Article

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Diversity, distribution and ecology of freshwater centric diatoms in Bosnia and Herzegovina

Abstract

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In this study diversity, distribution and ecology of freshwater centric diatoms from Bosnia and Herzegovina are presented. According to the literature review and conducted a field survey in this paper data about nine genera (*Aulacoseira*, *Cyclotella*, *Discotella, Ellerbeckia*, *Lindavia*, *Melosira*, *Orthoseira*, *Pantocsekiella* and *Stephanodiscus*) with 17 species are reported. New data about distribution are presents for four taxa as follows: *Aulacoseira granulata*, *Melosira varians*, *Cyclotella meneghiniana* and *Discotella steligera*. New species for the flora of the algae of Bosnia and Herzegovina presented in the paper is *Orthoseira roeseana*.

Key words: *Orthoseira*, centric diatoms, diversity, conservation, monitoring, Balkan Peninsula.

Introduction

Diatoms are unicellular algae that possess an unusual and unique feature: a cell wall composed of silicon dioxide (SiO_2) (Wehr & al. 2015).

Centric diatoms are abundant in the plankton and as fossils, unlike the benthic habitats (Round & al. 1990).

Freshwater non-pennate diatoms are a major component of many aquatic ecosystems. They grow singly, and within colonies held together by mucopolysaccharides, chitin or interconnecting siliceous spines (Wehr & al. 2015).

Centric diatoms are more common in marine waters. The majority of genera have no freshwater representatives, and relatively few predominantly freshwater genera have species represented in strictly marine waters. Based on available evidence, it appears that the major genera occurring in freshwater are ultimately derived from multiple invasions from the marine realm (Wehr & al. 2015).

Some have evolved extensively in freshwater. Others retain very close morphological similarities to their marine ancestors (Wehr & al. 2015).

The presence of centric diatoms is characteristic of European lakes especially in spring, but they are also dominant and frequently abundant in large, slowly flowing rivers from early spring to autumn. Therefore, this is an important group of primary producers and water quality indicators (Kiss & al. 2012).

On the territory of Bosnia and Herzegovina centric diatoms were reported from different habitat types and these data are found in various publications [see Mašić (2020) and references herein].

The main aim of this study was to investigate the diversity of centric diatoms in Bosnia and Herzegovina, with two specific aims as follows: establishment a comprehensive check-list of freshwater centric diatoms of Bosnia and Herzegovina with a description of general data about morphology, ecology and distribution of identified taxa and establishment of database which will be used for the future monitoring of biodiversity of this very interesting group of algae.

This paper also contains notes about new records for Bosnia and Hercegovina and new distributional data for selected taxa of centric diatoms.

Material and methods

Samples of phytobenthos were collected from different types of substrates: epilithon, periphyton and epipelon. Sample from submerged stones was collected by scraping with a scalpel blade or brushing the upper surface of submerged stones. Periphyton samples contained non-washed parts of submerged macroalgae and macrophytes. Epipelon samples were collected from the uppermost layer of mud with a spoon or pipette aspirator. The collected material was fixed with a 4% formalin.

Laboratory processing of diatoms was carried out by applying methods used by (Hustedt 1930).

To obtain pure valves of diatoms, part of the obtained material was digested with sulfuric acid (H_2SO_4), potassium permanganate ($KMnO_4$) and oxalic acid ($C_2H_2O_4$). The cleaned valves of diatoms are then mounted in a Canada balsam. Species composition is estimated from the permanent slides under 1000x magnification using light microscope Best Scope 2020. The identification of diatoms was supported by the following references: Lange-Bertalot & Metzeltin (1996) and Lange-Bertalort & al. (2017).

The nomenclature of identified diatoms species was adjusted according to the following internet base: Guiry & Guiry (2021).

Omnidia software version 6.0.8 was used to assess ecological and taxonomic data. Measurements of diatom frustules were taken using Omnidia database (Lecointe & al. 1993). Data about the Red list of diatoms were taken according to Hofmann & al. (2018).

The main physical characteristics of investigated localities is shown in Table 1.

