

## Diatoms of the Dojkinci River (Stara Planina Nature Park, Serbia)

JELENA KRIZMANIĆ<sup>1\*</sup>, MARIJA ILIĆ<sup>2</sup>, DANIJELA VIDAKOVIĆ<sup>1</sup>,  
GORDANA SUBAKOV-SIMIĆ<sup>1</sup>, JELENA PETROVIĆ<sup>1</sup>, KATARINA CVETANOVIĆ<sup>3</sup>

<sup>1</sup> University of Belgrade, Faculty of Biology, Institute of Botany and Botanical Garden  
»Jevremovac«, 43 Takovska, 11000 Belgrade, Serbia

<sup>2</sup> University of Belgrade, Institute for Biological Research »Siniša Stanković«,  
142 Bulevar despota Stefana, 11060 Belgrade, Serbia

<sup>3</sup> University of Belgrade, Faculty of Chemistry, 12–16 Studentski trg,  
11000 Belgrade, Serbia

**Abstract** – Diatom samples were collected during July 2010 at 15 localities from different types of substrate (stone surfaces, sand, mud, filamentous algae and submerged mosses) from the Dojkinci River. During the research period, 124 taxa were determined within 43 genera. Among numerous common diatoms we recorded three taxa for the first time in Serbia: *Brachysira intermedia* (Øst.) Lange-Bertalot, *Chamaepinnularia mediocris* (Krass.) Lange-Bertalot and *Navicula tridentula* Krass. Also, we observed 21 taxa which are rarely recorded taxa for Serbia. The most interesting was *Diatomella balfouriana* Grevill. that was previously known only from the River Tisa near Titel. In the studied material, it was identified only in samples collected from the surface of boulders with mosses at the third locality. Their morphology, distribution and ecology are presented in this paper.

**Key words:** *Brachysira intermedia*, *Chamaepinnularia mediocris*, *Diatomella balfouriana*, diatoms, distribution, Dojkinci River, *Navicula tridentula*.

### Introduction

In lotic ecosystems, diatoms are considered to be the most diverse group of algae (ROUND et al. 1990). Regularly found diatom species in European freshwater habitats have well known ecological preferences (VAN DAM et al. 1994, COSTE et al. 2009). However, data about the distribution and ecology of diatom species that are rarely observed may be incomplete (e.g. WOJTAL 2001, 2004, SZABO et al. 2007, VAN DE VIJVER and LANGE-BERTALOT 2009, KELLY et al. 2009, ANDREJIĆ et al. 2012). As diatoms are very important indicators of

---

\* Corresponding author, e-mail: kjelena@bio.bg.ac.rs

environmental changes and for the biological monitoring of lotic ecosystems (STEVENSON and PAN 1999, BERE and TUNDISI 2010), it is of great significance to describe their prevalence and ecology as well as possible.

The mountain Stara planina (Balkan mountain) belongs to the system of Balkan mountains which ranges from Black Sea in the east to Vrška Čuka in the west (MARKOVIĆ 1980). It is one of the floristically and faunistically most diverse parts of Serbia and the entire Balkan Peninsula. The overall richness and diversity of species, as well as the presence of numerous endemic and relic forms point to a specific genesis that influenced the remarkable diversity of this mountain, which makes it distinct from other parts of the Balkans and Europe from the biogeographical aspect.

In 1997, at the suggestion of the Institute for Nature Conservation of Serbia, the Government of the Republic of Serbia adopted the Regulation on the Protection of Stara Planina Nature Park which put Stara Planina under protection as a natural resource of great importance, and led to its being placed within the first category of protection (MIJOVIĆ 2001). The total protected area of Stara Planina Nature Park is about 114.332 ha and it has a three-level system of protection (the first degree of protection is applied to an area of 3.680 ha, or 3.23%; the second degree of protection applies to an area 20.159 ha, or 17.63%, and the third degree of protection to an area 90.493 ha, or 79.14%) (OFFICIAL GAZETTE RS, 2009). Stara Planina Nature Park is a protected natural resource nominated for the Program »Man and the Biosphere« (UNESCO-MAB) (IVANČEVIĆ et al. 2007).

The Dojkinci River is formed by the merging of two streams: Belčin Dol and Tri kladenca. It is about 25 km long and ends in its confluence with the Jelovička River. This way the Visočica River is formed which belongs to the Black Sea basin. The substrate through the longest part of the Dojkinci River runs is red fine-grained sandstone, whose color comes from the large amount of Fe<sub>2</sub>O<sub>3</sub> and is extremely rich in quartz sand (ANDJELKOVIĆ 1958), as opposed to most of rivers in Serbia, which have their beds made dominantly of carbonate (MARKOVIĆ 1980). These siliceous, low-conductivity mountain habitats are currently being shown to host benthic diatom communities of high species richness (CANTONATI and LANGE-BERTALOT 2011, CANTONATI et al. 2011, LIU et al. 2011).

The morphology, distribution and ecology of algal flora of Stara planina is poorly known (SIMIĆ 1995, 1996, 2002), especially for diatoms from Dojkinci River (OBUŠKOVIĆ 1993, OBUŠKOVIĆ et al. 1994).

In this paper, we present the results of a floristic study of the diatoms of the Dojkinci River (Stara planina, Serbia). Among numerous common diatoms three new taxa for Serbia were identified, as well as 21 taxa that are rarely recorded in Serbia.

## Materials and methods

During July of 2010 the material which is used in the present study was collected from 15 localities along the Dojkinci River. From the gravel surface and boulders epilithic samples were scraped by scalpel blade and brush. Epipsamic samples were collected from the surface of sand and mud substrates, while the epiphyton was taken from mosses *Plagiomnium* sp. and *Philonotis* sp. and liverwort *Marchantia polymorpha* Line subsp. *polymorpha*. Samples were immediately fixed with formaldehyde to a final concentration of 4%. In order to remove organic matter, field samples were treated with concentrated acid (H<sub>2</sub>SO<sub>4</sub>) and

KMnO<sub>4</sub>, and then washed several times with distilled water in a laboratory. Afterwards the material was airdried on cover glasses and mounted in Naphrax<sup>®</sup>. Permanent slides, prepared material and aliquots of the samples were deposited in the diatom collection of the University of Belgrade, Faculty of Biology. Light microscope observations and micrographs were made using a Zeiss AxioImagerM.1 microscope with DIC optics and AxioVision4.8 software. Conductivity, oxygen, pH and water temperature were measured with a Lovibond Multimeter WTW 340i at each sampling site. Ammonium ions, nitrates, phosphates, alkalinity and total hardness were measured using a Lovibond MultiDirect Photometer.

