

EPIPELIC DIATOM COMMUNITIES IN THE ŠERIĆKA BARA MARSH (NORTHEAST BOSNIA AND HERZEGOVINA)

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Epipellic diatom communities were studied in the Šerićka bara marsh in northeast Bosnia and Herzegovina throughout 2009. During spring and summer a total of 57 species was found at 6 sampling points. The highest number of species was noted for genera *Gomphonema* (8) and *Nitzschia* (5). The most abundant species were *Melosira varians* C.Agardh, *Gyrosigma acuminatum* (Kützing) Rabenhorst, *Lemnicola hungarica* (Grunow) F.E.Round & P.W.Basson, *Navicula cryptocephala* Kützing, *Cocconeis placentula* var. *placentula* Ehrenberg, *Hippodonta capitata* (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski, *Fallacia pygmaea* (Kützing) A.J.Stickle & D.G.Mann, *Anomoeoneis sphaerophora* E.Pfizer, *Craticula cuspidata* (Kützing) D.G.Mann, *Cyclotella meneghiniana* (Kützing) D.G.Mann and *Tryblionella hungarica* (Grunow) Frenguelli. The spatial variation of the epipellic community was higher in summer as summarized by PCO analysis. Values of the Shannon-Wiener Diversity Index ranged from 2.47 to 2.96, while the Rott Trophic Index ranged from 2.7 to 3.4. Most of the species were eutraphentic (61%) and alkaliphilous (60%), indicating the eutrophic and polytrophic status of this wetland.

Key words: epipelon, diatoms, biodiversity, eutrophication, ecological status, wetland, Bosnia and Herzegovina, Šerićka bara

Kamberović, J., Kralj Borojević, K., Razić, A. & Barudanović, S.: Epipelonske dijatomeje u Šerićkoj bari (sjeveroistočna Bosna i Hercegovina). Nat. Croat., Vol. 26, No. 1., 17–32, Zagreb, 2017.

U radu su istraživane epipelonske zajednice dijatomeja tijekom 2009. godine u Šerićkoj bari u sjeveroistočnoj Bosni i Hercegovini. Determinirano je 57 vrsta na 6 lokaliteta u proljetnoj i ljetnoj sezoni uzorkovanja. Rodovi najbrojniji vrstama su *Gomphonema* (8) i *Nitzschia* (5), a dominantne vrste bile su *Melosira varians* C.Agardh, *Gyrosigma acuminatum* (Kützing) Rabenhorst, *Lemnicola hungarica* (Grunow) F.E.Round & P.W.Basson, *Navicula cryptocephala* Kützing, *Cocconeis placentula* var. *placentula* Ehrenberg, *Hippodonta capitata* (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski, *Fallacia pygmaea* (Kützing) A.J.Stickle & D.G.Mann, *Anomoeoneis sphaerophora* E.Pfizer, *Craticula cuspidata* (Kützing) D.G.Mann, *Cyclotella meneghiniana* Kützing i *Tryblionella hungarica* (Grunow) Frenguelli. Struktura epipelonske zajednice bila je prostorno raznolikija u ljetnoj u odnosu na proljetnu sezonu uzorkovanja. Shannon-Wienerov indeks raznolikosti iznosio je od 2,47 do 2,96, dok se trofički indeks prema Rott-u kretao u rasponu od 2,7 do 3,4. Najveći broj vrsta pripadao je kategoriji alkalofilnih (60%) i eutrofnih (61%) po-kazatelja i upućuje na eutrofni i politrofni status močvare.

Ključne riječi: epipelon, dijatomeje, bioraznolikost, eutrofikacija, ekološki status, Bosna i Hercegovina, Šerićka bara.

INTRODUCTION

Epipelon is a community of autotrophic microorganisms (cyanobacteria, algae) on the sediment at the bottom of stagnant and running waters (POULÍČKOVÁ *et al.*, 2008). The first studies on algal epipellic communities were performed by ROUND (1953). Epipellic communities are significant primary producers in shallow marshes (VELASCO *et al.*, 2003; ŠPAČKOVÁ *et al.*, 2009), thus being important in water quality assessment (GÓMEZ, 1998), trophic interactions (MOULTEN *et al.*, 2004) and regulation of the nutrient cycle between water and sediment (DODS, 2003). Algal communities reflect environmental conditions and their community structure indicates the trophic status of the ecosystem (YANG & DICKMAN, 1993).

Compared to that of phytoplankton and epiphyton, the importance of the epipellic communities of lake ecosystems is often greatly underestimated, thus needing a comprehensive review (POULÍČKOVÁ *et al.*, 2008; 2014).

Wetlands are among the most endangered ecosystems in Bosnia and Herzegovina and are, due to permanent land reclamation and drainage, limited to small areas. The First National Report of Bosnia and Herzegovina for the Biodiversity Convention recognized wetland areas around Lake Modrac and Šerićka bara marsh as important refuge habitats (REĐŽIĆ *et al.*, 2008). During the last several decades Šerićka bara has been used as a hunting ground, and thus lacks any form of legal protection. Currently, there is an ongoing local legislative procedure in progress (www.vladatk.kim.ba, 2017), with a proposal to establish a fifth category of protected area according to IUCN categorization. The only published data about the biological diversity of the Šerićka bara marsh comprised birds and insects (KULIJEV & ŠIMIĆ, 2011). There are no records of previous ecological and floristic research into this wetland.

In general, diatom research into the wetlands in Bosnia and Herzegovina is extremely scarce. HAFNER *et al.* (2013) investigated epiphytic diatoms of the sub-Mediterranean wetland Hutovo blato, whilst phytoplankton communities in Bardača (northern Bosnia) were studied by LOLIĆ *et al.* (2015).

