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THE FIRST SIGN OF *SURIRELLA TIENTSINENSIS* (SURIRELLACEAE, BACILLARIOPHYCEAE) SPREADING IN THE CARPATHIAN REGION

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Abstract: A characteristic, panduriform, large (*ca* 80 µm in length) diatom was sporadically detected in the Hungarian rivers in 2021 and 2022. *Surirella tientsinensis* Skvortzov emend. Liu was regarded as an Asian endemic species practically from its description until the second decade of the 21st century. Here we present the first Hungarian occurrence of the taxon from 2021, which is the second record for Europe, after the previously published Ukrainian data. In 2022 *Surirella tientsinensis* was detected from two other Hungarian river sampling localities. Due to the unmistakable outlook of the species, probably it is a new member of the Hungarian diatom flora, and its parallel occurrences in some localities within a short time, is noteworthy.

Key words: biogeography, Danube, diatoms, Maros/Mureș, phytoplankton, Tisza

INTRODUCTION

Diatoms are a ubiquitous and widely used group of organisms in the study of environmental issues (Smol and Stoermer 2010). Despite the importance and usefulness of these photoautotrophs, biogeography and the pattern of their distribution have been under discovery, but we are very far from understanding it. The exploration of the range of diatom taxa is also hampered by their rapidly changing distribution pattern. The biotic exchange, the invasion is one of

the main serious environmental risks, as main drivers of declining biota diversity (VÖRÖSMARTY *et al.* 2010). The biogeography of invasive microorganisms is a neglected research field mainly due to difficulties in sampling, inefficient detection strategies, and outstanding problems in their taxonomy (BUCZKÓ *et al.* 2022, MACÊDO *et al.* 2021). Invasive species are able to rapidly establish, proliferate, and modify or completely reorganise communities.

All data that can contribute to the better understanding of moving and rearrangements of aquatic biota could be significant. The aim of this paper is to present the first record of a *Surirella* species in the Carpathian region.

The genus name *Surirella* was introduced by TURPIN in 1828. Cells of *Surirella* grow as single, isolated cells; the raphe system is positioned along the margin of the valve. The valve is located within a canal, which may be raised above the valve surface in some species. Cells may be highly silicified, with spines and silica nodules on the valve surface (ROUND *et al.* 1990, SPAULDING and EDLUND 2010). More than 2000 names of *Surirella* taxa have been reported worldwide (KOCIOLEK *et al.* 2023), which is a large freshwater to marine, epipelic genus (ROUND *et al.* 1990). *Surirella*, *Cymatopleura*, *Stenopterobia*, and *Campylodiscus* are part of the order Surirellales (sensu ROUND *et al.* 1990), which are canal-raphe-bearing diatoms with a circumferential raphe at the entire valve margin (JAHN *et al.* 2017) and they have been under the permanent interest of diatom taxonomy (LONG *et al.* 2022, WANG 2018).

One characteristic representative of the genus is *Surirella tientsinensis*. It was described by SKVORTZOV in 1927, from Tientsin, North China. The history of the species presented by LIU *et al.* (2019) in detail includes the following data: in the original description only one individual was measured: 64.6 μm long, 10.2 μm wide (at centre), 13.6 μm (at broadest part), costae 6 in 10 μm (SKVORTZOV 1927: 107, fig. 24; LIU *et al.* 2019). Later, SKVORTZOV observed another individual from Lake Hanke, Eastern Siberia, and this individual was measured 59 μm long, 12 μm wide (at centre), 14 μm (at broadest part), costae 6 in 10 μm (SKVORTZOV 1938). LIU *et al.* (2019) found a *Surirella tientsinensis* population in Lake Dongting, and due to the earlier unknown ultrastructure of the taxon, they provided an emended description based on scanning electron microscopical study.

MATERIALS AND METHODS

Phytoplankton samples were collected from the river Danube in monthly frequency in 2021 in the frame of the riverine project (web1).

