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THE COMPOSITION OF EPIPHYTIC DIATOMS (BACILLARIOPHYTA) ON CHAROPHYCEAE IN THE DINARIC KARSTIC ECOSYSTEMS

Dubravka Hafner[1]* & Nenad Jasprica[2]

[1]University of Mostar, Faculty of Natural Sciences and Education, BiH-88000 Mostar, Bosnia and Herzegovina (E-mail: dubhafner@gmail.com)

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

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The diatom composition on some Charophyceae taxa was investigated in different freshwater ecosystems in Bosnia and Herzegovina, Croatia and Montenegro during 2007. A total of 91 taxa belonging to 37 genera were identified. The genus *Gomphonema* with 9 taxa was the most diverse, followed by *Navicula* (7), *Nitzschia*, *Pinnularia* and *Gyrosigma* (5). The number of taxa at the localities varied from nine in Lake Kalajli on Bjelašnica Mountain to 33 in the Trebižat River (both in Bosnia and Herzegovina). The most frequent taxa (found in more than three localities) were: *Amphora ovalis*, *Cocconeis placentula*, *Gomphonema coronatum*, *Melosira varians*, *Navicula tripunctata*, *N. radiosa* and *Ulnaria oxyrhynchus*. In total, 52 taxa appeared only in one particular locality.

Keywords: epiphytic diatoms, Charophyceae, biodiversity, Dinaric karst, the Balkans

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Taksonomski sastav epifitskih dijatomeja na nekoliko svojta iz razreda Charophyceae istraživan je u različitim krškim vodenim ekosustavima u Bosni i Hercegovini, Hrvatskoj i Crnoj Gori tijekom 2007. Ukupno je utvrđeno 91 svojti svrstanih unutar 37 rodova. Rodovi s najvećim brojem svojta su *Gomphonema* (9), *Navicula* (7), *Nitzschia*, *Pinnularia* i *Gyrosigma* (5). Broj svojta bio je od devet u jezeru Kalajli na planini Bjelašnici do 33 u rijeci Trebižat (Bosna i Hercegovina). Najučestalije svojte (prisutne na više od tri lokaliteta) su: *Amphora ovalis*, *Cocconeis placentula*, *Gomphonema coronatum*, *Melosira varians*, *Navicula tripunctata*, *N. radiosa* i *Ulnaria oxyrhynchus*, Ukupno se 52 svojte pojavljuju samo na jednom od lokaliteta.

Ključne riječi: epifitske dijatomeje, Charophyceae, raznolikost, Dinarski krš, Balkanski poluotok

INTRODUCTION

Macrophytes constitute a vast substrate for the growth of periphytic communities especially epiphytic (attached) algae (Gons, 1979). Epiphytic algae play an important role in many water bodies. For example, as a significant source of primary production, they can provide energy for consumers (Lamberti, 1996).

Many studies have been made on epiphytic diatoms living on macroalgae and macrophyte in shallow freshwater ecosystems (cf. Blanco *et al*., 2004, Cejudo-Figueiras *et*

* corresponding author

al., 2010). Epiphytic diatoms on some macrophytes have been recently studied in the Dinaric karst area (cf. Caput & Plenković-Moraj, 2000, Hafner *et al*., 2013).

Charophyceae of the Balkan Peninsula are well known (cf. Blaženčić *et al*., 1998, Blaženčić & Blaženčić, 2003). There are more than 40 species (with a great number of varieties and forms) in the region, and some of them are being increasingly threatened by the destruction of their biotopes. In contrast, data on epiphytic algae on Charophyceae on the Balkans are scarce. Hustedt (1945) noted 25 diatom taxa on *Chara* L. from Plitvice lakes.

In this paper, the composition of epiphytic diatoms on some Charophyceae taxa was investigated in three Balkan countries: Bosnia and Herzegovina, Croatia and Montenegro. This is the first detailed floristic research on the epiphytic diatoms in this part of the Dinaric karst.