This study of epipellic diatom communities presents the first insight into the algal assemblages of the Šerićka bara marsh. The objectives of the study were to: (i) describe the diatom epipellic communities of the Šerićka bara marsh, (ii) compare the community structure in spring and summer, and (iii) assess the trophic status of the wetland.

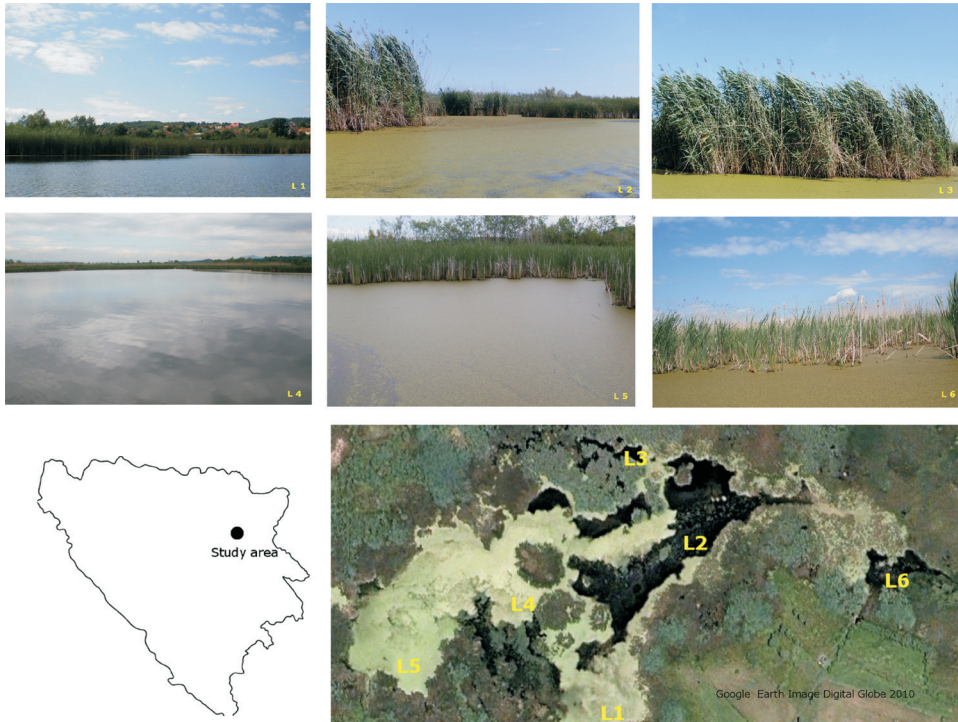
STUDY AREA

Šerićka bara marsh is situated in northeastern Bosnia and Herzegovina at the south side of the mouth of Spreča River into Lake Modrac. It originated after the formation of Lake Modrac, by the deposition of sediment from Spreča River and the formation of the bank that has separated it from the lake for the last 30 years. This permanent wetland ecosystem is fed by several small surface streams flowing from the surrounding settlements. It is overgrown by thick vegetation of reeds and rushes, submerged and floating aquatic plants. The climate is moderate continental. Physical properties of the study area are presented in Tab. 1 (obtained using Google Earth 2010/Tele Atlas 2010/Image 2010 Digital Globe and field research).

Algal samples were collected at 6 sampling points during two seasons (Fig. 1). Most sampling points (L2-L6) were shaded by floating vegetation of *Lemnaceae* species, especially in the summer.

Tab. 1. Physical properties of the study site

Geographic position		Altitude (m a.s.l.)	Max. length (m)	Max. width (m)	Max. depth (m)	Surface (ha)
Latitude	Longitude					
44°28'17"	18°34'02"	198	860	250	1	30

**Fig. 1.** Study area and sampling localities of the Šerička bara marsh

MATERIALS AND METHODS

Temperature and pH were measured using a standard thermometer and a WT – pH inolab probe (Xylem Analytics Germany GmbH & Co. KG.). Transparency was measured with Secchi disk. Organic matter was determined using the oxidation method with potassium permanganate (TRAJKOVIĆ *et al.*, 1983)

Diatom samples were collected two times, by pipetting mud at 6 sampling points in spring and summer of 2009. Samples were preserved with 4% formaldehyde. Diatoms were acid cleaned following HUSTEDT (1930) and identified on permanent slides prepared using Naphrax (Brunel Microscopes Ltd., U.K.). Algae were identified using light microscopes BA310 Motic optical microscope (Speed Fair Co. Ltd., China) and Olympus BX41 (Olympus Corporation, Japan) at a magnification of 1000x and following KRAMMER & LANGE-BERTALOT (1986; 1988; 1991a; 1991b), KRAMMER (2001; 2000; 2002) and HOFMANN *et al.* (2011). Microphotographs were taken with Optika Pro 3LT camera and processed with Optika Vision Pro Software (Optika Microscopes, Italy). Relative abundance was

calculated by counting up to 400 frustules on permanent slides. Nomenclature was double checked following the Algaebase webpage (GUIRY & GUIRY, 2015). Trophic status was determined using Trophic Index according to ROTT *et al.* (1999), representing the average of indicator values weighted by relative abundance, and using the Trophic Index according to VAN DAM *et al.* (1994), representing the arithmetic average of species indicator values. Biodiversity of species was estimated for each sample using the Shannon-Wiener diversity index (SHANNON & WIENER, 1949).

All analyses were performed using the software PRIMER-E (CLARKE & GORLEY, 2006) with the add-on package PERMANOVA+ (ANDERSON *et al.*, 2008). PERMANOVA analysis (4999 permutations) based on Bray-Curtis similarity matrix was used to test for statistical differences on the species composition between two sampled periods. Principal coordinates analysis (PCO) was used for the visualisation of the multivariate patterns of the epipellic composition (ANDERSON *et al.*, 2008).

