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# Rare diatom *Stauroneis balatonis* Pantocsek recorded in Lake Savsko, Serbia

by

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**Abstract**

Although well represented in the fossil diatom flora throughout Europe and Asia, from the early-middle Miocene to the Quaternary, *Stauroneis balatonis* is considered a very rare diatom with a contemporary distribution limited to two ancient lakes – Ohrid and Prespa. The objective of this study was to describe the first finding of *S. balatonis* in Serbia in Lake Savsko and to update information on the distribution and ecology of this rare species. Periphyton samples were collected from artificial substrates incubated at three depths (0.5 m, 0.8 m and 1.4 m) in Lake Savsko and the epilithic community was sampled in the littoral zone. Samples were collected weekly in summer 2014, from mid-July to mid-September. Diatom permanent slides were prepared and small numbers of *S. balatonis* specimens were observed only in samples collected in September from artificial substrates incubated at the greatest depth (1.4 m). Our results significantly contribute to the information on the contemporary distribution and the ecology of this rare diatom taxon, especially considering the fact that *S. balatonis* specimens were observed in our study in diatom communities developed on artificial substrates and in an urban reservoir, i.e. Lake Savsko.

**Key words:** periphyton, Bacillariophyceae, artificial substrates, urban reservoir

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## Introduction

Representatives of the genus *Stauroneis* Ehrenberg are widely distributed in various types of freshwater, as well as in subaerial habitats (Lange-Bertalot & Metzeltin 1996; Van de Vijver et al. 2004) and even caves (Falasco et al. 2015). A typical morphological feature that makes the *Stauroneis* species easily distinguishable from all other diatoms is the presence of a hyaline thickening of silica in the central area of a valve, the so called "stauros" (Round et al. 1990).

The diversity of the genus *Stauroneis* in Serbia encompasses 14 species (Krizmanić 2009; Andrejić et al. 2012; Krizmanić et al. 2015; Vidaković et al. 2015), including *Stauroneis smithii* Grunow and *Stauroneis separanda* Lange-Bertalot & Werum. *S. smithii* Grunow is actually considered a species complex comprising more than 20 infraspecific taxa, including *S. separanda* (Werum & Lange-Bertalot 2004). Recently, Levkov et al. (2016) revised this highly variable complex from Macedonia and in their revision, *Stauroneis balatonis* Pantocsek, *Stauroneis smithii* var. *incisa* Pantocsek and *S. legumen* var. *balatonis* Pantocsek are considered conspecific and at the same time significantly different from typical *S. smithii* Grunow. For this reason, these three species have been grouped under the name of *S. balatonis* Pantocsek. *S. balatonis* is widely distributed in the fossil diatom flora in Europe and Asia (Krasske 1932; Kobayasi & Ando 1978; Temniskova-Topalova & Ognjanova-Rumenova 1997; Buczkó et al. 2005). In Europe, this taxon has recently been confirmed only in the contemporary diatom flora in the ancient lakes of Ohrid and Prespa (where it has also been observed in the fossil flora; Levkov et al. 2016). This diatom species is therefore considered very rare, even in Lake Ohrid and Lake Prespa, where it is observed infrequently and sparsely.

The objective of this study was to describe the first finding of *S. balatonis* in an urban reservoir – Lake Savsko in Serbia, and to update the biogeography and ecology of this rare species.

## Materials and methods

Lake Savsko (44°47'02.28"N, 20°23'25.64"E; 73 m a.s.l.) was created by embanking the Sava River near its confluence with the Danube River (Fig. 1). Lake Savsko is a shallow urban reservoir surrounded by many cafes and restaurants, intensively used for recreation during summer months. The average depth of Lake Savsko is 4.5 m (maximum 12 m), the length is about 4.4 km and the width is about 250 m (Trbojević et al. 2017).

Artificial substrates for periphyton development (glass, ceramic, as well as willow and yew wooden tiles) were submerged at three depths (0.5 m, 0.8 m and 1.4 m) in the photic zone of Lake Savsko on 11 July 2014 and continuously incubated for the next two months (Fig. 1). Periphyton samples from artificial substrates were collected weekly from 20 July to 9 September.

