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EPIPHYTIC DIATOMS ON *NYMPHAEA ALBA* L. LEAVES IN A SUB-MEDITERRANEAN WETLAND (SOUTH BOSNIA AND HERZEGOVINA)

Dubravka Hafner[1*], Nenad Jasprica[2] & Marina Carić[2]

[1] University of Mostar, Faculty of Science and Education, BiH-88000 Mostar, Bosnia and Herzegovina

[2] Institute for Marine and Coastal Research, University of Dubrovnik, P.O. Box 83, HR-20000 Dubrovnik, Croatia (E-mail: nenad.jasprica@unidu.hr)

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Epiphytic diatoms on *Nymphaea alba* L. floating leaves during plant growing seasons in the oligotrophic Sub-Mediterranean wetland Hutovo Blato, South Bosnia and Herzegovina, were investigated in 2003 and 2004. In total, 135 taxa (species and infraspecific taxa) of epiphytic diatoms were identified. Genera with the largest number of taxa were: *Eunotia* (14), *Gomphonema* (13), *Cymbella* and *Navicula* (9), *Cyclotella* (6), *Diatoma* and *Nitzschia* (5). Only three taxa were recorded in all samples: *Brebissonia lanceolata*, *Eunotia arcus* and *Navicula radiosa.* The most abundant taxa were *Cocconeis placentula*, *Cyclotella comta*, *Eunotia arcus* and *Gomphonema longiceps*.

Key words: **epiphytic diatoms, *Nymphaea alba*, karstic wetland, the Balkans**

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U vegetacijskim sezonama 2003. i 2004. istraživana je flora epifitskih dijatomeja na listovima lopoča (*Nymphaea alba* L.) u oligotrofnoj močvari Hutovo Blato u Hercegovini, južna Bosna i Hercegovina. Ukupno je utvrđena 135 svojta (vrsta i nižih taksonomskih jedinica). Rodovi s najvećim brojem svojta su *Eunotia* (14), *Gomphonema* (13), *Cymbella* i *Navicula* (9), *Cyclotella* (6), *Diatoma* i *Nitzschia* (5). Tri su svojte prisutne u svim uzorcima: *Brebissonia lanceolata*, *Eunotia arcus* i *Navicula radiosa.* Najveću abundanciju imaju svojte *Cocconeis placentula*, *Cyclotella comta*, *Eunotia arcus* i *Gomphonema longiceps*.

Ključne riječi: **epifitske dijatomeje, *Nymphaea alba*, krška močvara, Balkanski poluotok**

INTRODUCTION

Diatoms occupy a wide variety of niches within lotic and lentic environments. For the most part they are attached, living on rock surfaces (epilithon), larger plants (epiphyton), mud and silt (epipelon), and sand (epipsammon) (Reid *et al*., 1995). They have been extensively used as biomonitors of water quality, and they are one of the most suitable biological components of aquatic ecosystems for tracking environmental disturbances (Dixit *et al*., 1992). Diatoms are very sensitive to changes in water chemistry and many taxa have well defined ecological optima and tolerances (Yang & Dickman,

* corresponding author's e-mail: dubhafner@gmail.com

1993). They are also used to monitor wetland ecosystems and human impact (Lane & Brown, 2007) including nutrient enrichment (e.g. McCormick & Stevenson, 1998).

The European White Water Lily (*Nymphaea alba* L.) is an aquatic floating-leaved macrophyte of the family *Nymphaeaceae*. It is found in freshwater all over Europe, in parts of North Africa and the Middle East. This species is a very widespread in deep stagnant waters in the Dinaric karstic region (Jasprica & Carić, 2002; Jasprica, 2009; Lasić *et al*., 2014). It provides shelter and nourishment for macroinvertebrate grazers (Kok & Van der Velde, 1994), like insects, snails and leeches (Paillisson & Marion, 2001). On the other hand, high phenolic concentrations were found in floating leaves (Kok *et al*., 1992; Smolders *et al*., 2000). These substances are important in the defence of plants against herbivores.