RESULTS

The average water temperature in the spring sampling period was 18°C, while higher values were noted in summer, reaching 22.3°C. Transparency was lower in spring than in summer, 24 cm and 31.3 cm respectively. Water colour was mostly brown, indicating a probable influence by soil substances. The consumption of potassium permanganate (KMnO₄) ranged from 20.3 to 44.3 mg L⁻¹, indicating a greater presence of organic material in the water. Water was slightly alkaline with pH values ranging from 6.8 to 8 (Tab. 2). Statistically significant ($p < 0.05$) positive correlations between temperature and permanganate value ($r = 0.6$) and negative correlation between temperature and pH ($r = -6.9$) were established using Pearson's correlation coefficient.

A total of 57 diatom species belonging to 33 genera were noted in epipellic samples of the Šerička bara marsh. Most diatom species belonged to the genera *Gomphonema* (8) and *Nitzschia* (5). The number of species in a sample ranged from 18 to 32. The most abundant species were *Melosira varians* C.Agardh, *Gyrosigma acuminatum* (Kützing) Rabenhorst, *Lemnicola hungarica* (Grunow) F.E.Round & P.W.Basson, *Navicula cryptocephala* Kützing, *Cocconeis placentula* var. *placentula* (Ehrenberg) Grunow, *Hippodonta capitata* (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski, *Fallacia pygmaea* (Kützing) A.J.Stickle & D.G.Mann, *Anomooneis sphaerophora* E.Pfitzer, *Craticula cuspidata* (Kützing) D.G.Mann, *Cyclotella meneghiniana* Kützing and *Tryblionella hungarica* (Grunow) Frenguelli (Fig. 2). Shannon-Wiener index ranged from 2.47 to 2.96, indicating high diversity in the epipe-

Tab. 2. Environmental characteristics of sampling points (first values represent spring, and second summer measurements)

Sampling point	L1	L2	L3	L4	L5	L6
Water temperature (°C)	18–22	18–22	17,5–22	18–24	19–22	18–22
pH	7.5–7.1	7.5–6.8	7.4–7	7.5–7	8–7.4	7.5–7.3
Transparency (cm)	15–25	16–27	25–23	17–28	16–32	55–53
Depth (cm)	45–45	66–51	40–36	47–40	45–40	55–53
Permanganate value (mg L ⁻¹ KMnO ₄)	25.3–35.5	34.2–39.3	20.3–50.7	29.8–44.3	30.4–30.4	32.9–25.3
Coverage by floating vegetation (%)	0–30	5–95	20–100	0–100	100–100	100–35