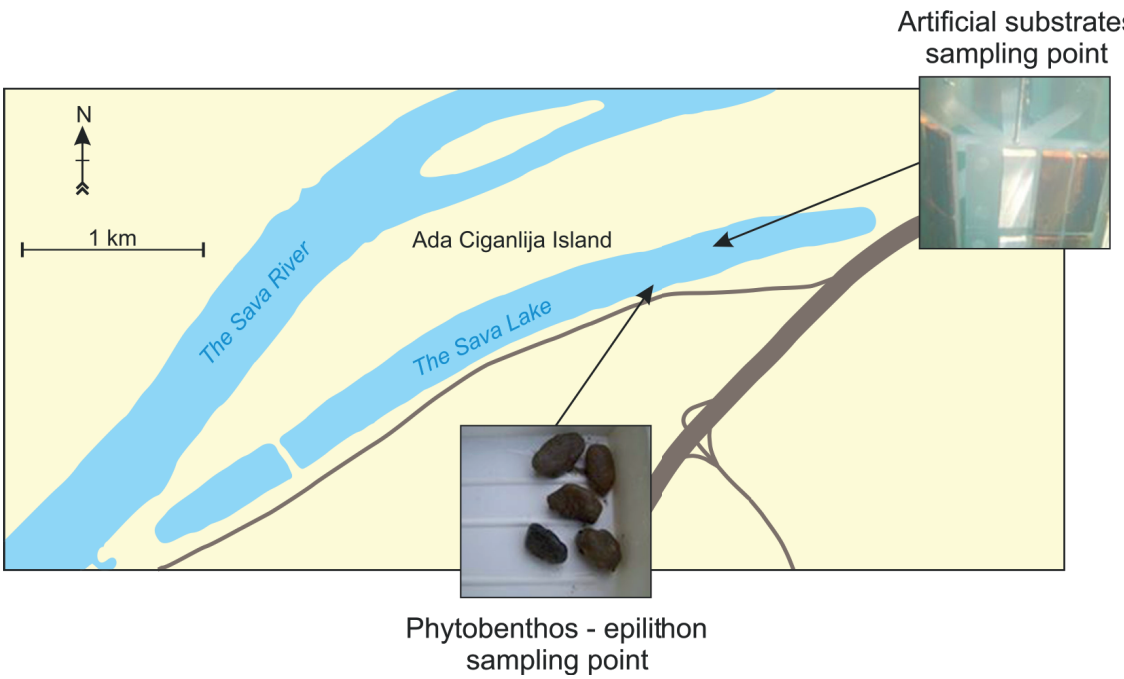


**Figure 1**

Map of Lake Savsko with the location of sampling points

Simultaneously with artificial substrates, the epilithic community was sampled in the littoral zone of Lake Savsko (approx. at a depth of 0.5 m; Fig. 1). Tiles were transported to the laboratory at the Department of Algology, Mycology and Lichenology at the Institute of Botany and Botanical Garden "Jevremovac", Faculty of Biology, University of Belgrade. In laboratory conditions, periphyton was scraped off the tiles using a stainless steel razorblade tool and samples were preserved with formaldehyde (4% final concentration) shortly after sampling. The material was treated with acid (Taylor et al. 2005) and mounted on Naphrax® to prepare permanent diatom slides. Sampling and processing of samples are described in detail by Trbojević (2018). Diatom taxonomic analyses were performed using a Carl Zeiss AxioImager M1 microscope and a digital camera AxioCam MRc5 with AxioVision 4.8 software. The identification of *S. balatonis* Pantocsek was performed using the standard literature references (Lange-Bertalot & Metzeltin 1996; Van de Vijver et al. 2004; Lange-Bertalot et al. 2017) and the most recent revision of the *S. smithii* Grunow complex in Macedonia (Levkov et al. 2016). Water samples were collected at each sampling occasion and physical and chemical analysis was carried out at the laboratories of the Institute of Public Health of Serbia according to the standard procedures (APHA 1995).

## Results

The results of water chemistry of Lake Savsko are presented in Table 1 as a contribution to the description of the habitat and ecology of *S. balatonis*.

*S. balatonis* specimens were found in very small numbers in periphyton samples collected in early September, and only in samples collected from the artificial substrates incubated at a depth of 1.4 m. *S. balatonis* specimens were not recorded in samples incubated at shallower depths and in samples of the epilithic community collected from the littoral zone.

*Stauroneis balatonis* Pantocsek collected from Lake Savsko is shown in Figure 2. It has rhomboid to elliptical-lanceolate valves, with short to slightly elongated subrostrate apices. The length of valves ranges from 20.5 µm to 32.5 µm, and their width from 6.4 µm to 7.5 µm. A subtle marginal undulation in the mid-valve region can be noticed at the same focus as pseudosepta. Distinct pseudosepta are present at both apices. The axial area is narrow. The central area has a distinct rectangular, but very narrow stauros. The raphe is filiform and straight. Transapical striae are not easily detectable under a light microscope (LM). They are fine, parallel to very slightly radiate, indistinctly punctuate, 24–25 in 10 µm. Areolae are not distinct and not countable under LM.