The main aim of this study was to examine the completely unknown epiphytic algal flora of Bosnia and Herzegovina, i.e.,its diversity, and the epiphytic species richness found on *Nymphaea alba*. Epiphytic diatoms growing on *Nymphaea alba* leaves were surveyed in the lakes and canals in the Sub-Mediterranean wetland Hutovo Blato, South Bosnia and Herzegovina.

STUDY AREA

The Hutovo Blato wetland is one of the most important parts of the Neretva River delta in Bosnia and Herzegovina. The Neretva River delta stretches through Croatia and Bosnia and Herzegovina, 30% of its area belonging to Bosnia and Herzegovina. The wetland is situated 20 km inland from the Adriatic Sea, along the frontier between Bosnia and Herzegovina and Croatia.

This area was classified as a natural park in 1995. It was listed in the Ramsar Convention as international protected wetland in 2001. The total area of Hutovo Blato Park covers 74 km^2. The geology consists mostly of Cretaceous and Eocene limestone (Juračić, 1998). There are six lakes in the park: Škrka, Jelim, Drijen, Orah and Deran, and Donje Blato, the latter being a reservoir. Most of these lakes are shallow (1–2 m depth), except for Lake Jelim (max. depth of 17 m). The altitudinal range of the area is between sea level and 3 m. The water masses of these lakes originate from numerous karstic springs that are very active from autumn to late spring. Thermal stratification does not occur in the lakes during year and they never freeze.

The main waterway in the wetland is the Krupa River, 20 km long. It originates in the western region of Lake Deran and flows through the plain area towards the Neretva River. In autumn and winter, the water level of the Neretva River rises rapidly, due to disproportions between the quantity of water flowing from the upper reaches of the Neretva River and the capacity of its basin in its lower reaches. This, in turn, changes the hydrographic orientation of the Krupa River, which deflects the water into Hutovo Blato. Almost the entire valley is flooded in this period, if not quite all of it. Over the last few decades, numerous anthropogenic influences have significantly changed the hydrological regime, which has also affected water quality (Štambuk-Giljanović, 1998).

The climate is mostly warm and dry. The mean annual air temperature is 14.6°C (data for the nearest station of Ljubuški for the period 1971–2000, recorded by Meteorological and Hydrological Service of Bosnia and Herzegovina). The warmest part of the year is summer, with an average temperature for the season of 23.4°C. The warmest month is

July, with an average monthly temperature always above 23°C, while the coldest month is January, with a mean monthly temperature around or above 5°C. Mean monthly temperatures above 20°C were recorded for the period from June to September.

Phytogeographically, this area belongs to the Sub-Mediterranean vegetation zone of hop and oriental hornbeam forests (the *Ostryo-Carpinion orientalis* Horvat 1954 emend. 1958 alliance), mainly communities of shrub forests of pubescent oak and oriental hornbeam (the *Querco-Carpinetum orientalis* Horvatić 1939 association). In total, 39 plant communities within nine vegetation classes were recognized in the park (Jasprica & Carić, 2002). Some associations have been recently recorded in the area and one new has been described, too (Jasprica *et al*., 2008, 2009; Jasprica & Kovačić, 2011). Although the park belongs to the Sub-Mediterranean vegetation zone, the aquatic vegetation is not significantly different from that found in the inland Balkans. The overall picture of vegetation in the Hutovo Blato wetland does not show serious degradation trends, although the area is affected by multiple human impacts (Jasprica *et al*., 2003).

MATERIAL AND METHODS

The study was carried out during the plant growing seasons: in June, August and September 2003, and October 2004 in the lakes area and along the Krupa River. In June 2003, samples were collected from 13 stations in the park, encompassing the entire area