Terminology of valve morphology is based according BARBER and HAWORTH (1981) and ROUND et al. (1990). The abundance was estimated by counting 400 valves of each taxa present on a slide.

Sampling sites along with levels of protection in Stara Planina Nature Park are presented on the map (Fig. 1).

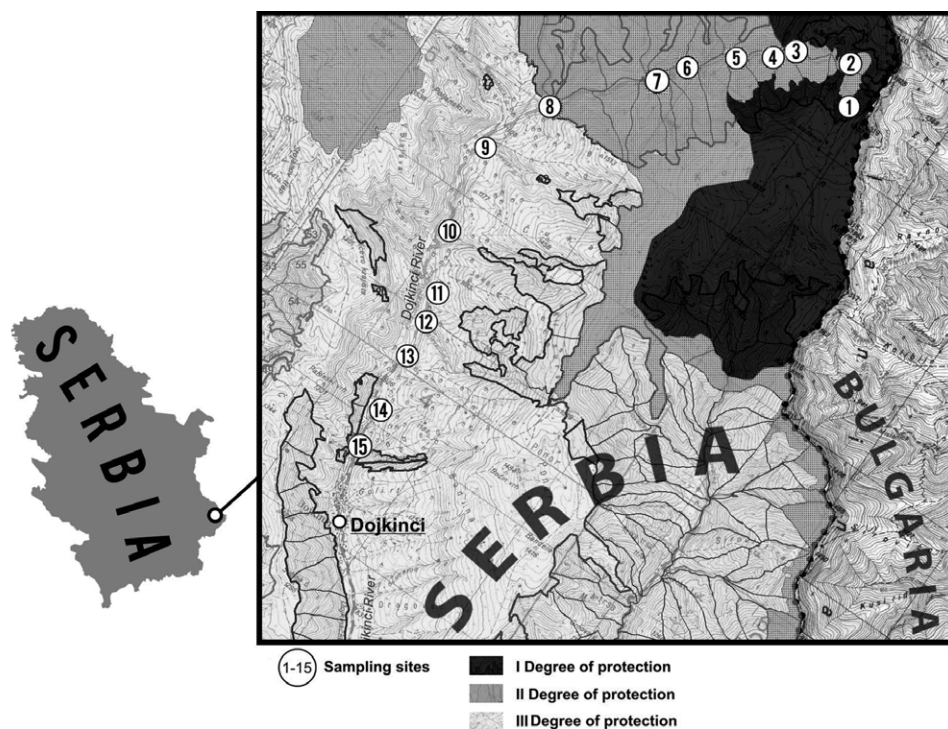


Fig. 1. Sampling sites along the Dojkinci River with levels of protection in Stara Planina Nature Park.

## Results

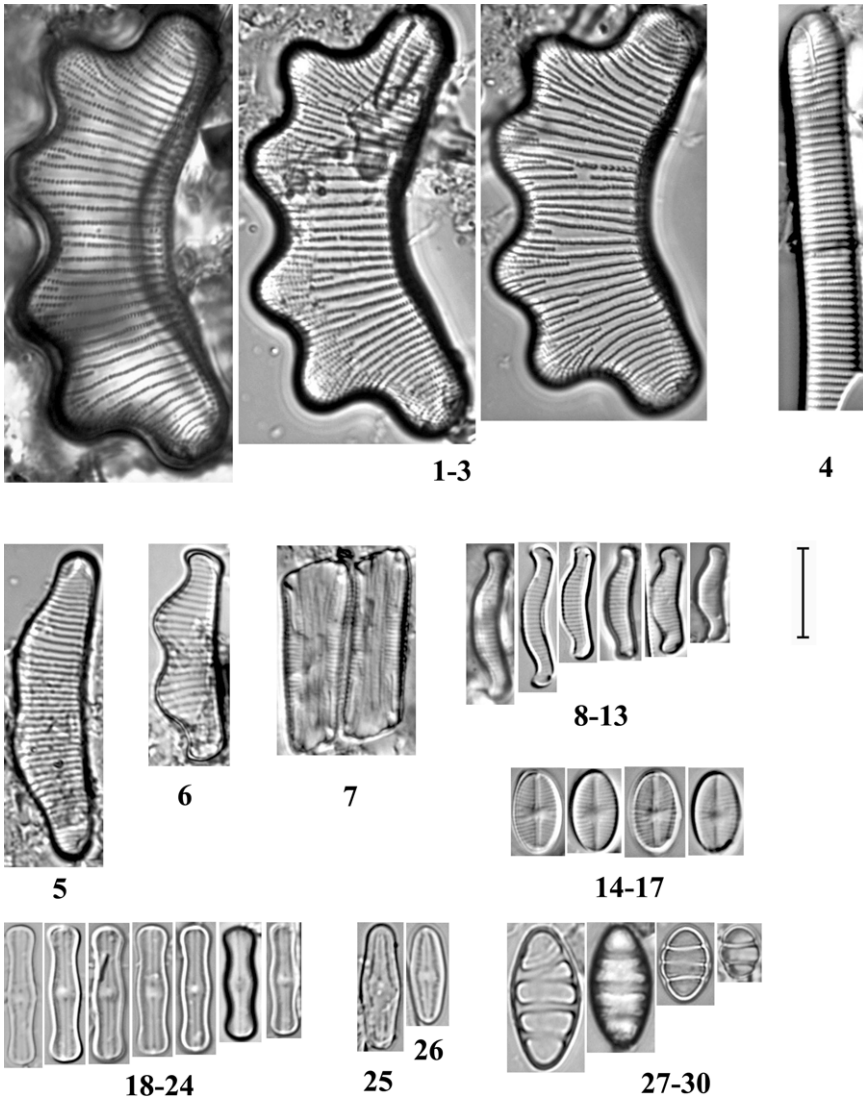
A total of 125 diatom taxa (Tab. 1) belonging to 43 genera were determined in material from the Dojkinci River. The genus with the highest number of species was *Eunotia* Ehrenberg with 18 taxa. *Eunotia paludosa* was the dominant taxon with an abundance of as much

