Nova Hedwigia Vol. 93 issue 1–2, 125–151 **Article**
Stuttgart, August 2011

Diatoms in a poor fen of Bijambare protected landscape, Bosnia & Herzegovina

Tatjana Kapetanović[1*], Regine Jahn[1], Sulejman Redžić[2] and Marina Carić[3]

[1] Botanischer Garten und Botanisches Museum Berlin-Dahlem, Freie Universität Berlin, Königin-Luise-Straße, 14195 Berlin, Germany

[2] Biology Department, Faculty of Science, University of Sarajevo, Zmaja od Bosne 32–35, 71 000 Sarajevo, Bosnia & Herzegovina

[3] Institute for Marine and Coastal Research, Kneza Damjana Jude 12, 20000 Dubrovnik, Croatia

With 121 figures and 2 tables

Kapetanović, T., R. Jahn, S. Redžić & M. Carić (2011): Diatoms in a poor fen of Bijambare protected landscape, Bosnia & Herzegovina. – Nova Hedwigia 93: 125–151.

Abstract: Diatom populations of five microhabitats of a poor (*Sphagnum*) fen in Bijambare Protected Landscape area were studied. The fen is situated at an altitude 930 m a.s.l., on a slope of Mt. Zvijezda near Sarajevo. The major part of the fen is covered with *Sphagnum recurvum* and *Sphagnum subsecundum*, while at the outer borders communities are dominated by *Carex* spp. Samples were taken in May, July and October 2007 and May 2008, in vegetationally different microhabitats by squeezing water from mosses and taking material from pools. The diatom flora was studied under LM and SEM. The part of the fen that is characterized by *Sphagnum* species has a very poor diatom assemblage dominated by acidobiontic and acidophilous species such as *Eunotia exigua*, *E. glacialis, E. paludosa* and *Pinnularia rhombarea*. In the border area of the fen, diatom assemblages become richer with *Nitzschia acidoclinata*, *Eolimna minima* and *Eunotia bilunaris* as dominating species. According to published data, 45 taxa are recorded here for the first time for Bosnia and Herzegovina such as: *Chamaepinnularia mediocris*, *Navicula digitulus*, *Navicula medioconvexa* and *Placoneis hambergii*. *Sellaphora bosniaca* and *Sellaphora hafnerae* are described here as a new species.

Key words: diatoms, *Sellaphora bosniaca, S. hafnerae*, poor fen, oligotrophy, Bosnia and Herzegovina.

Introduction

The first phycological works on the region of Bosnia and Herzegovina were published at the end of 19th century and beginning of the 20th century (Beck 1886, 1890, 1928; Protić 1897, 1899, 1901, 1904, 1908, Gutwinski 1896, 1899a, 1899b, 1899c).

*Corresponding author; e-mail: t.kapetanovic@bgbm.org

DOI: 10.1127/0029-5035/2011/0093-0125 0029-5035/2011/0093-0125 $ 6.75

In these papers, biogeographical and, in some cases, ecological data were given in the form of simple lists as it was standard at that time, but there are no permanent slides or preserved samples left from those studies (Jerković & Rončević 1981). Diatoms and desmids were the groups that attracted most attention. Although they covered relatively small areas, "mire-like" habitats seemed to be most interesting to former scientists. Gutwinski (1896) recommended sampling of "*Sphagnum* mats and similar habitats" for future studies. Unfortunately, interest decreased, many mires disappeared and detailed studies on mires and fens in Bosnia and Herzegovina have never been conducted until now. More intensive phycological investigations especially on diatoms, started with Hustedt's work on the Balkans (Hustedt 1945). Diatom studies from the 1960's to 1990's focussed on rivers and lakes which are numerous in Bosnia and Herzegovina. The necessity of biodiversity studies in mires today is underlined by the fact that these small, oligotrophic and mountain habitats of glacial-relic origin are very sensitive to anthropogenic impacts and have become threatened in the last decades. Diatoms are currently recognized as dominant components of the algal flora in ombrotrophic and minerotrophic mires (Nováková 2002, Negro et al. 2003) and can be used as good indicators of the quality status of pristine areas.

Similar studies on diatom communities with various approaches have been conducted in Europe and worldwide. Some of the authors focus on bryophytic diatom communities (Beyens 1989, Cantonati 1998, Van de Vijver & Beyens 1997, Van de Vijver et al. 2004, Poulíčková et al. 2004; Buczko & Wojtal 2005); some on a specific type of mire (Wojtal et al. 1999; peat bog, Poulíčková et al. 2003, 2005; spring fen, Negro et al. 2003; mountain wetlands). In the Balkan mountains of Sara and Nidze (Republic of Macedonia) a study of diatoms was carried out in different mountain localities, including mires. The identified taxa were mostly oligotraphentic and dystraphentic and many of them were recognized as potentially new taxa specific for the refugial habitats (Levkov et al. 2005).

The aim of this study is to explore the diatom diversity in a small poor fen habitat in Bosnia and Herzegovina and to determine the spatial differences in diatom populations by comparing the diatom flora of *Sphagnum* dominating part of the fen with the diatom flora of the border area. This is also a first detailed floristic diatom study in this type of habitat in Bosnia and Herzegovina and shows some specific features of the regional diatom flora. Further studies will be carried out in the wider area of Bosnia and Herzegovina in the near future.

Material and methods

STUDY AREA: Bijambare Protected Landscape (370 ha) is situated on the northeastern slopes of the Zvijezda Mountain (within Canton Sarajevo) near Nišići Highland. In the first protected zone, at an altitude averaging 950 m a.s.l. (N44°05'85", E18°30'75") a fen is situated in a thick spruce forest (*Abieti-Picetum*). Climate of the Bijambare region (Milosavljević 1976) is moderately continental, with strong impacts of certain variants of mountain climate. The mean temperature value in the vegetation period (April–September) varies from 9°C to 14.6°C, while the mean January temperature is -1.9°C. In the area of Kladanj (closest meteorological station), the annual precipitation on average amounts to 1082 mm.

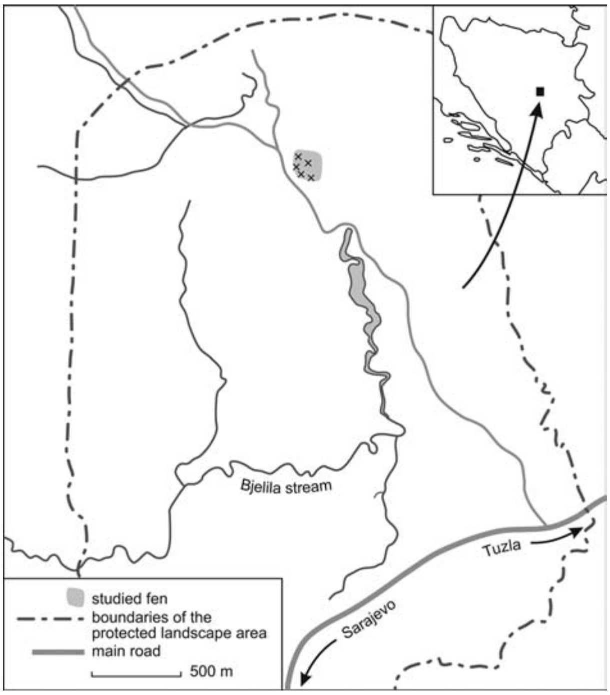


Fig. 1. Map of the investigated area in Bosnia and Herzegovina (sampling sites indicated with x; first row C, A and a second E, D, B).

Like other Dinaric mountain mires, this habitat is also of glacial-relict origin and covers a relatively small area (1 ha). The vegetation of the area was explored in the 1980's (Lakušić et al. 1991) and later during evaluation of natural resources (Redžić et al. 2002). According to syntaxonomical properties, the major (central) part of the area was recognized as *Sphagnetum recurvo-subsecundi* Grgić et al. (Lakušić et al. 1991) in *Oxycocco-Sphagnetea* class. Presence of *Carex canescens* L. indicated transition to fens in border microhabitats which are less acid. According to a new differentiation of bogs and fens, the studied area can be recognized as a poor fen (Hajek et al. 2006). This area has never been phycologically studied until now.

The diatom communities in five habitats with different vegetation in Bijambare poor fen were sampled by squeezing water from aquatic macrophytes and/or collecting material from the surface of pools. The sites have the following features:

A. Dominating vegetation: *Sphagnum recurvum P. Beauv.*, *Sphagnum subsecundum* Nees, *Carex canescens*, *Potentilla erecta* (L.) Raeusch., *Crepis paludosa* (L.) Moench, *Myosotis palustris* (L.) Hill., *Lythrum salicaria* L., *Veronica scutellata* L., *Epilobium palustre* L., *Lysimachia nummularia* L., *Alnus incana* (L.) Moench., *Picea abies* (L.) Karst., *Betula pubescens* Ehrh. (*Sphagnetum recurvo-subsecundi* Grgić et al.).

B. Dominating vegetation: *Polytrichum commune* L., *Sphagnum medium* Limpr., *S.recurvum*, *Potentilla erecta*, *Epilobium palustre*, *Lythrum salicaria* L. and *Picea abies* (*Polytricho-Sphagnetum medii* Horv.).

C. Dominating vegetation: *Carex echinata* Murray, *C. canescens*, *C. fusca* All., *Juncus effusus* L., *J. conglomeratus* L., *Potentilla erecta*, *Agrostis stolonifera* L., *Lysimachia vulgaris* L. (*Caricetum fuscae* Br.-Bl. 1915).

Table 1. Physico-chemical properties of the sampling sites.

Parameters of sampling sites	A	B	C	D	E
*pH	4.54	4.88	5.72	6.12	6.56
*Conductivity µS cm^{-1}	37	40	47	80	125
*Temperature °C	16.6	16.5	16.2	16.6	16.6
*NO_3 mg L^{-1}	0.03	0.08	0.05	0.02	0.02
*NO_2 mg L^{-1}	0.03	0.09	0.06	0.04	0.04
*PO_4 mg L^{-1}	0.77	0.73	0.17	0.06	0.06
*SiO_2 mg L^{-1}	0.28	0.46	0.39	0.68	0.68
•Rel. shadowing*	0	1	0	1	1
•Rel. moisture*	2	1	3	4	4
•Type of substrate*	1	1	1	0	0

* measured on 5.05.2008
• parameters estimated on a subjective scale-moisture: 1: dry, 2: wet, 3: very wet, 4: pools; shading: 0: no shade, 1: shade; type of substrate: 0: muddy 1: peaty.

D. Dominating vegetation: *Carex fusca*, *C. nigra* (L.) Reich., *Potentilla erecta* (*Caricetum nigrae* Braun 1915).

E. Dominating vegetation: *Carex nigra*, *C. echinata*, *Eleocharis palustris* (L.) Roem. & Schult. (*Caricetum nigrae* Braun 1915).

Sampling and microscopical analysis: Samples were taken in May and October 2007 and May 2008. Only one sample was taken in June 2007 (at sampling site A) because a drought impeded collecting at most sampling sites. Conductivity, pH, and temperature were measured in the field for each sampling site (with a portable pH- meter/thermometer pH-009 (III) ATC and conductivity tester Ec 138-2). Concentration of nutrients was analysed with standard spectrophotometric methods (APHA, AWWA & WEF 1995) using Perkin-Elmer lambda 15 UV/VIS spectrophotometer in the Laboratory for Oceanology of the Institute for Marine and Coastal Research (Dubrovnik). Samples were cleaned with 30% H_2O_2 and permanent slides were mounted in Naphrax. For estimation of relative abundance at least 500 valves, when possible, were counted. Micro-photographs were taken with a Zeiss microscope with DIC and an AXIOAM MRc camera and SEM Philips 515 at the BGBM, Berlin-Dahlem.

Identification was based on: Krammer & Lange-Bertalot (1985, 1997a, 1997b, 2000, 2004), Lange-Bertalot (1993), Lange-Bertalot & Metzeltin (1996), Krammer (2000, 2003), Lange-Bertalot et al. (2003) and Werum & Lange-Bertalot (2004).

For statistical analysis CANOCO for Windows 4.52 programme was used (ter Braak & Šmilauer 2002). DCA ordination was used to recognize unimodal structure of the data and to show distribution of the samples.

Results

In total, 126 diatom taxa were identified in 14 samples. Selected taxa are illustrated in Figs 3–121. Taxa from the genera *Pinnularia* (14 taxa) and *Eunotia* (9) were the most represented. Abundance of most species was very low (Table 2). There were 67 taxa with less than 5 valves in all samples.

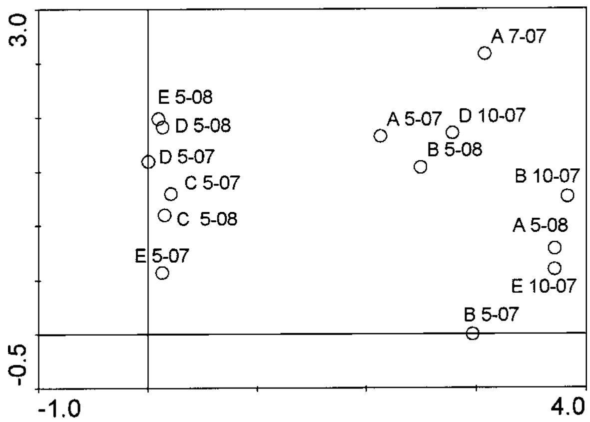


Fig. 2. DCA ordination diagram of the samples (based on data matrix with all taxa, all seasons and with log -transformation. Samples indicated as a: sampling site, month-year)

Fresh uncleaned samples were previewed, and it was recognized that diatoms dominate the algal flora. A few taxa from other groups were found in the samples, mostly *Desmidiales* and *Cyanobacteria*. Also, the occurence of the protozoan group *Testacea* is characteristic of the peat assemblages (A and B).

