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ALGAE IN THE PEAT BOGS LOVRENŠKA JEZERA AND ŠIJEC IN SLOVENIA

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In the years 1998, 1999 and 2000, samples were taken seasonally in the peat bogs of Lovrenška jezera and Šijec. The purpose of the investigation was to establish the qualitative species structure and abundance of the periphyton and the phytoplankton. The paper presents the first complete algological research in this area. In the year 1999, some physical and chemical parameters were also measured. Altogether, 116 species and subspecies of algae were determined. Most of them belonged to Bacillariophyceae, followed by Conjugatophyceae and Cyanobacteria. 17 species and subspecies are new to Slovenia, most of them belonging to Bacillariophyceae.

Key words: algae, peat bogs, periphyton, phytoplankton, Lovrenška jezera, Šijec

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Iz cretova Lovrenška jezera i Šijec sezonski su uzimani uzorci tijekom 1998., 1999. i 2000. Cilj istraživanja bio je utvrditi kvalitativni sastav vrsta i brojnost perifitona i fitoplanktona. Rad prikazuje prvo cjelovito algološko istraživanje tog područja. Tijekom 1999. mjereni su i neki fizikalni i kemijski parametri. Ukupno je determinirano 116 vrsta i podvrsta algi. Većina je pripadala skupini Bacillariophyceae, slijedile su Conjugatophyceae i Cyanobacteria. Sedamnaest vrsta je novih za Sloveniju, a uglavnom su iz skupine Bacillariophyceae.

Ključne riječi: alge, cretovi, perifiton, fitoplankton, Lovrenška jezera, Šijec

INTRODUCTION

Peat bogs are ecosystems with extreme life conditions. The first, and for many organisms an insuperable parameter, is the low pH, followed by the lack of nutrients (phosphorus, nitrogen) and high daily fluctuation of temperature. During the day the surface of the peat and water around it develop very high temperatures,

and by night the temperature drops. Such extreme conditions are the reason why many species of algae live only in peat bogs (MARTINČIČ, 1983).

The peat bogs Lovrenška jezera and Šijec are both situated at the top of a hill, so precipitation is the only source of water and influences from the surroundings are minimal since there is no inflow or surface runoff. The Lovrenška jezera are overgrown with *Pinus mugo* Turra and characteristic peat bogs species: *Andromeda polifolia* L., *Carex limosa* L., *C. pauciflora* Lightf., *Eriophorum vaginatum* L., *Drosera rotundifolia* L., *Oxycoccus microcarpus* Turcz., *Scheuchzeria palustris* L., *Trichophorum caespitosum* (L.) Hartm., *Vaccinium uliginosum* L. and different species of peat mosses (GAMS & MARTINČIČ, 1992). The macrophyte flora of the Šijec consist of *Pinus mugo* Turra, *Calluna vulgaris* (L.) Hull., *Vaccinium myrtillus* L., *Vaccinium vitis idaea* L., *Scheuchzeria palustris* L., *Carex limosa* L., *Lycopodium inundatum* L., *Rhynchospora alba* (L.) Vahl, *Carex pauciflora* Lightf., *Andromeda polifolia* L., *Eriophorum vaginatum* L., *Drosera rotundifolia* L. and different species of peat mosses (MARTINČIČ, 1983).

PEVALEK (1924) and LAZAR (1960, 1975) studied algae in both peat bogs. PEVALEK (1924) found in the peat bog Lovrenška jezera 51 and in the peat bog Šijec 21 different species of algae, most of them from the classes Chlorophyceae and Cyanobacteria. LAZAR (1960, 1975) determined in the peat bog Lovrenška jezera 32 and in the peat bog Šijec 22 different species of algae from the classes Chlorophyceae, Cyanobacteria and Xanthophyceae. Diatoms (Bacillariophyceae) were not included in either of the studies. BRANCELJ *et al.* (1999) analyzed sediment from one of the Lovrenška jezera and determined 27 different diatom species.

The aim of the current investigation was to establish the species structure and relative abundance of the periphyton and the phytoplankton in the peat bogs Lovrenška jezera in Pohorje and Šijec in Pokljuka, both in Slovenia.