**Tab. 1.** Diatom species list from Dojkinci River.

<i>Achnanthes coarctata</i> (Brébisson) Grunow	<i>Frustulia saxonica</i> Rabenhorst
<i>Achnantheidium exile</i> (Kützing) Heiberg	<i>Frustulia vulgaris</i> (Thwaites) De Toni
<i>Achnantheidium lineare</i> W. Smith	<i>Geissleria decussis</i> (Østrup) Lange-Bertalot & Metzeltin
<i>Achnantheidium microcephalum</i> Kützing	<i>Gomphonema acuminatum</i> Ehrenberg
<i>Achnantheidium minutissimum</i> (Kützing) Czarnocki	<i>Gomphonema exilissimum</i> (Grunow) Lange-Bertalot & E. Reichardt
<i>Amphora</i> sp.	<i>Gomphonema gracile</i> Ehrenberg
<i>Aulacoseira</i> sp.	<i>Gomphonema micropus</i> Kützing
<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen	<i>Gomphonema parvulus</i> (L.-B. & Reichardt) Lange-Bertalot & Reichardt
<i>Brachysira brebissonii</i> R. Ross	<i>Gomphonema parvulum</i> (Kützing) Kützing
<i>Brachysira intermedia</i> (Østrup) Lange-Bertalot	<i>Gomphonema pumilum</i> (Grunow) E. Reichardt & Lange-Bertalot
<i>Caloneis silicula</i> (Ehrenberg) Cleve	<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow
<i>Chamaepinnularia mediocris</i> (Krasske) Lange-Bertalot & Krammer	<i>Humidophila contenta</i> (Grunow) Lowe et al.
<i>Cocconeis pediculus</i> Ehrenberg	<i>Humidophila ingeae</i> (Van de Vijver) Lowe et al.
<i>Cocconeis placentula</i> Ehrenberg	<i>Humidophila perpusilla</i> (Grunow) Lowe et al.
<i>Cocconeis placentula</i> var. <i>lineata</i> (Ehrenberg) van Heurck	<i>Luticola mutica</i> (Kützing) D.G. Mann
<i>Cocconeis placentula</i> var. <i>pseudolineata</i> Geitler	<i>Melosira varians</i> C. Agardh
<i>Cymbatopleura solea</i> (Brébisson) W. Smith	<i>Meridion circulare</i> (Greville) C. Agardh
<i>Cymbella compacta</i> Østrup	<i>Navicula</i> sp.
<i>Cymbella parva</i> (W. Smith) Kirchner	<i>Navicula angusta</i> Grunow
<i>Cymbella perparva</i> Krammer	<i>Navicula cryptocephala</i> Kützing
<i>Cymboplectura anglica</i> (Lagerstedt) Krammer	<i>Navicula cryptotenella</i> Lange-Bertalot
<i>Cymboplectura naviculiformis</i> (Auerswald ex Heiberg) Krammer	<i>Navicula exilis</i> Kützing
<i>Diatoma ehrenbergii</i> Kützing	<i>Navicula gregaria</i> Donkin
<i>Diatoma ehrenbergii</i> f. <i>capitulata</i> (Grunow) Lange-Bertalot	<i>Navicula lanceolata</i> Ehrenberg
<i>Diatoma hyemalis</i> (Roth) Heiberg	<i>Navicula recens</i> (Lange-Bertalot) Lange-Bertalot
<i>Diatoma mesodon</i> (Ehrenberg) Kützing	<i>Navicula reichardtiana</i> Lange-Bertalot
<i>Diatoma moniliformis</i> (Kützing) D.M. Williams	<i>Navicula tridentula</i> Krasske
<i>Diatomella balfouriana</i> Greville	<i>Navicula tripunctata</i> (O. F. Müller) Bory de Saint-Vincent
<i>Diploneis</i> sp.	<i>Neidium</i> sp.
<i>Encyonema lunatum</i> (W. Smith) Van Heurck	<i>Neidium subampliatum</i> (Grunow) Flower
<i>Encyonema silesiacum</i> (Bleisch) D.G. Mann	<i>Nitzschia</i> sp.
<i>Encyonema ventricosum</i> (C. Agardh) Grunow	<i>Nitzschia acicularis</i> (Kützing) W. Smith
<i>Encyonopsis falaisensis</i> (Grunow) Krammer	<i>Nitzschia alpina</i> Hustedt