## Discussion

Lake Savsko is an urban reservoir exposed to multiple anthropogenic pressures. In terms of trophic conditions, Lake Savsko was predominantly mesotrophic in the summer of 2014, evolving toward eutrophic conditions at the end of August and the beginning of September (Trbojević et al. 2017). However, peaks in the phosphorus concentration in Lake Savsko indicate that the equilibrium of this reservoir may be compromised. Compared to the

**Table 1**

Physical and chemical parameters of Lake Savsko in summer 2014

| Parameter | Units | 20 July | 27 July | 3 August | 10 August | 17 August | 24 August | 1 September | 9 September |
|---|---|---|---|---|---|---|---|---|---|
| Water temperature | °C | 27 | 27 | 27 | 27 | 27 | 26 | 25 | 24 |
| Air temperature | | 30 | 28 | 30 | 27 | 22 | 24 | 24 | 27 |
| Transparency | m | 3.5 | 3.1 | 3 | 3 | 2.75 | 3.1 | 2.75 | 2.6 |
| Turbidity | NTU | 1.09 | 0.98 | 1.08 | 1.35 | 3.17 | 0.96 | 1.14 | 0.96 |
| pH | | 8.03 | 7.29 | 7.49 | 7.75 | 7.44 | 7.76 | 8.15 | 8.03 |
| Dissolved oxygen | mg $l^{-1}$ | 8.03 | 7.29 | 7.49 | 7.75 | 7.44 | 7.76 | 8.15 | 8.03 |
| Conductivity | µS $cm^{-1}$ | 229 | 222 | 225 | 218 | 214 | 222 | 222 | 224 |
| Silicon dioxide | mg $l^{-1}$ | 0.68 | 0.09 | 0.39 | 0.42 | 0.70 | 0.58 | 0.62 | 0.59 |
| Ammonia | | 0.06 | 0.05 | < 0.05 | < 0.05 | < 0.05 | 0.05 | 0.07 | <0.05 |
| Nitrites | | 0.0036 | 0.0013 | 0.0039 | 0.0007 | 0.0010 | 0.0033 | 0.0020 | 0.0033 |
| Nitrates | | 0.2657 | 0.0022 | 0.0022 | 0.2920 | 0.0198 | 0.0132 | 0.0022 | 0.0022 |
| Orthophosphates | | 0.0015 | 0.0432 | 0.0432 | 0.003 | 0.0013 | 0.1652 | 0.0392 | 0.015 |
| Total phosphorus | | 0.0111 | 0.0624 | 0.0591 | 0.0090 | 0.0105 | 0.1975 | 0.0714 | 0.0349 |
| Biological oxygen demand | mg $O_2$ $l^{-1}$ | 4.00 | 2.10 | 2.70 | 1.80 | 3.20 | 6.10 | 3.10 | 2.00 |