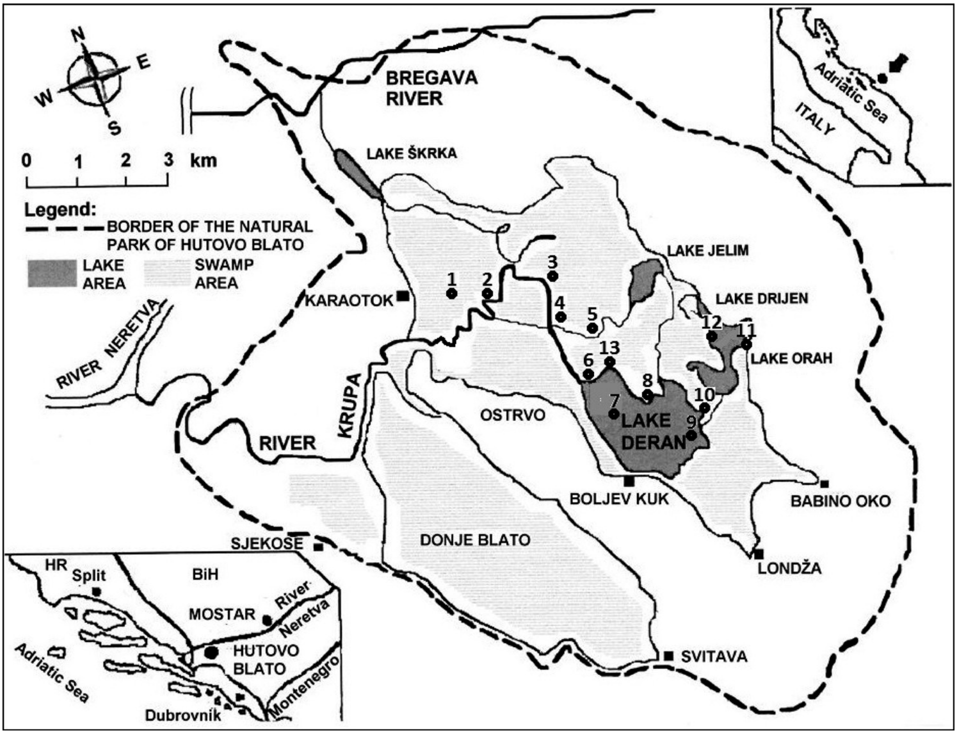

Fig. 1. Sampling site locations in the Hutovo Blato wetland. Abbreviations: HR: Croatia; BiH: Bosnia and Herzegovina; ■: towns and villages.

(Fig. 1). Samples were also collected at five (at stations 1, 2, 3, 4 and 5) and three (at stations 1, 2 and 3) stations on 12th August and 2nd September 2003, respectively. Additionally, four samples (at stations 1, 6, 7 and 9) were collected on 29th October 2004. A total of 25 samples were collected and analysed. In our case, June and August were considered as summer months, while September and October fall in autumn.

The main environmental parameters were collected along with the sampling of diatoms. The surface water temperature, pH, and nutrient (ammonia, nitrite, nitrate, reactive phosphorus, reactive silicate, total nitrogen and total phosphorus) concentrations were measured according to APHA (1989).

Data on environmental parameters between two seasons were tested using the *t*-test (at the 0.05 level of significance). Analyses were performed with STATISTICA 7.0 software (StatSoft Inc., Tulsa, OK, USA).

The epiphytic diatoms were collected by brushing off both sides of floating leaves of the macrophyte *Nymphaea alba*. Samples were preserved in 2.5% formaldehyde and processed according to standard procedures (Van der Werff, 1955). For each slide, a minimum of 400 valves were counted at 1000x on an Olympus BX51 microscope. The relative abundances of taxa were expressed as percentages of the total number of frustules counted, following Krammer & Lange-Bertalot (1986, 1988, 1991a, 1991b). Additionally, references used in the identification of diatoms are listed by Jasprica & Hafner (2005). The nomenclature of species and infraspecific taxa follows *Algaebase* website (M. D. Guiry & G. M. Guiry, 2013, searched on 23 January 2013).

RESULTS

The main environmental variables in the investigated area are shown in Tab. 1. During summer and autumn 2003, the oxygen saturation (O_2/O_2') in lakes and in the Krupa River ranged from 0.55 to 1.05. The nutrient concentrations (μmol L^{-1}) ranged for reactive silicate 17.70–83.40, reactive phosphorus 0.06–0.18, total phosphorus 0.19–0.61, ammonia 2.25–6.00, nitrite 0.02–0.13, nitrate 4.97–16.35, and total nitrogen 6.17–22.37, res-

Tab. 1. Main abiotic variables in the Hutovo Blato wetland.

