Phytoplankton of the Morava and Dyje Rivers in spring and summer 2006

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Abstract: Species composition and abundance of the phytoplankton of the Morava and Dyje Rivers are evaluated. Samples were collected at Olomouc, Lanžhot, Devín (the Morava River) and at Pohansko (the Dyje River) in May and August 2006. Both concentrated samples using plankton net and free water were taken at each sampling point. Environmental variables such as pH, temperature, conductivity and dissolved oxygen were also measured. Altogether 542 species and infraspecific taxa of cyanobacteria and algae were identified. Collected data of diversity and abundance were statistically analyzed using NCSS software and Canoco for Windows. Significant differences between sampling sites and sampling time were observed. A complete list of species found at investigated sites is supplied.

Key words: Morava and Dyje Rivers, potamoplankton, biodiversity, abundance, Czech Republic, Slovak Republic

Introduction

The Morava River belongs to the most important rivers together with the Labe and Vltava in the Czech Republic and is the first major left – side tributary of the Danube River in Slovakia near the point of its entry into Pannonian Lowland. It is a typical regulated lowland river draining about 24,000 km^2 of the Moravian Region of the Czech Republic and parts of Western Slovakia and the NE part of Lower Austria. The river can be divided into three major parts. The border between upper and middle stretch forms left – side tributary of the Bečva River with river basin of about 1,627 km^2, which is one of the main rivers flowing through the NE Moravia. The bioseston in the upper stretch mainly consists of drifting benthic diatoms and only low proportion of true planktonic species. Over the past century, the level of pollution has been changed as a result of rapid human development, including paper mill effluents and agricultural activities. The Dyje River forms the border between the lowermost and middle stretch. Important reservoires such as Nové Mlýny, Znojmo and Vranov have dammed the river. In the middle stretch with numerous left – and right – side tributaries as well as meanders along its whole length planktonic diatoms, green algae and flagellates prevail over tychoplankton. Generally, dam reservoirs and their impoundments as well as river bed regulations have led to changes in the species composition of potamoplankton (cf. MARVAN & HETEŠA 2000, MARVAN et al. 2004, HINDÁK et al. 2006).

Previous investigations in the lowermost stretch of the Morava River showed an extremely broad spectrum of algae from different taxonomic groups including 206 genera with 692 species and infraspecific taxa (HINDÁK 1977 – 1990, HINDÁK et al 2006, HINDÁK & HINDÁKOVÁ 1997, 1998, 2004, HINDÁKOVÁ 1994, HINDÁK & MAKOVINSKÁ 1996). Several new taxa from the Morava and Danube Rivers were described, e.g. cyanophytes *Cyanocatena planctonica* Hindák 1975, *C. verrucosa* HINDÁK 2002, *Radiocystis aphanothecoidea* HINDÁK 1996, *Cyanogranis basifixa* HINDÁK 1982, *C. libera* HINDÁK 2002, *Romeria simplex* (HINDÁK 1975) HINDÁK 1988, as well as chlorophytes, e.g. *Coenochloris astroidea* HINDÁK 1988, *Neocystis diplococca* (HINDÁK 1978) HINDÁK 1988, *Neodesmus danubialis* HINDÁK 1976, *Raphidocelis sigmoidea* HINDÁK 1977 and *Marvania geminata* HINDÁK 1976 (see also MARVAN et al. 2004). The upper Morava River was sampled occasionally and collected data did not allow a full comparison with the lower stretch possible (HETEŠA & MARVAN 1984, 1987, 1997, MARVAN et al. 2004). Last investigations on diversity and abundance of phytoplankton in the Morava and Dyje Rivers were carried out in November 2005 by HINDÁK et al. (2006). It was found the significant differences among sampling sites located in the upper, middle and lowermost stretches.