Table 1. The main physical characteristics of investigated localities

Site	Locality	Municipality	Coordinate (N)	Coordinate (E)	Altitude (m)
1.	Bašigovci	Živinice	44°25'02,74"	18°41'22,86"	250
2.	Bijambare	Ilijaš	44°05'39,20"	18°30'11.89"	981
3.	Bistrik	Kakanj	44°06'06,42"	18°09'45,73"	454
4.	Brestica	Banovići	44°23'03,84"	18°30'53,85"	405
5.	Ćenda	Živinice	44°24'06,81"	18°37'09,68"	274
6.	Haluge	Živinice	44°23'52,21"	18°36'09,22"	322
7.	Modrac	Lukavac	44°29'54,43"	18°34'38,81"	193
8.	Mošćanica	Zenica	44°10'11,16"	18°00'26,67"	672
9.	Mušići	Tuzla	44°31'38,68"	18°34'38,81"	210
10.	Požar	Živinice	44°24'32,47"	18°37'43,16"	289
11.	Ramići 1.	Banovići	44°25'02,60"	18°25'36,57"	380
12.	Ramići 2.	Banovići	44°25'01,09"	18°25'58,19"	392
13.	Smreka	Vareš	44°09'20,08"	18°19'03,66"	790
14.	Veovača	Vareš	44°08'15,97"	18°21'17,17"	929
15.	Vrtlište	Kakanj	44°08'09,73"	18°06'14,83"	493
16.	Zanesovići	Bugojno	44°00'40,03"	17°30'25,36"	616
17.	Zenuni	Živinice	44°23'34,32"	18°38'43,60"	291

Results

According to the literature review and conducted a field survey in this paper data about nine genera (*Aulacoseira* Thwaites, *Cyclotella* (Kützing) Brébisson, *Discostella* V.Houk & R.Klee, *Ellerbeckia* R.M.Crawford, *Lindavia* (Schütt) De Toni & Forti, *Melosira* C.Agardh, *Orthoseira* Thwaites, *Pantocsekiella* K.T.Kiss & E.Ács and *Stephanodiscus* Ehrenberg) with 17 species are reported.

Through this paper, new records and new data about the distribution of centric diatoms in Bosnia and Herzegovina are presented.

New data about distribution are presents for four taxa as follows: *Aulacoseira granulata* (Ehrenberg) Simonsen, *Melosira varians* C.Agardh, *Cyclotella meneghiniana* Kützing and *Discotella stelligera* (Cleve & Grunow) Houk & Klee.

In collected materials presence of new taxa for the flora of alge of Bosnia and Herzegovina was confirmed. New species presented in the paper is *Orthoseira roeseana* (Rabenhorst) Pfitzer (Fig. 1 and 2).

All identified species of centric diatoms belongs to the phylum Bacillariophyta and two subphyla as follows: *Coscinodiscophytina* and *Bacillariophytina* (Guiry & Guiry 2021).

Subphylum *Coscinodiscophytina* includes the following genera: *Aulacoseira*, *Ellerbeckia*, *Melosira* and *Orthoseira*, while subphylum *Bacillariophytina* includes genera as *Cyclotella*, *Discotella*, *Lindavia*, *Stephanodiscus* and *Pantocsekiella*.

In the continuation of the paper data about morphology, distribution in Bosnia and Herzegovina, ecology and conservation status of centric diatoms are presented.

Overview of the identified centric diatoms and basic autecological characteristics are shown in Table 2.

Table 2. Comprehensive check list of centric diatoms identified in freshwater habitat types in Bosnia and Herzegovina with presentation of basic environmental characteristics [RL – Hofmann & al. (2018): G – at risk, V – declining; D – Declining, * - Risk not estimated. Van Dam & al. (1994): M – moisture aerophile, N – nitrogen uptake, P – pH requirements, O – oxygen requirements, S1 – salinity, S2 – saprobity and T – trophic state]