MATERIAL AND METHODS

Samples of periphyton and phytoplankton were taken seasonally in the years 1998, 1999 and 2000, from the surface of the roots of pine trees (*Pinus mugo*) in the water and overgrowth with mosses. The samples of phytoplankton were taken with a plankton net with mesh size 25 μm. Five samples from Šijec (11.10.1998, 15.5.1999, 22.8.1999, 2.11.1999, 21.5.2000) and four samples from Lovrenška jezera (25.7.1998, 7.8.1999, 16.10.1999, 3.6.2000) were taken. The samples were immediately preserved in a solution of four per cent formaldehyde. Each of the samples was treated with concentrated HNO_3 to determine Bacillariophyceae species.

Species and subspecies of the algae were determined with the use of a light microscope and the following identification monographs: LAZAR (1960), STARMACH (1966, 1968, 1972, 1974, 1980), KRAMMER & LANGE-BERTALOT (1986, 1988, 1991a, 1991b), POPOVSKY & PFIESTER (1990), HINDAK (1996), HINDAK *et al.* (1978), LENZENWEGER (1996, 1997). Relative abundance was estimated with numbers 1, 3 and 5 (1-single, 3-customary, 5-dominant) (PANTLE & BUCK, 1955).

In Šijec, on 22.8.1999 and 2.11.1999 and in Lovrenška jezera on 7.8.1999 and 16.10.1999, temperature, conductivity, pH, dissolved oxygen and percentage saturation were measured (APHA, 1992).

RESULTS AND DISCUSSION

Physical and chemical parameters

In Tab. 1 the fluctuation of some physical and chemical parameters in both peat bogs in the year 1999 are presented. Changes of the temperature of the water in both peat bogs during the year follow the temperature of the air. Amounts of mineral substances in peat bogs are low, which shows also the results of conductivity, which were at the time of measuring in both peat bogs below 45 mS/cm. In the central parts of the peat bogs the most common pH is between 3.6 and 4.2 pH, but even at the margins never goes beyond 5.0 pH (MARTINČIČ *et al.*, 1979). In the peat bogs Lovrenška jezera and Šijec at the time of measuring pH was below 5 pH. Due to the high temperatures of water in the summer, dissolved oxygen in the water was below 10 mg/l and the percentage saturation below 100 %.

Biological parameters

Altogether 116 species and subspecies of algae were determined (Tab. 2). Most of them (40) belonged to Bacillariophyceae, 30 to Conjugatophyceae, 25 to Cyano-

Tab. 1: Range of some physical and chemical parameters in the Lovrenška jezera and Šijec peat bogs in 1999

sampling point	temperature °C	conductivity µS/cm	pH	oxygen mg/l	saturation %
Lovrenška jezera	8,7–25,5	9,53–25,4	4,10–5,0	6,8–10,3	73–97
Šijec	4,7–22,6	28,8–45,0	4,21–4,45	6,8–10,5	86–92

Tab. 2: Algal species list with estimation of average abundance from the Lovrenška jezera and Šijec peat bogs in the years 1998, 1999 and 2000 with marked species new to Slovenia

Taxa	Sampling sites			
	Lovrenška jezera		Šijec	
	PR	PL	PR	PL
PROKARYOTA				
CYANOPHYTA				
CYANOBACTERIA				
Aphanothece clathrata West		1		
Aphanothece saxicola Naegeli	1			
Aphanothece stagnina (Spreng.) A. Braun	1	1		
Gloeocapsa crepidinum Thuret	1		1	1
Gloeocapsa magma (Bréb.) Holler.		1		
Gloeocapsa punctata Naegeli			1	1
Gloeocapsa rupestris Kütz.			1	
Gloeocapsa sp.	1			
Gloeocapsa tenax (Kirch.) Holler.	1	1	3	1