Methods and localities

The phytoplankton samples of the Morava River were collected in May 24 and August 16, 2006, similarly as from the Dyje River (Fig. 1) using plankton net (mesh size 10 µm). Three sampling points were choosen at the Morava River as follows: Olomouc (232^{nd} river km, average discharge 27.1 $m^3.s^{-1}$), Lanžhot (78^{th} river km, average discharge 54 $m^3.s^{-1}$), Devín (average discharge 120 $m^3.s^{-1}$, near the confluence with the Danube River) and one at the Dyje River: Pohansko (the lowermost river stretch near the confluence with the Morava River, average discharge 41.7 $m^3.s^{-1}$). Samples for the quantitative analysis were immediately preserved by formaldehyde (preserved sample ~2% solution). Environmental variables such as pH, conductivity, temperature and dissolved oxygen were measured in situ using instruments by WTW (Tab. 1). All live samples were analysed no later than 24 h after sampling by light microscopes Leitz Diaplan and Zeiss Axio Imager equiped with HRc camera. Planktonic microorganisms were identified according to monographs of HINDÁK (1977, 1980, 1984, 1988, 1990, 1996, 2001), HUBER–PESTALOZZI (1955), KOMÁREK & ANAGNOSTIDIS (1998, 2005), KRAMMER & LANGE–BERTALOT (1986, 1988, 1991a, b) and WOŁOWSKI & HINDÁK (2005). Quantitative plankton analyses are based on counts of organisms in a Bürker chamber after samples concentration by ultrafiltration (pores size 1.2 µm). At least 400 organisms were canonical correspondence analysis (CCA, ŠMILAUER & TER BRAAK 1998). We used biplot scaling (L^a) focused on inter–species distances. Species data were Log transformed [Y´=log(A*Y+B, A=1, B=1)] with downweighting of rare species. Monte–Carlo permutation test with significance of first ordination axis under reduced model (499 permutations) was performed. Both automatic and manual selection with unrestricted permutations were used to test marginal and conditional effects of measured environmental variables. counted in all samples. Dissimilarity among sampling sites with respect to abundance of counted algal groups was evaluated with hierarchical clustering analysis (Wards´ method, NCSS software). Influence of environmental variables such as temperature, pH and conductivity on species data was evaluated with

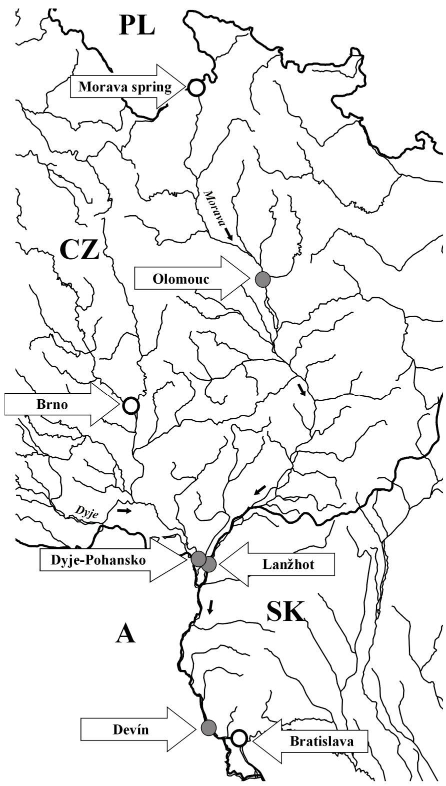

Fig. 1. Draining area of the Morava River and sampling sites (dark circles).