Ordinal numeral	TAXON NAME	Red List (Hofmnn & al. (2018)	Moisture aerophily - M	Nitrogen uptake - N	pH requirements - P	Oxygen requirements - O	Salinity - S1	Saprobity - S2	Trophic State - T	LIFE FORM (DENYS 1991)
1.	*Aulacoseira alpigena* (Grunow) Krammer	G	1	1	2	1	1	1	1	Tychoplanktonic, benthic origin
2.	*Aulacoseira crenulata* (Ehrenberg) Thwaites	G	2	1	3	1	1	1	1	.
3.	*Aulacoseira distans* (Ehrenberg) Simonsen	*	1	1	2	1	1	1	1	Tychoplanktonic, benthic origin
4.	*Aulacoseira granulata* (Ehrenberg) Simonsen	*	1	2	4	3	2	2	5	Euplanktonic
5.	*Ellerbeckia arenaria* (D. Moore ex Ralfs) R. M. Crawford	*	4	1	4	1	1	1	1	Tychoplanktonic, benthic origin
6.	*Melosira varians* C. Agardh	*	2	3	4	3	2	3	5	Tychoplnktonic, eponitic origin
7.	*Orthoseira dendroteres* (Ehrenberg) Genkal & Kulikovskiy in Kuli	D	.	.	.	.	.	.	.	.
8.	*Orthoseira roeseana* (Rabenhorst) Pfitzer.	D	5	1	4	1	2	1		Benthic
9.	*Cyclotella meneghiniana* Kützing	*	2	3	4	5	3	4	5	Tychoplanktonic, benthic origin
10.	*Lindavia radiosa , , runow, De , oni , , orti*	D	1	1	4	2	2	2	5	Euplanktonic
11.	*Discotella stelligera* (Cleve & Grunow) Houk & Klee	.	1	.	.	.	2			Tychoplanktonic, benthic origin
12.	*Lindavia bodanica* (Eulenstein ex Grunow) T. Nakov, Guilloy, Julius, Theriot & Alverson	V	1	1	3	1	1	1	1	.
13.	*Lindavia schroeteri* (Lemmermann) T. Nakov et al.	-	.	.	.	.	.		.	.
14.	*Stephanodiscus neoastraea* Håkansson & Hickel	*	1	2	5	2	2	2	5	Euplanktonic
15.	*Stephanodiscus hantzschii* Grunow in Cleve & Grunow	*	2	3	5	4	2	4	6	Euplanktonic
16.	*Pantocsekiella kuetzingiana* (Thwaites) K.T. Kiss	*	1	.	4	1	2	.	.	Tychoplanktonic, benthic origin
17.	*Pantocsekiella ocellata* (Pantocsek) K.T. Kiss & E. Ács in Ács et al.	*	1	1	4	1	1	1	4	Tychoplanktonic, benthic origin

Taxonomical and ecological parts

Aulacoseira Thwaites 1848
The genus *Aulacoseira* includes four species as follows:
1. *Aulacoseira alpigena* (Grunow) Krammer
2. *Aulacoseira crenulata* (Ehrenberg) Thwaites
3. *Aulacoseira distans* (Ehrenberg) Simonsen
4. *Aulacoseira granulata* (Ehrenberg) Simonsen

Aulacoseira alpigena (Grunow) Krammer
Dimensions: Diameter (μm): 4-15; Width (μm): 4-7 (Lecointe & al. 1993).
Biovolume: 195 μm^3.
Distribution in Bosnia and Herzegovina: Hafner & al. 2008; Mašić & al. 2019.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). According to Van Dam & al. (1994) species is aquatic (1), sensitve N-autotrophic (1), acidophilic (2), polyoxybiontic (100% sat.) (1), halophobe (1), oligosprobe (1) and oligotrophic (1). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), this species is at risk (G).

Aulacoseira crenulata (Ehrenberg) Thwaites
Dimensions: Diameter (μm): 5-32; Width (μm): 8-20 (Lecointe & al. 1993).
Biovolume: 3763 μm^3.
Distribution in Bosnia and Herzegovina: Gutwinski 1898a; Protić 1897; Mašić & al. 2019.
Ecology: According to Van Dam & al. (1994), species is occasionally aerophilic (2), sensitive N-autotrophic (1), neutrophilic (3), poloxybiontic (100% sat.) (1), halophobe (1), oligosaprobe (1) and oligotrophic (1). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), this species is at risk (G).