Concerning ecological properties of the sampling sites (Table 1), it is obvious that pH and conductivity increase from the central part of the fen (A, B) to the marginal parts (C, D, E). In contrast, phosphate value is the highest in the central part and lowest in the marginal part of the fen. In addition, sampling sites at the margin have more moisture than the central parts of the fen.

Parts of the fen (A, B), characterized by *Sphagnum* species, have a very poor diatom community (23–29 taxa per site) with acidobiontic and acidophilous species such as *Eunotia glacialis, E. exigua*, *E. paludosa*, *Pinnularia rhombarea* as most abundant. In the marginal area of the fen (C and especially D and E) with more moisture, higher pH and conductivity, diatom communities become richer (50–82 taxa per site) with a dominance of *Nitzschia acidoclinata*, *Gomphonema exilissimum*, *Eolimna minima* and *Eunotia bilunaris*. Species of the genus *Eolimna* are found only in the C, D, E assemblages and are absent in the peaty part of the fen (A, B). *Eunotia paludosa, E. exigua* and *E. glacialis* are very abundant in the *Sphagnum* rich part of the fen (A, B) but are also found in lower abundances at the border to the minerotrophic habitats (C, D, E). The highest number of species in one sample (71) was found in May 2007 on site E.

DCA ordination of samples based on diatom species composition and abundance (Fig. 2) shows that two groups of samples were differentiated along the first axis: the group C-D-E and the group A-B. The first two axes explain 37.3% of variance. Exceptions (one sample each in D and E in October 2007; C-107, D-107) can be explained by the very dry summer and autumn in 2007 when minerotrophic habitats turned dry like the rest of the fen.

Description of the new species

Sellaphora bosniaca Kapetanović & R.Jahn **sp. nov.** Figs 3–18

Valvae lanceolatae, apicibus subcapitatis, 3–3.7 µm latae, 9–14.7 µm longae. Area centralis parva, irregularis. Area axialis angusta, recta. Striae uniseriatae, delicatae, visibiles per microscopio electronico (SEM), leviter radiatae, distales recta, circa 46–52 in 10 µm, in partibus terminalibus valvarum breviores, areas hyalinas formantes, visibiles per microscopio photonico. Areolae circulares, parvae, circa 10–12 in 1 µm (transapicales), axilares majores. Raphe recta extremitatibus centralibus rotundis et terminalibus incurvatis in directiones oppositos. Valvarum frontes laeves, sine canalibus et conopea visibilibus.

HOLOTYPUS: B 40 0040717, slide deposited in the Botanic Garden and Botanical Museum Berlin-Dahlem (Fig. 10 is representing the holotype).

FURTHER ORIGINAL MATERIAL: B 40 0040718, SEM stub deposited in the Botanic Garden and Botanical Museum Berlin-Dahlem.

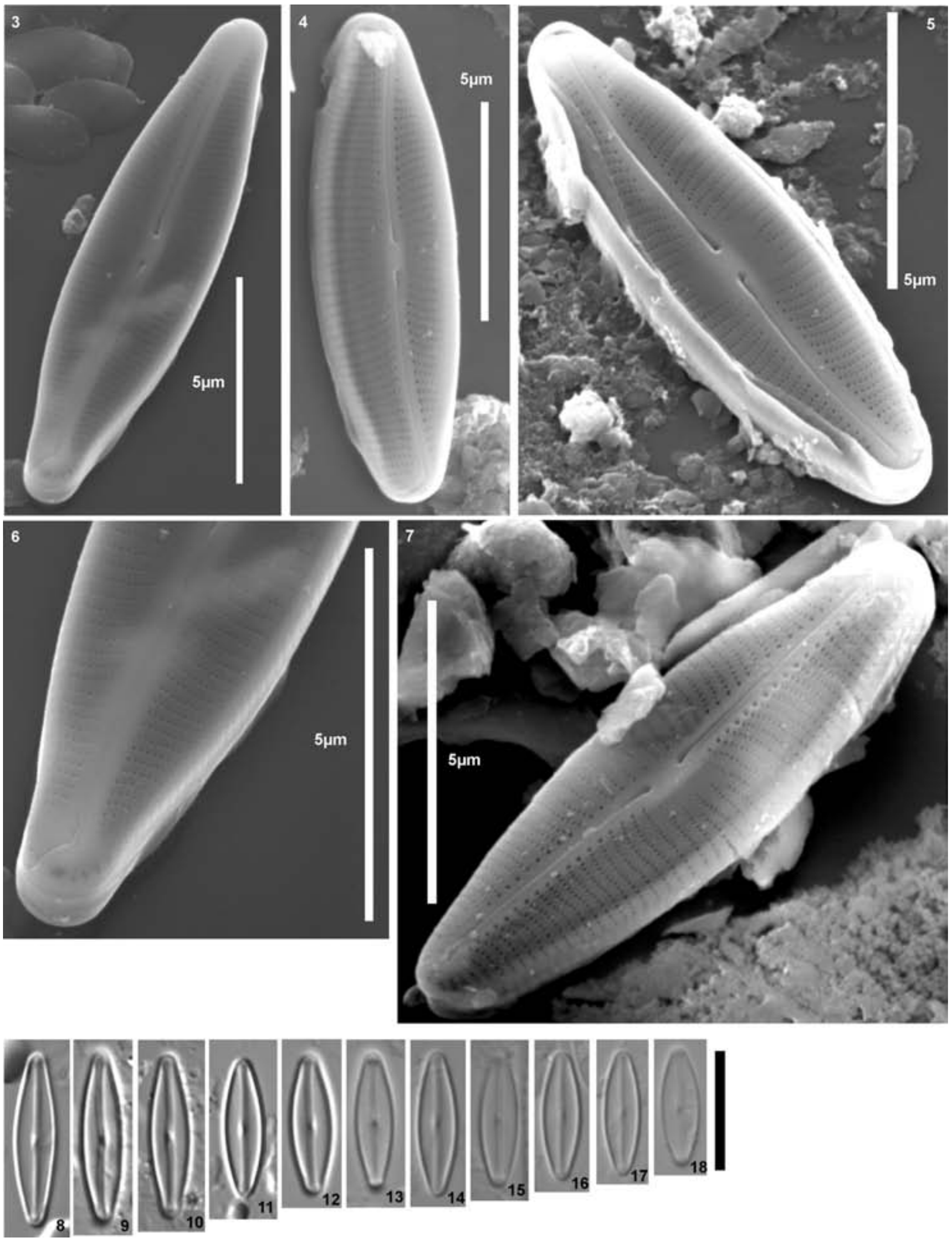
LOCUS TYPICUS: Bijambare, Bosnia and Herzegovina. Legit: Tatjana Kapetanović, 06.05.2007, (BI052007TK4/C).

ETYMOLOGY: The epithet "*bosniaca*" refers to the region "Bosnia" where this species was observed.

DESCRIPTION: Valves lanceolate, tapering gently towards the slightly capitate ends. Valves are 3–3.7 µm wide, 9–14.7 µm long. The central area is relatively small, irregularly shaped. Axial area relatively narrow, straight. The uniseriate striae are delicate and slightly radial turning straight towards the end, and continue deep unto the mantle. They have a density of about 46–52 in 10 µm only visible by SEM. Striae at the valve ends are short forming hyaline areas visible by LM. Areolae are circular, small, about 10–12 in 1µm transapically, those adjacent to the axial area bigger. Raphe is straight, with central round endings slightly curved into the opposite direction than the strongly curved terminal raphe fissures which are bent strongly but irregularly towards the same side. Valve face is smooth, without visible grooves or conopea.

The outline of the valve and the striation, irresolvable in LM, most closely resemble *Navicula indifferens* Hust. described from North-Western Germany (Hustedt 1942). This species was recombined to *Fallacia indifferens* (Hust.) D.G.Mann (Round et al. 1990) but there are no SEM photographs available in the literature to demonstrate the pertinent fine structure. Our taxon does not have the characteristics of the genus *Fallacia* (such as lyre-shape markings). Examination of photographs of the type specimen of *Navicula indifferens* (Simonsen 1987) and Hustedt's hand drawings (Hustedt 1942) showed that the latter taxon is characterized by smaller valve length (6–8 µm vs. 11.5 on average in *Sellaphora bosniaca*) and width (2.5–3 vs. average 3.3 in *S. bosniaca*). Length to breadth ratio in *S. bosniaca* is on average 3.5 (2.6–4.3) and according to Hustedt's documentation in *Navicula indifferens* 2.4–2.6. Also, in Hustedt's type material about 40 striae in 10 µm are counted whereas in our taxon this number is higher (46–52), as measured in SEM (Simonsen 1987).

There are similarities in the fine structure of the valve (striation irresolvable in LM, strongly bent terminal fissures, apical areas which resemble polar bars) with other small species from the "former" Minusculae group within the *Navicula* s.l. genus; such as *Navicula difficilima* Hust. (with short and blunt to slightly capitate ends) and *Navicula tridentula* Krasske (with undulate outline). Werum & Lange-Bertalot (2004)



Figs 3–18: *Sellaphora bosniaca* Kapetanović & R.Jahn nov. sp. Figs 3–7. Different external views of several frustules (Figs 3, 4, 6 from SEM stub B 40 0040718 and Figs 5, 7 from BI052007TK4/E). Figs 8–18. Population in LM (scalebar = 10 µm) from holotype slide B 40 0040717.

presumed that for this group of small and delicate species the genus *Sellaphora* cannot be excluded as adequate but they may as well belong to an undescribed genus.

According to Mann (in Round et al.1990) *Sellaphora* Mereschk. should be the adequate genus for most of the species in the former *Navicula* sect. *Minusculae*. Some of the recently described *Sellaphora* species also have a delicate structure, flat valve face and absence of groove or conopeum (Levkov et al. 2007, Potapova & Ponader 2008, Enache & Potapova 2009). Since the studied population of *Sellaphora bosniaca* has not been observed alive and species is not very common, at present no information concerning life cycle or plastids can be given. Concerning small-celled *Sellaphora* species, we agree with Mann et al. (2008) that in future it may be more efficient to use DNA sequence data rather than cytological detail.

DISTRIBUTION & ECOLOGY: So far only known from the mineral rich part of the oligotrophic fen Bijambare with a very low relative abundance (950 m a.s.l.; N44°05'27.99", E18°30'15.14"; measurements on May 2008: pH: 5.7–6.6; conductivity 47–125 µScm^{-1}).

Sellaphora hafnerae Kapetanović & R.Jahn **sp. nov.** Figs 19–31

Valvae elongato-ellipticae, apicibus late capitatis, 9.9–16.7 µm longae, (mediocres 12.7 µm) et 3–3.6 µm latae (mediocres 3.2 µm). Area centralis rectangularis marginatus cum striis brevis. Striae transapicales uniseriatae radiatae, circa 23–24 in 10 µm. Raphe recta, poris centralibus indistinctis, fissuris terminalibus deflexis. Areae in partes terminales valvarum hyalinae, striis brevibus marginatae, transgredientes in serie areolarum in limbo.

HOLOTYPE: B 40 0040724, slide deposited in the Botanic Garden and Botanical Museum Berlin-Dahlem (Fig. 25 is representing the holotype).

FURTHER ORIGINAL MATERIAL: B 40 0040725, SEM stub deposited in the Botanic Garden and Botanical Museum Berlin-Dahlem .

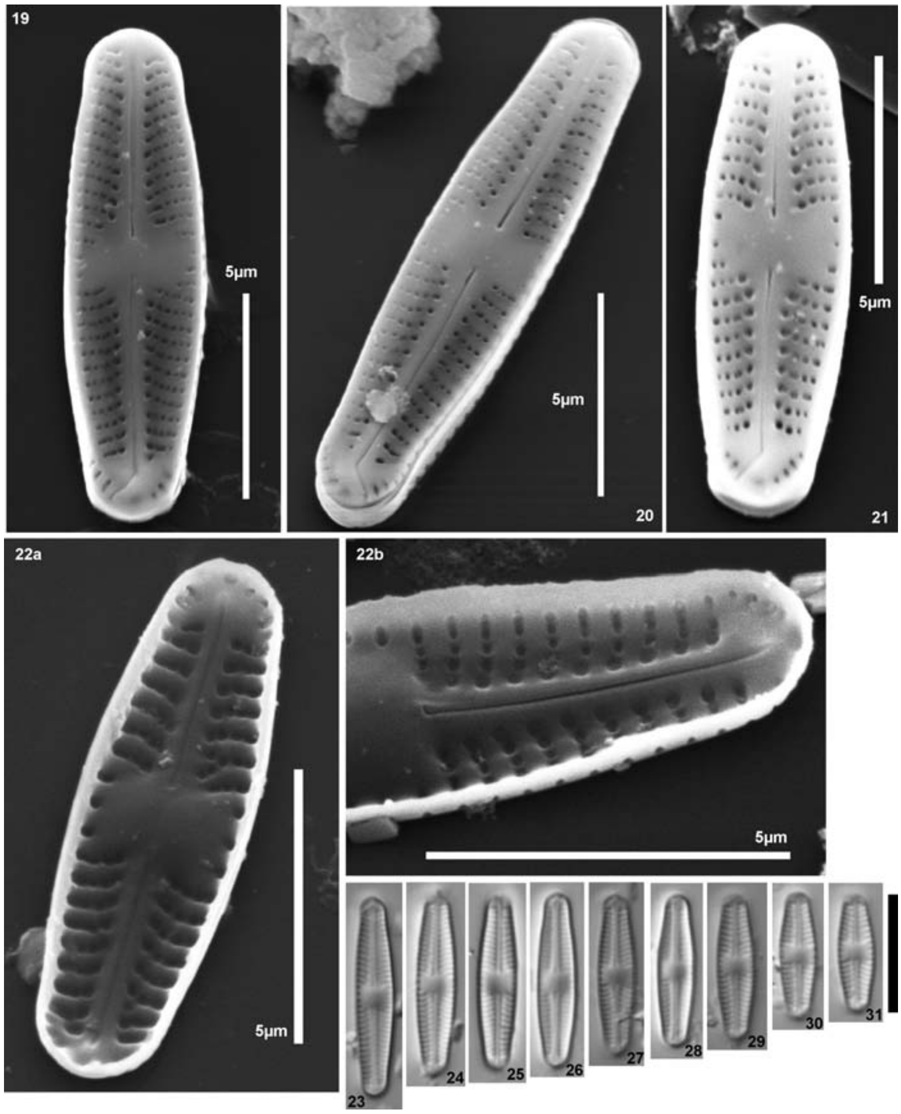
LOCUS TYPICUS: Bijambare, Bosnia and Herzegovina. Legit: Tatjana Kapetanović, 06.05.2007, (BI052007TK4/E).