		pH	T (°C)	O_2/O_2'	NO_3	NO_2	NH_4	TIN	PO_4	TP	SiO_4
Summer	MIN	–	21.90	0.73	13.41	0.02	2.25	15.99	0.09	0.19	64.40
2003	MAX	–	24.75	1.05	16.35	0.03	6.00	22.37	0.18	0.46	67.30
	AVG	–	23.35	0.89	14.81	0.03	3.84	18.74	0.12	0.30	65.88
	SD	–	1.15	0.13	1.29	0.01	1.52	2.29	0.04	0.12	1.40
Autumn	MIN	7.29	22.10	0.55	4.97	0.04	1.07	6.17	0.06	0.43	17.70
2003	MAX	7.63	25.00	0.96	15.77	0.13	2.85	18.43	0.10	0.61	83.40
	AVG	7.45	23.24	0.82	12.89	0.07	2.29	15.26	0.08	0.53	60.80
	SD	0.15	1.18	0.19	5.28	0.04	0.82	6.06	0.02	0.08	29.35

O_2/O_2' – oxygen saturation, TIN – total nitrogen, TP – total phosphorus. Nutrient concentrations are expressed in μmol L^{-1}.

pectively. According to *t*-test, there were no differences ($P>0.05$) between summer and autumn values, except for total phosphorus ($P<0.05$).

Altogether, 135 diatom taxa belonging to 43 genera were identified in the samples (Tab. 2). Genera with the highest number of taxa were: *Eunotia* (14), *Gomphonema* (13), *Cymbella* and *Navicula* (9), *Cyclotella* (6), *Diatoma* and *Nitzschia* (5). Only three taxa were recorded in every sample: *Brebissonia lanceolata*, *Eunotia arcus* and *Navicula radiosa.* In addition, 19 taxa were present in at least one sample per sampling month: *Amphora ovalis*, *Cocconeis placentula*, *C. placentula* var. *lineata*, *Cyclotella comta*, *Cymatopleura solea*, *Denticula tenuis*, *Encyonema silesiacum*, *Epithemia turgida*, *Eunotia bilunaris*, *E. tenella*, *Gomphonema intricatum*, *G. longiceps*, *G. truncatum*, *Gyrosigma acuminatum*, *Rhopalodia gibba*, *Staurosira construens*, *Stauroneis phoenicenteron*, *Ulnaria capitata* and *U. ulna*.

Taking into consideration all localities, the highest number of taxa (101) was recorded in June 2003, followed by October 2004 (60), then August (54) and September 2003 (48). However, average number of taxa per locality in June and August 2003 was 38 and 25, respectively. There was no difference in average number of taxa per locality between September 2003 (35) and October 2004 (38). Some taxa appeared only in particular months; the highest number of these taxa with restricted occurrence (36) was recorded in June 2003.

Cocconeis placentula, *Cyclotella comta*, *Eunotia arcus* and *Gomphonema longiceps* were the most abundant taxa (Tab. 3). Among them, *Eunotia arcus* had the highest abundances (1–95%). Beside this taxon, *Gomphonema longiceps* was also found during all sampling months.

DISCUSSION

This study considered the diversity and abundances of epiphytic diatoms on *Nymphaea alba* floating leaves during the plant growing seasons. Much of the Hutovo Blato wetland area is covered by floating-leaved plant species from April to October only; mainly *Nymphaea alba* and *Nuphar lutea* forming a mosaic of monospecific patches (Jasprica & Carić, 2002).

We did not investigate in detail the relationship between epiphytic diatoms and physico-chemical variables, and further, more detailed studies are required to define it. However, nutrient concentrations were used in order to assess the trophic state of the wetland. According to nutrient concentrations in summer and autumn, the Hutovo Blato wetland can be classified as oligotrophic (OECD, 1982). This agrees with findings of Jasprica *et al.* (2005), and Jasprica & Hafner (2005) based on whole-year data for the lakes in the lower Neretva River delta.