Taxa	Sampling sites			
	Lovrenška jezera		Šijec	
	PR	PL	PR	PL
Gloeocapsa turgida (Kütz.) Holler.		1	1	1
Gomphosphaeria aponina Kütz.		1		
Hapalosiphon intricatus W. & G.S. West	1	1	1	1
Microcystis elachista (W. & G.S.West) Starm.			1	1
Microcystis grevillei (Hass.) Elen.		1	1	1
Microcystis incerta (Lemm.) Lemm.	1	1	1	1
✧*Microcystis viridis* (A. Braun) Lemm.	1	1		
Microcystis wesenbergii Kom.	1			
✧*Nostoc spongiaeforme* Agardh			1	
Phormidium molle (Kütz.) Gomont			1	
Rhabdoderma lineare Schm.	1	1	1	
Schizothrix sp.			1	
✧*Spirulina meneghiniana* Zanar.			1	1
Synechococcus elongatus Naegeli			1	1
Synechocystis pevaleckii Erceg.	1			1
✧*Synechocystis septentrionalis* Skuja		1	1	1
EUKARYOTA				
HETEROKONTOPHYTA				
CHRYSOPHYCEAE				
Dinobryon sertularia Ehren.	1		1	
XANTHOPHYCEAE				
Characiopsis acuta (Br.) Borzi	1	1		
✧*Characiopsis minima* Pascher	1	1		1
BACILLARIOPHYCEAE				
Achnanthes lanceolata (Bréb.) Grun.		1		
Achnanthes minutissima Kütz.		3		
Amphora ovalis (Kuetz.) Kütz.		3		
Anomoeoneis vitrea (Grun.) Ross		1		
Aulacoseira granulata (Ehren.) Simon.		1	1	1
Cocconeis placentula Ehren.		1		
Cyclotella ocellata Panto.		1		
Cyclotella sp.		1		1
Cymbella affinis Kütz.		1		
Cymbella cesatii (Raben.) Grun.		1		
Cymbella delicatula Kütz.		1		
Cymbella microcephala Grun.		1		
Cymbella silesiaca Bleisch		1		
Cymbella sinuata Greg.		1		
✧*Denticula kuetzingii* Grun.		1		
Denticula tenuis Kütz.		1		
Diatoma mesodon (Ehren.) Kütz.		1		
Diatoma vulgaris Bory		1		
Diploneis elliptica (Kütz.) Cleve		1		
✧*Eunotia denticulata* (Bréb.) Raben.	3	5	5	5
Eunotia exigua (Bréb.) Raben.	1	1		
✧*Eunotia paludosa* Grun.	1		1	1
Fragilaria capucina Desm.		1		
Fragilaria ulna var. *ulna* (Nitzsch) Lan.-Bert.	1	1		
Frustulia rhomboides (Ehren.) De Toni	3	1	5	5

Taxa	Sampling sites			
	Lovrenška jezera		Šijec	
	PR	PL	PR	PL
✧*Frustulia spicula* Amosse		1	3	1
Gomphonema angustatum (Kütz.) Raben.		1		
Gomphonema angustum Agardh		3		
Gomphonema olivaceum (Horn.) Bréb.		1		
Gomphonema parvulum Kütz.	1	1		
Melosira varians Agardh		1		
Navicula capitatoradiata Germain		1		
Navicula cryptocephala Kütz.		1		
✧*Navicula pseudokotschyi* Lan.-Bert.	1	1		
Navicula subtilissima Cleve	3	1		
Nitzschia fonticola Grun.		1		
✧*Nitzschia perspicua* Choln.	1			
Nitzschia sp.		1		
✧*Pinnularia rupestris* Hant.	1	1	5	1
Pinnularia subcapitata Greg.	1			
DINOPHYTA				
DINOPHYCEAE				
Peridinium umbonatum Stein	1	1		1
Peridinium willei Huit. – Kass.		1		
CHLOROPHYTA				
CHLOROPHYCEAE				
Botryococcus braunii Kütz.	1	1		
Coelastrum reticulatum (Dang.) Senn.		1		
✧*Elakatothrix biplex* (Nyg.) Hindak	1	1		
✧*Elakatothrix spirochroma* (Rev.) Hindak	1	1		
Microspora amoena (Kütz.) Raben.	1	1	5	3
Microspora floccosa (Vauch.) Thuret.	1	1		
Microspora pachyderma (Wille) Lagerh.	1	1		
Microspora quadrata Hazen	1	1		
Oedogonium sp.	1	1	1	1
Oocystis naegelii A. Braun.	1	1		
Oocystis solitaria Witt.	5	1	1	1
Pediastrum sp.		1		
Scenedesmus brasiliensis Bohl.	1			
Scenedesmus quadricauda (Turp.) Bréb.		1		
Trentepohlia aurea (L.) Martius	1			
Uronema sp.	1	1		
CONJUGATOPHYCEAE				
Actinotaenium rufescens (Cleve) Teil.	1	1		
Bambusina brebissonii Kütz.	3	1	1	1
Closterium acutum Bréb.			1	3
Closterium gracile Bréb.	1	1		
Closterium navicula (Bréb.) Luetkem	1	1		
Closterium striolatum Ehren.	1	1		
Cosmarium palangula Bréb.	1	1		
✧*Cosmarium pseudamoenum* Wille			1	1
Cosmarium sp.	1	1		
Cylindrocystis brebissonii Menegh.	1		1	
Cylindrocystis crassa De Bary	1		1	1