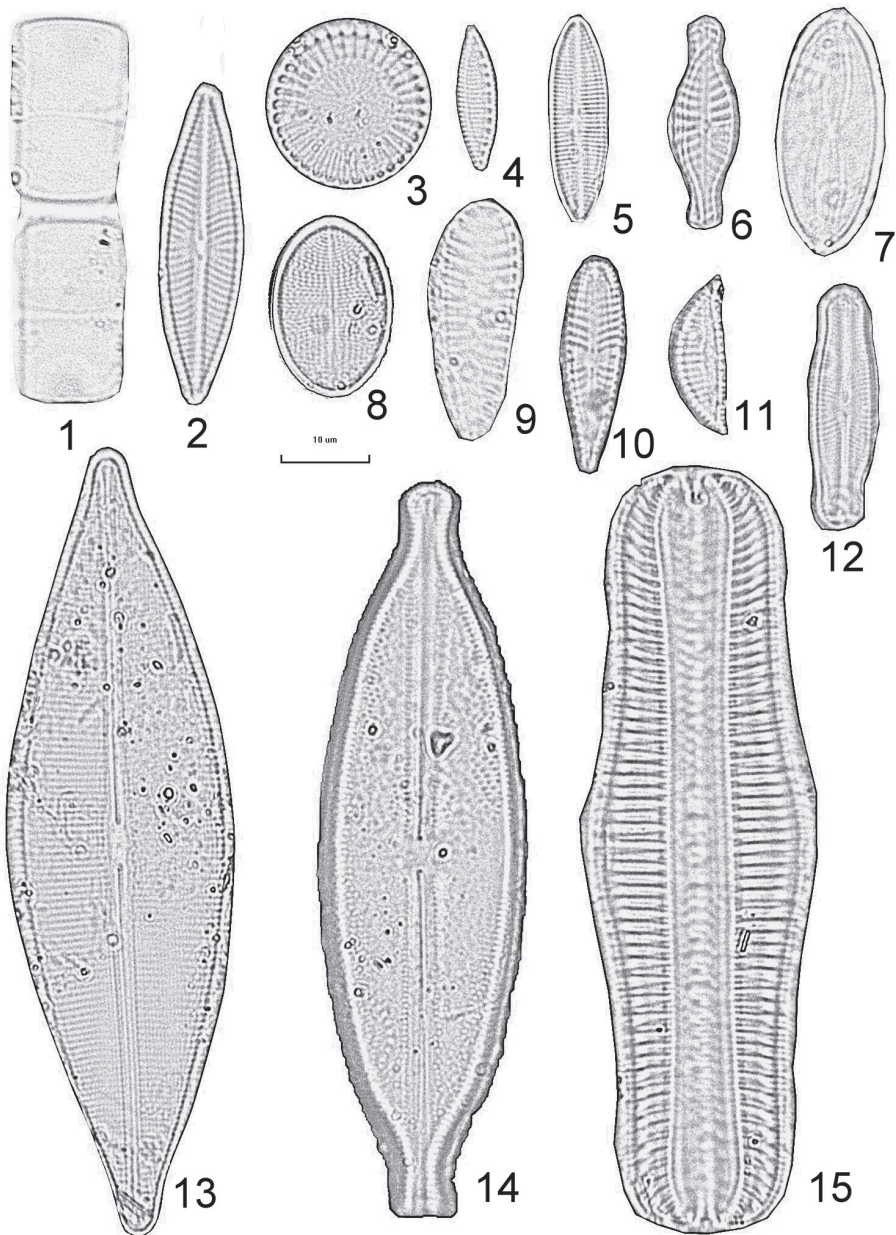


Fig. 2. The most abundant diatoms in the Šerićka bara marsh

1 – *Melosira varians* C.Agardh, 2 – *Navicula cryptocephala* Kützing, 3 – *Cyclotella meneghiniana* Kützing, 4 – *Nitzschia frustulum* (Kützing) Grunow, 5 – *Lemnicola hungarica* (Grunow) F.E.Round & P.W.Basson, 6 – *Hippodonta capitata* (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski, 7 – *Fallacia pygmaea* (Kützing) A.J.Stickle & D.G.Mann, 8 – *Cocconeis placentula* var. *placentula* Ehrenberg, 9 – *Surirella terricola* Lange-Bertalot & E.Alles, 10 – *Gomphonema olivaceum* (Hornemann) Brébisson, 11 – *Encyonema minutum* (Hilse) D.G.Mann, 12 – *Sellaphora pupula* sensu lato, 13 – *Craticula cuspidata* (Kützing) D.G.Mann, 14 – *Anomooneis sphaerophora* E.Pfitzer, 15 – *Rhopalodia gibba* (Ehrenberg) Otto Müller

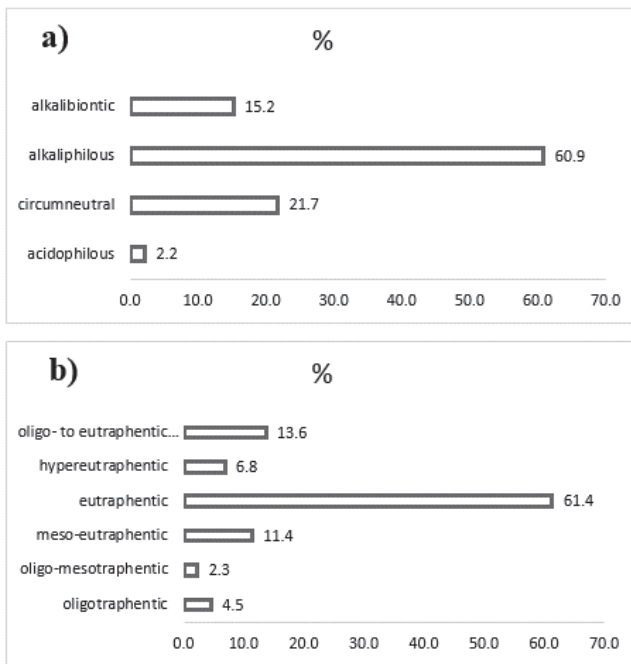


Fig. 3. Representation of percentages of diatoms in relation to (a) indicator values of water reaction and (b) trophic status by VAN DAM *et al.*, 1994.

lic communities. Rott Trophic Index varied between 2.7 and 3.4, thus indicating a eupolytrophic to polytrophic status for the marsh (Tab. 3). Indicator values for water reaction (R) and trophic status (T) by VAN DAM *et al.* (1994) were established for the majority of identified species (80% and 77%, respectively). Most of the identified species (Fig. 3) were eutrathentic (61%) and alkaliphilous (60%). The average indicator trophic value (VAN DAM *et al.*, 1994) for all identified species in all samples was 4.97, which corresponds to a eutrathentic status for the wetland.

The epipellic community showed higher spatial variation in the summer, as summarized by PCO analysis (Tab. 4). The first two axes accounted for approximately 55.8% of the total variance. The first PCO axis was best described by water transparency ($r = -0.58$) and coverage by floating vegetation ($r = -0.46$), while the second axis was described by water temperature ($r = 0.59$) and transparency ($r = 0.71$). Summer samples were mostly distributed along the PCO Axis 1, mainly differing in the percentage of coverage by floating vegetation. Positive values of Pearson's correlation coefficient with the first PCO axis were noted for the following species: *Anomoeoneis sphaerophora*, *Nitzschia frustulum* (Kützing) Grunow and *Tryblionella hungarica*. Negative correlation coefficient values have been established for the species *Cocconeis placentula* var. *euglypta* (Ehrenberg) Grunow, *Navicula radiosa* Kützing, *Navicula cryptocephala* and *Nitzschia palea* (Kützing) W.Smith. Positive values of Pearson's correlation coefficient ($r > 0.5$) with the second PCO axis and higher water temperature were noted for the species *Cyclotella meneghiniana*, *Anomoeoneis sphaerophora*, *Gomphonema pumilum* (Grunow) E.Reichardt & Lange-Bertalot and *Gomphonema psedoaugur* Lange-Bertalot. Negative values of Pearson's correlation coeffi-

Tab. 3. Diatom abundance (%) number of species and values of trophic and diversity index per sampling point,