ETYMOLOGY: the species is named in honour of Prof. Dr. Dubravka Hafner, a colleague who has done extensive research on algae in Bosnia and Herzegovina.

DESCRIPTION: Valves linear-elliptical with produced widely capitated apices (the tip of the valve sometimes appears wedged in LM); 9.9–16.7 µm long (average 12.7) and 3–3.6 µm wide (average 3.2). Central area is large, almost rectangular, bordered by several very short striae. The uniseriate transapical striae are radial, about 23–24 in 10 µm. Areolae are big and dot like; 4–6 in 1 µm. Raphe filiform, straight with indistinct central pores and deflected terminal fissures towards the same side. In the apices, there are distinctive hyaline areas bordered by shortened striae which continue as a line of areolae on the valve mantel.

In LM, our taxon most closely resembles *Eolimna tantula* (Hust.) Lange- Bert., but the latter taxon has a different valve outline (broadly rounded apices), denser striae (30 vs. 24 in 10 µm in our taxon) and no hyaline areas at the poles. These two taxa were found in association in one sample where the distinctive shaped apices of *Sellaphora hafnerae* differentiate this species from the "group" *Eolimna minima* (Grunow) Lange-Bert. – *Eolimna tantula*.

Other small species resembling our taxon such as *Sellaphora subantartica* Van de Vijver & Beyens and *Sellaphora joubaudii* (Germain) Aboal with a similar valve



Figs 19–31: *Sellaphora hafnerae* Kapetanović & R.Jahn nov. sp. Figs 19–22b. Different views of several frustules (SEM stub, original material B 40 0040725); Figs 19–21. External views; Figs 22a–b. Internal views. Figs 23–31. Population in LM (scalebar = 10 µm) from holotype slide B 40 0040724.

outline, differ by more rounded apices, a different number of striae in 10 µm, no distinctive hyaline areas and finer areolation (Van de Vijver et al. 2002, Wojtal 2009).

The difference between the genera *Eolimna* and *Sellaphora* is currently not clear, since recent studies showed that *Eolimna minima* appears to be molecularly a "part" of the genus *Sellaphora* (Evans et al. 2008). In the protologue of the genus *Eolimna* (Schiller & Lange-Bertalot 1997) similarities to the genus *Sellaphora* were discussed. Following the fact that species from the genus *Eolimna* in LM do not show distinctive hyaline areas at the poles, we decided to include this taxon in the genus *Sellaphora*

DISTRIBUTION & ECOLOGY: so far only known from the mineral rich part of the oligotrophic fen Bijambare with a low relative abundance (950 m a.s.l.; N44°05'27.12", E18°30'15.01"; measurements on May 2008: pH 6.1–6.6; conductivity 80–125 μScm^{-1}).

Remarks on some of the new records for Bosnia and Herzegovina

Cavinula cocconeiformis Fig. 43

Length 17.9–20.7 μm, width 9–9.4 μm; 24–25 striae in10 μm (n = 3; LM).

Cosmopolitan species, common in alpine and mountain habitats (Krammer & Lange Bertalot 1997a). In Bijambare fen it was found in mineral rich microhabitats. It is presumably endangered in Germany (Table 2).

Cymbella pervarians Fig. 48

Length 48.5–54 μm, width 10.5–11 μm, 8–12 striae in 10 μm 10 areolae in 5μm (n = 3, LM).

Occurs in temperate and subarctic areas, prefers dystrophic moory waters with low to average electrolyte content (Krammer 2003). It occurred in Bijambare fen only in one mineral rich microhabitat in significant number. It is presumably endangered in Gemany (Table 2).

Eunotia circumborealis Fig. 59

Length 31, width 6.5 μm, 13 striae in10 μm.

It occurred in the mineral rich part of Bijambare fen, and was rare. It has critical status in Germany (Table 2.).

Navicula digitulus Figs 94, 95, 96

Length 10.6, width 4.5 μm, 32 striae in10 μm, 50–60 areolae in 10μm (SEM);

Length 9.2–13.8 μm, width 3.8–4.1 μm (n = 3, LM).

Table 2. Relative abundancies of diatoms in the studied sampling sites (in %; average of three samples) and some ecological data available from literature [**RL-DE** = Rote Liste Deutschland (Hofmann et al., subm.): **E** = ecological data (eu = meso-eutraphentic, tol = oligo- to eutraphentic, o = oligotraphentic, od = oligotraphentic (carbonate waters), oc = oligotraphentic (acid water with more or less humic acid), hal = halophil, ae = aerophil). **K** = category in red list (1 = threathened with extinction, 2 = severely endangered, 3 = endangered, V = decreasing, G = presumed endangered, R = extremely rare, D = data scarce, *= not threathened). **AT** = Data from Austria (Rott et al. 1997, 1999): **S** = Saprobity value, **G** = Geochemical preference: ACB = acidobiont, ACF = acidophilous, CN = circumneutral, ALF = alkaliphilous, ALB = alkalibiontic, IND = indifferent. **NL** = Data from Netherlands (van Dam et al. 1994): **R** = indicator value for pH (ACB = acidobiont, ACF = acidiophilous, CN = circumneutral,

ALF = alkaliphilous, ALB = alkalibiontic, IND = indifferent), **T** = trophic status (o = oligotraphentic, o-m = oligo-mesotraphentic, m = mesotraphentic, m-eu = meso-eutraphentic, eu = eutraphentic, heu = hypereutraphentic, o-eu = oligo- to eutraphentic), **M** = moisture preferences (1 = allmost never occuring outside water bodies, 2 = mainly occuring outside water bodies, 3 = mainly occuring in water bodies and regularly on wet places, 4 = mainly occuring on wet places, 5 = nearly exclusively occuring outside water bodies). °new records for Bosnia & Herzegovina]

Taxa	**A**	**B**	**C**	**D**	**E**	**RL-DE**		**AT**		**NL**		
						E	**K**	**S**	**G**	**R**	**T**	**M**
?Achnanthes sp. I	-	-	0.1	-	0.2							
?Achnanthes sp. II	-	-	0.3	-	-							
Achnanthidium minutissimum (Kütz.) Czarn.	0.3	0.8	0.1	-	0.2	tol	*	1.7	CN	CN	o-eu	3
Adlafia bryophila (J.B.Petersen) Gerd Moser, Lange-Bert. & Metzeltin	-	-	-	-	0.1	tol	*	1.1	IND	CN	m	5
Adlafia minuscula (Grunow) Lange-Bert.	-	-	0.1	-	-	tol	*		ACF	ALF	o	4
Amphora pediculus (Kütz.) Grunow	-	0.3	-	-	-	tol	*	2.1	ALF	ALF	eu	3
Aulacoseira sp.	0.2	0.5	-	-	-							
Caloneis bacillum (Grunow) Cleve	0.1	0.3	-	-	-	eu	*	2.0	ALF	ALF	m-eu	2
Caloneis silicula (Ehrenb.) Cleve	-	-	0.2	0.2	-	tol	*	1.2	ALF	ALF	m-eu	1
Caloneis tenuis (W.Greg.) Krammer	-	-	-	-	0.1	o	G	1.0	CN	CN	m	4
°*Cavinula cocconeiformis* (W.Greg. ex. Grev.) D.G. Mann & Stickle	-	-	0.2	-	1.2	o	G	1.0	CN	CN	o-m	3
°*Chamaepinnularia evanida* (Hust) Lange-Bert.	0.1	-	-	-	-	tol	*	1.0	CN	CN	m	4
°*Chamaepinnularia mediocris* (Krasske) Lange-Bert.	-	-	-	-	0.2	od	V	1.0	ACF	ACF	o	4
Chamaepinnularia soehrensis var. *hassiaca* (Krasske) Lange-Bert.	-	-	0.1	-	0.1	o	3	1.0	ACF	ACF	o	4
°*Chamaepinnularia soehrensis* var. *soehrensis* (Krasske) Lange-Bert. & Krammer	-	-	0.2	-	-	od	V	1.0	ACF	ACF	o	4
°*Cocconeis neodiminuta* Krammer	-	-	-	0.3	-		R		ACF			
Cocconeis placentula Ehrenb.	2.2	-	-	-	-	tol	*	1.8	ALF	ALF	eu	2
Cyclotella ocellata Pant.	-	0.3	-	0.3	-	eu	*		ALF	ALF	m-eu	1
Cymbella aspera (Ehrenb.) H.Perag.	0.6	0.5	-	0.2	0.1	o	V		ALF	ALF	o-eu	
Cymbella naviculiformis Auersw.	-	-	-	-	0.1	tol	*	1.3	CN	CN	eu	2
°*Cymbella pervarians* Krammer	-	-	-	-	2.3	od	G					
Decussata hexagona (Torka) Lange-Bert.	-	-	-	0.2	0.3		R					
Denticula tenuis Kütz.	-	-	0.1	-	-		*	1.3	IND	ALF	m	3
°*Diadesmis brekkaensis* (J.B.Petersen) D.G.Mann	-	-	0.2	0.2	1.5	ac	*			CN		4
Diadesmis perpusilla (Grunow)D.G.Mann	0.1	-	-	-	-	ac/o	*					
Diatoma mesodon Kütz.	0.2	-	-	0.2	-	tol	*	1.3	ACF	CN	m	2
°*Diploneis fontium* Reich. & Lange-Bert	-	-	-	-	0.2	o	G					
Diploneis petersenii Hust.	-	-	-	0.2	1.2	o	3	1.1	CN	CN	m	4
°*Encyonema neogracile* Krammer	-	-	-	0.2	0.6	od	3	1.0	ACF	ACF	o-m	3
Encyonema minutum (Hilse) D.G.Mann	-	0.3	0.1	-	-	tol	*	1.6	IND	CN		
Encyonema neomesianum Krammer	0.1	-	0.1	1.3	0.3	o	V	1.0	ALF	ALF		
Encyonema perpusillum (A.Cleve) D.G.Mann	-	-	0.1	-	0.2	od	G	1.0	ACF	ACF	o	4
Encyonopsis microcephala (Grunow) Krammer	0.2	-	0.1	-	-	tol	*	1.2	ALF	ALF	m-eu	3
Eolimna minima (Grunow) Lange-Bert.	-	-	16,4	21.0	6.6	tol	*	2.6	IND	ALF	eu	3
Eolimna sp. I	-	-	0.2	0.8	0.2							
Eolimna sp. II	-	-	0.4	1.3	1.3							
°*Eolimna tantula* (Hust.)Lange-Bert.	-	-	7.1	2.4	-	o	D					
°*Eunotia bilunaris* (Ehrenb.) Schaarschm.	0.1	-	0.5	17.1	3.7	tol	*	1.7	ACF	IND	o-eu	3
°*Eunotia circumborealis* Lange-Bert & Nörpel	-	-	0.1	0.2	0.3	od	1					
Eunotia exigua (Bréb.ex Kütz.) Rabenh.	4.7	33.9	1.2	0.3	7.5		*	1.1	ACB	ACB	o-eu	3
°*Eunotia glacialis* F.Meister	17.8	39.2	0.7	5.7	3.6	od	G	1.0	ACF	ACF	o-m	3
°*Eunotia meisteri* Hust.	-	0.5	0.5	-	0.8	od	G		ACF	ACF	o	4
Eunotia minor (Kütz.) Grunow	0.1	-	3.1	2.1	2.5	tol	*	1.5	ACF	ACF		4
Eunotia paludosa Grunow	23.5	18.7	0.2	-	5.2	od	V			ACB	o	4
Eunotia praerupta Ehrenb. s.l.	-	-	-	-	0.1				ACF	ACF	o-m	3
Eunotia septentrionalis Oestrup	-	-	-	-	0.2					ACF	o	3
Eunotia steineckei Petersen	-	-	-	-	0.8	od	G				o	
°*Fallacia insociabilis* (Krasske) D.G.Mann	-	-	0.1	-	-	ac	*			CN	m	4
Fragilaria leptostauron (Ehrenb.) Hust.	-	0.3	-	-	-		*		ALF	ALF	m-eu	2
Fragilaria ulna (Nitzsch) Lange-Bert.	-	0.3	-	-	-		*	2.7	ALB	ALF	o-eu	2
Fragilaria ulna var. *acus* (Kütz.) Lange-Bert.	-	-	-	-	0.1		*		CN	ALF	eu	2
Fragilaria virescens Ralfs	0.1	0.3	0.1	0.3	-	o	V	1.2	CN	CN	o-m	1
Fragilaria virescens var. *capitata* Krasske	0.1	-	-	-	-					CN		
Frustulia vulgaris (Thwaites) De Toni	-	-	0.1	0.2	-	tol	*	2.0	IND	ALF	m-eu	3
°*Geissleria paludosa* (Hust.) Lange-Bert. & Metzeltin	-	-	0.1	-	0.1	od	3					
°*Gomphonema acidoclinatum* Lange-Bert. & E.Reichardt	-	-	0.2	-	0.4	od	D					
Gomphonema acuminatum Ehrenb.	0.1	-	-	-	-	tol	*	1.5	ALF	ALF	eu	2
°*Gomphonema bozenae* Lange-Bert. & E.Reichardt	-	-	-	0.7	0.1	od	G					
°*Gomphonema exilissimum* (Grunow) Lange-Bert. & E.Reichardt	0.3	0.3	0.2	3.3	6.5	od	V					
Gomphonema micropus Kütz.	-	-	0.1	-	0.3	tol	*	1.9	IND	ALF	eu	3
°*Gomphonema productum* (Grunow) Lange-Bert. & E.Reichardt	-	-	0.1	-	1.2	o	G	1.2	CN	CN	o-m	3