Aulacoseira distans (Ehrenberg) Simonsen
Dimensions: Diameter (μm): 4-20; Width (μm): 4-9 (Lecointe & al. 1993).
Biovolume: 735 μm^3.
Distribution in Bosnia and Herzegovina: Karlinski 1896; Protić 1897, 1903, 1906, 1907, 1921, 1926, 1927, 1928a, 1928e.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). According to Van Dam & al. (1994), species is aquatic (1), sensitive N-autotrophic (1), acidophilic (2), polyoxybiontic (100% sat.) (1), halophobe (1), oligosaprobe (1) and oligotrophic (1). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Aulacoseira granulata (Ehrenberg) Simonsen
Dimensions: Diameter (μm): 4-30; Width (μm): 5-24; Striae count (per 10 μm, at centre): 10-15 (Lecointe & al. 1993).
Biovolume: 3291 μm^3.

Distribution in Bosnia and Herzegovina: Gutwinski 1898a; Protić 1925, 1928a; Hafner 1991; Mašić 2018; Mašić & al. 2019.
New localities: Mine pit lakes Veovača, Bistrik, Zanesovići, Bašigovci and Modrac.
Ecology: Euplanktonic (Denys 1991). According to Van Dam & al. (1994), species is aquatic (1), tolerant N-autotrophic (2), alkalophilic (4), moderate O_2 (>50% sat.) (3), oligohalobous (2), β-mesosaprobe (2) and eutrophic (5). *A. granulata* is a cosmopolitan species occurring in eutrophic rivers, ponds and lakes (Kiss & al. 2012). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Ellerbeckia R.M. Crawford 1988
The genus *Ellerbeckia* includes one species as follows:
1. *Ellerbeckia arenaria* (D. Moore ex Ralfs) R.M. Crawford

Ellerbeckia arenaria (D. Moore ex Ralfs) R.M. Crawford
Dimensions: Diameter (µm): 38-135; Width (µm): 10-15 (Lecointe & al. 1993).
Biovolume: 73457 μm^3.
Distribution in Bosnia and Herzegovina: Dedić & al. 2014; Forti 1903; Gutwinski 1898a, 1902; Hafner & al. 2013; Hafner & Jasprica 2013; Hafner & Mirković 2008; Karlinski 1896; Protić 1928e, 1925, 1928a.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). Subaerophilous (Katrantsiotis & al. 2016). Cosmopolitan, aerophilous and littoral diatom (Krammer & Lange-Bertalot 1991a) of a wide trophic spectrum (Lange-Bertalot 1996). According to Van Dam & al. (1994), species is aerophilic (4), sensitive N-autotrophic (1), alkaliphilic (4), polyoxybiontic (100% sat.) (1), halophobe (1), oligosaprobe (1) and oligotrophic (1). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Melosira C.Agardh 1824
The genus *Melosira* includes one species as follows:
1. *Melosira varians* C.Agardh

Melosira varians C.Agardh
Dimensions: Diameter (µm): 8-35; Width (µm): 8-17 (Lecointe & al. 1993).
Biovolume: 3267 μm^3.
Distribution in Bosnia and Herzegovina: Gutwinski 1898b, 1902; Protić 1897, 1903, 1906, 1907, 1921, 1925, 1926, 1927; Blagojević 1966; Blagojević & Hafner 1979; Hafner 1991; Redžić 1988, 1991; Hafner & Mirković 2008; Sejdić & al. 2010; Hafner & al. 2013; Hafner & Jasprica 2013; Dedić & al. 2014, 2015; Salkić & al. 2014; Kamberović & al. 2017; Mašić 2018; Mašić & al. 2019.
New localities: Mine pit lake Veovača.
Ecology: Tychoplanktonic, epontic origin (Denys 1991). Cosmopolitan, benthic and planktic, in waters of a broad spectrum of trophic states and conductivity (Krammer &

Lange-Bertalot 1991a). According to Van Dam & al. (1994), species is occasionally aerophilic (2), facultative N-heterotrophic (3), alkaliphilic (4), moderate O2 (>50% sat.) (3), oligohalobous (2), α-mesosaprobe (3) and eutrophic (5). *M. varians* is a cosmopolitan species that occurs both in benthos and plankton. It can be found in dystrophic and oligotrophic to eutrophic waters (Kiss & al. 2012). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Orthoseira Thwaites 1848
The genus *Orthoseira* includes two species as follows:
1. *Orthoseira dendroteres* (Ehrenberg) Genkal & Kulikovskiy in Kulikovskiy & al.
2. *Orthoseira roeseana* (Rabenhorst) Pfitzer

Orthoseira dendroteres (Ehrenberg) Genkal & Kulikovskiy in Kulikovskiy & al.
Dimensions: Diameter (μm): 8-27; Width (μm): 6-22 (Lecointe & al. 1993).
Biovolume: 3367 μm^3.
Distribution in Bosnia and Herzegovina: Gutwinski 1902.
Ecology: This is a freshwater/terrestrial species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), this species is declining (D).

