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Surirella barrowcliffia Donkin 1869 (Bacillariophyta, Surirellaceae): the first observation of the diatom in Poland

by

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Abstract

Diatoms of the genus *Surirella* are considered to be a very diverse group, many of them are endemic species found in old lakes as well as in tropical regions worldwide. This study describes a new location of *Surirella barrowcliffia*. In 2005-2007, algological research on the taxonomic composition of benthic diatoms was conducted in the middle section of the Pilica River (Central Poland). A total of 23 benthic samples were collected from a single sampling site located in the town of Sulejów (159.8 km upriver). Altogether 242 diatom species were identified in the collected material. One of the most interesting taxa in this community was *S. barrowcliffia*. According to the information available in the world's algological databases, such as Algaterra and AlgaeBase, *S. barrowcliffia* has so far been found only in England, France, Finland, northern Germany – in the Weser and the Kleine Wumme rivers, near Bremen, and in Romania in the Crapina-Jijila lake complex. *S. barrowcliffia* has not been recorded in the previous research conducted not only in the middle section of the Pilica River, but also in other Polish aquatic ecosystems.

Key words: *Surirella barrowcliffia*, benthic diatoms, Pilica River, species diversity

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Introduction

The *Surirella* genus (Turpin 1828: 362, 363) is considered to be one of the oldest ones. The name "Surirelle" appeared for the first time in a general diatomological description by Turpin (1828: 362: 363) as *Surirella striatula* (Turpin 1828: 363, pl. 15, 1-8). The genus *Surirella* includes over 630 taxa (species, varieties and forms) (Fourtanier & Kociołek 2011; Guiry & Guiry 2015).

In Europe, only 54 species have been reported so far (Krammer & Lange-Bertalot 1988). In recent years, new species of *Surirella* have been described mainly from equatorial regions such as Indonesia (Bramburger et al. 2006; 11 species) and Africa (Metzeltin & Lange-Beltalot 2002; Cocquyt & Jahn 2005; 2007a,b; 6 species). In North America, *Surirella* is a very rare genus with only six species – *Surirella acredula, S. adumbratus, S. alicula, S. barca, S. stalagma, S. stiri* and one variety – *S. striatula* var. *spinifera* described by Hohn and Hellerman (1963, 1966). In the next 10 years, Lowe (1973) described two more species from Iowa: *Surirella iowensis* Lowe and *S. stoermerii* Lowe (Lowe 1973). Only one new species (*Surirella lacrimula*) has been recently added to this list from Virginia, the USA (Vesela & Potapova 2014).

In the Acadia National Park, Maine, the USA, two very interesting species of *Surirella* were found. At first they seemed to be new to science, but careful examination under light and scanning electron microscopes revealed that these were extremely rare species (*Surirella cruciata* and *S. terryi* Terry) recorded more than 100 years ago (Schmidt et al. 1874-1959; Terry 1907), which have not been reported ever since.

Diatoms of the *Surirella* Turpin genus can be found in all climate zones on all continents. Taxa from this genus occur in all marine, brackish and freshwater environments (Van Heurck 1880; Cleve-Euler et al. 1952; Krammer & Lange-Bertalot 1988; Hartley et al. 1996).

Due to the unique nature of *Surirella barrowcliffia* and the fact that it is one of the rarest species, the main objective of this paper was to present the first observation of the diatom in Poland.

Materials and methods

The Pilica River is located in Central Poland in the Łódź Province (Fig. 1). It is 342 km long and is the longest tributary of the Vistula. The sources of the Pilica are located in the Kraków-Czestochowa Upland, close to the village of Wola Kącikowa. The Pilica flows into the Vistula at 457 km upriver, near the village of

Figure 1

Location of the Pilica River in Poland

Potycz. The catchment area of the Pilica is over 9245 km^2. The research was conducted at one selected sampling site – Sulejów [N: 51°20'58.18'', E: 19°52'52.04'' PUWG (State Geodetic Coordinate System) 1992] (Fig. 2).