Sampling point	L1/1	L1/2	L2/1	L2/2	L3/1	L3/2	L4/1	L4/2	L5/1	L5/2	L6/1	L6/2
Trophic index (Rott <i>et al.</i> , 1999)	3.4	3.4	3.2	3.3	3.2	3.2	3.2	2.9	3.1	3.1	2.7	3.1
Shannon-Wiener diversity index H'(log _e)	2.96	2.7	2.57	2.66	2.66	2.62	2.47	2.7	2.72	2.73	2.54	2.6
Number of species	32	27	29	30	26	26	18	23	28	27	21	19
Taxa (%)												
Acronym												
<i>Achnanthydium</i> sp. Kützing	2.2		0.9	0.5								
<i>Amphora ovalis</i> (Kützing) Kützing						0.8	0.5			0.9		2
<i>Amphora pediculus</i> (Kützing) Grunow ex A.Schmidt					6.4	0.8		0.3				
<i>Anomoeoneis sphaerophora</i> E.Pfitzer	0.7	17.8	5.7	4.7	4.5	4.2		7.3	5.3	0.3		8.5
<i>Galoneis</i> sp. Cleve										0.3		0.3
<i>Cocconeis pediculus</i> Ehrenberg			0.5	2.8								
<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehrenberg) Grunow											5.6	
<i>Cocconeis placentula</i> var. <i>placentula</i> Ehrenberg	7	2.5	6.6	11.3	4.5	5.9	13.7	9.5	3	1.5	5.6	19.8
<i>Craticula cuspidata</i> (Kützing) D.G.Mann	2.9	1.5		4		4.2		0.9	2.5	4.5	2.2	3
<i>Cyclotella meneghiniana</i> Kützing	1.5	0.8	0.9	0.9	1	3.4	3.2	8	2.3	0.3	6	7.8
<i>Cymatopleura elliptica</i> (Brébisson) W.Smith		0.3										
<i>Cymatopleura solea</i> (Brébisson) W.Smith	0.7	0.8	0.9	0.9	4.5			0.9	1	0.9	0.5	
<i>Cymbella aspera</i> (Ehrenberg) Cleve	0.3											
<i>Cymbella neocistula</i> Krammer	0.3	0.5				0.3			0.3			
<i>Diadema paracorentia</i> Lange-Bertalot & Werum				0.3								
<i>Diatoma vulgare</i> Bory de Saint-Vincent								0.9				
<i>Encyonema minutum</i> (Hilse) D.G.Mann	0.3	0.8	0.8		1.8							

Sampling point	L1/1	L1/2	L2/1	L2/2	L3/1	L3/2	L4/1	L4/2	L5/1	L5/2	L6/1	L6/2
<i>Encyonema prostratum</i> (Berkeley) Kützing		0.5	0.5						1.5	0.9		
<i>Encyonema vulgare</i> Krammer				0.3							0.3	1.4
<i>Epithemia adnata</i> (Kützing) Brébisson	0.3			0.3	0.3					0.9	3.4	
<i>Eunotia</i> sp. Ehrenberg				0.3			0.5	1.8				
<i>Fallacia pygmaea</i> (Kützing) A.J. Stickle & D.G. Mann	2.2	1.8	4		1.8	4.2	5.8	1.5	6.3	3.5		4
<i>Fragilaria acus</i> (Kützing) Lange-Bertalot	2.9	2.1		0.5			2.2					
<i>Gomphonema acuminatum</i> Ehrenberg	0.5		0.9	0.8	1				0.8			
<i>Gomphonema angustum</i> C. Agardh			0.9	0.9	0.8	0.8	2.2		3.8			
<i>Gomphonema italicum</i> Kützing		0.8	0.5				2.2		0.5			
<i>Gomphonema micropus</i> Kützing										0.9		
<i>Gomphonema olivaceum</i> (Hornemann) Brébisson				0.8					0.5			
<i>Gomphonema pala</i> E. Reichardt	2.2				0.5	0.5			0.5	0.9		
<i>Gomphonema pseudoaugur</i> Lange-Bertalot	0.7	3.5	1.5	3	0.5	0.8		2.5		4.5		4.5
<i>Gomphonema pumilum</i> (Grunow) E. Reichardt & Lange-Bertalot			0.9		0.5					0.9	1.1	4.8
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst	9.3	1.6	18.9	15.8	14.3	9.3	15.5	5.8	4	9.3	19.3	6.3
<i>Hippodontia capitata</i> (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski	2.9	4.8	8.3	1.5	10	5.5	5.4	8.5	1.3	9.5	1.5	1.8
<i>Lemnicola hungarica</i> (Grunow) F.E. Round & P.W. Basson	13		12.8	12	11.5	17.3	13.7	11	8	2.5	1.5	3.3
<i>Melosira varians</i> C. Agardh	3	4	21.3	3	13.3	22.3	17.9	15.3	24.8	15.8	7	4
<i>Navicula cryptocephala</i> Kützing	3.6	3.3	2.3	9	12	5.5	3.8	9.3	8.8	15.3	16	1.5
<i>Navicula radiosa</i> Kützing					1	1.7		6.3		6	13.8	1.8