MATERIAL AND METHODS

Epiphytic diatoms attached to various Charophyceae were collected in different freshwater ecosystems of three Balkan countries (Fig. 1). In Bosnia and Herzegovina, material was gathered at four localities: 1) in canals of the Lištica River in the karstic depression of Mostarsko Blato (»Mostar Mud«) (43°21'13.9" N, 17°43'58.6" E, altitude of 230 *m a.s.l.*); 2) from a small stream within fen vegetation of the class *Scheuchzerio palustris-Caricetea fuscae* Tüxen 1937 at Blidinje Nature park on Čvrsnica Mountain (43°38'09.8" N, 17°32'26.3" E, 1290 m *a.s.l.*); 3) in the Trebižat River near Kravice falls (43°09'21.8" N, 17°36'31.2" E, 47 m *a.s.l.*); 4) in Lake Kalajli on Bjelašnica Mountain (43°43'27.4" N, 18°07'32.3" E, 1650 m *a.s.l.*). In Croatia, two localities were surveyed: 1) in Lake Sladinac, which is part of the small coastal inter-connected Baćina Lakes (43°04'16.1" N, 17°25'22.4" E, 40 m *a.s.l.*); 2) in the Sobra pool on Mljet Island (42°43'57.3" N, 17°35'57.6" E, 8 m *a.s.l.*). Samples were taken from the pool on Orjen Mountain in Montenegro (42°33'28.1" N, 18°33'06.1" E, 1592 m *a.s.l.*). On most localities stoneworts cover extensive areas of the lake or pool bottoms, thus creating compact and continuous plant beds. The study was carried out from May to July 2007.

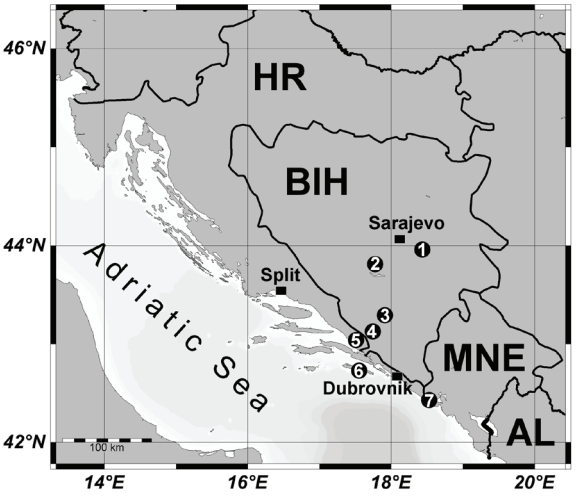

Fig. 1. Position of localities (Bosnia and Herzegovina: 1 = Mt. Bjelašnica, 2 = Mt. Čvrsnica, 3 = Mostarsko Blato; 4 = River Trebižat; Croatia: 5 = Baćina Lakes; 6 = Island of Mljet; Montenegro: 7 = Mt. Orijen). Abbreviations: HR – Croatia, BIH – Bosnia and Herzegovina, MNE – Montenegro

Diatom samples, taken from adult thalli of *Nitella syncarpa* (J.L.Thuillier) Kützing, *N. hyalina* (De Candolle) C.Agardh, *N. confervacea* (Brébisson) A.Braun ex Leonhardi, *Nitella* sp., *Lychnothamnus barbatus* (L.Meyen) H.von Leonhardi, *Chara aspera* C.L.Willdenow, *Ch. connivens* P.Salzmann ex A.Braun, *Ch. vulgaris* L. (=*Ch. foetida* A. Braun), *Ch. hispida* L., *Ch. polyacantha* A.Braun, *Chara* sp. and *Tolypella prolifera* (Ziz ex A.Braun) Leonhardi, were preserved in 2.5% formaldehyde and processed according to procedures given by Van der Werff (1955). Samples were examined using a light microscope equipped with phase contrast, using an oil immersion objective 100x. References used in the identification of diatoms are listed by Jasprica & Hafner (2005). The nomenclature was adjusted according to *Algaebase* website (Guiry & Guiry, 2013, searched on February 8, 2013).

RESULTS AND DISCUSSION

A total of 91 taxa belonging to 37 genera were identified in the samples (Tab. 1). The genus *Gomphonema* (9) had the most taxa followed by *Navicula* Bory (7), *Nitzschia* Hassall, *Pinnularia* Ehrenberg and *Gyrosigma* Hassall (5).

Tab. 1. The list of epiphytic diatoms found on Charophyceae at the localities investigates (Bosnia and Herzegovina: 1 = Mt. Bjelašnica, 2 = Mt. Čvrsnica, 3 = Mostarsko Blato; 4 = River Trebižat; Croatia: 5 = Baćina Lakes; 6 = Island of Mljet; Montenegro: 7 = Mt. Orijen).