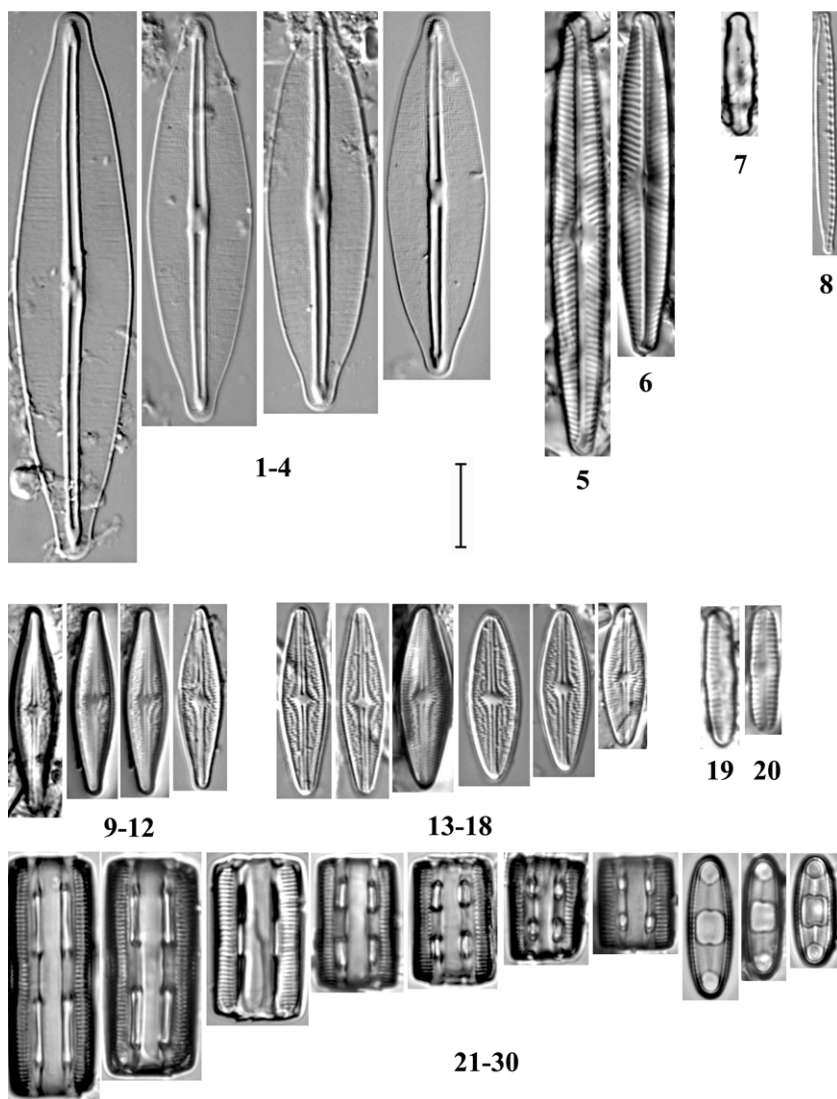
<i>Encyonopsis microcephala</i> (Grunow) Krammer	<i>Nitzschia fonticola</i> (Grunow) Grunow
<i>Epithemia adnata</i> (Kützing) Brébisson	<i>Nitzschia linearis</i> W. Smith
<i>Eunotia</i> sp.	<i>Nitzschia palea</i> (Kützing) W. Smith
<i>Eunotia bilunaris</i> (Ehrenberg) Schaarschmidt	<i>Nitzschia recta</i> Hantzsch ex Rabenhorst
<i>Eunotia boreoalpina</i> Lange-Bertalot & Nörpel-Schempp	<i>Orthoseira</i> sp.
<i>Eunotia circumborealis</i> Lange-Bertalot & Norpel	<i>Pinnularia</i> sp.
<i>Eunotia diodon</i> Ehrenberg	<i>Pinnularia acoricola</i> Hustedt
<i>Eunotia exigua</i> (Brébisson ex Kützing) Rabenhorst	<i>Pinnularia borealis</i> Ehrenberg
<i>Eunotia fallax</i> A. Cleve	<i>Pinnularia borealis</i> var. <i>rectangularis</i> Carlson
<i>Eunotia flexuosa</i> (Brébisson ex Kützing) Kützing	<i>Pinnularia microstauron</i> var. <i>nonfasciata</i> Krammer
<i>Eunotia groenlandica</i> (Grunow) Nörpel-Schempp & Lange-Bertalot	<i>Pinnularia subcapitata</i> var. <i>subrostrata</i> Krammer
<i>Eunotia minor</i> (Kützing) Grunow	<i>Pinnularia viridiformis</i> Krammer
<i>Eunotia nymanniana</i> Grunow	<i>Placoneis</i> sp.
<i>Eunotia paludosa</i> Grunow	<i>Planothidium</i> sp.
<i>Eunotia paratridentula</i> Lange-Bertalot & Kulikovskiy	<i>Planothidium frequentissimum</i> (Lange-Bertalot) Lange-Bertalot
<i>Eunotia praerupta</i> Ehrenberg	<i>Planothidium lanceolatum</i> (Brébisson ex Kützing) Bukhtiyarova
<i>Eunotia rhomboidea</i> Hustedt	<i>Psammothidium</i> sp
<i>Eunotia subherkiniensis</i> Lange-Bertalot	<i>Psammothidium subatomoides</i> (Hustedt) L. Bukhtiyarova & Round
<i>Eunotia tetraodon</i> Ehrenberg	<i>Reimeria sinuata</i> (Gregory) Kociolek & Stoermer
<i>Eunotia trinacria</i> Krasske	<i>Rhoicosphenia abbreviata</i> (C. Agardh) Lange-Bertalot
<i>Eunotia valida</i> Hustedt	<i>Stauroneis anceps</i> Ehrenberg
<i>Fallacia subhamulata</i> (Grunow) D. G. Mann	<i>Stauroneis gracilis</i> Ehrenberg
<i>Fragilaria arcus</i> (Ehrenberg) Cleve	<i>Stauroneis smithii</i> Grunow
<i>Fragilaria biceps</i> (Kützing) Lange-Bertalot	<i>Staurosirella pinnata</i> (Ehrenberg) D. M. Williams & Round
<i>Fragilaria capucina</i> Desmazières	<i>Surirella brebissonii</i> var. <i>kuetzingii</i> Krammer & Lange-Bertalot
<i>Fragilaria capucina</i> var. <i>gracilis</i> (Oestrup) Hustedt	<i>Surirella linearis</i> W. Smith
<i>Fragilaria ulna</i> (Nitzsch) Lange-Bertalot	<i>Surirella minuta</i> Brébisson
<i>Fragilaria vaucheriae</i> (Kützing) J. B. Petersen	<i>Tabellaria flocculosa</i> (Roth) Kützing
<i>Fragilariforma virescens</i> (Ralfs) D. M. Williams & Round	<i>Tetracyclus rupestris</i> (Braun) Grunow
<i>Frustulia crassinervia</i> (Brébisson) Lange-Bertalot & Krammer	

as 80% and was found on all types of substrates. Subdominant taxon was *Achnantheidium minutissimum* with the abundance of 9.28–42.13%. Of these identified taxa, three were new records to Serbia: *Brachysira intermedia*, *Chamaepinnularia mediocris* and *Navicula tri-dentula*. They were rarely distributed with very low abundance in samples. Twenty one rarely observed taxa were: *Achnanthes coarctata* (Brébisson) Grunow, *Achnantheidium exile* (Kützing) Heiberg, *Brachysira brebissonii* R. Ross (Pl. 2, Figs. 13–18), *Humidophila ingeae* (Van de Vijver) Lowe et al. (Pl. 1, Figs. 18–24), *H. perpusilla* (Grunow) Lowe et al. (Pl 1,



**Plate 1.** Light microscope micrographs. *Eunotia tetraodon* (Figs. 1–3); *E. flexuosa* (Fig. 4); *E. diodon* (Fig. 5); *E. subherkiniensis* (Fig. 6); *E. rhomboidea* (Fig. 7); *E. exigua* (Figs. 8–13); *Psammothidium subatomoides* (Figs. 14–17); *Humidophila ingeae* (Figs. 18–24); *H. perpusilla* (Figs. 25–26); *Tetracyclus rupestris* (Figs. 27–30). Scale bar = 10  $\mu$ m.

Figs. 25–26), *Diatomella balfouriana* Greville (Pl. 2, Figs. 21–30), *Eunotia diodon* Ehrenberg (Pl. 1, Fig. 5), *E. exigua* (Brébisson ex Kützing) Rabenhorst (Pl. 1, Figs. 8–13), *E. flexuosa* (Brébisson ex Kützing) Kützing (Pl. 1, Fig. 4), *E. praeurupta* Ehrenberg, *E. rhomboidea* Hustedt (Pl. 1, Fig. 7), *E. subherkiniensis* Lange-Bertalot (Pl. 1, Fig. 6), *E. tetradon* Ehrenberg (Pl. 1, Figs. 1–3), *Fallacia subhamulata* (Grunow) D.G. Mann, *Frustulia crassinervia* (Brébisson) Lange-Bertalot & Krammer (Pl. 2, Fig. 1–4), *F. saxonica* Rabenhorst, *Navicula angusta* Grunow (Pl. 2, Fig. 5–6), *Nitzschia alpina* Hustedt (Pl. 2, Fig. 8),



**Plate 2.** Light microscope micrographs. *Frustulia crassinervia* (Figs. 1–4); *Navicula angusta* (Figs. 5–6); *Navicula tridentula* (Fig. 7); *Nitzschia alpina* (Fig. 8); *Brachysira intermedia* (Figs. 9–12); *B. brebissonii* (Figs. 13–18); *Chamaepinnularia mediocris* (Figs. 19–20); *Diatomella balfouriana* (Figs. 21–30). Scale bar = 10  $\mu$ m.