Samples were collected at the selected sampling site once a month for a period of 24 months from October 2005 to September 2007. Diatom samples

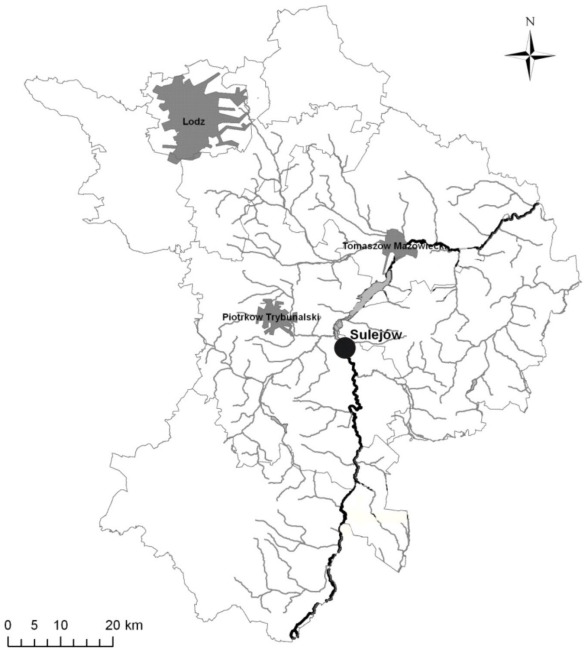

Figure 2

Location of the sampling site on the Pilica River (sampling site is marked with a black spot)

were collected from benthic sediments using a single volume pipette (25 cm^3) and a rubber bulb. The collected material was poured into opaque bottles of 40 ml each. Samples were preserved in 4% formalin. Then, the collected samples were subjected to chemical reactions (mixture of chromic and sulfuric acids in the ratio of 1:2) to erase any organic contamination and to remove the cell contents so that the frustules of diatoms were empty. Next, permanent slides were prepared using a few drops of a washed sample and synthetic mounting medium Naphrax of refractive index 1.65. Diatom taxa from permanent slides were identified following the study by Krammer and Lange-Bertalot (1988). A light microscope (NIKON Eclipse 50i) with Plan 100×/1.25 immersion lens and 10x ocular lens was used to identify diatoms in the collected material. Scanning photos were made using a SEM microscope EVO 50. The SEM microscope allows you to observe all details of diatom valves that are needed for correct identification. To use the scanning electron microscope, a drop of a thoroughly washed sample was placed onto a cover slip and left to dry. The dry cover slip was then attached to a metal stub. A thin gold or gold/palladium coating was applied to the cover slip and specimen by sputtering or by evaporation under vacuum. This process is essential to ensure a good electrical contact between the stub itself and a thin metal coating. The gold film on the cover slip provides greater contrast and sharpness of photos (Round et al. 1990).

Analyses of physicochemical parameters were conducted by a laboratory of the Provincial Environmental Protection Inspectorate in the city of Łódź. The water quality was assessed on the basis of 13 parameters: water temperature, pH, BOD5, COD-Cr, dissolved oxygen, Kjeldahl nitrogen, total nitrogen, nitrates, nitrites, total phosphorus, phosphates, conductivity and chlorides (Table 1). The assessment of the physicochemical parameters was conducted in accordance with the regulations of the Minister of the Environment of 9 November 2011 on the classification of the ecological status, ecological potential and chemical status of surface water bodies [Dz.U. (Journal of Laws) No. 258, item 1549 of 2011].