Floating leaves of *Nymphaea alba* supported diverse populations of epiphytic diatoms in this wetland; we recorded 135 taxa in 25 samples from 13 sites for the months June, July, August, September and October. In contrast, Neyran Soylu *et al.* (2005) found 40 diatom taxa on the leaves and stems of *Nuphar lutea* in northern Turkish lakes and lagoons, but they studied only spring-summer period. On the other hand, regarding the number of taxa, our study coincided with results of Caput & Plenković-Moraj (2000), but the similarity of diatoms between the Plitvice Lakes and Hutovo Blato wetland – characterized by the Jaccard index (Jaccard, 1908) – was relatively low (32%).

Concerning the number of taxa, the highest was in June 2003 when the most samples were collected. During late summer, especially in the extreme drought of 2003 (UNDP,

Tab. 2. The list of taxa and their frequency of occurrence (%).

Taxa	6 June, 2003	12 August, 2003	2 September, 2003	29 October, 2004
n =	13	5	3	4
Achnanthes exigua Grunow	42	–	33	–
Achnanthes lanceolata var. *minuta* (Skvortzov) Sheshukova	8.3	–	–	–
Achnanthidium affine (Grunow) Czarnecki	17	–	–	–
Achnanthidium minutissimum (Kützing) Czarnecki	67	40	–	50
Amphora ovalis (Kützing) Kützing	75	60	66	75
Amphora ovalis var. *gracilis* (Ehrenberg) van Heurck	8.3	–	–	–
Amphora pediculus (Kützing) Grunow ex A. Schmidt	42	–	66	50
Anomoeoneis elliptica Zakrz.	–	–	33	–
Anomoeoneis sphaerophora E. Pfitzer	8.3	–	–	–
Brebissonia lanceolata (C. Agardh) Mahoney & Reimer	100	100	100	100
Caloneis bacillum (Grunow) Cleve	17	–	–	–
Caloneis silicula var. *truncatula* (Grunow) Cleve	17	20	66	–
Caloneis ventricosa (Ehrenberg) F.Meister	8.3	20	–	–
Cocconeis pediculus Ehrenberg	50	–	33	–
Cocconeis placentula Ehrenberg	100	60	100	75
Coconeis placentula var. *euglypta* (Ehrenberg) Grunow	8.3	–	–	–
Cocconeis placentula var. *lineata* (Ehrenberg) van Heurck	33	20	33	50
Cyclotella comta (Ehrenberg) Kützing	83	80	33	100
Cyclotella meneghiniana Kützing	–	–	–	100
Cyclotella sp. 1	50	–	–	–
Cyclotella sp. 2	–	–	–	25
Cyclotella sp. 3	–	–	–	25
Cyclotella sp. 4	–	–	–	25
Cymatopleura elliptica (Brébissoni) W. Smith	8.3	20	–	50
Cymatopleura solea (Brébisson) W.Smith	25	40	66	50
Cymbella affinis Kützing	83	20	66	–
Cymbella aspera (Ehrenberg) Cleve	17	20	–	–
Cymbella capricornis Skvortzov	8.3	20	–	–
Cymbella cistula (Hemprich & Ehrenberg) O.Kirchner	58	–	33	75
Cymbella cymbiformis C. Agardh	25	–	–	–
Cymbella ehrenbergii Kützing	8.3	–	–	–
Cymbella leptoceros (Ehrenberg) Grunow	8.3	–	–	–
Cymbella turgidula Grunow	–	20	–	–
Cymbella sp.	–	–	–	75
Cymbopleura lata (Grunow) Krammer	8.3	20	33	–
Coscinodiscus lacustris Grunow	8.3	–	–	–

