehman 2007), explaining probably the seasonality of the *P. balatonis* growth in Rusałka Lake, as its high development finished with the stratification onset. Relatively high numbers of frustules in deeper water layers might also indicate a significant role of the sedimentation process.

Conclusions

The morphology of *Puncticulata balatonis* in Rusałka Lake corresponds well to other species around *P. comta*, with the exception of the location of marginal fultoportula openings and the length of the shortened striae (notae). Analysis of the morphological characters enabled the transfer of *Cyclotella balatonis* into the genus *Puncticulata*. A large population of the species in the eutrophic to hypereutrophic Rusałka Lake remains congruent with its tolerance ranges, with respect to the trophic state, proposed by Houk et al. (2010). The variation in the cell number and average dimension of frustules indicated the species preference to develop large populations in spring.

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