Results

Taxonomy:

Division: Bacillariophyta
Subdivision: Bacillariophytina Medlin & Kaczmarska (2004)
Class: Bacillariophyceae Haeckel 1878 (emended diagnosis Medlin & Kaczmarska 2004)
Order: Surirellales Round, Crawford & Mann (1990)
Family: Surirellaceae Kützing (1844)
Genus: *Surirella* Turpin 1828
Surirella barrowcliffia Donkin 1869 (Figs 1-15)

Table 1

Physical and chemical characteristics of water in the Pilica River

Parameter	Unit	03-10-2005	07-11-2005	05-12-2005	03-07-2006	01-08-2006	04-09-2006	02-10-2006	04-12-2006	09-07-2007	07-08-2007	10-09-2007
Water temperature	°C	13.7	7.5	3.7	19.4	20.4	17.3	15.3	5.4	20.6	20.8	15.0
pH	-	7.7	7.7	8.0	8.0	8.0	7.8	7.6	8.1	8.1	8.1	8.1
Dissolved oxygen	mg O_2 l^{-1}	9.6	10.9	12.0	8.2	7.9	8.9	9.5	10.9	9.3	8.76	8.89
BOD5	mg O_2 l^{-1}	3.4	4.1	3.6	2.1	5.1	2.0	2.7	2.4	3.1	5.6	1.9
COD-Cr	mg O_2 l^{-1}	12.0	19.7	16.0	36.0	22.0	16.9	36	12.8	23.0	16.5	16.0
Kjeldahl nitrogen	mg N l^{-1}	0.67	0.45	0.46	0.71	0.64	0.35	0.28	0.63	0.79	0.24	0.55
Nitrates	mg NO_3 l^{-1}	3.45	4.15	5.30	5.30	1.90	3.71	4.42	7.52	2.16	3.05	0.66
Nitrites	mg NO_2 l^{-1}	0.013	0.016	0.036	0.03	0.03	0.026	0.016	0.033	0.016	0.013	0.01
Total nitrogen	mg N l^{-1}	1.5	1.4	1.7	1.9	1.1	1.2	1.3	2.3	1.3	0.93	1.2
Phosphates	mg PO_4 l^{-1}	0.09	0.08	0.07	0.11	0.12	0.13	0.15	0.09	0.12	0.12	0.11
Total phosphorus	mg P l^{-1}	0.03	0.05	0.05	0.08	0.05	0.07	0.06	0.07	0.13	0.05	0.05
Conductivity	µS cm^{-1}	366.0	358.0	391.0	369.0	360.0	348.0	366.0	361.0	353.0	348.0	335.0
Chlorides	mg Cl l^{-1}	9.8	11.2	11.8	12.2	10.6	12.1	12.5	11.7	10.3	12.1	10.4

Observations and species description:

Measurements of 100 valves of *Surirella barrowcliffia* were made during the research so that the results were reliable.

Under LM and SEM, frustules were rectangular in girdle view with alar wings. Both valves in surface views were elongated, narrow, moderately concave in the central area, which was becoming more visiblein the head and foot poles. Valves were isopolar, panduriform in marginal and surface view (Fig. 3, photo 1), with a clear stenosis in the central part of the cell and with four equidistant, expanded, flexed alae. In the surface view, apices were rounded with a central notch; alae were expanded backward, panduriform, strongly carinated; plicae (canaliculi) were transverse, wide and semi-cylindrical, widening toward the carinae. Carinae (points of flexure) are sinuously constricted in the middle and rounded toward the truncated apices (Donkin 1869) (Fig. 4).