*Pinnularia acoricola* Hustedt, *Psammothidium subatomoides* (Hustedt) L. Bukhtiyarova & Round (Pl. 1, Figs. 14–17) and *Tetracyclus rupestris* (Braun) Grunow (Pl. 1, Figs. 27–30). The most interesting was *Diatomella balfouriana*. The paper presents the description and distribution of four species and their ecology. Main valve measurements of the populations in the Dojkinci River are shown in Tab. 2, and chemical analyses of the water in Tab. 3.

**Tab. 2.** Main valve measurements of the four species in the Dojkinci River.

Taxon	Length (µm)	Width (µm)	Striae in 10 µm
<i>Brachysira intermedia</i>	22.13–27.3	5.18–6.26	26–27
<i>Chamaepinnularia mediocris</i>	10.26–12.74	2.81–3.02	17–20
<i>Navicula tridentila</i>	15	4.1	
<i>Diatomella balfouriana</i>	13.6–23.86	4.97–5.83	19–20

**Tab. 3.** Physico-chemical parameters of the water during sampling period.

Variable	Values
Water temperature (°C)	6.4–12.5
Altitude (m)	924–1723.5
Conductivity (µS cm <sup>-1</sup> )	213–302
pH	5.46–6.5
Hardness (mg L <sup>-1</sup> )	25–67
Total alkalinity (mg L <sup>-1</sup> )	0.1
Alkalinity P (mg L <sup>-1</sup> )	0.1
NO <sub>3</sub> -N (µg L <sup>-1</sup> )	0.635
PO <sub>4</sub> -P (µg L <sup>-1</sup> )	1.45

### Description of the three new taxa for Serbian diatom flora and one rarely observed taxon

*Brachysira intermedia* (Østrup) Lange-Bertalot in LANGE-BERTALOT and MOSER (1994) (Pl. 2, Figs. 9–12)

Description: Valves are lanceolate, gradually narrowed and at the ends almost pointed, length 22.13–27.3 µm, breadth 5.18–6.26 µm. The axial area is narrow linear near the apices, small and rhombic at the central area. The raphe is filiform. The striae are parallel, at the ends sometimes parallel to slightly convergent, 26–27 in 10 µm.

Ecology: Water temperature range from 6.4 °C to 12.5 °C, pH varied from 5.46 to 6.5 and concentrations of other nutrients were low.

Distribution (Serbia): along the upper course of the Dojkinci River (locality 1–5), on the surface of boulders, mud and on the mosses, with low abundance (0.23–0.61%), at the altitude from 1442.5 to 1723.5 m a.s.l.



***Chamaepinnularia mediocris*** (Krasske) Lange-Bertalot and Krammer in LANGE-BERTALOT and METZELTIN (1996) (Pl. 2, Figs. 19–20)

Description: Valves are linear to broadly oval, with rounded apices and a gibbous middle, length 10.26–12.74  $\mu\text{m}$ , breath 2.81–3.02  $\mu\text{m}$ . The axial area is narrow near the apices, becoming wider near the central area. The central area is a transverse fascia. The raphe is filiform and slightly arched. The striae are parallel, 17–20 in 10  $\mu\text{m}$ .

Ecology: Water temperature 12.5 °C, pH 6.5 and concentrations of other nutrients were low.

Distribution (Serbia): in the upper course of the Dojkinci River at only one locality (4) with very low abundance (0.12%), on surface of mud, at the altitude 1432 m a.s.l.

***Navicula tridentula*** Krasske (1923) (Pl. 2, Fig. 7)

Description: Valve is linear, triundulate, with capitate ends, length 15  $\mu\text{m}$ , breath 4.1  $\mu\text{m}$ . The axial area is very narrow, linear, central area is variables size, often difficult to see. The raphe is filiform.

Ecology: Water temperature 12.5 °C, pH 6.5 and concentrations of other nutrients were low.

Distribution (Serbia): in the lower course of the Dojkinci River at locality 11, only one specimen, on surface of sand at the altitude of 1015.5 m a.s.l.

***Diatomella balfouriana*** Greville (1855) (Pl. 2, Figs. 21–30)

Description: Valves are linear with rounded apices, length 13.6–23.86  $\mu\text{m}$ , breath 4.97–5.83  $\mu\text{m}$ . The axial area is wide. The raphe is filiform, with dilated external proximal raphe ends that terminate relatively distant from one another. The striae are short and parallel to radiate, 19–20 in 10  $\mu\text{m}$ . The general character of this species is a septum which is present on each valvocopula. The septum extends the entire length of the valve and has three large openings, the largest in the center and two smaller at the ends.

Ecology: Water temperature 12.5 °C, pH 6.5 and concentrations of other nutrients were low.

Distribution (Serbia): in the upper course of the Dojkinci River at only one locality (3) with an abundance of 23.78%, on surface of boulders with mosses, at the altitude 1503.5 m a.s.l.; Tisa River at Titel (SZABADOS 1966).

## Discussion

The main purpose of the study was to collect records on diatom assemblages from the Dojkinci River, which has a bottom substrate (red sandstone) unusual when compared with the substrates of other rivers in Serbia.

In many mountainous areas of the word the highest elevations are reached on siliceous crystalline mountain ranges. These sites are often pristine, relatively remote, and included in nature preserves because of their value for biodiversity conservation, recreation, and as storages of good-quality water (CANTONATI and LANGE-BERTALOT 2011). Stara Planina Nature Park has similar characteristics and very rich valuable flora and fauna with an important role in biodiversity conservation in Serbia, as well as, in the Balkan Peninsula.

The diatom flora of Dojkinci River was mainly formed by acidophilic, limno-terrestrial, moss-inhabiting, widely distributed species. The large development of acidophilic species is related to siliceous riverbed rocks of the Dojkinci River. The dominant diatom genus in the Dojkinci River was *Eunotia*, with 18 taxa. According to LANGE-BERTALOT et al. (2011) the genus *Eunotia* is mainly restricted to freshwater oligotrophic and oligosaprobic habitats, which enables it to play an important role as indicator in water monitoring (ALLES et al. 1991, KWANDRANS 2007). Physico-chemical conditions of the Dojkinci River are suitable for dominance of different *Eunotia* species. According to PAVLOV and LEVKOV (2013) and WOJTAL et al. (1999) *E. paludosa* was established as dominant taxon in the samples taken from the mud substrates and from mosses.