As a part of a regional monitoring survey, the Maros (Mureș) and Tisza rivers were investigated six times a year by the County Government Office. The Maros

at Nagylak (close to the border of Hungary and Romania) was sampled on 5 April 2022, while the Tisza river, on 20 April 2022, at Tiszasziget stream-channel as well as from the banks of the river. Chlorophyll-*a* content was measured, and quantitative counting of phytoplankton was carried out. Samples were treated with 10% hydrochloric acids (HCl) to remove carbonates and 30% hydrogen peroxide (H_2O_2) to remove organic matter (Battarbee 1986). The cleaned samples were mounted permanently onto microscope slides into Naphrax resin (refractive index = 1.7). For diatom counting a Leica DM LB2 light microscope (equipped with 100 HCX PLAN APO objective and Olympus SC180 digital camera) at ×1,000 magnification under oil immersion and phase contrast in the Algological Collection of the Hungarian Natural History Museum was used. Diatom slides are deposited in the Algological Collection of the Hungarian Natural History Museum marked as HNHM-ALG-D 2023/53. AlgaeBase (Guiry and Guiry 2018) and DiatomBase (Kociolek *et al.* 2023) were used for checking the taxonomical position and the distribution data of the taxon.

RESULTS

The first record of the occurrence of *Surirella tientsinensis* from Hungary was found in May, 2021, in the phytoplankton of the river Danube at Baja. Only one valve was found during the supplementary investigation.

In chronological order the second Hungarian emergence of the taxon came from a national border; from the Maros river (at Nagylak). The chlorophyll-*a* content was 29.6 mg/l. The number of "living algal number" was 6,110 ind/ml; and the relative abundance of *Surirella tientsinensis* was 0.8%. Noteworthily, there were several empty valves in the sample (dead cells) of the taxon.

The third Hungarian record of *Surirella tientsinensis* was from the stream-channel of the river Tisza at Tiszasziget. This sampling point is also close to the Romanian–Hungarian border. From this locality only one valve was detected. The chlorophyll-*a* content was 5.9 mg/l, while the "living algal number" was 1,530 ind/ml; and the relative abundance of *Surirella tientsinensis* was 0.25%. *Surirella tientsinensis* was found only in the stream-channel, it was not detected in samples near the riverbank.

DISCUSSION

Species of *Surirella* are common in the benthos, especially in epipelic habitats, across a wide range of water chemistry. Because of the extensive raphe system, species of *Surirella* have high motility as compared to other diatom genera. They are able to live within sand grains and fine sediment and can move through

the sediment by means of the raphe system (SPAULDING and EDLUND 2010). In the present study *Surirella tientsinensis* was found in all the three phytoplankton samples, but no data has been recorded from the phytobenthos. Because of the large cell size and moving ability of this diatom, it can be regarded as a member of tychoplankton instead of the euplanktic ones.