Achnanthidium affine (Grunow) Czarnecki (4)
Achnanthidium minutissimum (Kützing) Czarnecki (3, 5)
Amphora lybica Ehrenberg (2)
Amphora ovalis (Kützing) Kützing (2, 3, 4, 5)
Amphora pediculus (Kützing) Grunow ex A.Schmidt (2, 6)
Aulacoseira italica ssp. *subarctica* (O. Müller) Simonsen (7)
Caloneis ventricosa (Ehrenberg) F.Meister (2, 5, 6)
Caloneis ventricosa var. *truncatula* (Grunow) Meister (2)
Campylodiscus bicostatus W.Smith in Roper (7)
Cocconeis pediculus Ehrenberg (1, 4, 5)
Cocconeis placentula Ehrenberg (3, 4, 5, 7)
Cocconeis placentula var. *euglypta* (Ehrenberg) Grunow (3, 4)
Coscinodiscus sp. (2)
Craticula cuspidata (Kutzing) D.G.Mann (6, 7)
Cyclotella bodanica Eulenstein ex Grunow (7)
Cyclotella meneghiniana Kützing (4)
Cymatopleura elliptica (Brèbisson) W. Smith (4, 5)
Cymatopleura solea (Brèbisson) W. Smith (2, 3, 6)
Cymbella affinis Kützing (5)
Cymbella cymbiformis C.Agardh (5)
Cymbella lanceolata (C.Agardh) C.Agardh (2, 4, 6)
Cymbella turgida W. Gregory (4)
Denticula sp. (4)
Diatoma ehrenbergii f. *capitulata* (Grunow) Lange-Bertalot (4, 5)
Diatoma elongatum var. *minor* Grunow (4)
Diatoma tenuis C.Agardh (6)
Diploneis oblongella (Nägeli ex Kützing) Cleve-Euler (2, 4)
Diploneis ovalis (Hilse) Cleve (2, 4)
Ellerbeckia arenaria (Moore ex Ralfs) R.M.Crawford (4)
Encyonema prostratum (Berkeley) Kützing (4)
Encyonema ventricosa (Kützing) Grunow (3, 4, 5)
Epithemia adnata (Kützing) Brébisson (4, 5, 7)
Epithemia sp. (6)
Eucocconeis flexella (Kützing) Meister (2)
Eunotia bilunaris (Ehrenberg) Schaarschmidt (5)
Eunotia tenella (Grunow) Hustedt (2, 5)
Eunotia pectinalis (Kützing) Rabenhorst (2, 5)
Eunotia praerupta Ehrenberg (4)
Gomphonema acuminatum Ehrenberg (6)
Gomphonema augur Ehrenberg (4)
Gomphonema clavatum Ehrenberg (5)
Gomphonema coronatum Ehrenberg (3, 4, 5, 6)
Gomphonema olivaceum var. *calcareum* (Cleve) Van Heurck (4)
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot (5)
Gomphonema truncatum Ehrenberg (3, 5)
Gomphonema sp. 1 (2)
Gomphonema sp. 2 (7)
Grunowia sinuata (Thwaites) Rabenhorst (2)
Gyrosigma attenuatum (Kützing) Rabenhorst (5)
Gyrosigma scalproides (Rabenhorst) Cleve (3, 4)
Gyrosigma sp. 1 (1)
Gyrosigma sp. 2 (3)
Gyrosigma sp. 3 (4)
Hantzschia amphioxys (Ehrenberg) Grunow (1, 6)
Mastogloia lacustris (Grunow) Grunow (2, 6)
Melosira varians C. Agardh. (1, 3, 5, 7)
Navicula capitatoradiata Germain (7)
Navicula cryptotenella Lange-Bertalot (2, 4)
Navicula exigua Gregory (3)
Navicula menisculus Schumann (5)
Navicula oblonga (Kützing) Kützing (3,6)
Navicula radiosa Kützing (2, 3, 5, 6, 7)
Navicula tripunctata (O.F.Müller) Bory de Saint-Vincent (1, 3, 4, 5)
Neidium affine var. *amphirhynchus* (Ehrenberg) Cleve (1)
Neidium bisulcatum var. *subundulatum* (Grunow) Reimer (6)
Nitzschia sigmoidea (Nitzsch) W. Smith. (4)
Nitzschia sublinearis Hustedt (2, 5)
Nitzschia vermicularis (Kützing) Hantzsch (3)
Nitzschia vitrea G. Norman (6)
Nitzschia sp. (1)
Pinnularia borealis Ehrenberg (1, 7)
Pinnularia maior (Kützing) Cleve (2, 6)