Sampling point	L1/1	L1/2	L2/1	L2/2	L3/1	L3/2	L4/1	L4/2	L5/1	L5/2	L6/1	L6/2
<i>Neidium affine</i> var. <i>longiceps</i> (W.Gregory) Cleve			0.3		0.3			0.3		0.9		
<i>Nitzschia frustulum</i> (Kützing) Grunow	2.2	7	2.3	16.8	6.4	5	6.3		1.5	8.5		
<i>Nitzschia heufferiana</i> Grunow	0.7	1.4		0.9						0.9		
<i>Nitzschia palea</i> (Kützing) W.Smith	3.6		2			0.5		4.3	2	5.3	5.6	
<i>Nitzschia sigmoidea</i> (Nitzsch) W.Smith	0.7	0.8										
<i>Nitzschia umbonata</i> (Ehrenberg) Lange-Bertalot											0.5	
<i>Pinnularia acutobrevissimii</i> Kulikovskiy, Lange-Bertalot & Metzeltin			0.3									
<i>Pinnularia viridis</i> (Nitzsch) Ehrenberg		0.3			0.3			0.5	0.5	0.9		
<i>Planolithidium lanceolatum</i> (Brébisson ex Kützing) Bukhtiyarova	1.5					0.5	1.5				1.1	
<i>Planolithidium minutissimum</i> (Krasske) E.A.Morales	2.2		0.3		1.8			2	0.9			
<i>Rhoicosphenia abbreviata</i> (C.Agardh) Lange-Bertalot		0.8				1.7					1.1	
<i>Rhopalodia gibba</i> (Ehrenberg) Otto Müller	0.7	1	2.5	0.5		1.7	3.2	1.5	0.9			
<i>Sellaphora pupula</i> (Kützing) Mereschkovsky				0.3					1.5		1.1	
<i>Surirella amphioxys</i> W.Smith		0.3		0.3	0.3	0.3			1.5			
<i>Surirella angusta</i> Kützing	0.7		0.3									
<i>Surirella terricola</i> Lange-Bertalot & E.Alles	0.7							1.3				
<i>Tryblionella hungarica</i> (Grunow) Frenguelli	2.2	3.8	1.9	1.5	1.8	0.8			1.3			1.3
<i>Tryblionella littoralis</i> (Grunow) D.C.Mann	0.7	1.4	0.8	4.3	0.5	1.7	2.2		4.8	3.5	2.2	4.5
<i>Ulnaria capitata</i> (Ehrenberg) P.Compère	0.5	0.8	0.5	1.9								
<i>Ulnaria ulna</i> (Nitzsch) P.Compère				0.3		0.5	1.3	1	1.3	0.9	4.5	2.8

Tab. 4. Values of the Pearson correlation coefficient (r) of the examined parameters and species abundances with first two PCO axes

Parameters and species	Pearson correlation Index (r)	
	PCO1 (38.2% of total variation)	PCO2 (17.6% of total variation)
Temp. [°C]	0.12	0.59
pH	-0.25	-0.33
Secchi depth [cm]	-0.58	0.71
Depth [cm]	-0.09	0.19
Consumption KMnO_4	-0.02	0.04
Floating vegetation [%]	-0.46	0.20
Species		
<i>Amphora pediculus</i>	0.11	-0.33
<i>Anomoeoneis sphaerophora</i>	0.64	0.50
<i>Cocconeis placentula</i> var. <i>euglypta</i>	-0.75	0.10
<i>Cocconeis placentula</i> var. <i>placentula</i>	-0.07	0.23
<i>Cyclotella meneghiniana</i>	-0.53	0.41
<i>Fallacia pygmaea</i>	0.28	-0.18
<i>Gomphonema pseudoaugur</i>	0.30	0.65
<i>Gomphonema pumilum</i>	-0.32	0.63
<i>Gyrosigma acuminatum</i>	-0.47	-0.48
<i>Hippodonta capitata</i>	0.13	-0.38
<i>Lemnicola hungarica</i>	0.02	-0.61
<i>Melosira varians</i>	-0.20	-0.51
<i>Navicula cryptocephala</i>	-0.54	-0.29
<i>Navicula radiosa</i>	-0.84	0.26
<i>Nitzschia frustulum</i>	0.57	-0.43
<i>Nitzschia palea</i>	-0.68	-0.12
<i>Tryblionella hungarica</i>	0.81	0.13
<i>Tryblionella littoralis</i>	-0.04	0.33

cient with the second PCO axis and associated lower water temperatures and lower transparency were noted for species *Melosira varians*, *Lemnicola hungarica*, *Gyrosigma acuminatum*, *Nitzschia frustulum* and *Hippodonta capitata* (Fig. 4).

Similar abundances in spring and summer were noted for the following species: *Cocconeis placentula* var. *placentula*, *Fallacia pygmaea*, *Fragilaria acus* (Kützing) Lange-Bertalot, *Hippodonta capitata*, *Lemnicola hungarica*, *Navicula cryptocephala*, *Nitzschia palea*, *Rhopalodia gibba* (Ehrenberg) Otto Müller and *Tryblionella hungarica*. PERMANOVA results did not show significant differences among samples for the season ($p = 0.337$). However, some species showed greater abundance in spring, such as *Amphora pediculus* Grunow ex A.Schmidt, *Cocconeis placentula* var. *euglypta*, *Gyrosigma acuminatum*, *Melosira varians*, *Navicula radiosa* and *Sellaphora pupula* sensu lato. Other species had higher abundance in summer: *Cocconeis pediculus* Ehrenberg, *Gomphonema pseudoaugur*, *Nitzschia frustulum*, *Tryblionella littoralis*, *Ulnaria capitata* (Ehrenberg) P.Compère and *Amphora ovalis* (Kützing) Kützing