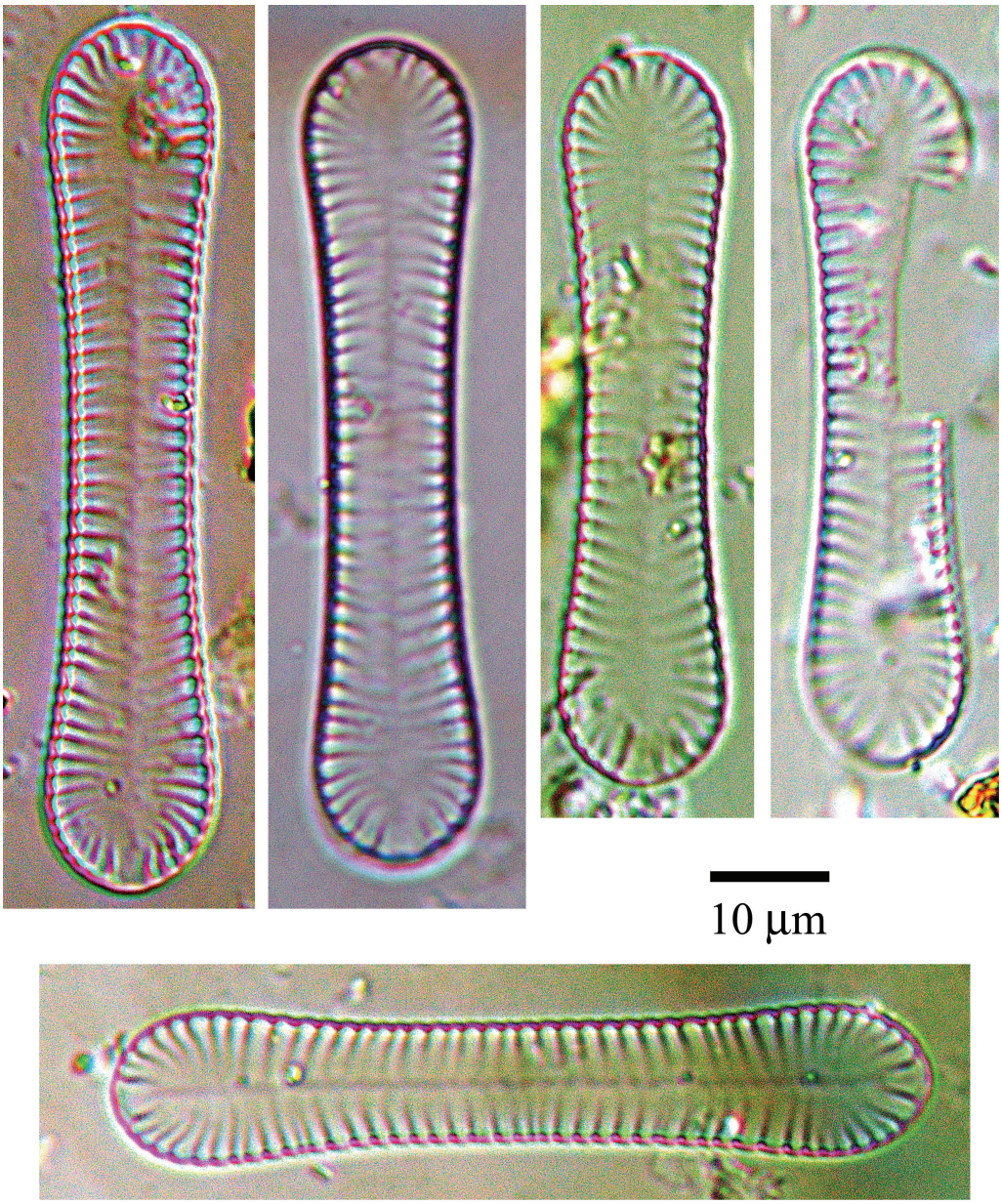

Fig. 1. *Surirella tientsinensis* from the Maros river at Nagylak collected on 5 April, 2022 (LM).

Regarding the distribution of *Surirella tientsinensis* changing in a longer time scale, its presence in Asia was confirmed from time to time (Fan and Hu 2004, Fan and Liu 2016, Proshkina-Lavrenko 1950). Nikulina and Medvedeva (2019) presented a summary of the diatom records in the southern part of the Russian Far East. Their detailed list mentions *Surirella tientsinensis* from the eastern part of the Russian Far East, namely from Primorye, the Khabarovsk, and the Sakhalin Territory (Medvedeva and Nikulina 2014). Since the first description of the species (Skvortzov 1927) it has been a member of the flora lists published in 1948, 1963, 1981, 1984, 1986, 1989, 1999, 2004, 2006, 2014 (for the detailed citation see Nikulina and Medvedeva (2019)).

Gontcharov (1996) summarised the biogeography of diatoms in the Primorsky Region of the Russian Far East and considered *Surirella tientsinensis* an endemics of Asia with some other prominent *Surirella* taxa, like *Surirella alisoviana* Skvortzov, *S. robusta* var. *hankensis* Skvortzov, and also *S. pantocsekii* F. Meister. Kharitonov (2010) detected only one valve of the taxon in three mountain oligotrophic lakes of the Amguema River Basin (Chukotka), and considered it as a very rare species, however the genus *Surirella* was highlighted as a diverse group of diatoms in the studied lakes.

Haraguchii (1997) mentioned the presence of *Surirella tientsinensis* from Lake Aoki, Central Japan, among 242 taxa, which were mainly benthic and periphytic. A light microscopic picture was also presented (p 226., fig. 42.). Later, the same author (Haraguchii 2000) reported the occurrence of *Surirella tientsinensis* from the Sugao Swamp, Central Japan.