Orthoseira roeseana (Rabenhorst) Pfitzer (Fig. 1 and 2)
Dimensions: Diameter (μm): 8-70; Width (μm): 6-13; Striae count (per 10 μm, at centre): 14-20 (Lecointe & al. 1993).
Distribution in Bosnia and Herzegovina: First record for Bosnia and Herzegovina – Bijambare cave.
Ecology: Caves (Czerwik-Marcinkowska & Mrozinska, 2011). This is a freshwater/terrestrial species (Guiry & Guiry 2021). Benthic (Denys 1991).
Conservation status: According to Red List (Hoffman & al. 2018), this species is declining (D).

Cyclotella (Kützing) Brébisson 1838
The genus *Cyclotella* includes one species as follows:
1. *Cyclotella meneghiniana* Kützing

Cyclotella meneghiniana Kützing
Dimensions: Diameter (μm): 5-60; Striae count (per 10 μm, at centre): 6-9 (Lecointe & al. 1993).
Biovolume: 1244 μm^3.
Distribution in Bosnia and Herzegovina: Karlinski 1896; Gutwinski 1898a; Protić 1897, 1903, 1908, 1925, 1926, 1927, 1928c, 1934; Hafner 1991; Redžić 1991; Hafner & Mirković 2008; Sejdić & al. 2010; Kamberović & Barudanović 2012; Hafner & al. 2013; Hafner & Jasprica 2013; Dedić & al. 2015; Močić-Čičić & Sejdić 2016; Kamberović & al. 2017; Mašić 2018.
New localities: Mine pit lake Veovača, Bistrik, Vrtlište, Mošćanica, Zenuni, Požar, Ćenda, Haluge, Breštica, Ramići 1, Ramići 2, Bašigovci, Mušići and Modrac.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). A widespread littoral diatom, known from a broad spectrum of trophic states and conductivity (Krammer & Lange-Bertalot 1991a).

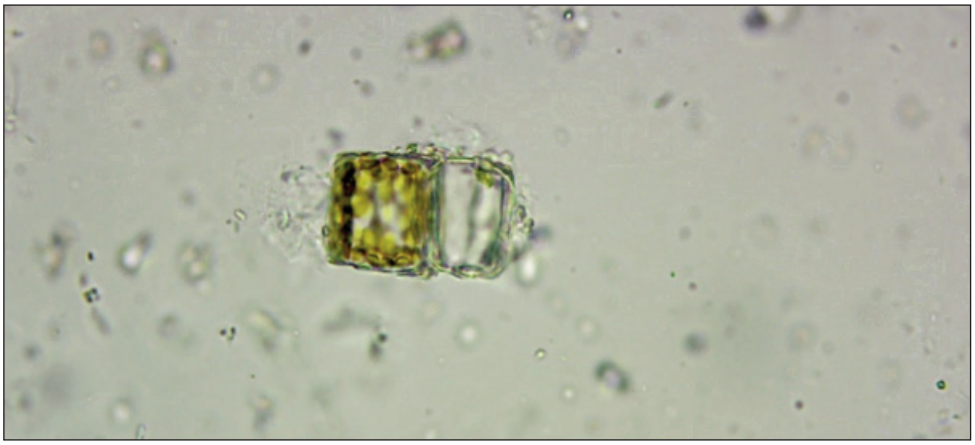

Fig. 1. Morphology of *Orthoseira roeseana* (Rabenhorst) Pfitzer (x400)