Coscinodiscus rothii var. *subsalsum* (Juhlin – Dannfelt) Hustedt	–	–	–	75
Coscinodiscus rothii (Ehrenberg) Grunow	–	–	33	–
Coscinodiscus sp.	8.3	20	–	–
Denticula elegans Kützing	–	–	–	25
Denticula tenuis Kützing	83	80	33	50
Denticula tenuis var. *crassula* (Nägeli) Hustedt	33	–	33	–
Diatoma hiemalis (Lyngbye) Heiberg	25	–	33	–
Diatoma mesodon (Ehrenberg) Kützing	8.3	–	–	50
Diatoma tenuis C.Agardh	25	–	–	–
Diatoma vulgaris Bory de Saint – Vincent	8.3	–	–	25
Diatoma vulgaris var. *capitulata* Grunow	17	–	–	–
Diploneis ovalis (Hilse) Cleve	–	20	33	–
Ellerbeckia arenaria (Moore ex Ralfs) R.M.Crawford	–	20	–	25
Encyonema prostratum (Berkeley) Kützing	42	–	–	25
Encyonema silesiacum (Bleisch) D. G. Mann	100	60	66	75
Encyonopsis microcephala (Grunow) Krammer	8.3	–	–	–
Epithemia turgida (Ehrenberg) Kützing	50	40	33	25
Epithemia turgida var. *granulata* (Ehrenberg) Brun	17	–	–	–
Epithemia zebra (Ehrenberg) Kützing	8.3	–	–	–
Eunotia arcus Ehrenberg	100	100	100	100
Eunotia arcus var. *bidens* Grunow in van Heurck	8.3	–	–	–
Eunotia arcus var. *uncinata* (Ehrenberg) Grunow in van Heurck	8.3	–	–	–
Eunotia bilunaris (Ehrenberg) Schaarschmidt	17	20	33	50
Eunotia exigua (Brébisson ex Kützing) Rabenhorst	33	100	66	–
Eunotia exigua var. *compacta* Hustedt	–	40	–	–
Eunotia glacialis Meister	8.3	40	–	–
Eunotia flexuosa (Brébisson) A.Berg	25	–	33	25
Eunotia paralella Ehrenberg	–	–	–	25
Eunotia pectinalis (Kützing) Rabenhorst	–	–	33	–
Eunotia praerupta Ehrenberg	–	40	–	25
Eunotia tenella (Grunow) Hustedt in Schmidt	50	60	33	25
Eunotia valida Hustedt	505	–	–	75
Eunotia sp.	–	–	–	25
Fragilaria capucina var. *mesolepta* (Rabenhorst) Rabenhorst	8.3	–	–	–
Fragilaria crotonensis Kitton	–	–	–	25
Fragilaria virescens var. *capitata* Østrup	8.3	–	–	–
Frustulia creuzburgensis (Krasske) Hustedt	–	–	33	–
Gomphonema acuminatum Ehrenberg	17	–	–	25
Gomphonema acuminatum var. *coronatum* (Ehrenberg) Ehrenberg	42	60	–	75
Gomphonema angustatum (Kützing) Rabenhorst	33	20	33	–
Gomphonema augur Ehrenberg	42	–	–	–
Gomphonema constrictum var. *capitatum* Ehrenberg	8.3	–	–	–
Gomphonema gracile Ehrenberg	–	20	–	–
Gomphonema intricatum Kützing	50	80	66	100