*Achnantheidium minutissimum* is one of the most frequently occurring diatoms in freshwater benthic samples globally (PATRICK and REIMER 1966; KRAMMER and LANGE-BERTALOT 1991; POTAPOVA and HAMILTON 2007; HOFMANN et al. 2013). This species has been reported from different type of waters, alkaline and acidic, oligotrophic and hypertrophic (VAN DAM et al. 1994; POTAPOVA and HAMILTON 2007).

*Brachysira intermedia* is widespread in waters of mountain regions on silica surfaces with low electrolyte content and in oligo- to dystrophic waters. According to LANGE-BERTALOT and MOSER (1994) and HOFMANN et al. (2013), valve length is 25–33 µm, valve breadth 5–6.5 µm, striae 26–30 in 10 µm. Valve measurements in our samples were similar to those in the literature.

*Chamaepinnularia mediocris* can be found in oligo- to dystrophic freshwaters of mountain regions (springs, streams and lakes) on silica substrates. According to VAN DAM et al. (1994), *C. mediocris* is an acidophilic species, mainly occurring at pH < 7. HOFMANN et al. (2013) state that this species prefers moderately acidic waters. Our results showed that the water of the Dojkinci River is moderately acidic (pH was 6.5) at the site at which this alga was recorded. *C. mediocris* mainly occurs on wet and moist or temporarily dry places. FRÁNKOVÁ et al. (2009) found *C. mediocris* in *Sphagnum* fens, as did KAPETANOVIĆ et al. (2011). Also, BUCZKÓ and WOJTAL (2005) and VAN DE VIJVER and BEYENS (1997) found this species on different type of mosses. In our sample *C. mediocris* was found on a mud substrate, at an altitude of 1432 m a.s.l., which is higher than that shown by KAPETANOVIĆ et al. (2011) (at an altitude 930 m a.s.l.). Researches of BUCZKÓ and WOJTAL (2005) noted *C. mediocris* along with *Eunotia exigua* which is complementary with our findings. Morphological data show that the valve is 9–16 µm long, 2–3 µm wide and has 20–30 striae in 10 µm (HOFMANN et al. 2013). According to VESELA and JOHANSEN (2009), valve length is 10–12 µm, valve breadth 2.7 µm, striae 18–21 in 10 µm. Valve measurements in our samples were similar those in literatures.

*Chamaepinnularia mediocris* is known from: Strømness Bay area, South Georgia, Antarctica (VANDEVIJVER and BEYENS 1997); Laurentian Great Lakes (STOERMER et al. 1999); Hungary (BUCZKÓ and WOJTAL 2005, BUCZKÓ 2006); Great Smoky Mountains National Park, USA (JOHANSEN et al. 2007); Penza oblast, European Russia (KULIKOVSKII 2008); Elbsandsteingebirge region, Czech Republic (VESELA and JOHANSEN 2009); Western Carpathian spring fens, between the Czech Republic and Slovakia (FRÁNKOVÁ et al. 2009); Mt. Zvijezda near Sarajevo, Bosnia and Herzegovina (KAPETANOVIĆ et al. 2011); lakes in the Azores archipelago, Portugal (PEREIRA et al. 2014).

*Navicula tridentula* has cosmopolitan widespread, sporadically at typical habitat, such as springhead of stream, peat bogs, swamp. KRAMMER and LANGE-BERTALOT (1986) state that the species prefers fresh water with low concentrations of electrolytes. According to VAN DAM et al. (1994), *N. tridentula* is an alcalophilic species, mainly occurring at pH < 7, in wet and moist or temporarily dry places. In the Dojkinci River *N. tridentula* was found at one locality at pH 6.5, on a sandy surface. In Thailand (LEELAHAKRIENGKRA 2013) the species was recorded at an altitude 478–489 m a.s.l., but in Dojkinci River the same species was recorded on higher altitude (1015.5 m a.s.l.). Valve measurements of the population from the Dojkinci River had similar values, as well as, values according to KRAMMER and LANGE-BERTALOT (1986): valve length 11–19 µm, breadth 3.5–4 µm, striae are not visible on LM.

*Navicula tridentula* is known from: north western United States (BAHLS 2009); western Carpathian spring fens, between the Czech Republic and Slovakia (FRÁNKOVÁ 2009); Chiang Dao District, Thailand (LEELAHAKRIENGKRA 2013).

New species for diatom flora of Serbia recorded at localities of the Dojkinci River were found with very low abundances, although they were on substratum typical for them.

A cosmopolitan species, *Diatomella balfouriana* is widespread from the Arctic to Antarctica. It is characteristic for oligo- to dystrophic boreo-alpine mountain freshwaters, with low conductivity and nutrient poor (KRAMMER and LANGE-BERTALOT 1986). However, *D. balfouriana* was recorded in temporary pools of brackish water, as well as in moist soil near the ocean round Antarctica (VAN DE VIJVER et al. 2012). Until now, there is only one published record about *D. balfouriana* for Serbia, in the Tisa River (plain river in northern part of Serbia, pH mainly occurring about 7) (SZABADOS 1966). This can be considered poorly reliable information, because there are no microphotographs which can confirm the finding. In addition, the type of substrate (mud at the bottom of the river) and pH are not typical of *D. balfouriana*. Our findings are complementary with literature data: oligo- to dystrophic freshwater, low-conductivity and nutrient-poor, boreo-alpine mountain habitats. KRAMMER and LANGE-BERTALOT (1986) states that the valve is 12–52 µm long, 6–8 µm wide and 18–21 striae in 10 µm. According to KOCIOLEK (2011), valve length is 12–40 µm, breadth is 3.5–6 µm and there are 18–22 striae in 10 µm. Valve measurements of the population from the Dojkinci River had values similar to those given by KOCIOLEK (2011), but the breadths of the valves reported here are smaller than those given by KRAMMER and LANGE-BERTALOT (1986).

### Acknowledgments

Financial support was provided by the Ministry of Education and Science of the Republic of Serbia (Project No. TR 037009).

### References

- ALLES, E., NÖRPEL-SCHEMP, M., LANGE-BERTALOT, H., 1991: Zur Systematik und Ökologie charakteristischer *Eunotia*-Arten (Bacillariophyceae) in elektrolytarmen Bachberläufen. *Nova Hedwigia* 53, 171–213.