Table 2. Continued

Taxa	A	B	C	D	E	RL-DE		AT		NL		
						E	K	S	G	R	T	M
Gomphonema subclavatum Grunow	-	-	0.1	-	0.1		*	1.2	CN	CN	o-m	3
Hannaea arcus (Ehrenb.) R.M. Patrick	-	0.3	-	-	-	tol	*			ALF	o-m	3
°*Hantzschia abundans* Lange-Bert.	-	-	0.6	1.1	0.1	ac	*					
Hantzschia amphioxys (Ehrenb.) Grunow	-	0.3	0.1	-	0.1	ac	*	1.8	ALF	CN	o-eu	4
Hantzschia cf. *calcifuga* E.Reichardt & Lange-Bert.	-	-	0.1	-	-	od	D					
°*Luticola acidoclinata* Lange-Bert.	-	-	0.1	-	0.1	od	G					
Luticola mutica (Kütz.)D.G.Mann	0.2	-	0.1	-	-	tol	*	2.0	ALF	CN	eu	4
Luticola nivalis (Ehrenb.) D.G.Mann	-	0.3	-	-	-	ac	*		CN	CN	eu	4
Luticola sp.	-	-	0.1	-	-							
°*Luticola ventriconfusa* Lange-Bert	-	-	-	-	0.1	eu	D					
°*Mayamaea fossalis* (Krasske)Lange-Bert.	-	-	-	-	0.1		*			CN		4
Meridion circulare (Grev.) C.Agardh	-	-	0.2	-	-	eu	**	1.9	ALF	ALF	o-eu	1
Meridion circulare var. *constrictum* (Ralfs) Van Heurck	0.4	-	-	-	-	tol	**	1.2	ALF	ALF	o-eu	2
°*Navicula digitulus* Hust.	-	-	-	-	0.8	od	3					
Navicula exilis Kütz.	-	-	-	-	1.7	o	G	1.1	ALF			
°*Navicula medioconvexa* Hust.	-	-	-	-	0.1	o	R		CN	CN		
°*Navicula tridentula* Krasske	-	-	0.2	-	-	o	R		ACF	ACF		4
Naviculadicta cf. *stauroneioides* Lange-Bert.	-	-	0.1	-	-	od	R					
Neidium affine (Ehrenb.) Pfitzer	-	-	-	-	0.1	o	V	1.0	CN	CN	m-eu	1
°*Neidium alpinum* Hust.	-	-	0.1	0.2	0.1	od	3	1.0	ACF	ACF	o	3
Neidium bisulcatum (Lagerst.) Cleve	-	-	0.8	0.2	1.0	od	3	1.0	CN	CN	o	3
°*Nitzschia acidoclinata* Lange-Bert.	0.2	0.3	29.8	15.3	10.3	tol	*	1.3	CN	CN	m	3
Nitzschia alpina Hust.	-	-	-	-	0.1	o	G				o	
Nitzschia hantzschiana Rabenh.	-	-	-	0.3	-	tol	*	1.6	ACF	CN	m	4
Nitzschia palea (Kütz.) W.Sm.	-	-	0.2	0.2	0.1	eu	*	2.8	ALF	CN	h eu	3
Nitzschia perminuta (Grunow) Perag.	-	-	0.4	-	-	tol	*	1.3	CN	ALF	o-m	3
°*Nitzschia terrestris* J.B. Petersen (Hust)	-	-	0.7	0.2	-	ac	*			CN		4
Nupela cf. *imperfecta* (Schim.) Lange-Bert.	-	-	-	-	0.3	o	G					
°*Pinnularia eifelana* Krammer	-	-	1.8	2.8	0.6	o	G					
°*Pinnularia esoxiformis* Krammer	-	-	-	0.2	-	o	G					
°*Pinnularia rhombarea* Krammer	47.7	-	2.2	4.7	0.1	od	G					
°*Pinnularia microstauron* var. *rostrata* Krammer	-	-	0.8	0.2	0.6		G					
°*Pinnularia nobilis* var. *regularis* Krammer	-	-	-	0.2	-		G					
Pinnularia nodosa (Ehrenb.) W.Sm.	-	-	0.7	1.0	1.2	o	G		ACF	ACF	o	3
°*Pinnularia obscura* Krasske	-	-	0.4	0.5	0.7	ac	*		CN	CN		4
°*Pinnularia obscuriformis* Krammer	-	-	0.3	-	0.7	o	G					
°*Pinnularia perirrorata* Krammer	-	-	0.5	-	2.1	od	*					
°*Pinnularia sinistra* Krammer	-	0.5	6.8	1,3	5.3	od	*					
Pinnularia stomatophora (Grunow) Cleve	-	-	0.2	0.7	0.3	od	G		ACF	ACF	o	4
°*Pinnularia substreptoraphe* Krammer	-	-	-	-	0.1	od	R					
°*Pinnularia viridiformis* Krammer	-	-	3.7	0.2	1.3	od	G					
Pinnularia viridis (Nitzsch) Ehrenb.	-	-	-	-	0.1		D		CN	CN	o-eu	3
Placoneis elginensis (W.Greg.) E.J.Cox	0.1	-	7.7	2.6	3.8	eu	D			ALF	eu	3
°*Placoneis hambergii* (Hust.) Bruder	-	-	-	-	0.1		*			ACF		4
Placoneis ignorata (Schim.) Lange-Bert.	-	-	3.0	1.1	0.5		*		ACF	ALF	eu	3
Planothidium dubium (Grunow) Round & Bukht.	-	-	-	-	0.2	eu	*		ALF			
°*Planothidium frequentissimum* (Lange-Bert.) Lange-Bert.	0.1	-	0.1	0.5	1.5	eu	*	2.5	ALF	ALF	o-eu	
Planothidium lanceolatum (Bréb. ex Kütz.) Lange-Bert.	0.2	-	-	-	0.2	tol	*			ALF	eu	3
Rhophalodia sp.	0.1	-	-	-	-							
Sellaphora bosniaca Kapetanović & R. Jahn	-	-	0.8	-	0.2							
Sellaphora cf. *hustedtii* (Krasske) Lange-Bert. & Werum	-	-	-	-	0.1		R		ACF	ACF		4
Sellaphora hafnerae Kapetanović & R. Jahn	-	-	-	3.7	4.0							
Sellaphora nana (Hust.) Lange-Bert., Cavacini, Tagliaventi & Alfinito	-	-	0.1	-	-		R					
Sellaphora pupula (Kütz.) Mereschk.	-	-	0.2	0.8	4.3	eu	D	2.4	ALF	CN	m-eu	2
Sellaphora seminulum (Grunow) D.G.Mann	-	-	3.1	2.6	4.0	eu	*	3.2	ALF	CN	eu	3
°*Stauroneis acidoclinata* Lange-Bert. & Werum	-	-	1.2	0.5	0.4	od	D					
Stauroneis gracilis Ehrenb.	-	-	0.2	0.2	0.1	od	V					
°*Stauroneis montana* var. *lanceolata* Hust.	-	0.3	-	-	1.0							
Stauroneis reichardtii Lange-Bert., Cavacini, Tagliaventi & Alfinito	-	0.3	-	-	-		D					
°*Stauroneis thermicola* (J.B. Petersen) Lund	-	-	-	-	0.1	ac	*	1.4	CN	CN	o-eu	4
Staurosira pinnata Ehrenb.	0.1	0.5	-	-	-	tol	*	1.4	IND	ALF	o-eu	3
Staurosira venter (Ehrenb.) H.Kobayasi	0.3	-	-	-	-	tol	*			ALF	m-eu	1
Stephanodiscus sp.	0.1	-	-	-	0.1							
Surirella angusta Kütz.	-	1.1	0.3	0.7	0.4	eu	*	2.2	ALF	ALF	eu	3
Tabellaria flocculosa (Roth.)Kütz.	0.1	-	-	-	0.8	tol	*	1.1	ACF	ACF	m	3

Fallu et al. (2000) differentiated two forms. We also found one valve which has a more linear prolonged shape and dimensions of 19.2 × 4.4 µm; 28 striae/10µm (Fig. 73). In addition, in Hustedt's original material there are also different forms (Simonsen 1987). Most specimens from our population (etc. Fig. 74) agree with the valve on plate 470: fig 5. in Simonsen (1987). Recorded in mountain to alpine habitats of boreal Eurasia and North America (Lange-Bertalot & Metzeltin 1996) and in a mineral rich spring fen in West Carpathian (Frankova et al. 2009). In our study, we found it only in microhabitat E that is also mineral rich. It is considered to be endangered in Germany (Table 2).

Navicula medioconvexa Figs 92, 93

Length 14.5, width 4.1µm, 26 striae in 10 µm.

Occurs in mountain and alpine habitats. In Bijambare fen only few valves were found mostly in mineral rich microhabitats. It is considered to be extremely rare in Germany (Table 2).

Pinnularia eifelana Fig. 68

Length 54–88 µm, width 9–12 µm, 8–9 striae in 10 µm (n = 3, LM).

Prefers oligotrophic waters with average electrolyte content (Krammer 2000). In Bijambare it was found in the mineral rich part of the fen. Presumed to be endangered in Gemany (Table 2).

Pinnularia perirorrata Fig. 70

Length 17.5–19.0 µm, 3.0–3.5 µm, 16–17striae in10 µm (n = 3, LM).

Boreal to subartic cosmopolitan species, occurring in oligotrophic, electrolyte poor acidic habitats, particularly in moorland waters. In Bijambare it was found in the mineral rich part of the fen. It is presumed not to be endangered in Germany (Table 2).

Pinnularia rhombarea Fig. 66

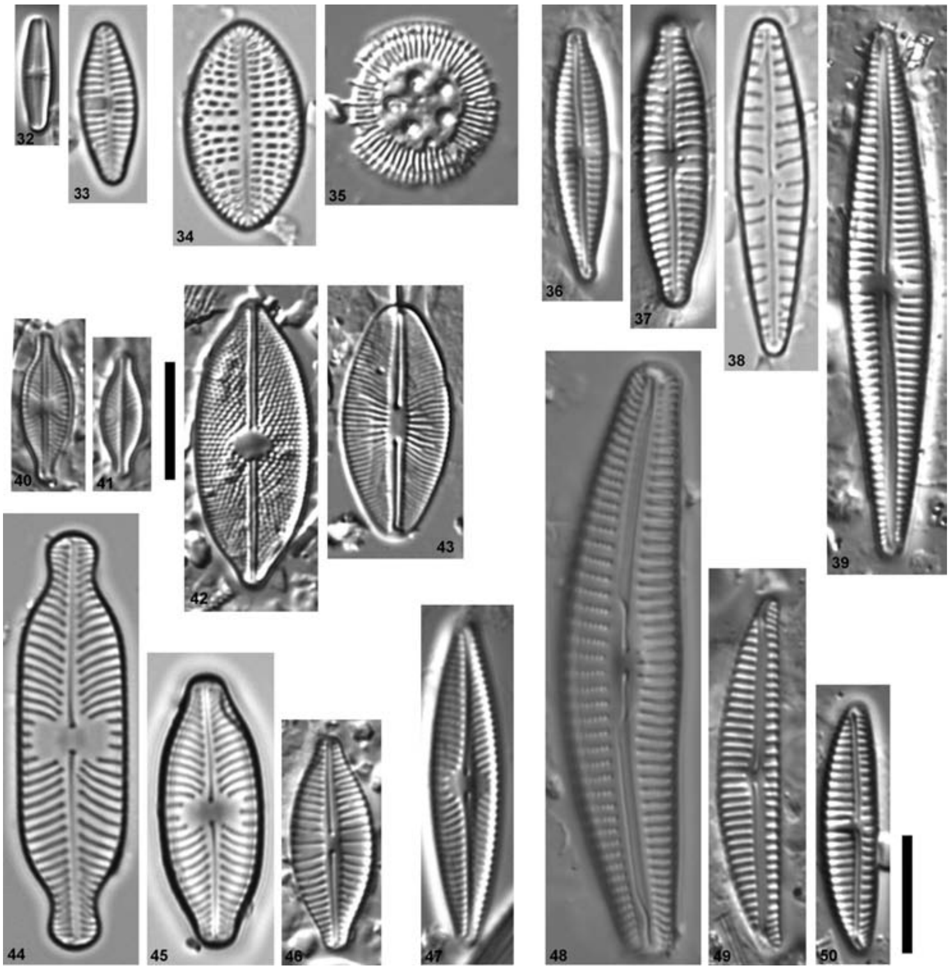
Length 61.1–79.5 µm, width 11–12.5 µm, 9–10 striae in10 µm (n = 4, LM).