According to Van Dam & al. (1994), species is occasionally aerophylic (2), facultative N-heterotrophic (3), alkaliphilic (4), very low O_2 (10% sat.) (5), halophilic (3), α-meso ► polysprobe (4), eutrophic (5). *C. meneghiniana* is cosmopolitan, frequent and abundant in rivers and lakes, under different trophic conditions. Authors Houk & al. in Kiss & al. (2012) defined it as a common species in the littoral and pelagic zone of eutrophic stagnant waters or slowly running rivers. This is a marine/freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Discostella V. Houk & R. Klee 2004
The genus *Discostella* includes one species as follows:
1. *Discostella stelligera* (Cleve & Grunow) Houk & Klee

Discostella stelligera (Cleve & Grunow) Houk & Klee
Dimensions: Diameter (μm): 5-40; Striae count (per 10 μm, at centre): 8-12 (Lecointe & al. 1993).
Biovolume: 895 μm^3.
Distribution in Bosnia and Herzegovina: Gutwinski 1898b.
New localities: Mine pit lakes Mošćanica, Zenuni, Ćenda, Haluge, Mušići and Modrac.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). Cosmopolitan diatom (Krammer & Lange-Bertalot 1991a). According to Van Dam & al. (1994), species is aquatic (1) and oligohalobous (2). *D. stelligera* is a cosmopolitan species, it can be found in lakes or lowland rivers. It prefers oligotrophic, mesotrophic waters (Kiss & al. 2012). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk is not estimated (*).

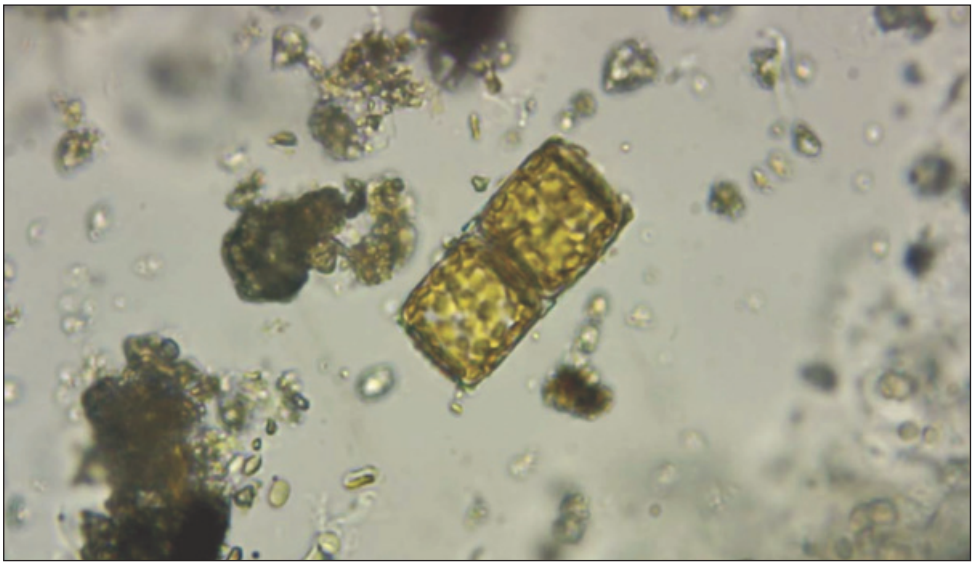

Fig. 2. Morphology of *Orthoseira roeseana* (Rabenhorst) Pfitzer (x400)

Lindavia (Schütt) De Toni & Forti 1900
The genus *Lindavia* includes three species as follows:
1. *Lindavia bodanica* (Eulenstein ex Grunow) T.Nakov, Guillory, Julius, Theriot & Alverson
2. *Lindavia radiosa* (Grunow) Lemmermann
3. *Lindavia schroeteri* (Lemmermann) T.Nakov & al.