Taxa	Sampling sites			
	Lovrenška jezera		Šijec	
	PR	PL	PR	PL
Euastrum binale (Turp.) Ehren.	1	1	1	1
Micrasterias truncata (Corda) Bréb.	1	1		
Mougeotia sp.	1	1	5	5
Netrium digitus (Ehren.) Itzigs. & Rothe	1	1	1	1
Netrium oblongum (De Bary) Luetkem.	1	1	1	1
Penium cylindrus (Ehren.) Bréb.			1	
Penium margaritaceum (Ehren.) Bréb.	1		1	
Penium polymorphum (Perty) Perty	1		1	1
Penium spirostriolatum Bark.	1	1		
Pleurotaenium minutum (Ralfs) Delp.			1	1
✧*Spondylosium pulchellum* Arch.	1	1		
✧*Spondylosium tetragonum* W.West	1	1		
Staurastrum echinatum Bréb.			1	3
Staurastrum furcatum (Ehren.) Bréb.	1	1	1	1
Staurastrum margaritaceum (Ehren.) Mengh.			1	1
Staurastrum pokljukense Pevalek			1	1
Staurastrum subbrebissonii Schm.		1		
Tetmemorus brebissonii (Meneg.) Ralfs			1	1
Tetmemorus laevis (Kütz.) Ralfs	1		1	1

Legend: PR – periphyton
PL – phytoplankton
✧ – species and subspecies new to Slovenia

bacteria, 16 to Chlorophyceae, two to Xanthophyceae, two to Dinophyceae and one to Chrysophyceae.

In the peat bog Lovrenška jezera 100 and in the peat bog Šijec 49 species and subspecies of algae were determined (Tab. 2). Algal structure is shown in Fig. 1. The most frequent algae in the Lovrenška jezera were Bacillariophyceae followed by Conjugatophyceae and Cyanobacteria and the most frequent algae in the Šijec bog were Conjugatophyceae, followed by Cyanobacteria and Bacillariophyceae. In research of other authors too (DUTHIE, 1965; KINGSTON, 1982; SCHERER, 1988) the Conjugatophyceae were the most frequent algae in different peat bogs, Bacillariophyceae and Cyanobacteria being less common. In acid waters common diatom genera are Eunotia, Frustulia and Pinnularia, and *Tabellaria flocculosa* (Roth) Kütz. is also a common species (PATRICK, 1977).

Lovrenška jezera (Tab. 2)

In the Lovrenška jezera four diatoms appeared typical of acidic and dystrophic peat bogs, among them the most frequent being *Eunotia denticulata* (Breb.) Raben. and *Navicula subtilissima* Cleve. The optimum pH for *Navicula subtilissima* is at 5.6 pH (CHOLNOKY, 1968). Most diatoms found in the Lovrenška jezera prefer water with higher values of electrolytes. BRANCELJ *et al.* (1999) found that airborne pollution is the main source of allochthonous substances that influence the Lovrenška jezera. The pollution of the Lovrenška jezera is shown by the appearance of Cyanobacteria and Chlorophyceae, which are typical of eutrophic environments rich in nutrients.