Gomphonema intricatum var. *pumilum* Grunow	8.3	–	–	25
Gomphonema longiceps Ehrenberg	92	100	100	100
Gomphonema longiceps var. *subclavatum* Grunow	25	40	33	–
Gomphonema parvulum (Kützing) Kützing	–	–	33	–
Gomphonema parvulum var. *subellipticum* Cleve	8.3	–	–	–
Gomphonema truncatum Ehrenberg	75	80	100	50
Gyrosigma acuminatum (Kützing) Rabenhorst	33	40	66	25
Gyrosigma attenuatum (Kützing) Rabenhorst	8.3	–	33	–
Halamphora veneta (Kützing) Levkov	8.3	20	33	–
Melosira varians C. Agardh	25	–	–	–
Melosira sp.	8.3	–	–	–
Navicula capitatoradiata Germain	–	–	–	25
Navicula cryptocephala Kützing	–	–	–	50
Navicula exigua Gregory	8.3	–	–	–
Navicula gracilis Lauby	8.3	–	66	–
Navicula gregaria Donkin	–	–	–	50
Navicula hasta Pantocsek	–	20	–	–
Navicula miniscula Grunow	–	–	33	–
Navicula oblonga (Kützing) Kützing	42	20	–	50
Navicula radiosa Kützing	100	100	100	100
Neidium dubium (Ehrenberg) Cleve	17	–	–	50
Nitzschia gracilis Hantzsch	–	20	–	–
Nitzschia linearis West	33	20	–	–
Nitzschia sigmoidea (Nitzsch) W. Smith	25	–	–	25
Nitzschia sublinearis Hustedt	8.3	–	–	–
Nitzschia vermicularis (Kützing) Hantzsch	8.3	–	–	–
Pinnularia major (Kützing) Rabenhorst	17	–	–	–
Pinnularia sudetica (Hilse) Hilse	–	20	33	–
Planothidium ellipticum (Cleve) M. B. Edlund	8.3	–	–	25
Planothidium lanceolatum (Brébisson ex Kützing) Lange–Bertalot	25	–	–	25
Pseudostaurosira subsalina (Hustedt) E.A.Morales	8.3	20	–	25
Rhoicosphenia abbreviata (C. Agardh) Lange–Bertalot	–	–	–	25
Rhopalodia gibba (Ehrenberg) Otto Müller	25	60	33	50
Rhopalodia gibba var. *parallela* (Grunow) H.Peragallo & M.Peragallo	–	20	–	–
Sellaphora pupula (Kützing) Mereschkovsky	8.3	–	–	–
Sellaphora. rectangularis (Gregory) Lange–Bertalot & Metzeltin	–	–	–	50
Staurosira construens Ehrenberg	33	20	66	100
Staurosira construens var. *binodis* (Ehrenberg) P.B.Hamilton	17	–	–	–
Staurosira venter (Ehrenberg) H.Kobayasi	25	20	–	–
Staurosira construens var. *triundulata* (Reichelt ex Hartz & Østrup) E.Y.Haworth & M.G.Kelly	8.3	–	–	–
Staurosirella leptostauron (Ehrenberg) D.M.Williams & Round	50	–	33	–
Staurosirella pinnata (Ehrenberg) D. M. Williams & Round	42	20	–	–
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	42	20	33	25

Stauroneis parvula (Grunow) Cleve	8.3	–	–	–
Surirella linearis W. Smith	33	–	–	–
Surirella spiralis Kützing	8.3	–	–	–
Synedra affinis var. *fasciculata* (Lyngbye) Grunow in van Heurck	–	40	–	–
Synedra amphicephala Kützing	–	–	–	50
Tryblionella acuta (Cleve) D.G.Mann	8.3	–	–	–
Tabellaria flocculosa (Roth) Kützing	8.3	–	–	–
Tabellaria flocculosa (Roth) Kützing	33	–	–	50
Ulnaria biceps (Kützing) P.Compère	–	40	–	50
Ulnaria capitata (Ehrenberg) P.Compère	50	100	66	100
Ulnaria danica (Kützing) Compère & Bukhtiyarova	8.3	–	33	–
Ulnaria ulna (Nitzsch) P.Compère	100	100	100	50

Tab. 3. Range of abundances for the most abundant (≥ 1%) diatom taxa in the samples.

	2003	2003	2003	2004
Taxa	June	August	September	October
	n=13	n=5	n =3	n=4
Cocconeis placentula Ehrenberg	1 – 51	–	–	–
Cyclotella comta (Ehrenberg) Kützing	–	–	–	10 – 79
Brebissonia lanceolata (C. Agardh) Mahoney & Reimer	–	–	–	1 – 5
Encyonema silesiacum (Bleisch) D. G. Mann	1 – 15	–	–	–
Eunotia arcus Ehrenberg	1 – 61	80 – 95	65 – 91	2 – 58
Gomphonema longiceps Ehrenberg	1 – 54	2 – 9	2 – 22	2 – 64
Navicula radiosa Kützing	–	–	–	1 – 3

2011; Dragojlović & Mokorić, 2012), the water level of the Neretva River delta decreased and many karstic springs located around the marsh edges, which support the region with water, ran dry. In addition, strong evaporation rates occurred in July and August (200 mm per month) in these shallow karstic lakes (Bonacci, 2001). Due to the extremely low water level there was no possibility of collecting samples from the same stations in the lakes.