Distributed in northern and subartic regions, more frequent in the central European region (Krammer 2000). This was the most abundant species in the Sphagnum part of the Bijambare fen (A) in May 2007. Presumed to be endangered in Gemany (Table 2).

Stauroneis acidoclinata Figs 75, 77

Length 40–44.5, width 8 µm, 19–21 striae in10 µm (n = 3, LM)

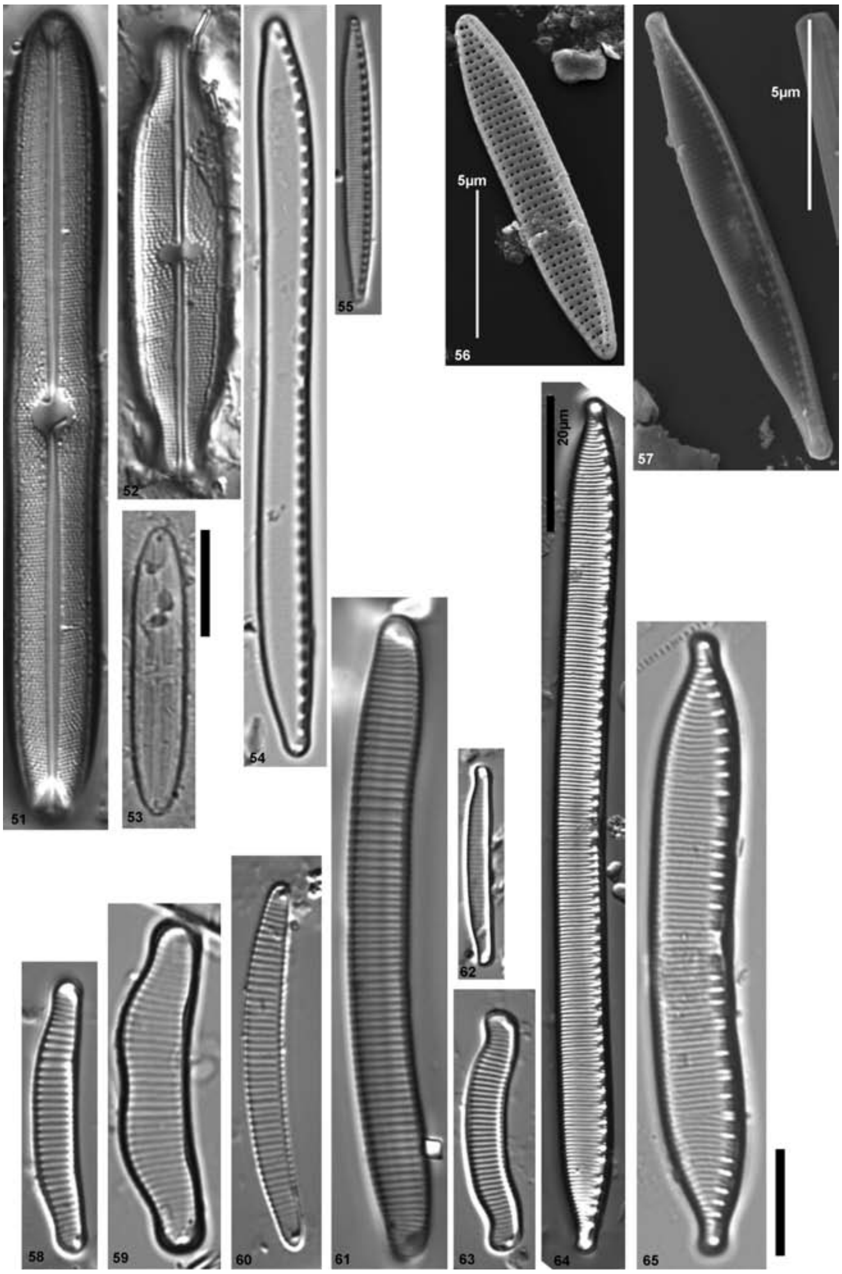
In Bijambare, it was found in the mineral rich part of the fen. It occurs in electrolyte poor springs in association with acidophilous diatoms, especially *Eunotia* species. Recorded in Austria, central Alps and Tatra mountains (Werum & Lage-Bertalot 2004). Data about the Red List Status of this taxon in Germany are insufficient (Table 2).



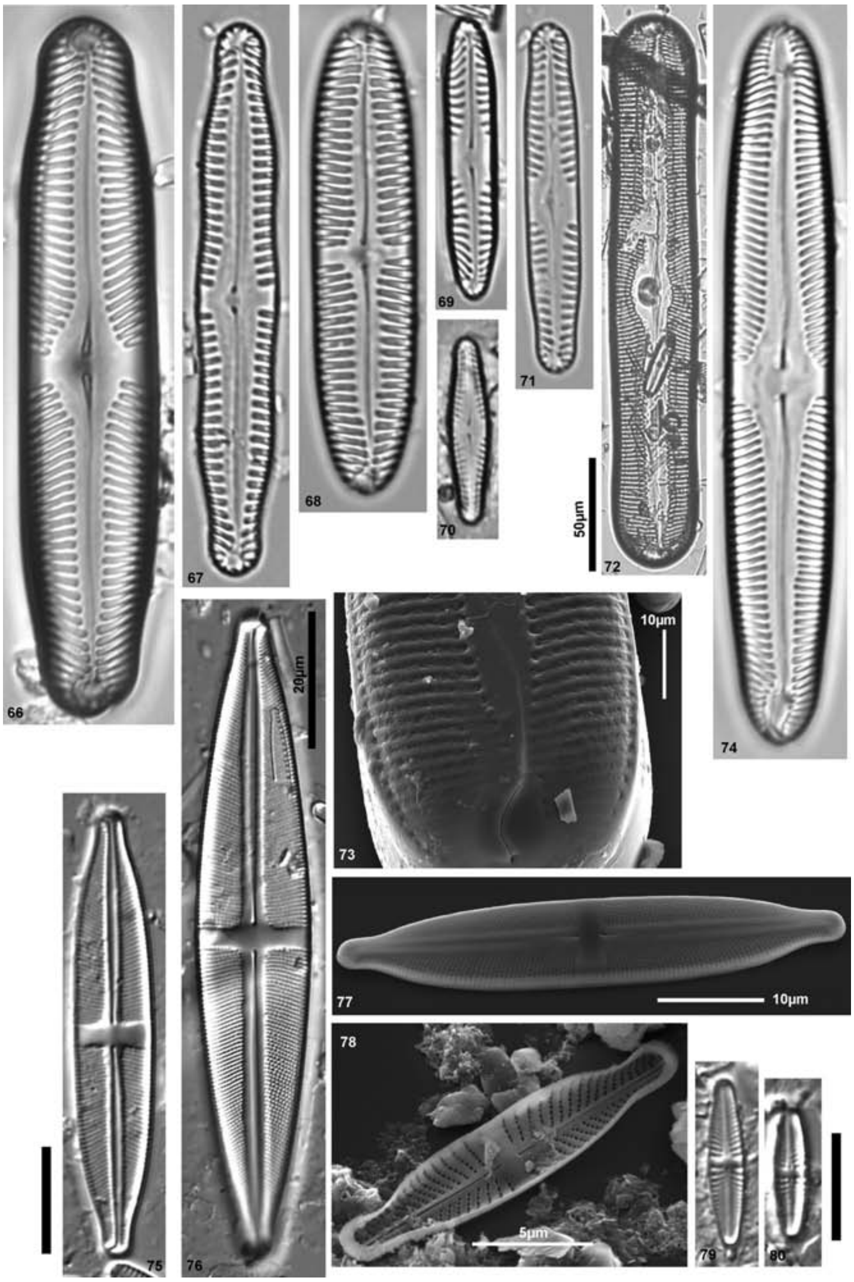
Figs 32–50: Divers taxa from Bijambare fen in LM. 32. *Achnanthidium minutissimum;* 33. *Planothidium frequentissimum;* 34. *Cocconeis neodiminuta;* 35. *Cyclotella ocellata;* 36. *Gomphonema exilissimum;* 37. *Gomphonema productum;* 38. *Gomphonema bozenae;* 39. *Gomphonema acidoclinatum;* 40–41. *Sellaphora* cf. *hustedtii;* 42. *Decussata hexagona;* 43. *Cavinula cocconeiformis;* 44. *Placoneis paraelginensis;* 45. *Placoneis ignorata;* 46. *Placoneis hambergii;* 47. *Navicula exilis;* 48. *Cymbella pervarians;* 49. *Encyonema neogracile;* 50. *Encyonema perpusillum.*

Discussion

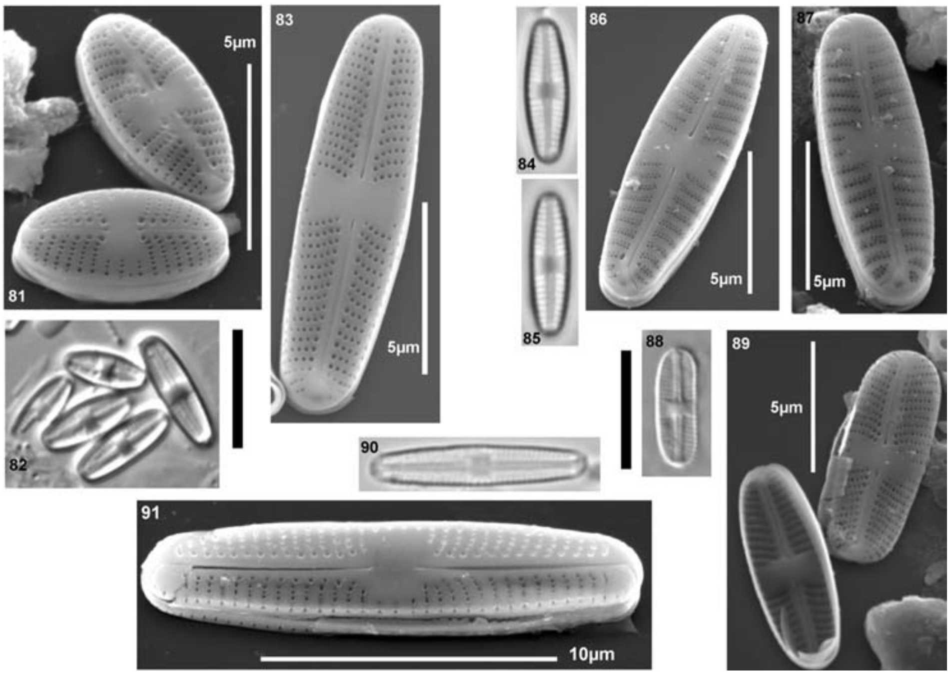
Large bogs do not necessarily have the most diverse diatom flora (Buczko & Wojtal 2005). Algal richness and diversity in mires are correlated with the richness and diversity of microhabitats (Lederer & Soukupova 2002). The biodiversity of diatoms in the Bijambare fen, in total 1 ha large, is relatively high with 126 taxa. Eighty-



Figs 51–65: Divers taxa from Bijambare fen in LM; Figs 56, 57 by SEM. 51. *Neidium bisulcatum;* 52. *Neidium affine;* 53. *Neidium alpinum;* 54. *Nitzschia terrestris;* 55. *Nitzschia acidoclinata;* 56. *Nitzschia alpine;* 57. *Nitzschia perminuta;* 58. *Eunotia minor;* 59. *Eunotia circumborealis;* 60. *Eunotia bilunaris;* 61. *Eunotia glacialis;* 62. *Eunotia paludosa;* 63. *Eunotia exigua;* 64. *Hantzschia* cf. *calcifuga;* 65. *Hantzschia abundans.*