- ANDREJIĆ, J., KRIZMANIĆ, J., CVIJAN, M., 2012: Three new records for diatoms from the Nišava River and its tributary, the Jerma River (Southern Serbia). *Oceanological and Hydrobiological Studies* 41, 17–23.
- ANĐELKOVIĆ, M., 1958: Geological composition and tectonics of the south-western slope of the Stara planina Mountain (in Serbian). *Srpska Kraljevska akademija, Posebna izdanja, Prirodnjački i matematički spisi* 24, 1–48.
- BAHLS, L. L., 2009: A checklist of diatoms from inland waters of the northwestern United States. *Proceedings of the Academy of Natural Sciences of Philadelphia* 158, 1–35.
- BARBER, H. G., HAWORTH, E. Y., 1981: *A guide to the morphology of the diatom frustule*. Freshwater Biological Association. Ambleside, Cumbria.
- BERE, T., TUNDISI, J. G., 2010: Biological monitoring of lotic ecosystems: the role of diatoms. *Brazilian Journal of Biology* 70, 493–502.
- BUCZKÓ, K., 2006: Bryophytic diatoms from Hungary. *Proceedings of the 18<sup>th</sup> International Diatom Symposium, 2–7 September 2004, Miedzyzdroje, Poland*, 1–15.
- BUCZKÓ, K., WOJTAŁ, A., 2005: Moss inhabiting siliceous algae from Hungarian peat bogs. *Studia Botanica Hungarica* 36, 21–42.
- CANTONATI, M., LANGE-BERTALOT, H., 2011: Diatom monitors of close-to-pristine, very-low alkalinity habitats: three new *Eunotia* species from springs in Nature Parks of the south-eastern Alps. *Journal of Limnology* 70, 209–221.
- CANTONATI, M., LANGE-BERTALOT, H., DECET, F., GABRIELI, J., 2011: Diatoms in very-shallow pools of the Site of Community Importance Danta di Cadore Mires (southeastern Alps), and the potential contribution of these habitats to diatom biodiversity conservation. *Nova Hedwigia* 93, 475–507.
- COSTE, M., BOUTRY, S., TISON-ROSEBERY, J., DELMAS, F., 2009: Improvements of the Biological Diatom Index (BDI): Description and efficiency of the new version (BDI-2006). *Ecological Indicators* 9, 621–650.
- FRÁNKOVÁ, M., 2009: *Ecology and taxonomy of diatoms of Western Carpathian spring fens*. PhD Thesis, Faculty of Science Masaryk University, Brno.
- FRÁNKOVÁ, M., BOJKOVÁ, J., POULÍČKOVÁ, A., HÁJEK, M., 2009: The structure and species richness of the diatom assemblages of the Western Carpathian spring fens along the gradient of mineral richness. *Fottea* 9, 355–368.
- GREVILLE, R. K., 1855: Report on a collection of Diatomaceae made in the district of Braemar by Professor Balfour and Mr. George Lawson. *Annals and Magazine of Natural History* 15, 252–261.
- HOFMANN, G., WERUM, M., LANGE-BERTALOT, H., 2013: *Diatomeen im Süßwasser-Benthos von Mitteleuropa*. Koeltz Scientific Books, Königstein.
- JOHANSEN, J. R., LOWE, R. L., CARTY, S., FUČIKOVÁ, K., OLSEN, C. E., FITZPATRICK, M. H., RESS, J. A., FUREY, P. C., 2007: New algal species records for Great Smoky Mountains National Park, with an annotated check list of all reported algal taxa for the park. *Southeastern Naturalist* 6, 99–134.
- KAPETANOVIĆ, T., JAHN, R., REDŽIĆ, S., CARIĆ, M., 2011: Diatoms in a poor fen of Bijambare protected landscape, Bosnia & Herzegovina. *Nova Hedwigia* 93, 125–151.

- KELLY, M., BENNION, H., BURGESS, A., ELLIS, J., JUGGINS, S., GUTHRIE, R., JAMIESON, J., ADRIENSENS, V., YALLOP, M., 2009: Uncertainty in ecological status assessments of lakes and rivers using diatoms. *Hydrobiologia* 633, 5–15.
- KOCIOLEK, P., 2011: *Diatomella balfouriana*. In: Diatoms of the United States. Retrieved May 28, 2013 from [http://westerndiatoms.colorado.edu/taxa/species/diatomella\\_balfouriana](http://westerndiatoms.colorado.edu/taxa/species/diatomella_balfouriana).
- KRAMMER, K., LANGE-BERTALOT, H., 1986: Bacillariophyceae. 1. Teil: Naviculaceae. In: Ettl, H., Gerloff, J., Heynig, H., Mollenhauer, D. (eds.), Süßwasserflora von Mitteleuropa 2/1, 1–876. G. Fischer Verlag, Jena.
- KRAMMER, K., LANGE-BERTALOT, H., 1991: *Bacillariophyceae*. 4. Teil: *Achnantheaceae*. Kritische Ergänzungen zu *Navicula (Lineolatae)* und *Gomphonema*. In: Ettl, H., Gartner, G., Gerloff, J., Heynig, H., Mollenhauer, D. (eds.), Süßwasserflora von Mitteleuropa 2/4, 437. G. Fischer Verlag, Stuttgart & New York.
- KRASSKE, G., 1923: Die Diatomeen des Casseler Beckens und seiner Randegebirge einigen wichtigen Funden aus niederhessen. *Botanisches Archiv* 3, 198.
- KULIKOVSKII, M. S., 2008: The species composition and distribution of diatoms in Sphagnum bogs of European Russia: ecosystems of the Volga Upland. *Inland Water Biology* 1, 347–355.
- KWANDRANS, J., 2007: Diversity and ecology of benthic diatom communities in relation to acidity, acification and recovery of lakes and rivers. *Diatom Monographs* 9.
- IVANČEVIĆ, B., Savić, S., Sabovljević, M., Niketić, M., Tomović, G., Zlatković, B., Ranđelović, V., Lakušić, D., Četković, A., Pavićević, D., Krpo-Četković, J., Crnobrnja-Isailović, J., Pužović, S., Paunović, M., 2007: Checklist of the species at mountain Stara Planina in Serbia. In: Lakušić, D., Četković, A. (eds.), Biodiversity of the Stara planina Mountain in Serbia: results of the Project: »Trans-boundary cooperation through the management of shared natural resources—Promotion of networks and exchanges in the countries of South-Eastern Europe« (in Serbian), 150–151. Regional Environmental Center of Central and East Europe, Office in Serbia, Belgrade.
- LANGE-BERTALOT, H., Moser, G., 1994: *Brachysira* – Monographie der Gattung. *Bibliotheca Diatomologica* 29. J. Cramer, Berlin–Stuttgart.
- LANGE-BERTALOT, H., Metzeltin, D., 1996: Indicators of oligotrophy. 800 Taxa representative of three ecologically distinct lake types, carbonate buffered-oligodystrophic-weakly buffered soft water. In: Lange-Bertalot, H. (ed.), *Iconographia Diatomologica*. Annotated Diatom Monographs. Vol. 2. Ecology, Diversity, Taxonomy, 1–390. Koeltz Scientific Books, Königstein.
- LANGE-BERTALOT, H., Bak, M., Witkowski, A., Tagliaventi, N., 2011: *Eunotia* and some related genera. *Diatoms of Europe* 6. Koeltz Scientific Books, Königstein.
- LEELAHAKRIENGKRA, P., 2013: Diversity of freshwater benthos in the ecotourism area at Chiang Dao District in Chiang Mai Province, Thailand. *Biodiversity Journal* 4, 399–406.
- LIU, Y., Wang, Q., Fu, Ch., 2011: Taxonomy and distribution of diatoms in the genus *Eunotia* from the Da'erbin Lake and Surrounding Bogs in the Great Xing'an Mountains, China. *Nova Hedwigia* 92, 205–232.
- MARKOVIĆ, J., 1980: Regional geography of SFR Yugoslavia (in Serbian). GRO »Nikola Nikolić«, Kragujevac.