Results

Phytoplankton abundance

The highest abundance of phytoplankton was counted at Devín (124,627 $cells.ml^{-1}$) in spring, while the lowest one was found at Olomouc also in spring (6,414 $cells.ml^{-1}$) (Tab. 2). The most abundant groups were found cyanobacteria, diatoms and green coccal algae in all samples forming the majority of biomass, but in different ratios (spring: 26 : 41 : 22%, summer 34 : 37 : 17%, average ratios from all investigated localities). Diatoms dominated in all investigated samples, with the highest portion in spring at Devín (Fig. 3). In comparison with spring, the lower abundance of all phytoplankton was found in summer at Devín as a consequence of a flood in the beginning of August when diatoms and cyanobacteria formed an important portion of phytoplankton. Coccal green algae represented approximately 20% of phytoplankton with maximum in spring (Fig. 3). The other counted groups of algae such as Cryptophyceae, Chrysophyceae, green flagellates, Ulotrichales, Conjugatophyceae and Euglenophyceae were usually found on low level. Results of hierarchical clustering analysis (Ward´s method) based on abundances of counted groups of cyanobacteria and algae show differences among investigated sites (Figs 2A, B). Both spring and summer samples could be divided into two major groups containing the Morava River at Olomouc and the Dyje River with lower abundance, and the Morava River at Lanžhot and Devín with higher abundance of phytoplankton.

Table 1. Measured environmental variables: Tem – Temperature /°C, pH, Con – Conductivity /µS.cm^{-1}, OxA–Oxygen–abs /mg.l^{-1}, OxR – Oxygen–rel /%, OL – Morava at Olomouc, LA – Morava at Lanžhot, DE – Morava at Devín, DY – Dyje at Pohansko.

	May				August			
	OL	**LA**	**DE**	**DY**	**OL**	**LA**	**DE**	**DY**
Tem	7.5	8.9	8.9	9.4	14.4	17.2	16.5	17.3
pH	7.65	8.07	7.67	8.27	7.39	8.19	8.05	8.96
Con	334	668	651	581	298	523	594	504
OxA	8.5	9.2	–	8.4	8.8	8.4	8.6	8.6
OxR	100	106	–	93	98	100	102	102
NO_3^-	–	–	–	–	9.9	9.9	9.8	11.8
NH_4^+	–	–	–	–	0.07	< 0.03	< 0.03	0.18
PO_4^{3-}	–	–	–	–	0.23	0.16	0.35	0.52

Table 2. Phytoplankton abundance in counted major groups (cells.ml^{-1}).

Groups	Locality/ Month	OL	LA	DE	DY
Cyanobacteria	**May**	1463	6343	34632	3891
	August	12549	16764	16020	14680
Cryptophyceae	**May**	160	426	452	213
	August	264	534	445	356
Chrysophyceae	**May**	186	1812	8214	0
	August	712	1157	267	267
Coscinodiscales	**May**	1170	13165	36408	5064
	August	5340	25543	15664	8360
Naviculales	**May**	479	2237	13776	906
	August	3916	2403	2403	2072
Volvocales	**May**	426	924	1554	373
	August	665	712	1335	798
Chlorococcales	**May**	1702	6129	27750	3944
	August	5054	8366	11392	5607
Ulotrichales	**May**	267	380	313	88
	August	534	534	614	176
Conjugatophyceae	**May**	534	801	640	580
	August	1068	1602	1273	1149
Euglenophyceae	**May**	27	160	888	320
	August	801	2670	1602	931
Σ	**May**	6414	32377	124627	15379
	August	30903	60285	51015	34396

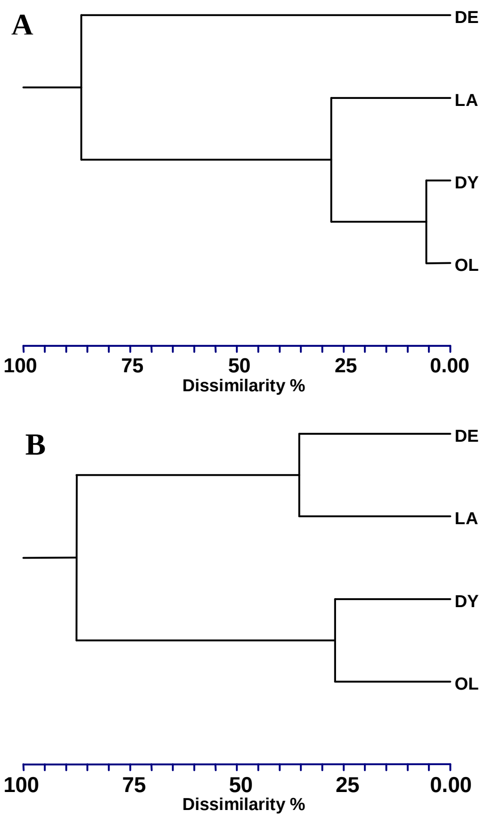

Fig. 2. Dendrograms of hierarchical clustering (Ward´s method) based on abundances of counted groups of cyanobacteria and algae: A – May, B – August.