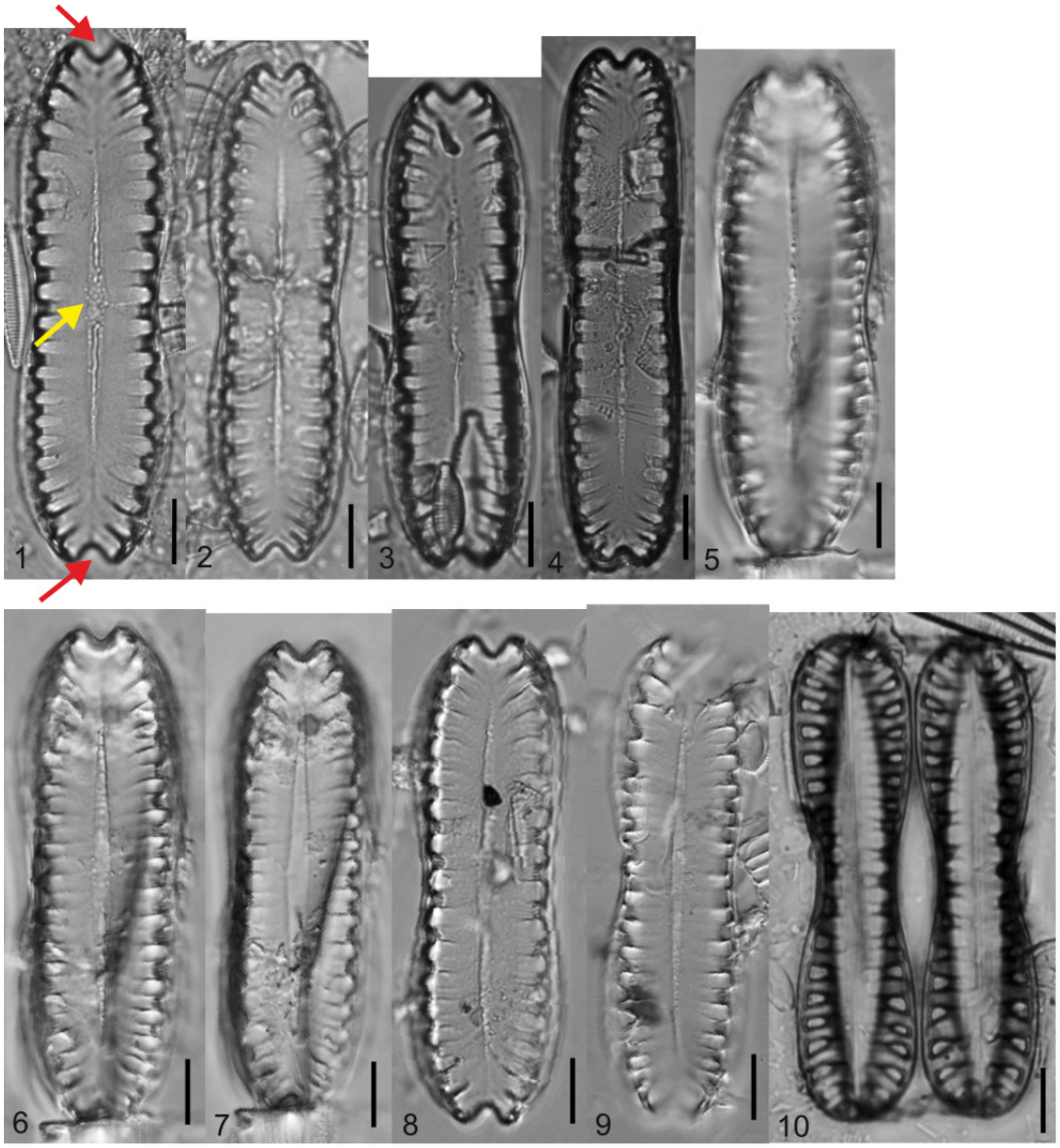

Figure 3

Surirella barrowcliffia. LM micrographs from the type locality

Photos 1-4 and 10 individuals from the Pilica River. Photos 5-9 – individuals from the Hustedt collection (Photos 5-7 No. H 76878 – slide number 143/33; Photo 8 No. H 93219 – slide number X7/12; Photo 9 No. H 83213 – slide number X1/37). Scale bars = 10 µm

Photo 1 shows isopolar valves (marked with red arrows) and a narrow-lanceolate hyaline axial area (marked with yellow arrow).