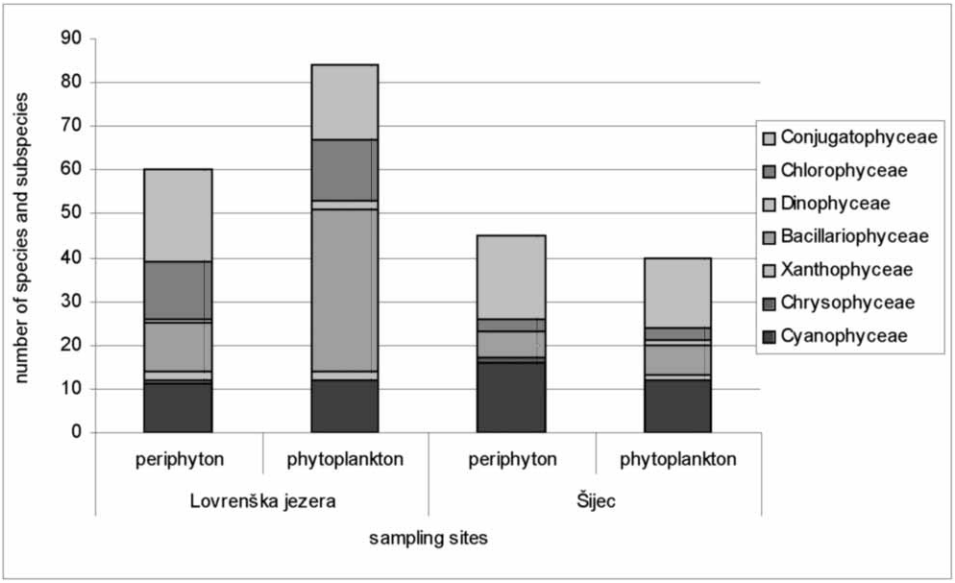

Fig. 1. Algal structure by classes in the Lovrenška jezera and Šijec peat bogs in the years 1998, 1999 and 2000.

In all periphyton and phytoplankton Lovrenška jezera samples the following species were recorded: *Microcystis incerta* (Lemm.) Starm., *Eunotia denticulata*, *E. exigua* (Breb.) Raben., *Frustulia rhomboides* (Ehren.) De Toni, *Pinnularia rupestris* Hant., *Peridinium umbonatum* Stein, *Bambusina brebissonii* Kütz., *Euastrum binale* (Turp.) Ehren., *Microspora amoena* (Kütz) Raben., *M. pachyderma* (Wille) Lagerh., *Netrium digitus* (Ehren.) Itzigs & Rothe, *Oedogonium* sp., *Oocystis solitaria* Witt., *Penium polymorphum* (Perty) Perty, *Spondylosium pulchellum* Arch., *S. tetragonum* W. West and *Staurastrum subbrebissonii* Schm. In periphyton samples the predominant (relative abundance = 5) species was *Oocystis solitaria*. Customary (relative abundance = 3) found were *Eunotia denticulata*, *Frustulia rhomboides*, *Navicula subtilissima* and *Bambusina brebissonii*. In phytoplankton samples the predominant (relative abundance = 5) species was *Eunotia denticulata*. Customary (relative abundance = 3) species found were *Achnanthes minutissima* Kütz., *Amphora ovalis* (Kütz) Kütz and *Gomphonema angustum* Agardh.