Pinnularia microstauron (Ehrenberg) Cleve (6)
Pinnularia rabenhorstii (Grunow) Krammer (2)
Pinnularia viridis (Nitzsch) Ehrenberg (2)
Planothidium hauckianum (Grunow) Round & Bukhtiyarova (4)
Planithidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot (5)
Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot (3, 4, 7)
Rhopalodia gibba (Ehrenberg) Otto Müller (2, 6)
Rhopalodia gibba var. *parallela* (Grunow) H.Peragallo & M.Peragallo (2)
Rossithidium linearis (W.Smith) Round & Bukhtiyarova (2, 4, 7)
Stauroneis anceps Ehrenberg (2, 4, 5)
Stauroneis smithii Grunow (3)
Staurosirella leptostauron (Ehrenberg) D.M.Williams & Round (2)
Staurosirella pinnata (Ehrenberg) D.M.Williams & Round (2, 7)
Surirella minuta Brébisson in Kützing (3, 5)
Surirella ovalis Brèbisson (6)
Surirella spiralis Kützing (2)
Ulnaria danica (Kützing) Compère & Bukhtiyarova (1, 6)
Ulnaria oxyrhynchus (Kützing) M.Aboal (3, 4, 5, 6)
Ulnaria ulna (Nitzsch) P.Compère (2, 4)

The highest number of taxa (33) was in the Trebižat River and the lowest on Bjelašnica Mountain (9). In Baćina Lakes and the island of Mljet, 28 and 21 taxa were noted, respectively. Thirty taxa were noted on Čvrsnica Mountain, 20 in Mostarsko Blato and 14 on Orjen Mountain. There were no taxa common to all localities. The most frequent taxa (found in more than three localities) were: *Amphora ovalis* (Kützing) Kützing, *Cocconeis placentula* Ehrenberg, *Gomphonema coronatum* Ehrenberg, *Melosira varians* Agardh, *Navicula tripunctata* (O.F. Müller) Bory, *N. radiosa* Kützing and *Ulnaria oxyrhynchus* (Kützing) M.Aboal. In total, 52 taxa appeared only in one particular locality. The greatest similarity of diatom flora was found in Mostarsko Blato, Baćina Lakes and Trebižat River. This may be explained by a combination of proximity and hydrologic similarity.

Charophyceae supported diverse populations of epiphytic diatoms in these ecosystems. Most of the taxa recorded are characterized by wide geographic distributions (c.f. Krammer & Lange-Bertalot, 1986–2001). The genera *Navicula*, *Nitzschia* and *Pinnularia* were also found on *Chara* L. and *Najas* L. in the United States (Troeger, 1978), and European *Chara*-dominated lakes (e.g. Messyasz & Kuczyńska-Kippen, 2006).

The localities showed differences in the structure of their epiphytic diatom communities. This can be explained by the different ecological conditions among them. A study of the environmental conditions of these investigated ecosystems is required in order to provide information on the relationship between limnological variables and diatom distribution.

The presence of the mesohalobous species *Amphora lybica* Ehrenberg and *Mastogloia lacustris* (Grunow) Grunow on the Čvrsnica Mountain must be stressed, and this finding should be clarified by further analysis. We found high conductivity levels (1056 $\mu S\ cm^{-1}$) in the small streams within fen vegetation.

Although the aim of this study was not to compare the composition of epiphytic diatoms among particular species of Charophyceae, generally, a larger number of diatom taxa was observed on *Nitella* C.Agardh than on *Chara* species.

During this study we observed only five diatom taxa on Charophyceae reported by Hustedt (1945) for Plitvice Lakes: *Achnanthidium minutissimum* (Kützing) Czarnecki, *Amphora ovalis* (Kützing) Kützing, *A. pediculus* (Kützing) Grunow ex A.Schmidt, *Gomphonema pumilum* (Grunow) Reichardt & Lange-Bertalot and *Planothidium lanceolatum* (Brébisson ex Kützing) Lange-Bertalot. In addition, our inventory had 33 and 36 taxa found on *Cladium mariscus* Pohl. in the Croatian karstic Plitvice Lakes and *Nymphaea alba* L. in the Hutovo Blato wetland (Bosnia and Herzegovina), respectively (Caput & Plenković-Moraj, 2000; Hafner *et al*., 2013). On the contrary, only 17 taxa found in this study have been previously recorded on *Cladophora rivularis* (L.) Hoek and *Potamogeton pectinatus* L. in Lake Simenit, Turkey (Ersanli & Gonulol, 2007).

Generally, researchers have reported contradictory results on the distribution patterns of epiphytic algae on the basis of variations in host species. Some authors observed that different macrophytes from the same location host very similar algal assemblages (Marvan *et al*., 1978). Other studies find differences in the epiphytic communities among macrophyte species and/or plant parts (Blanco *et al*., 2004). Finally, Cejudo-Figueiras *et al.* (2010) showed significant differences in the composition of diatom assemblages among trophic levels but not in different plant substrata. This supports the use of epiphytic diatoms as biological indicators for shallow freshwater ecosystems (e.g. lakes) irrespective of the dominant macrophyte.

Our findings contribute essential base-line information that should aid in evaluating the state of these ecosystems in the future.

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