The genera *Eunotia*, *Gomphonema*, *Cymbella*, *Navicula*, *Cyclotella*, *Diatoma* and *Nitzschia* were the richest in taxa. Although there were some differences among our inventory and those by other authors for epiphyton from waterbodies of similar latitudes, most of the taxa recorded are characterized by wide geographic distributions (e.g. Cambra, 1992; Tesolín & Tell, 1996; Blanco *et al.*, 2004; Kociolek, 2005, etc.).

The most common taxa were also observed in freshwater inland environments of North America (Stoermer & Kreis, 1978; Bahls, 2009). *Brebissonia lanceolata* was also found in rivers of Siberia and the Russian Far East at both clean and moderately polluted sites (Potapova, 1996). *Eunotia arcus* is known to be a cosmopolitan taxon occurring in slightly acid to circumneutral waters (Mayama & Kobayasi, 1991; Poulícková *et al.*, 2004).

In general, *Eunotia*-dominated diatom communities and filamentous green algae are known to be common in streams with low pH (Kinross *et al.*, 1993). *Navicula radiosa* is a world-wide distributed taxon reported from different habitats (e.g. Souffreau *et al.*, 2010; Żelazna-Wieczorek, 2011).

The most abundant and frequent taxa (e.g. *Cocconeis placentula*) were also observed on floating-leaved and submerged macrophytes in small eutrophic lakes of Northern Italy (Cattaneo *et al.*, 1998), and on the macrophytes *Phragmites australis* (Cav.) Trin. ex Steud., *Potamogeton pectinatus* L. and alga *Cladophora rivularis* (L.) Hoek in eutrophic Bafra Fish Lakes and Lake Simenit, Turkey (Gonulol, 1993, Ersanli & Gonulol, 2007). According to a survey of epiphytes on various *Charophyceae* on the Balkans, *Cocconeis placentula* has been reported as one of the most frequent taxa (Hafner & Jasprica, 2013).

In this survey, the planktonic taxon *Cyclotella comta*, abundant in October 2004, was more frequent than we expected, but benthic or periphytic were more common than planktonic taxa. This taxon has been also reported from mesotrophic small- and medium-sized lakes (Padisák *et al.*, 2003; Borics *et al.*, 2007). According to Jerković (1978), there are only a few true planktonic diatom taxa in the lakes of this wetland. However, planktonic and epiphytic diatoms can provide complementary information on ecological conditions in the area.

Our results confirmed the data of Wojtal (2003) who designated *Gomphonema intricatum*, *G. longiceps* and *G. truncatum* as sensitive taxa found in the unpolluted karstic streams in Poland.

We investigated epiphytic diatoms from the entire surface on both sides of the leaf. However, Delbecque (1983) found differences in composition of the epiphytic diatom communities growing of the marginal parts and the central part of the underside of floating leaves of *Nuphar lutea*.

Generally, the distribution patterns of epiphytic algae on the basis of variation of their host species are well documented (e.g. Laugaste & Reunanen, 2005; Karosienė & Kasperovičienė, 2012), and contradictory results have been reported on the selectivity of epiphytic taxa with respect to substrate. Marvan *et al.* (1978) suggested that different macrophytes from the same location host very similar algal assemblages. According to Cattaneo *et al.* (1998), species composition is more closely related to the chemical characteristics of the lake water than the macrophyte type. On the other hand, differences in the epiphytic communities between macrophyte species or plant parts have proven to be significant (Blanco *et al.*, 2004). Specific relationships between periphyton and macrophyte are more evident under low nutrient conditions (Eminson & Moss, 1980). Only the submerged part of hydrophytes (e.g. *Typha* spp., *Scirpus* spp., *Phragmites* spp.) and sediments can be considered universal substrates in shallow lakes, which show homogeneity in their periphyitic communities. More recently, Cejudo-Figueiras *et al.* (2010) showed significant differences in the composition of diatom assemblages between trophic levels but not between different plant substrata. This supports the use of epiphytic diatoms as biological indicators for shallow lakes irrespective of the dominant macrophyte.

The present study describes the diversity of the epiphytic algal flora of the Hutovo Blato wetland. The waters of this wetland are a prime example of natural systems unaffected by any pollution to date. We can therefore regard the algal assemblages of the wetland as 'models' that will be of great value in providing baseline data for future monitoring and for assessing the effects of human activity.

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