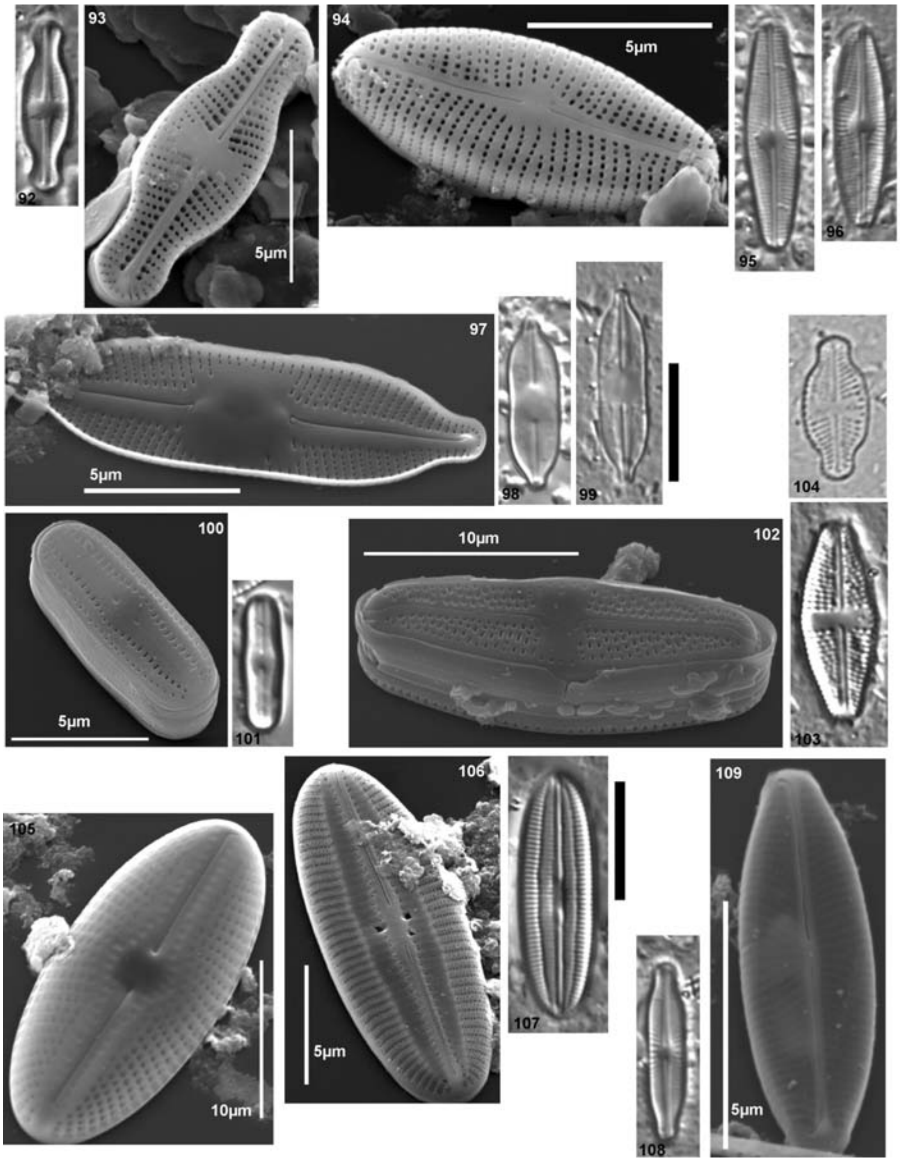
Figs 66–80: Divers taxa from Bijambare fen in LM; Figs 73, 77, 78 by SEM. 66. *Pinnularia rhombarea;* 67. *Pinnularia nodosa;* 68. *Pinnularia eifelana;* 69. *Pinnularia obscura;* 70. *Pinnularia perirrorata;* 71. *Pinnularia sinistra;* 72–73. *Pinnularia nobilis* var. *regularis;* 74. *Pinnularia stomatophora;* 75. *Stauroneis acidoclinata;* 76. *Stauroneis gracilis;* 77. *Stauroneis acidoclinata;* 78. *Stauroneis thermicola;* 79–80. *Stauroneis montana* var. *lanceolata.*



Figs 81–91: Divers taxa from Bijambare fen in LM; Figs 81, 83, 86, 87, 89, 91 are SEM pictures. 81. *Eolimna minima;* 82–83. *Eolimna tantula;* 84–87. *Sellaphora seminulum;* 88–89. *Eolimna* sp.I; 90–91. *Eolimna* sp. II .

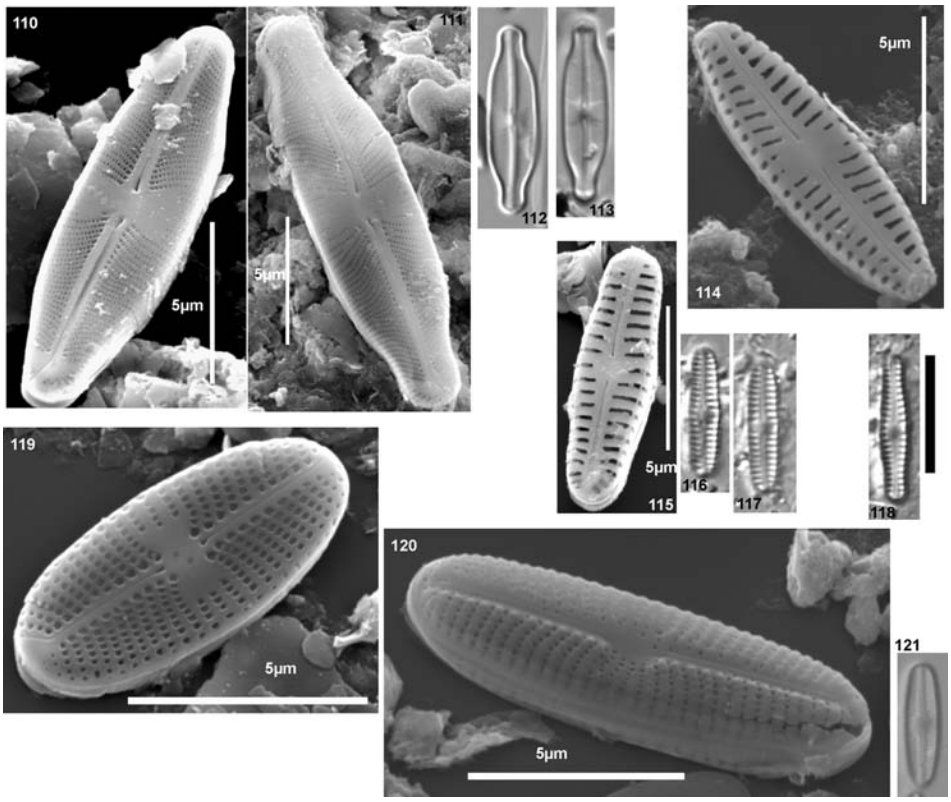
three taxa are recorded exclusively in the marginal area of the fen (C, D, E sampling sites). As in other types of mires (Nováková 2002, Negro et al. 2003) diatoms are recognized as the dominant component of the algal flora in Bijambare fen. The low abundances of the majority of the species correspond well to the results of other authors in similar oligotrophic habitats (Buczko 2006, Buczko & Wojtal 2005, Wojtal et al. 1999, Van de Vijver & Beyens 1997, van der Werff 1975).

The marginal, minerotrophic part of the Bijambare fen has species rich diatom communities (109 species recorded on sites C, D and E) with dominant species such as *Nitzschia acidoclinata* and *Eunotia bilunaris* that are more tolerant to various trophic conditions. The central, peaty part of the fen is characterized by species poor diatom communities (44 species recorded on sites A and B). Although the DCA ordination of all taxa and samples shows relatively low variance by the first two axes (37.3%) which is to be expected for abundance data that are usually very noisy (ter Braak & Šmilauer 2002), DCA ordination clearly differentiated these two groups of assemblages – central and marginal – along the first axis (Fig. 2). Differentiation between marginal and central diatom assemblages was also evidenced by other authors in similar habitats (Krieger 1929, Wojtal et al. 1999). In contrast, studies focussing only on bryophytic diatoms in mires usually evidenced low biodiversity due to extreme conditions but contributed much to the knowledge of ecological preferences of



Figs 92–109: Divers taxa from Bijambare fen in LM; Figs 93, 94, 97, 100, 102, 105, 106, 109 are SEM pictures. 92–93. *Navicula medioconvexa;* 94–96. *Navicula digitulus;* 97–99. *Nupela* cf. *imperfecta;* 100–101. *Diadesmis brekkaensis;* 102–103. *Luticola acidoclinata;* 104. *Luticola ventriconfusa;* 105. *Diploneis fontium;* 106–107. *Diploneis petersenii ;* 108. *Adlafia bryophylla ;* 109. *Adlafia minuscula.*

particular diatom species (Nováková & Poulíčková 2004, Buczko & Wojtal 2005). Kingston (1982) linked distribution of diatoms in mires of Minnesota (USA) with



Figs 110–121: Divers taxa from Bijambare fen in LM; Figs 110, 111, 114, 115, 119, 120 are SEM pictures. 110. *Sellaphora nana;* 111–113. *Naviculadicta* cf. *stauroneioides;* 114. *Chamaepinnularia evanida;* 115–117. *Chamaepinnularia mediocris;* 118. *Chamaepinnularia soehrensis* var. *soehrensis;* 119. *?Achnanthes* sp. I 120–121. *?Achnanthes* sp. II

the type of macro-vegetation, trophic level and position regarding water level and concluded that biodiversity increases with minerotrophy. Algal populations, in general, have a more diversified flora in mineral ground pools of the mires (Nováková 2007).

Previous studies show that the composition and abundances of the algal floras in fens are closely related to the variation of environmental variables, especially pH and conductivity (Poulíčková et al. 2003, Nováková 2007). Basic measurements in this study agree with the previous conclusions (Table 1). Generally, the most stable variables measured in fens are pH and conductivity, while PO_4 and NO_3 can be used only with limitations (Hájek et al. 2005). In Bijambare fen, the variables that differ the most between microhabitats are phosphates and pH. The relatively higher content of phosphates in Bijambare might be explained as a characteristic of poor fens that are dominated by species from the *Spagnum recurvum*-group. Hájková & Hájek (2003) and Hájek et al. (2002) evidenced higher amounts of phosphates in poor fen assemblages of *Carici echinatae-Sphagnetum recurvi* and, following Kooijman & Kanne (1993) and Limpens et al. (2003), discuss the importance of phosphates for the growth of species from the *Sphagnum recurvum*-group.

As there are a number of variations in the values of ecological parameters due to precipitation and evaporation, Nováková (2002) suggested that other environmental variables such as vegetation and shadowing could help in determining different micro-biotopes. Vascular plants and bryophytes have a similar variation in species composition related to environmental variables as algal species. Therefore, vegetationally different localities of fens show a different composition in the diatom flora and variation of abundancies which might be closely related to the variation in ecological parameters of the biotope (Poulíčková et al. 2003, 2005). In larger fen areas, Nováková (2004) found that, even though there is a correlation between the algal flora and distance between sites in subalpine mires, a similarity in the composition of algal communities between close ponds is the result of similar ecological conditions (i.e. vegetation) but not the result of the vicinity itself. In Bijambare fen, differences in vegetation are reflected by the difference in diatom composition. Within the group of vegetationally similar habitats like C, D, E in contrast to A, B there are some minor differences in diatom composition. Chemical properties (pH and conductivity) of the site C are more similar to those of A and B, but it is a more wet habitat (as are D and E). Also, site C is in a transitional zone more close to the central peaty part of the fen where *Sphagnum* spp. can occur, while sites D and E are "real" minerotrophic and the structure of the habitat is different (small pools in grassy vegetation instead of peaty vegetation). This difference in type of substrate can be an important factor which influences algal populations (Nováková, 2002). Sampling site B (with *Polytrichum* hummocks) is drier than A but both are peaty habitats. The major part of the fen (A) has a few more species but the abundant species are the same: *Eunotia paludosa, E. glacialis and E. exigua*. In both localities (especially at site E), single specimens of alkaliphilous species can be found.

Previous studies in similar habitats did not show a significant seasonality. In this study, the difference in total number of species between May 2007 and May 2008 was most likely induced by a "late spring" in 2008 because diatom populations were not well developed. Generally, samples of May 2007, at all sites, were the richest in species. A significant decrease in diversity of diatoms in summer and autumn 2007 was most likely caused by unusually dry weather conditions. Novakova (2007) observed among other algal species that *Eunotia glacialis* decreased during the summer months which would correspond to the psychrophilic character of the species. In Bijambare fen *Eunotia glacialis* was also most abundant in colder months (at sampling site B in Oktober 2008, at sampling site A in May 2008).

Most of the species identified in Bijambare fen can be recognized as belonging to the 'common mire flora' found worldwide (e.g. *Eunotia* spp., *Neidium* spp., *Chamaepinnularia* spp.). The dominance of *Eunotia paludosa* and *E. exigua* in peaty areas was reported by other authors in similar habitats in Germany, Poland, Korea (Messikommer 1927, Krieger 1929, Wojtal et al. 1999, Kim et al. 2007). Differences in the diatom floras can be explained as biogeographically induced by regional climate and history of distribution patterns; for example, we did not evidence any *Frustulia* *saxonica* or *F. crassinervia*, usually typical for most Central and North European peat bogs (Messikommer 1927, Krieger 1929, Budde 1934, Fetzmann 1961, Wuthrich & Matthey 1977, Compère 1980, Wojtal et al. 1999, Kulikovskii 2008). In Bosnia and Herzegovina, *F. crassinervia* was found in subalpine spring areas (Kapetanović & Hafner 2007), including also *Brachysira brebissonii* R.Ross and *Eunotia incisa* W.Greg. but they were not found in Bijambare fen. Likewise, *Kobayasiella subtilissima* (Cleve) Lange-Bert., which is reported from Central and North European mires (Krieger 1929, Compère 1980, Krammer & Lange-Bertalot 1997a, Kulikovskii 2008, Buczko et al. 2009), was not found. *Tabellaria flocculosa*, often reported as dominant or subdominant in mires (Kim et al. 2007, Frankova et al. 2009) occurs in Bijambare fen with only low abundances. *Decussata hexagona* (Fig.15), considered to be extremely rare in Germany, seems to be more common in Balkan mountain habitats (Nidze and Shara mountains in Macedonia; Central Sredna Gora Mountains in Bulgaria) where it has been recently reported from mire habitats (Levkov et al 2005, Stanceva & Temniskova 2006, Edlund et al. 2006); in Bosnia and Herzegovina it was found by now only at locality Čavljak, near Sarajevo, in a mountain heathland creek (Hafner et al. 2008). It could be that some mire types reach their biogeographical southern limit in Bosnia and Herzegovina and also exhibit some specificity in floristic composition. Part of the explanation could also be that the term mire includes a too wide range of various habitats in Europe as well as worldwide and that a comparison between different types of mires is difficult due to different micro-ecological conditions and different methods of sampling (Lederer & Soukupova 2002).