Close to the Sea of Japan (East Sea), Obrezkova (2009) studied the distribution of diatoms around the River Amur Estuary and adjacent marine areas. She reported the presence of *Surirella tientsinensis* from surface sediment samples from the River Amur Estuary and adjacent marine areas. It was listed in the table as a rare freshwater diatom, but it was found in all the three distinguished areas.

Ukraine and Hungary are neighbouring countries, and the closest records of the occurrence of *Surirella tientsinensis* come from Ukraine. Since the end of the 20th century, its presence in Ukraine has been validated from time to time (e.g. Barinova *et al.* 2019, Bukhtiyarova 1999, Tsarenko *et al.* 1999).

Surirella tientsinensis can be found in the Omnidia softver (Lecointe *et al.* 1993), but only taxonomical, morphological features are available about the taxon without ecological implication. According to the physical description, the taxon's length range is 27–67 μm, the width is 9–14, the number of striae is 23–26 in 10 μm, while the number of fibulae is 6–7 in 10 μm. Based on our morphometric data, the length range is 59–73 μm, the width is 9–14, the number of striae is 23–26 in 10 μm, while the number of fibulae is 6–8 in 10 μm. The number of

fibulae in the description of the taxon (6–7 in 10 μm) is also a little bit smaller than the valves found in Hungarian running waters.

Based on this preliminary observation on the distribution of *Surirella tientsinensis* regarding the concentration of chlorophyll-*a* (Chl-a) our data are contradictory. The phytoplankton is one of the five biological quality elements (BQE) for the assessment of the ecological status of the rivers (Water Framework Directive 2000/60/EC). The unusually high Chl-a concentration of the river Maros implied a bad ecological status (WFD 2000), while the river Tisza was on excellent ecological status. The river Danube is usually in good ecological status (Stanković *et al.* 2023). Summarising, we could not find a correlation between the phytoplankton productivity and the occurrence of *Surirella tientsinensis* yet.

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Summary: In 2021, a relatively large, panduriform diatom appeared in the Danube, and in 2022 it was found in the rivers Maros/Mureș and Tisza. Due to its characteristic appearance, *Surirella tientsienses* (unmistakable) is plausibly new to the Carpathian region. The taxon, described in 1927 by Skvortzov from the Tiantshin Province in North China, was considered endemic to Asia by several authors. Later, its presence was detected in the Arctic lakes. At the end of the 20th century, occurrence records were reported from Central Japan and from Ukraine. Overall, however, *Surirella tientsienses* is still known as a rare species. Its appearance in Hungary and the fact that it was found in three rivers within a short period of time indicate that the species is spreading. Although algae, including diatoms, are considered cosmopolitan, broadly distributed organisms, it is clear that the patterns of communities and the biogeography of species are definite and well defined. The study of invasive species in rapidly changing living spaces is justified and necessary.

Összefoglaló: 2021-ben a Dunában, 2022-ben a Marosban és Tiszában jelent meg egy viszonylag nagytestű, piskótaformájú kovaalga. A *Surirella tientsienses*-ként határozott diatóma nagyon karakteres megjelenése miatt (összetéveszthetetlen) hihetően valóban új a Kárpáti régióban. Az 1927-ben, Észak Kínából, Tientsin tartományból, Skvortzov által leírt taxont több szerző is sokáig Ázsiára nézve endemikusnak tartotta. Később az arktikus területeken mutatták ki a jelenlétét. A 20. század végén Japán középső részéről és Ukrajnából közöltek róla előfordulási adatokat. Összességében azonban a *Surirella tientsienses* jelenleg is ritka fajként ismert. Magyarországi megjelenése, és az, hogy rövid időn belül 3 különböző folyóból is előkerült, arra utal, hogy a faj terjedőben van. Bár az algákat és ezen belül a kovaalgákat is kozmopolita, széles elterjedésű szervezeteknek tartják, egyértelmű, hogy a közösségek mintázata, a fajok biogeográfiája határozott, jól definiált. Az invazív fajok vizsgálata a gyorsan változó életterekben indokolt és szükséges.

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