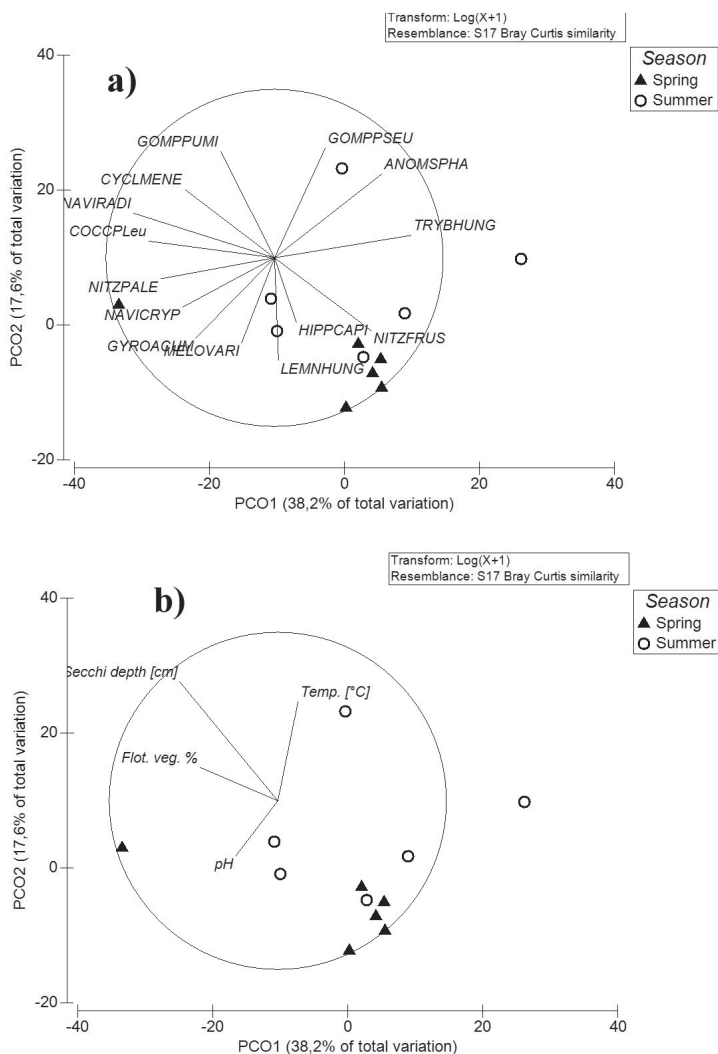


Fig. 4. Principal coordinates analysis (PCO) comparing the community composition between localities in spring and summer season. PCO plot coded by the species vectors indicates taxa positively correlated ($r > 0.4$) with the axes (a) and environmental vectors (b).

DISCUSSION

The most representative taxa in Šerička bara marsh (*Cocconeis placentula*, *Gyrosigma acuminatum*, *Navicula cryptocephala*, *Nitzschia palea* and *Cyclotella meneghiniana*) were also described in similar investigations of epipellic communities in 16 and 45 fishponds in the Czech Republic (Lysáková *et al.*, 2007; Poulíčková *et al.*, 2009, respectively). However, species that were abundant in these fishponds, such as *Gomphonema parvulum* (Kützing) Kützing, *Nitzschia acicularis* (Kützing) W.Smith, *Tabellaria flocculosa* (Roth) Kützing and *Aulacoseira* spp., were not recorded in this study. Unlike the fishponds, the species *Fallacia*

pygmaea was represented in this study in almost every sample with abundance of up to 6.3%. According to HOFFMAN *et al.* (2011), this species is common in brackish water or freshwater rich in electrolytes. *Lemnicola hungarica*, a common epiphyte on the roots of *Lemnaceae* species such as *Lemna minor*, *L. gibba* and *Wolffia arrhiza* (BUCZKÓ, 2007) in slow-flowing channels and lowland marshes with high trophic status and medium high to high electrolyte contents was also relatively abundant. In Šerička bara marsh it was very abundant in epipelon, since the floating vegetation of *Lemnaceae* species covering the marsh could provide a habitat from which *L. hungarica* could easily detach and fall to the bottom. However, no positive correlation between coverage of floating vegetation and abundance of *L. hungarica* was found, probably due to wind impact on this floating cover. *Anomoeoneis sphaerophora*, a typically brackish species which is common in lowland waters with high electrolyte content, was also common in this study (HOFMANN *et al.*, 2011).

Epipellic algae have been used as bioindicators in deep-water ecosystems (SMOL & STOERMER, 2010). However, POULÍČKOVÁ *et al.* (2004) speculated that littoral sediments contain a mixture of planktonic, epiphytic and epipellic algae which are rarely taken into account. They have established significant differences among epilithic, epiphytic and epipellic samples in evaluation of the trophic states of peri-alpine lakes in Austria, where epipelon overestimated the trophic status when compared to the trophic status deduced from open water samples. HAŠLER *et al.* (2008) reported that epipellic assemblages reflect sediment quality rather than water-column chemistry. However, a study by KITNER & POULÍČKOVÁ (2003) showed that no significant differences in index values for epipellic, epiphytic and epilithic communities in littoral part of the shallow lakes exist. Considering that diatom indices can give different results in the evaluation of trophic status, two diatom indices were used in this study. Both of them indicated ongoing eutrophication processes in the marsh, followed by the massive growth of emergent and floating vegetation, due which the area has a tendency to become a terrestrial ecosystem. The greater presence of dominant epipellic species in this study also indicated high trophic status and electrolyte-rich water. Species *Hippodonta capitata*, *Tryblionella hungarica*, *Navicula cryptocephala* and *Gyrosigma acuminatum* are common in eutrophic and polytrophic waters of β - to α -mesosaprobic zone, while very abundant species *Craticula cuspidata* is also known in industrial waste waters (HOFMANN *et al.*, 2011). Following the classification of VAN DAM *et al.* (1994) most frequent and dominant taxa in the Šerička bara marsh were alkaliphilous and alkalibiontic, fres – brakish, nitrogen autotrophic or facultatively nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen, with moderate oxygen requirements, indicating eutrophic state. Moreover, the marsh is surrounded by agricultural land and villages that greatly affect the eutrophication processes in it.

Using diatoms known for cryptic and pseudocryptic diversity, such as *Navicula cryptocephala* and *Sellaphora pupula* sensu lato, in bioindication of water quality becomes difficult. FINLAY *et al.* (2002) discussed *Cyclotella meneghiniana*, *Nitzschia palea* and *Navicula cryptocephala* as widely distributed and ecologically eurivalent species, but detection of cryptic and pseudocryptic diversity introduced doubts concerning their cosmopolitan distribution (POULÍČKOVÁ *et al.*, 2008; POULÍČKOVÁ *et al.*, 2010). Species *Navicula cryptocephala* was the most common species in epipellic community of the Šerička bara marsh. Since this study gives only the first results on epipellic communities, more detailed studies about taxonomy and distribution of heterogeneous species in the geographic area of Bosnia and Herzegovina are needed.