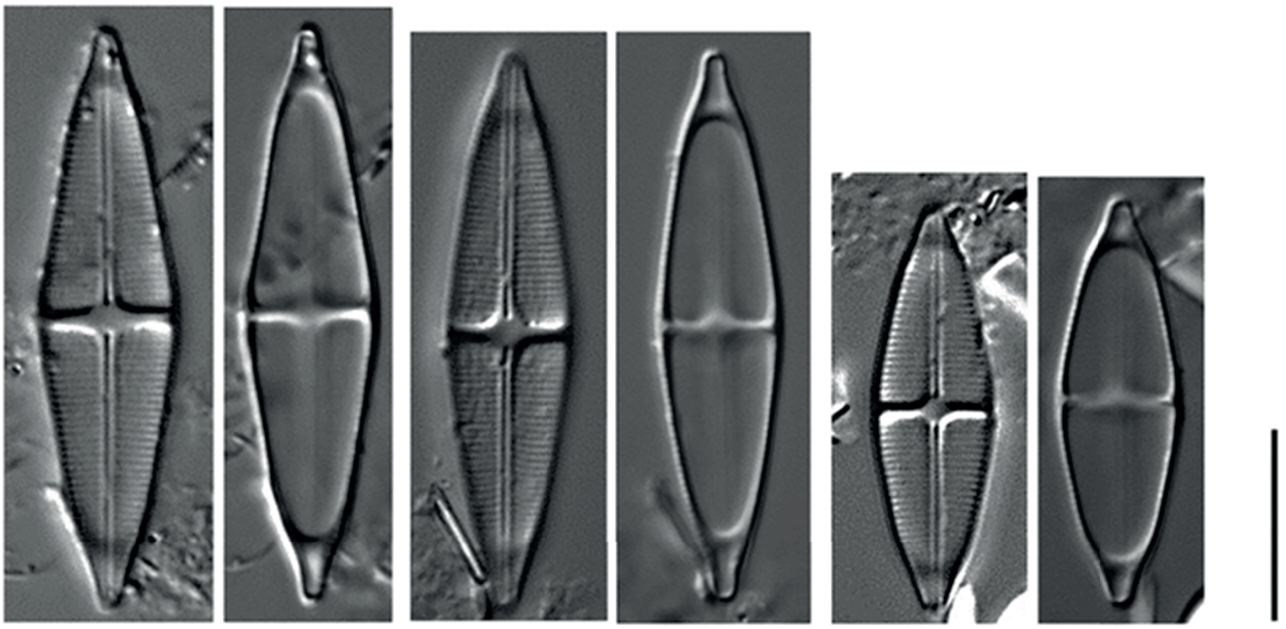

**Figure 2**

Diminution series of the *Stauroneis balatonis* population from Lake Savsko. Scale: 10 µm

contemporary confirmed habitats of *S. balatonis*, i.e. Lake Ohrid and Lake Prespa, Lake Savsko is a different type of freshwater ecosystem, because it is a shallow urban reservoir and not a deep ancient lake of tectonic origin as in the case of the two other lakes. The most recent assessment of the trophic state of these two ancient lakes revealed that Lake Ohrid is still a stable oligotrophic ecosystem, while Lake Prespa is basically mesotrophic, but exposed to the process of eutrophication (Peveling et al. 2015). A comparison of the trophic status of Lake Savsko, Lake Ohrid and Lake Prespa potentially indicates that this factor does not appear to be a limiting factor for the distribution of *S. balatonis*.

Although the population of *S. balatonis* found in Lake Savsko was not abundant, some morphological plasticity could also be observed. Levkov et al. (2016) distinguished two morphotypes of *S. balatonis*, one in the contemporary flora of Lake Ohrid characterized by larger valves and the second one (smaller valves) in the sediment of Lake Prespa. According to the described morphological features, our population resembles more the contemporary population from Lake Ohrid rather than the one from the sediment in Lake Prespa.

It has already been mentioned that Levkov et al. (2016) considered *S. balatonis*, *S. smithii* var. *incisa* and *S. legumen* var. *balatonis* as conspecific, thus the authors grouped these three taxa under one name – *S. balatonis*. Interestingly, all these three taxa from Lake Balaton were described by Pantocsek (1902) as specific because, despite an extremely similar morphology, they differed in size. Later, Hustedt (1959) consolidated these three taxa under the name *S. smithii* var. *incisa*. Uherkovich (1996) recorded this taxon in the surface sediment of Lake Balaton collected in 1978–1981, when it occurred with low abundance. The latest record of the taxon under this name was made by Buczkó et al. (2005), who found the taxon in Lake Balaton only in a sediment core collected in 1989, but not in recent (surface) sediment. Due to the limited contemporary occurrence of this taxon, there is a considerable gap in the knowledge of *S. balatonis* autecology. The only relatively up-to-date autecological data are provided on *S. smithii* var. *incisa* recorded in North America, which is described as rare but abundant in late summer and early fall, as well as preferring epilithic substrates (Bishop 2016). Our observations of *S. balatonis* in Lake Savsko, carried out only in September and not earlier in summer, support the autecological data on the seasonality of *S. smithii* var. *incisa*, but on the other hand, they contradict data on substrate preferences presented in the assessment for Long Branch Creek, South Carolina, the U.S. (Bishop 2016). Our data provide an update on possible depth preferences of *S. balatonis,* as the taxon was found only on artificial substrates incubated at a depth of 1.4 m. We cannot speculate on substrate preferences based on our data as the epilithic community was sampled only from a maximum depth of 0.5 m in the littoral zone.

## Conclusion

Given the contemporary distribution of *S. balatonis* and the fact that Lake Savsko is an urban reservoir located near the center of Belgrade, used for both water supply and recreational purposes, our finding of this rare diatom taxon in this particular water body is at least unusual and unexpected. This finding could also initiate a debate on the distribution of rare diatom species, in fact, the question may arise as to whether these species are perhaps rare because they are not searched in various types of water bodies, including the artificial ones, such as Lake Savsko. Nevertheless, our finding significantly contributes to the data on the contemporary distribution of *S. balatonis* in Europe and encourages the intensification of research on diatoms in lakes and reservoirs in Serbia.

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