Recent changes in the concept of some taxa and the rarity of many oligotraphentic species in Europe, due to a loss of oligotrophic habitats, are the main reasons that ecological data for a number of taxa is scarce in the available literature. About 50–65% of all the taxa from this study are cited as indicators for trophic status and moisture requirements, according to Van Dam et al. 1994 (Table 2). The most abundant taxa are oligotraphentic or oligo-mesotraphentic species. It is expected that taxa from genera such as *Pinnularia* and *Eunotia* will be most represented, as *Pinnularia* taxa can be found in wide range of water habitats but are indicative for acid, oligotrophic freshwaters and *Eunotia* taxa are strong indicators for acid, fresh, oligotrophic waters rich in oxygen and poor in organic nitrogen compounds (Van Dam et al. 1994).

In "requirements for moisture" the majority of the species are categorized as "mainly occurring in the water bodies and also rather regularly on wet and moist places" but also a number of them (35%) are "mainly occurring on wet and temporarily dry places" such as *Eunotia paludosa*, *E. meisteri*, *Chamaepinnularia* spp., *Hantzschia* spp., *Diploneis petersenii*, *Diadesmis brekkaensis, P. stomatophora, Pinnularia obscura* and *Stauroneis thermicola.* Occurrence of truly aerophytic species such as *Hantzschia* spp. and *Luticola* spp. can be explained with drying out which occurs periodically. According to Rott et al. (1999), pH preferences can be cited for about 50% of taxa. Of these, alkaliphilous, acidiphilous and circumneutral taxa are almost equally present with about 30% each, but the most abundant taxa are acidophilous taxa, such as: *Eunotia exigua*, *E. paludosa* and *Pinnularia nodosa*. A circumneutral species very abundant in minerotrophic samples is *Nitzschia acidoclinata*.

Alkaliphilous taxa such as *Amphora pediculus*, *Caloneis bacillum*, *Fragilaria leptostauron*, are mostly rare in the studied samples with the exception of *Sellaphora seminulum* which is abundant.

A Red List of the Diatoms of Bosnia and Herzegovina is not yet completed and therefore we can only illustrate the status of the studied flora by comparing it with other published European data. Data for 95 taxa (Table 2) can be found in the Red List of Diatoms in Germany (Lange-Bertalot & Steindorf 1996, revised by Hofmann et al., subm.) and it shows a prevalence of oligotraphentic taxa (51,6%). Most of them (23) are presumably endangered such as: *Caloneis tenuis, Cavinula cocconeiformis, Cymbella pervarians, Diploneis fontium, Encyonema perpusillum, Eunotia glacialis, E. meisteri.* Nine are vulnerable (e.g. *Chamaepinnularia mediocris, Cymbella aspera, Eunotia paludosa)* and eight extremely rare (e.g. *Cocconeis neodiminuta, Decussata hexagona, Navicula medioconvexa*). Endangered are *Chamaepinnularia soehrensis var. hassiaca, Diploneis petersenii, Encyonema neogracile, Geissleria paludosa, Navicula digitulus, Neidium alpinum* and *Neidium bisulcatum*. *Eunotia circumborealis* has critical status in Germany. Data are deficient for some species, such as: *Eolimna tantula, Gomphonema acidoclinatum* and *Stauroneis acidoclinata*.

For the oligotrophic habitat of Bijambare fen, a significant portion of "sensitive" taxa (more than 50% of all taxa) is to be expected. Globally, there is a need for recognition of pristine oligotrophic areas and for a detailed analyses of rare species that could be indicators of oligotrophy (Kociolek & Stoermer 2008).

Conclusion

This study is a contribution to our understanding of diatom diversity in Bosnia and Herzegovina. According to published data – there is currently no checklist of algae in Bosnia and Herzegovina – 45 species are recorded here for the first time for Bosnia and Hercegovina (Table 2). Reasons for many new records at only one locality are various: mire like habitats were not studied until now in Bosnia and Herzegovina, taxonomic concepts and knowledge about some "taxon groups" has changed in recent times (e.g. *Hantzschia abundans*, *Gomphonema acidoclinatum*, *Pinnularia eifelana*, *Stauroneis acidoclinata*) and detailed studies with SEM enable a more exact identification. There are also some taxonomically unsolved taxa that have low abundances in the studied material but they are presented here as possible, biogeographically interesting records or even new taxa.

Definition of mires and their classification into bogs and fens was by now mostly determined on the basis of differences in pH of water and source of water (Damman & French, 1987). In the last years, there are some efforts to include vegetation data in the classification in order to serve a more "holistic" ecological approach (Hajek et al. 2006). Other phycological and also malacological data have been recognized as useful contributions to this approach. A recent study in Carpathian spring fens shows that classification of diatom species data follows similar patterns as habitat typology based on vegetation data (Frankova et. al 2009). Future studies of diatoms in various types of fens in the wider area of Bosnia and Herzegovina will test if they add to information in this direction.

Acknowledgements

We are grateful to Prof. Dr. Dubravka Hafner (University of Mostar, Bosnia and Herzegovina) for co-operation in sampling, and to Wolf-Henning Kusber and Dr. Nelida Abarca (Botanic Garden and Botanical Museum, Berlin-Dahlem) for helpful comments. Special thanks to Dr. Harrie Sipman for his help with Latin and to Mr. Michael Rodewald for help with graphics. Dr. Herman van Dam and one anonymous referee are acknowledged for valuable comments on the manuscript.

References

APHA- AWWA-WEF (1995): Standard Methods for the Examination of Water and Wastewater, 19th Edition.

BECK, G. (1886): Flora von Südbosnien und der angrenzenden Hercegovina. – Ann. Naturhist. Hofmus. Wien. **1**: 287–297.

BECK, G. (1890): Flora von Südbosnien und der angrenzenden Hercegovina. – Ann. Naturhist. Hofmus. Wien. **4**: 342–348.

BECK, G.M. (1928): Zur Kenntnis der Algen von Bosnien. – Bulletin de l'institut et du jardin botaniques de l'Univer. de Belgrad **1**: 36–42.

BEYENS, L. (1989): Moss dwelling diatom assemblages from Edgeøya (Svalbard). – Polar Biol. **9**: 423–430.

BUCZKO, K. & A. WOJTAL (2005): Moss inhabiting siliceous algae from Hungarian peat bogs. – Stud. Bot. Hung. **36**: 21–42.

BUCZKO, K. (2006): Bryophytic diatoms from Hungary. – In: WITKOWSKI, A. (ed.): Proceedings of the Eighteenth International Diatom Symposium 2004 Miedzyzdroje, Poland: 1–15.

BUCZKO, K., WOJTAL, A. & R. JAHN (2009): *Kobayasiella* species of the Carpathian region: Morphology, Taxonomy and description of *K. tintinnus* spec. nov. – Diatom Res. **24**(1): 1–21.

BUDDE, H. (1934): Algenuntersuchungen in westfälischen Mooren, insbes. algensoziologischer Art. – Abhandlungen aus dem Westfälischen Provinzial-Museum für Naturkunde **5**: 1–48.

CANTONATI, M. (1998): Diatom communities of springs in the Southern Alps. – Diatom Res. **13**(2): 201–220.

COMPÈRE, P. (1980): Quelques algues de la région de Brûly (France, dépt. des Ardennes: Belgique, prov. de Namur). – Bulletin Soc. Bot. Belg. **112**: 151–165.

DAMMAN, A.W.H. & T.W. FRENCH (1987): The Ecology of Peat Bogs of the Glaciated Northeastern United States. – U.S. Fish & Wildlife Serv. Biol. Rep. **85** (7.16).

EDLUND M.B, L.A. BRANT, Z. LEVKOV & T. NAKOV (2006): An emended description of Decussata (Patrick)Lange-Bertalot & Metzeltin that includes protoplast organization and detailed valve and cingulum ultrastructure. – Diatom Res. **21**(2):269–280.

ENACHE M.D & M. POTAPOVA (2009): A new species of Sellaphora (Sellaphoraceae) from Hannaberry Lake, Arkansas, U.S.A. Acta. – Bot. Croat. **68**(2): 231–237.

EVANS, K.M., A.H. WORTLEY, G.E. SIMPSON, V.A. CHEPURNOV & D.G. MANN (2008): A molecular systematic approach to explore diversity within the *Sellaphora pupula* species complex (Bacillariophyta). – J. Phycol. **44**: 215–231.

FALLU, M.A., N. ALLAIRE & R. PIENITZ (2000): Freshwater Diatoms from Northern Québec and Labrador (Canada). – Bib. Diatomol. **45**: 1–192.

FETZMANN, E. (1961): Ein Beitrag zur Algenvegetation des Filzmooses bei Tarsdorf (Oberösterreich). – Öster. Bot. Zeit. **108**: 217–227.

FRÁNKOVÁ, M., J. BOJKOVÁ, A. POULÍČKOVÁ & M. HÁJEK (2009): The structure and species richness of the diatom assemblages of the Western Carpathian spring fens along the gradient of mineral richness. – Fottea **9**(2): 355–368.

GUTWINSKI, R. (1896): O nagjenim dosele u Bosni i Hercegovini halugama (isključivši diatomacee). (About algae found by now in Bosnia and Herzegovina, except diatoms). – Glasn. Zemaljsk. Muz. Bosni Hercegovini **8**: 367–381.

GUTWINSKI, R. (1899a): Ein Beitrag zur Kenntniss der fossilen Diatomaceen Bosniens. – Wiss. Mitt. Bosnien Hercegov. **6**: 679–684.

GUTWINSKI, R. (1899b): Ueber die von Hochw. Prof. Erich Brandis Soc. jes. in der Umgegend von Travnik gesammelten Algen. – Wiss. Mitt. Bosnien Hercegov. **6**: 685–698.

GUTWINSKI, R. (1899c): Systematische Uebersicht der von Dr. Justin Karlinski in der Umgebung von Gračanica während des Herbstes 1897 gesammelten Algen. – Wiss. Mitt. Bosnien Hercegov. **6**: 699–707.

HAFNER D., M. CARIĆ, T. KAPETANOVIĆ, N. JASPRICA & A. LONČAR (2008): Diatoms in two heathland creeks in Bosnia and Herzegovina. – In: CANTONATI, SCALFI & BERTUZZI (eds.) Abstract book of the 2. Central European Diatom Meeting 12–15 June 2008, Trento, Italy: 38.

HÁJEK, M., P. HÁJKOVÁ , K. RYBNÍČEK & P. HEKERA (2005): Present vegetation of spring fens and its relation to water chemistry. – In: POULÍČKOVÁ, A., M. HÁJEK, & K. RYBNÍČEK (eds): Ecology and palaeoecology of spring fens of the West Carpathians. – Vydavatelství UP Olomouc. 69–96.

HÁJEK, M., P. HEKERA & P. HÁJKOVÁ (2002): Spring fen vegetation and water chemistry in the Western Carpathian flysch zone. – Fol. Geobot. **37**: 205–224.

HÁJEK, M., M. HORSÁK , P. HAJKOVÁ & D. DÍTĚ (2006): Habitat diversity of central European fens in relation to environmental gradients and an effort to standardise fen terminology in ecological studies. – Perspect. Pl. Ecol. Evol. Syst. **8**(2): 97–114.

HÁJKOVÁ, P. & M. HÁJEK (2003): Species richness and above-ground biomass of poor and calcareous spring fens in the flysch West Carpathians, and their relationships to water and soil chemistry. – Preslia **75**: 271–287.

HOFMANN, G., M. WERUM & H. LANGE-BERTALOT (subm.): Rote Liste der limnischen Kieselalgen (Bacillariophyceae) Deutschlands.

HUSTEDT, F. (1942): Aerophile Diatomeen in der nordwestdeutschen Flora. – Ber. Deutsch. Bot. Ges. **60**: 55–73

HUSTEDT, F. (1945): Diatomeen aus Seen und Quellgebieten der Balkan-Halbinsel. – Arch. Hydrobiol.: **40**(4): 867–973.

JERKOVIĆ, L. & S. RONČEVIĆ (1981): Razvoj i stanje istraživanja flore kriptogama BiH.- Zbornik sažetaka savjetovanja o razvoju i stanju istraživanja flore Bosne i Hercegovine. Akademija nauka i umjetnosti. (Development and status in the studies of cryptograms of Bosnia and Herzegovina. Conference on development and status in the studies of flora of Bosnia and Herzegovina – Book of abstracts. Academy of Science and Arts, Sarajevo).

KAPETANOVIĆ, T. & D. HAFNER (2007): Diatoms of wet habitats in the subalpine belt of Mt. Vranica (Bosnia and Herzegovina) – In: KUSBER, W.-H. & R. JAHN (eds.): Proceedings of the 1st Central European Diatom Meeting 2007 Berlin-Dahlem, 23–25 March: 73–78. – BGBM Press, Berlin.