Light and temperature significantly influence diatom abundance in different communities (HILL, 1996). POULÍČKOVÁ *et al.* (2014) stressed that epipelon distribution is affected

primarily by the depth of the overlying water, light, temperature, and sediment type. The most influential factor in this investigation was water transparency, which is in accordance with GOLDENBERG *et al.* (2014), who also pointed out the influence of particles that decrease transparency, and thus change the structure of diatom communities. The increased abundance of facultatively heterotrophic species *Cyclotella meneghiniana* (LYLIS & TRAINOR, 1973) in epipelagic communities is probably the consequence of decreased transparency and limitation by light in lower water layers. POULIČKOVA *et al.* (2014) showed that diatom epipelagic communities are closely related to environmental gradients, pH and conductivity. However, except for the coverage of floating vegetation, the ecological parameters in this study were in quite narrow ranges, most likely too narrow to influence shifts in diatom assemblages in the research period, thus making it difficult to distinguish the most relevant parameters driving the structure and composition of epipelagic diatom communities.

Seasonally, the greatest differences among the investigated sites were noted for lower water temperature ranges, accompanied by increased abundance of *Gomphonema acuminatum* and *Cymatopleura solea* in spring, in relation to summer, when increased abundance of *Amphora ovalis* was noted. Seasonal variations in epipelagic communities were observed by ŠPAČKOVA *et al.* (2009), with a greater presence of cyanobacteria in summer due to increase of organic matter content. As in this study, *Sellaphora pupula* sensu lato was the most abundant in spring months, and *Navicula cryptocephala*, *Achnanthydium minutissimum* and *Nitzschia palea* were more or less equally distributed during both seasons. The species *Sellaphora pupula* sensu lato was observed with an occurrence of up to 1.5%, which was in accordance with the results of ŠPAČKOVA *et al.* (2009), whilst POULIČKOVA *et al.* (2008) found this species in up to 40% of epipelagic samples of British lakes. Since this species has been found only in spring, it is possible that higher distribution of *Sellaphora pupula* sensu lato in British waters is influenced by lower water temperature and different climate conditions. Although there were variations in the abundances of several species during spring and summer, diversity index values remained quite constant throughout both the research seasons.

CONCLUSION

Epipelagic communities of the Šerička bara marsh presented a high diversity of diatoms, and most of identified species were eutraphentic and alkaliphilous, indicating the high eutrophic status of the marsh. No statistical difference in diatom communities between spring and summer was established, although several species had more or less different abundances during these two sampling periods. The eutrophication process is followed by the dense growth of floating and emerged vegetation. Considering the growing worldwide threat to marshes, measures for conservation of this marsh, currently a completely unprotected ecosystem, are desperately needed in order to secure the habitat for many marsh species.

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SAŽETAK

Epipelonske dijatomeje Šeričke bare (sjeveroistočna Bosna i Hercegovina)

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Močvare su jedan od najugroženijih ekosustava u Bosni i Hercegovini, ograničenih na male površine zbog učestalih zahvata melioracije i isušivanja. Iako do sada nisu provedena istraživanja zajednica primarnih proizvođača na području Šeričke bare u sjeveroistočnoj Bosni i Hercegovini, ona je prepoznata kao značajno močvarno stanište u nacionalnim programima ocjene biološke raznolikosti. U radu su istraživane epipelonske dijatomeje, značajni pokazatelji promjena u vodenim ekosustavima. Ciljevi istraživanja bili su: 1) uvrstiti dijatomejski sastav bentoskih zajednica Šeričke bare, 2) uporediti strukturu dijatomeja tijekom proljetnog i ljetnog razdoblja te 3) procijeniti trofički status ove močvare. Utvrđeno je 57

vrsta dijatomeja iz 33 roda. Najveći broj vrsta pripadao je rodovima *Gomphonema* (8) i *Nitzschia* (5). Najbrojnije vrste bile su *Melosira varians*, *Gyrosigma acuminatum*, *Lemnicola hungarica*, *Navicula cryptocephala*, *Cocconeis placentula* var. *placentula*, *Hippodonta capitata*, *Fallacia pygmaea*, *Anomoeoneis sphaerophora*, *Craticula cuspidata*, *Cyclotella meneghiniana* i *Tryblionella hungarica*. Shannon–Wienerov indeks raznolikosti varirao je od 2,47 do 2,96 ukazujući na visoku raznolikost vrsta u epipelonskim zajednicama. Trofički indeks prema Rott-u kretao se u vrijednostima od 2,7 do 3,4 i ukazujući na eupolitrofni do politrofni status močvare. Iako analizom PERMANOVA nisu utvrđene statistički značajne razlike u strukturi zajednice proljetnih i ljetnih uzoraka epipelona, nekoliko je vrsta imalo veću brojnost u proljeće, dok su druge bile zastupljenije u ljeto. Povećanjem temperature povećala se brojnost vrsta *Amphora ovalis* i *Caloneis* sp., dok su u proljetnoj sezoni s nižim temperaturama vode bile zastupljene *Gomphonema angustum*, *Cocconeis pediculus*, *Cymatopleura solea*, *Gomphonema acuminatum* i *Gyrosigma acuminatum*. Dominatne vrste u epipelonu istraživane močvare ukazuju na visoki stupanj trofije i vodu bogatu elektrolitima. Procese eutrofikacije prati bujni porast emerzne i flotantne vegetacije. Imajući u vidu sve veću ugroženost močvara u svijetu, mjere očuvanja ovog ekosustava, koji trenutno nažalost ne podliježe nikakvoj zaštiti, neophodne su zbog osiguranja staništa za mnoge biljne i životinjske močvarne vrste.