Šijec

The algal species list with estimations of abundance from the peat bog Šijec in the years 1998, 1999 and 2000 is shown in Tab. 2. In all samples *Staurastrum pokljukense* Pevalek appeared, which has a classic finding-place on the Pokljuka plateau (PEVALEK, 1924). Among seven species of diatoms appearing in the Šijec peat bog only *Eunotia denticulata* and *Eunotia paludosa* Grun. were typical of acidified peat bog waters. The diatom *Aulacoseira granulata* (Ehren.) Simon. is typical of eutrophic envi-

ronments rich in nutrients. The only species from the class Xanthophyceae found in the Šijec peat bog, *Characiopsis minima* Pascher, and some species from the class Cyanobacteria are also typical of food rich waters. In all periphyton and phytoplankton samples from Šijec the following species were determined: *Hapalosiphon intricatus* W. & G. S. West, *Microcystis grevillei* (Hass.) Elenkin, *Eunotia denticulata*, *Frustulia rhomboides*, *F. spicula* Amosse, *Cosmarium pseudamoenum* Wille, *Microspora amoena*, *Mougeotia* sp., *Netrium digitus*, *N. oblongum* (De Bary) Luetkem., *Oocystis solitaria*, *Staurastrum pokljukense*, *Tetmemorus laevis* (Kütz.) Ralfs and *T. brebissonii* (Meneg.) Ralfs. In periphyton samples the predominant (relative abundance = 5) species were *Eunotia denticulata*, *Frustulia rhomboides*, *Pinnularia rupestris*, *Microspora amoena* and *Mougeotia* sp. In phytoplankton samples the predominant (relative abundance = 5) species were *Eunotia denticulata*, *Frustulia rhomboides* and *Mougeotia* sp.

In the two peat bogs, seventeen species and subspecies new to Slovenia were determined, of these fourteen in Lovrenška jezera and eight in Šijec. Seven of the new species and subspecies belonged to Bacillariophyceae, four to Cyanobacteria, three to Conjugatophyceae, two to Chlorophyceae and one to Xanthophyceae (Tab. 2).

Summary

A periphyton and phytoplankton study was carried out in the peat bogs Lovrenška jezera and Šijec. The purpose of the investigation was to establish the qualitative species structure and relative abundance in both peat bogs in the years 1998, 1999 and 2000. This is the first complete algological research in this area. Five samples of periphyton and five samples of phytoplankton were taken from each peat bog. Algal species were determined using a light microscope. Relative abundance was estimated with numbers 1, 3 and 5 (1-single, 3-customary, 5-dominant). In the year 1999 various physical and chemical parameters were measured.

Altogether 116 species and subspecies of algae (of seven classes) were determined, of these 100 in the Lovrenška jezera peat bog and 49 in the Šijec peat bog. The most frequent species in Lovrenška jezera was Bacillariophyceae followed by Conjugatophyceae and Cyanobacteria and the most frequent species in the Šijec was Conjugatophyceae, followed by Cyanobacteria and Bacillariophyceae. In the Lovrenška jezera four diatoms appeared that are typical of acidic and dystrophic peat bogs, among which the most frequently found were *Eunotia denticulata* and *Navicula subtilissima*. Many species from the classes Cyanobacteria and Chlorophyceae, typical of eutrophic environments rich in nutrients, are indicative of the pollution of the Lovrenška jezera. In periphyton samples the predominant (relative abundance = 5) species was *Oocystis solitaria*. Customary (relative abundance = 3) species found were *Eunotia denticulata*, *Frustulia rhomboides*, *Navicula subtilissima* and *Bambusina brebissonii*. In phytoplankton samples the predominant (relative abundance = 5) species was *Eunotia denticulata*. Customary (relative abundance = 3) species found were *Achnanthes minutissima*, *Amphora ovalis* and *Gomphonema angustum*.

In all samples from Šijec, *Staurastrum pokljukense* appeared; this species has its classic finding-place on the Pokljuka plateau. Among seven species of diatoms ap-

pearing in the Šijec peat bog only *Eunotia denticulata* and *Eunotia paludosa* were typical of acidified peat bog waters. In periphyton samples the predominant (relative abundance = 5) species were *Eunotia denticulata*, *Frustulia rhomboides*, *Pinnularia rupestris*, *Microspora amoena* and *Mougeotia* sp. In phytoplankton samples the predominant (relative abundance = 5) species were *Eunotia denticulata*, *Frustulia rhomboides* and *Mougeotia* sp.

In the two peat bogs seventeen species and subspecies new to Slovenia were determined, fourteen of them in the Lovrenška jezera peat bog and eight in the Šijec peat bog.

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