KIM Y.S., J.S. CHOI & H.S. KIM (2007): Epiphytic diatom communities from two mountain bogs in South Korea. – Nova Hedw. **84**: 363–379.

KINGSTON, J.C. (1982): Association and Distribution of Common Diatoms in Surface Samples from Northern Minnesota Peatlands. – Nova Hedw. **73**: 333–346.

KOCIOLEK, J.P & E.F STOERMER (2008): Oligotrophy: The ignored part of the water quality spectrum. – In: JASPRICA, N., A. CAR & M. ČALIĆ (eds.): Abstract book of the 20[th] International Diatom Symposium, 7–13 September, 2008 Dubrovnik.

KOOIJMAN, A.M. & D.M. KANNE (1993): Effects of water chemistry, nutrient supply and interspecific interaction on the replacement of *Sphagnum subnitens* by *Sphagnum fallax* in fens. – J. Bryol. **16**: 619–627.

KRAMMER, K. & H. LANGE-BERTALOT (1985): Naviculaceae. – Bibli. Diatomol. **9**: 1–230.

KRAMMER, K. & H. LANGE-BERTALOT (1997a): Bacillariophyceae. 1. Teil: Naviculaceae. – In: ETTL, H., J. GERLOFF, H. HEYNIG & D. MOLLENHAUER (eds): Süsswasserflora von Mitteleuropa. **2**(1). G. Fischer, Jena.

KRAMMER, K. & H. LANGE-BERTALOT (1997b): Bacillariophyceae. 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae. – In: ETTL, H., J. GERLOFF, H. HEYNIG & D. MOLLENHAUER (eds): Süsswasserflora von Mitteleuropa. **2**(2). G. Fischer, Jena.

KRAMMER, K. & H. LANGE-BERTALOT (2000): Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. – In: Ettl, H., J. Gerloff , H. Heynig & D. Mollenhauer (eds): Süsswasserflora von Mitteleuropa. **2**(3). Spektrum, Heidelberg & Berlin.

KRAMMER, K. & H. LANGE-BERTALOT (2004): Bacillariophyceae. 4. Teil: Achnanthaceae. Kritische Ergänzungen zu *Achnanthes s.l.*, *Navicula s.str.*,*Gomphonema.* Gesamtliteraturverzeichnis. Teil 1–4. – In: ETTL, H., J. GERLOFF, H. HEYNIG & D. MOLLENHAUER (eds): Süsswasserflora von Mitteleuropa. **2**(4). – G. Fischer, Stuttgart & Jena.

KRAMMER, K. (2000): The genus *Pinnularia*. – Diatoms of Europe **1**: 1–703. Gantner, Ruggell.

KRAMMER, K. (2003): *Cymbella*. – Diatoms of Europe **3**: 1–584. Gantner, Ruggell.

KRIEGER, W. (1929): Algologisch-monographische Untersuchungen über das Hochmoor am Diebelsee. – Beitr. Naturdenkmalpflege **13**: 232–298 + bijl..

KULIKOVSKII, M.S (2008): The Species Composition and Distribution of Diatoms in Sphagnum bogs of European Russia: Ecosystems of The Volga Upland. – Inland Water Biology **1**(4): 347– 355.

LAKUŠIĆ, R., P. GRGIĆ, L. KUTLEŠA , D. MURATSPAHIĆ, S. REDŽIĆ & S. OMEROVIĆ (1991): Struktura i dinamika fitocenoza u ekosistemima tresetišta na planinama Bosne (Structure and dynamic phytocenosis at the ecosystems peat bogs on mountains of Bosnia). – Bilten društva ekologa Bosne i Hercegovine. Ser.A. Vol. **7**: 35–84.

LANGE-BERTALOT, H. & D. METZELTIN (1996): Indicators of Oligotrophy. – Iconogr. Diatomol. **2**: 1–390.

LANGE-BERTALOT, H. (1993): 85 Neue Taxa und über 100 weitere neu definierte Taxa ergänzend zur Süßwasserflora von Mitteleuropa Vol. 2/1–4. – Biblioth. Diatomol. **27**: 1–428.

LANGE-BERTALOT, H. & A. STEINDORF (1996): Rote Liste der limnischen Kieselalgen (Bacillariophyceae) Deutschlands. – Schrift. Vegetationsk. **28**: 633–677.

LANGE-BERTALOT, H., P. CAVACINI, N. TAGLIAVENTI & S. ALFINITO (2003): Diatoms from Sardinia. – Iconogr. Diatomol. **12**: 1– 438.

LEDERER, F. & L. SOUKUPOVA (2002): Biodiversity and ecology of algae in mountain bogs (Bohemian Forest, Central Europe). – Algol. Stud. **106**: 141–155.

LEVKOV, Z., S. KRSTIĆ, T. NAKOV & L. MELOVSKI (2005): Diatom assemblages on Shara and Nidze Mountains, Macedonia. – Nova Hedw. **81**(3–4): 501–538.

LEVKOV, Z., S. KRSTIĆ, D. METZELTIN & T. NAKOV (2007): Diatoms of Lakes Prespa and Ohrid. – Iconogr. Diatomol. **16**: 1–613.

LIMPENS, J., H.B.M. TOMASSEN & F. BERENDSE (2003): Expansion of *Sphagnum fallax* in bogs: striking the balance between N and P availability. – J. Bryol. **25**: 83–90.

MANN, D.G., S.J. THOMAS & K.M. EVANS (2008): Revision of the diatom genus *Sellaphora*: a first account of the larger species in the British Isles. – Fottea **8**(1): 15–78.

MESSIKOMMER, E., (1927): Biologische Studien im Torfmoor von Robenhausen unter besonderer Berücksichtigung der Algenvegetation. Mitt. Bot. Mus. Univ. Zürich (Inaugural-Dissertation) **122**: 171p. + ann.

MILOSAVLJEVIĆ, R. (1976): Neke karakteristike relativne vlažnosti u Bosni i Hercegovini.(Some characteristics of relative humidity in Bosna and Herzegovina). – Geografski pregled (Geographical society of Bosnia and Herzegovina, Sarajevo) **20**: 47–64.

NEGRO, A.I., C. DE HOYOS & J.J. ALDASORO (2003): Diatom and desmid relationships with the environment in mountain lakes and mires of NW Spain. – Hydrobiol. **505**: 1–13.

NOVÁKOVÁ, J. & A. POULÍČKOVÁ (2004): Moss diatom (Bacillariophyceae) flora of the Nature Reserve Adršpašsko-Teplické Rocks (Czech Republic) [Rozsivková flóra mechorostů NPR Adršpašsko-Teplické skály (ČR)]. – Czech Phycol. **4**: 75–86.

NOVÁKOVÁ, S. (2002): Algal flora of subalpine peat bog pools in the Krkonoše Mts. – Preslia **74**: 45–56.

NOVÁKOVÁ, S. (2004): Spatial heterogenity of algal flora in subalpine mires in the eastern Krkonoše Mts. – Algol. Stud. **114**: 23-37.

NOVÁKOVÁ, S. (2007): Structure and dynamics of the algal flora in subalpine mires in the Krkonoše Mountains (Giant Mountains; Czech Republic) – Nova Hedw. **84**(3–4): 441–458.

POTAPOVA, M.G & K.C. PONADER (2008): New species and combinations in the diatom genus Sellaphora (Sellaphoraceae) from Southeastern United States. – Harvard Papers in Botany **13**(1): 171–181.

POULÍČKOVÁ, A., K. BOGDANOVA, P. HEKERA & P. HAJKOVA (2003): Epiphytic diatoms of the spring fens in the flysh area of the Western Carpathians. – Biologia-Bratislava **58**: 749–757.

POULÍČKOVÁ, A., P. HÁJKOVÁ, P. KŘENKOVÁ & M. HÁJEK (2004): Distribution of diatoms and bryophytes on the linear transects through spring fens. – Nova Hedw. **78**(3): 411–424.

POULÍČKOVÁ, A., P. HAŠLER, & M. KITNER (2005): Cyanobacteria and algae. In: POULÍČKOVÁ, A., M. HÁJEK, & K. RYBNÍČEK, (ed.): Ecology and palaeoecology of spring fens of the West Carpathians. – Vydavatelství UP Olomouc. 105–130.

PROTIĆ, Đ. (1897): Prilozi k poznavanju flore resina (alge) Bosne i Hercegovine (Contributions to a knowledge of algae of Bosnia and Herzegovina). – Glasn. Zemaljsk. Muz. Bosni Hercegovini **9**: 539–559.

PROTIĆ, Đ. (1899): Beitrag zur Kenntniss der Kieselalgen Bosniens und der Hercegovina – Wiss. Mitt. Bosnien Hercegov. **6**: 708–718.

PROTIĆ, Đ. (1901): Treći prilog k poznavanju flore resina (alge) Bosne i Hercegovine (The third contribution to a knowledge of algae of Bosnia and Herzegovina). – Glasn. Zemaljsk. Muz. Bosni Hercegovini **13**: 201–226.

PROTIĆ, Đ. (1904): Prilog k poznavanju flore kriptogama (tajnocvjetaka) okoline Sarajeva. (Contribution to a knowledge of cryptogram flora of Sarajevo surrounding). – Glasn. Zemaljsk. Muz. Bosni Hercegovini **16**: 61–90.

PROTIĆ, Đ. (1908): Četvrti prilog k poznavanju flore resina (alge) Bosne i Hercegovine. (The fourth contribution to a knowledge of algae of Bosnia and Herzegovina). – Glasn. Zemaljsk. Muz. Bosni Hercegovini **19**: 191–202.

REDŽIĆ, S., S. ĐUG, S. BARUDANOVIĆ & S.VELIĆ (2002): Valorizacija prirodnih vrijednosti zašićenog područja Bijambare (Valorization of natural values of protected area Bijambare). CEPRES. Institute for cultural, historical and natural heritage protection – Kanton Sarajevo.

ROTT, E., G. HOFFMANN, K. PALL, P. PFISTER & E. PIPP (1997): Indikationslisten für Aufwuchsalgen in Fließgewässern in Öserreich. Teil 1: Saprobielle Indikation. – Bundesministerium für Land- und Forstwirtschaft. Wien. 1–73.

ROTT, E., P. PFISTER, H. VAN DAM, E. PIPP, K. PALL, N. BINDER & K. ORTLER (1999): Indikationslisten für Aufwuchsalgen in Fließgewässern Österreichs, Teil 2: Trophieindikation und autökologische Anmerkungen. Wasserwirtschaftskataster. – Bundesministerium für Land- und Forstwirtschaft. Wien. 1–248.

ROUND, F.E., R.M. CRAWFORD & D.G. MANN. (1990): The diatoms; biology and morphology of the genera. – Cambridge University Press, 747 pp.

SCHILLER & LANGE- BERTALOT (1997): *Eolimna martinii* n. gen., n. sp. (Bacillariophyceae) aus dem Unter-Oligozän von Sieblos/Rhön im Vergleich mit ähnlichen rezenten Taxa. – Paläont. Zeit. **71**(3–4).

SIMONSEN, R. (1987): Atlas and catalogue of the diatom types of Friedrich Hustedt 1–3. J. – Cramer Berlin /Stuttgart. 1–1741.

STANCEVA, R. & D. TEMNISKOVA (2006): Observations on *Decussata hexagona* (Torka) Lange-Bertalot (Bacillariophyta) from Holocene sediments in Bulgaria. – Nova. Hedw. **82**: 237–246.

TER BRAAK, C.J.F. & P. ŠMILAUER (2002): CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5). – Microcomputer Power (Ithaca NY, USA), 1–500.

VAN DAM, H., A. MERTENS & J. SINKELDAM (1994): A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. – Neth. J. Aquat. Ecol. **28**: 117–133.

VAN DE VIJVER, B. & L. BEYENS (1997): The epiphytic diatom flora of mosses from Strømness Bay area, South Georgia. – Polar Biol. **17**: 492–501.

VAN DE VIJVER, B., Y. FRENOT & L. BEYENS (2002): Freshwater diatoms from Ile de la Posesión (Crozet Archipiélago, Subantarctica). – Bibl. Diatomol. **46**: 1– 412.

VAN DE VIJVER, B., L. BEYENS, S. VINCKE & N.J.M GREMMEN (2004): Moss-inhabiting diatom communities from Heard Island, sub-Antartic. – Polar Biol. **27**: 532–543.

VAN DER WERFF, A., (1975): Diatoms and other algae from the moor of Fiave‘ in Trentino (Italy). – Studi Trent. Sci. Nat. **52**: 157–186.

WERUM, M. & H. LANGE-BERTALOT (2004): Diatoms in Springs from Central Europe and elsewhere under the influence of hydrogeology and anthropogenic impacts. – Iconogr. Diatomol. **13**: 1–417.

WOJTAL, A., A. WITKOWSKI & D. METZELTIN (1999): The diatom flora of the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basion (Souther Poland). – Fragm. Flor. Geobot. **44**(1): 167–192.

WOJTAL, A. (2009): Diatom flora of the Kobylanka stream near Kraków (S Poland). – Polish Bot. J. **54**(2): 129–330.

WUTHRICH, M. & W. MATTHEY (1977): Les diatomées de la Tourbière du Cachot (Jura Neuchatelois) I. Etude systématique. – Bull. Soc. Neuchat. Sci. Nat. **100**: 45–60.

Received 18 May 2009, accepted in revised form 16 June 2010.