- MIJOVIĆ, D., 2001: The review measure and perspective of protection of Stara planina Mt. (in Serbian). *Protection of Nature* 52 (2), 153–158.
- OBUŠKOVIĆ, LJ., 1993: Algological and saprobiological analyses of some waters in the river basin of the Visočica and the Temštica. *Proceedings 3<sup>rd</sup> Meeting of the Flora of South-eastern Serbia, Leskovac-Pirot*, 1–14.
- OBUŠKOVIĆ, LJ., MASLIĆ, M., ČAKIĆ, P., JAKOVČEV, D., 1994: Hydroecological investigations of some waters of Mt. Stara planina. *Proceedings 23<sup>rd</sup> Annual Conference of the Serbian Water Pollution Control Society »Water 1994«*, Igalo, 188–192.
- OFFICIAL GAZETTE OF THE REPUBLIC OF SERBIA, 2009: Regulation on the Protection of Nature Park »Stara Planina« 23/2009, (in Serbian), 1–3, Uredba o zaštiti parka prirode »Stara planina«.
- PATRICK, R., REIMER, C. W., 1966: The Diatoms of the United States exclusive of Alaska and Hawaii. *Academy of Natural Sciences of Philadelphia Monographs*. 13 (I), 688.
- PAVLOV, A., LEVKOV, Z., 2013: Diversity and distribution of taxa in the genus *Eunotia* Ehrenberg (Bacillariophyta) in Macedonia. *Phytotaxa* 86, 1–117.
- PEREIRA, C. L., RAPOSEIRO, P. M., COSTA, A. C., BAO, R., GIRALT, S., GONÇALVES, V., 2014: Biogeography and lake morphometry drive diatom and chironomid assemblages' composition in lacustrine surface sediments of oceanic islands. *Hydrobiologia* 730, 93–112.
- POTAPOVA, M., HAMILTON, P. B., 2007: Morphological and ecological variation within the *Achnantheidium minutissimum* (Bacillariophyceae) species complex. *Journal of Phycology* 43, 561–575.
- ROUND, F. E., CRAWFORD, R. M., MANN, D. G., 1990: The Diatoms: biology and morphology of the genera. Cambridge University Press, Cambridge.
- SIMIĆ, S., 1995: Benthic algal communities of the Trgoviški Timok River (in Serbian). Master thesis. University of Belgrade, Faculty of Biology.
- SIMIĆ, S., 1996: Algae from the Trgoviški Timok River (Serbia, Yugoslavia) (in Serbian). *Glasnik Instituta za botaniku i botaničke bašte Univerziteta u Beogradu* XXX, 107–118.
- SIMIĆ, S., 2002: Distribution of blue-green algae (Cyanophyta) in streams of Mt. Stara Planina Serbia. *Archives of Biological Science* 54, 141–148.
- STEVENSON, R. J., PAN, Y., 1999: Assessing environmental conditions in rivers and streams with diatoms. In: STOERMER, E. F., SMOL, J. P. (eds.), *The Diatoms: applications for the environmental and earth sciences*, 11–40. Cambridge University Press, Cambridge.
- STOERMER, E. F., KREIS, R. G. JR., ANDRESEN, N. A., 1999: Checklist of Diatoms from the Laurentian Great Lakes. II. *Journal of Great Lakes Research* 25, 515–566.
- SZABADOS, M., 1966: Data to the knowledge of the microorganisma of the Yugoslav reaches of Tisza and the »Danube-Tisza canal«. *Tiscia* II, 3–11.
- SZABO, K., KISS, K., TOTH, B., METZELTIN, D., ACS, E., 2007: *Navicula novaesiberica* Lange-Bertalot; a new record of the species from the Danube River in Hungary. *Diatom Research* 22, 497–502.
- VAN DAM, H., MERTENS, A., SINKELDAU, J., 1994: A coded checklist and ecological indicator values of freshwater diatoms from The Netherlands. *Netherlands Journal of Aquatic Ecology* 28, 117–133.

- VAN DE VIJVER, B., BEYENS, L., 1997: The epiphytic diatom flora from mosses of Strømness Bay area. *Polar Biology* 17, 492–501.
- VAN DE VIJVER, B., ECTOR, L., COX, E. J., 2012: Ultrastructure of *Diatomella balfouriana* with a discussion of septum-like structures in diatom genera. *Diatom Research* 27, 213–221.
- VAN DE VIJVER, B., LANGE-BERTALOT, H., 2009: New and interesting *Navicula* taxa from western and northern Europe. *Diatom Research* 24, 415–429.
- VESELA, J., JOHANSEN, J., 2009: The diatom flora of ephemeral headwater streams in the Elbsandsteingebirge region of the Czech Republic. *Diatom Research* 24, 443–477.
- WOJTAL, Z. A., WITKOWSKI, A., METZELTIN, D., 1999: The diatom flora of the »Bor na Czerwonem« raised peat-bog in the Nowy Targ Basin (Southern Poland). *Fragmenta Floristica et Geobotanica* 44, 167–192.
- WOJTAL, Z. A., 2001: New or rare species of the genera *Achnantheidium* and *Psammothidium* (Bacillariophyceae) in the diatom flora of Poland. *Polish Botanical Journal* 49, 215–220.
- WOJTAL, Z. A., 2004: New locality of *Diadesmis tabellariaeformis* (Krasske) Lange-Bertalot et Wojtal (Bacillariophyceae) in Europe. *Algological Studies Supplement* 112, 89–94.