Lindavia bodanica (Eulenstein ex Grunow) T.Nakov, Guillory, Julius, Theriot & Alverson
Dimensions: Diameter (μm): 20-80; Width (μm): 7-10; Striae count (per 10 μm, at centre): 20-30 (Lecointe & al. 1993).
Biovolume: 16690 μm^3.
Distribution in Bosnia and Herzegovina: Hafner 1991; Hafner & Mirković 2008.
Ecology: According to Van Dam & al. (1994), species is aquatic (1), sensitive N-autotrophic (1), neutrophilic (3), polyoxybiontic (100% sat.) (1), halophobe (1), oligosaprobe (1) and oligotrophic (1). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), this species is declining (D).
Lindavia radiosa (Grunow) Lemmermann

Dimensions: Diameter (μm): 7-25; Width (μm): 3-4; Striae count (per 10 μm, at centre): 15-18 (Lecointe & al. 1993).
Biovolume: 2147 μm^3.
Distribution in Bosnia and Herzegovina: Gutwinski 1898a; Protić 1925, 1928c.
Ecology: Euplanktonic (Denys 1991). According to Van Dam & al. (1994), species is aquatic (1), sensitive N-autotrophic (1), alkalophilic (4), oxybiontic (75% sat.) (2), oligohalobous (2), β-mesosaprobe (2) and eutrophic (5). *C. radiosa* is a pelagic species of lakes

and lowland rivers; it prefers eutrophic conditions with higher conductivity and alkalinity but can also be found in mesotrophic waters (Kiss & al. 2012). This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al., 2018), for this species risk is not estimated (*).

Lindavia schroeteri (Lemmermann) T.Nakov & al.
Dimensions: Diameter (μm): 12-40; Striae count (per 10 μm, at centre): 15-17 (Lecointe & al. 1993).
Distribution in Bosnia and Herzegovina: Protić 1926, 1935.
Ecology: This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Stephanodiscus Ehrenberg 1845
The genus *Stephanodiscus* includes two species as follows:
1. *Stephanodiscus astraea* (Kützing) Grunow
2. *Stephanodiscus hantzschii* Grunow in Cleve & Grunow

Stephanodiscus neoastraea Håkansson & Hickel
Dimensions: Diameter (μm): 15-70; Width (μm): 15-70; Striae count (per 10 μm, at centre): 7-9 (Lecointe & al. 1993).
Biovolume: 4.811 μm^3.
Distribution in Bosnia and Herzegovina: Hafner & al. 2015.
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Stephanodiscus hantzschii Grunow in Cleve & Grunow
Dimensions: Diameter (μm): 8-30; Width (μm): 8-30; Striae count (per 10 μm, at centre): 6-11 (Lecointe & al. 1993).
Biovolume: 541 μm^3.
Distribution in Bosnia and Herzegovina: Dedić & al. 2015.
Ecology: Euplanktonic (Denys 1991). Cosmopolitan diatom (Krammer & Lange-Bertalot 1991a). According to Van Dam & al. (1994), species is occasionally aerophilic (2), facultative N-heterotrophic (3), alkalibiontic (5), low O_2 (>30% sat.) (4), oligohalobous (2), α-meso ► polysaprobe (4) and hypereutrophic (6). *S. hantzschii* is a cosmoplitan species, recorded in rivers and lakes with different trophic levels and haloby. *S. hantzschii* is a cosmoplitan species, recorded in rivers and lakes with different trophic levels and halobity (Kiss & al. 2012). This is a marine/freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Pantocsekiella K.T. Kiss & E. Ács 2016
The genus *Pantocsekiella* includes two species as follows:
1. *Pantocsekiella kuetzingiana* (Thwaites) K.T.Kiss & E.Ács in Ács & al.
2. *Pantocsekiella ocellata* (Pantocsek) K.T.Kiss & E.Ács in Ács & al.