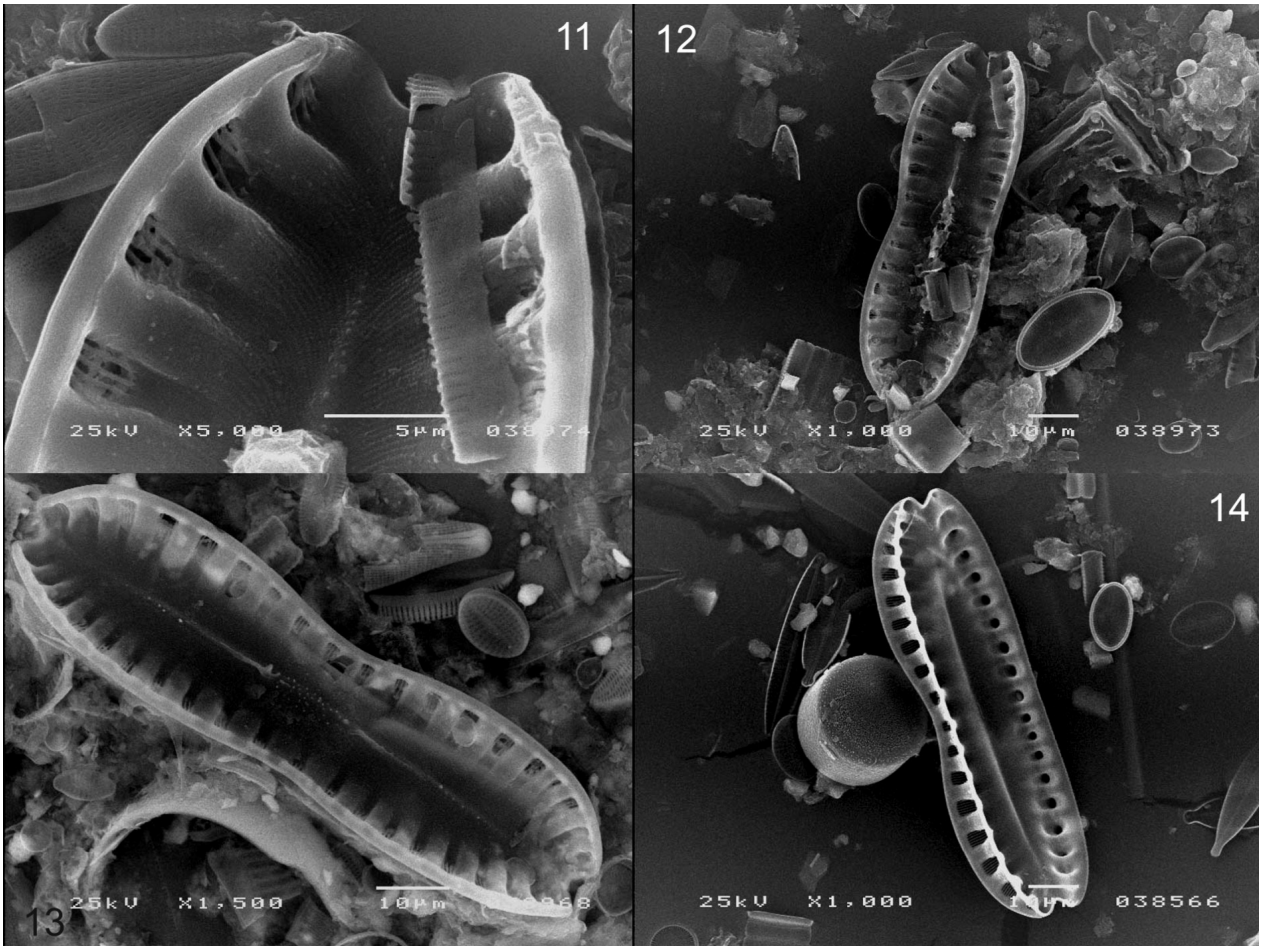

Figure 4

Photos 11-14. *Surirella barrowcliffia*, SEM micrographs of individuals from samples collected from the Pilica River

A narrow-lanceolate hyaline axial area was present in the center of the valve, along the apical axis (Fig. 3, photo 1). Porcae or transapical undulations were usually slightly alternately facing each other on either side of the apical axis. Porcae or transapical undulations were nearly regularly spaced, 20-25 in 100 µm.

The length of valves was in the range of 74-110 µm, the width ranged from 20 to 30 µm, the medium length of measured valves was 86.4 µm and the medium width was 24.3 µm (Fig. 3). According to the study by Krammer and Lange-Bertalot (1988), the length of *S. barrowcliffia* is within the range of 60-135 µm and the width within the range of 23-40 µm, while the number of wing canals ranges from 20 to 25 in 100 µm.