Pantocsekiella kuetzingiana (Thwaites) K.T.Kiss & E.Ács in Ács & al.
Dimensions: Diameter (μm): 8-45; Width (μm): 2-4; Striae count (per 10 μm, at centre): 12-18 (Lecointe & al. 1993).
Biovolume: 1357 μm^3.
Distribution in Bosnia and Herzegovina: Protić 1928c, 1928a, 1934, 1937, 1897, 1903, 1906, 1921, 1925, 1926, 1927, 1928b; Hafner 1991; Hafner & Mirković 2008.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). According to Van Dam & al. (1994), species is aquatic (1), alkaliphilic (4), polyoxybiontic (100% sat.) (1) and oligohalobous (2). This is a brackish species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Pantocsekiella ocellata (Pantocsek) K.T.Kiss & E.Ács in Ács & al.
Dimensions: Diameter (μm): 8-25; Width (μm): 2-3; Striae count (per 10 μm, at centre): 15-15 (Lecointe & al. 1993).
Biovolume: 425 μm^3.
Distribution in Bosnia and Herzegovina: Močić-Čičić & Sejdić 2016; Dedić & al. 2015; Kapetanović & al. 2011; Hafner & Mirković 2008; Redžić 1988; Jerković, 1978.
New localities: Mine pit lakes Smreka, Zanesovići, Zenuni, Ćenda, Ramići 1, Ramići 2, Mušići and Modrac.
Ecology: Tychoplanktonic, benthic origin (Denys 1991). According to Van Dam & al. (1994), species is aquatic (1), sensitive N-autotrophic (1), alkaliphilic (4), polyoxybiontic (100% sat.) (1), halophobe (1), oligosaprobe (1) and meso-eutrophic (4). Authors Houk & al. (2010) in (Kiss & al. 2012) define this centric species as littoral and pelagic species of mostly, oligo- to eutrophic waters, particularly with sandy or gravelly bottom, also found in slow-flowing rivers. It seems to be in close correlation with relatively high Ca^{2+} ion concentration. This is a freshwater species (Guiry & Guiry 2021).
Conservation status: According to Red List (Hoffman & al. 2018), for this species risk estimated (*).

Discussion

Biodiversity of Bosnia and Herzegovina is on an extremely high level (Redžić & al. 2008).

Numerous factors have caused a high degree of biodiversity in Bosnia and Herzegovina. Amongst them are different climate effects, complex orography, complex geological substrate and the mosaic of soils. Very diverse natural and semi-natural ecosystems are widespread in our country (Barudanović 2019).

According to the First report of Bosnia and Herzegovina to CBD, diversity of cyanobacteria and algae was assessed approximately about 1.859 species from 217 genera (Barudanović 2019; Redžić & al. 2008), but the detailed checklist is not available.

Overview of bibliography of phycological research in Bosnia and Herzegovina was recently published. In the period from 1849 to 2019, a total of 76 original scientific papers were published in the field of phycology (Mašić 2020).

Despite a long period of cyanobacteria and algae research in Bosnia and Herzegovina, detailed data about diversity and distribution are only available for genus *Eunotia* (Mašić & Barudanović 2020).

Taxonomic reviews of centric diatoms for the Balkan Peninsula are scarce. Data about distribution of centric diatoms are contained in different publications (Mašić 2020).

Relevant information about centric diatoms in Europe are available in the different publications (Houk & al. 2010, 2014, 2017; Kiss & al. 2012; Solak & al. 2012).

According to the literature review and conducted field survey data about nine genera and 17 species are reported.

In addition to the widespread species, rare and endangered species have been identified, as well as new species for the algae flora of Bosnia and Herzegovina.

New data about distribution are presents for four taxa as follows: *Aulacoseira granulata, Melosira varians, Cyclotella meneghiniana* and *Discotella steligera*.

New species for the flora of algae of Bosnia and Herzegovina presented in this paper is *Orthoseira roeseana*. This species are usually aerial or subaerial and are less frequently observed in planktons. Species is commonly as aerophytic diatom on wet rock, bryophytes and trees, especially in alkaline areas all over the world (Krammer & Lange-Bertalot, 1991a).

This species is commonly found on bryophytes and caves in alkaline environments (Joh 2010).

Centric algae are very unique and rare in Bosnia and Herzegovina. Due to different antropogenic pressures their habitat were under huge impact. In order to protect their habitats further investigation of this very unique algae are neccessary.

Conclusions

In this paper diversity, distribution and ecology of freshwater centric diatoms from Bosnia and Herzegovina are presented. According to the literature review and conducted a field survey in this paper data about nine genera are presented. New data about distribution are presents for four taxa as follows: *Aulacoseira granulata, Melosira varians, Cyclotella meneghiniana* and *Discotella steligera*. In collected materials presence of new taxa for the flora of alge of Bosnia and Herzegovina was confirmed. New species for the flora of the algae of Bosnia and Herzegovina presented in the paper is *Orthoseira roeseana* (Rabenhorst) Pfitzer. In order to protect centric diatom species in the future it is neccessary to protect their habitats and also establish a permanent monitoring.

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