The panduriform outline of the species, in every aspect in which the frustule can be viewed, together with the notched apices of the valves, immediately distinguishes it from every other member of the genus, making it impossible to be misidentified.

Abundance of the species: A total of 242 diatom taxa were identified during the research in 23 microbenthic samples collected from the Pilica River. The following diatom taxa were dominant at this sampling site: *Achnanthidium minutissimum* var. *affinis, Amphor ovalis, Cocconeis neodiminuta*, *Geissleria decusis, Gomphonema parvulum* var. *parvulum* f. *parvulum, Meridion circulare* var. *circulare*, *Navicula capitatoradiata, N. gregaria, N. novasiberica, Nitzschia palea, Pseudostaurosira brevistriata, Staurosirella leptostauron, Ulnaria ulna*. Of all the identified taxa, special attention was paid to *Surirella barrowcliffia* Donkin 1869, which occurred in October, November, December 2005, and in January, July, August, September, October and December 2006, and in July, August and September 2007. The percentage of valves in a sample ranged from 1 to 3%, depending on the month.

Ecology and distribution: The species occurs mainly in European oligotrophic waters of low electrolyte content. The Pilica River at the Sulejów sampling site,

where the species has been identified, is classified as an eutrophic river with moderate ecological status (water quality class III according to the regulation of the Minister of the Environment of 9 November 2011 on the classification of the ecological status, ecological potential and chemical status of surface water bodies (Dz.U. No. 258, item 1549 of 2011). The conditions of the river at the sampling site are relatively natural. The species *Surirell didyma* Kützing is similar in morphological structure, but it occurs in waters with high levels of electrolytes.

The epitype is designated on slide 143/33, X1/37, X7/12 from the Hustedt Collection, BRM (Fig. 3).

Discussion

Considering the frequency of occurrence of species from the *Surirella* genus in Polish freshwaters, it should be assumed that they can be found in almost all kinds of aquatic ecosystems such as springs, rivers, lakes and reservoirs (Kadłubowska et al. 1981; Wojtal et al. 2005; Żelazna-Wieczorek 2011; Noga et al. 2013; Szczepocka & Rakowska 2015), both in natural and eutrophic ecosystems (Picińska-Fałtynowicz 2007; Maciejczak & Czerwik-Marcinkowska 2010; Dembowska 2014). A large number of other *Surirella* species are also present in the Pilica River, such as: *Surirella biseriata, S. tugrida, S. ovalis, S. robusta* (Kadłubowska 1964a,b,c; Kalinowska-Kucharska & Ligowski 1976). One of the most interesting taxa is *Surirella barrowcliffia* Donkin 1869, which so far has never been reported from Poland. From the information available in the world's algological databases, such as Algaterra and AlgaeBase, it appears that *Surirella barrowcliffia* has already been reported from England (Whitton et al. 2003) (freshwater of the Coquet River in Northumberland, England, in 1869 by Donkin), in the Crapina-Jijila lake complex in Romania (Caraus 2012), France (Amossé 1932) as well as in Finland (Tynni 1980) and in northern Germany, near Bremen in the Weser and the Kleine Wumme rivers (notes by Hustedt 1910; 1955; 1956 from the Hustedt Collection, BRM; Hustedt 1957; Ludwig & Schnittler 1996). The species has also been found in the Baltic Sea region, but it was identified as a fossil species (Krammer, Lange-Bertalot 1988). According to the identification key by Krammer and Lange-Bertalot (1988), *S. barrowcliffia* prefers oligotrophic waters with low levels of electrolytes. The Pilica River, in which this species has been identified, is classified as an eutrophic river with moderate ecological status (water quality class III). However, at some distance from the sampling site, there is a limestone mine that may affect the pH of water at the site. The water there is slightly alkaline, and consequently, the conditions might be more favorable for the occurrence and reproduction of *S. barrowcliffia*.

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