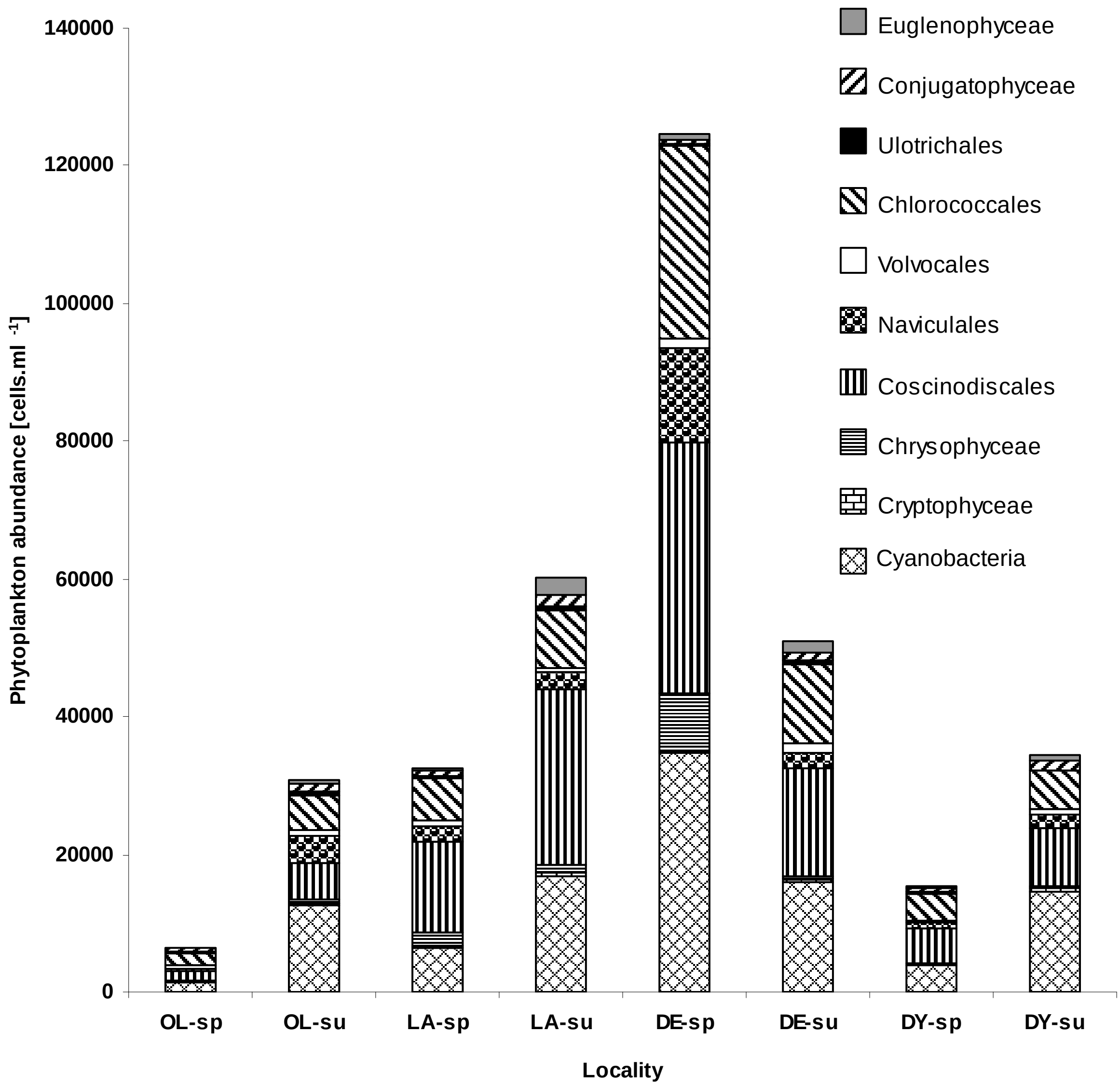

Fig. 3. Abundance of phytoplankton: OL – Morava River at Olomouc, LA – Morava river at Lanžhot, DE – Morava river at Devín, DY – Dyje River at Pohansko; suffix: sp-sampling in spring (May), su-sampling in summer (August).

Phytoplankton species composition

Altogether 542 taxa of cyanobacteria and algae were recorded at the investigated sites during our study (Tab. 3). The highest species richness were found in cyanobacteria with 53 taxa, in diatoms with 189 taxa and in green coccal algae with total number of 109 taxa (Tab. 5). The lowest richness was found in the Dyje River. The Morava River at Olomouc can be characterised by dominance of pennate diatoms in contrast to lower stretch (Lanžhot and Devín) dominated by green algae.

The canonical correspondence analysis (CCA) was performed to test influence of measured environmental variables on species composition of cyanobacteria and algae (Figs 4, 5). The Morava River at Olomouc was significantly different from other localities, they are influenced by Nové Mlýny Reservoir (F=1.316, P=0.032, Monte–Carlo permutation test for the first axis, reduced model, 499 permutations). Conductivity was found as an important factor influencing phytoplankton composition among sampling sites especially in spring (F=1.78, P=0.008), while summer phytoplankton was more influenced by gradient of temperature. Significance of measured pH was very low with respect to small differences among sampling sites (Tab. 4). Marginal effects summarize variance of individual environmental variables explaining singly (lambda–1). Conditional effects explain environmental variables in the model together (lambda–A). Using CCA four groups of cyanobacteria and algae can be recognized:

Group I: Species occurring at Olomouc more frequently than in the lower Morava stretch

As it follows from statistical reports (Fig. 5), the phytoplankton consist of pennate diatoms, several green flagellates, euglenophytes and coccal chlorophytes. Pennate diatoms are predominantly formed by benthic species (Fig. 5).

Group II: Species commonly occurring at Lanžhot and Devín in spring

Phytoplankton in the Morava River both at Lanžhot and Devín was rich in cyanobacteria, centric diatoms, coccal chlorophytes and particularly flagellates (Fig. 5).

Group III: Species commonly occurring at Lanžhot and Devín in summer

The highest richness at Lanžhot and Devín was found in the summer period. Together with the most developed coccal green algae also occurred cyanobacteria, pennate diatoms, euglenophytes and tetrasporalean algae.

Group IV: Group of commonly occurring species

The majority of species found in the Morava and Dyje Rivers is commonly occurring cyanophytes and algae in this region. There is no doubt that species of this group influenced total diversity of the Morava and Dyje Rivers (Fig. 5).

Table 3. List of species recorded in the Morava River at Olomouc (OL), Lanžhot (LA), Devín (DE) and in the Dyje River (DY), a –sampling May, b –sampling August. Taxa marked with asterisk (*) are new records for the Morava River.

	OL	LA	DE	DY
CYANOPHYCEAE				
Chroococcales				
Aphanocapsa incerta (LEMMERM.) CRONBERG et KOMÁREK	ab	ab	ab	
Aphanocapsa grevillei (BERKELEY) RABENH.			b	b
Aphanocapsa holsatica (LEMMERM.) CRONBERG et KOMÁREK	b		b	
Aphanocapsa minima MIGULA			b	
Aphanocapsa parasitica (KÜTZ.) KOMÁREK et ANAGN.		a		
Aphanothece bachmanii KOMÁRK.– LEGN. et CRONBERG			b	
Aphanothece clathrata W. et G.S. WEST		ab		ab
Aphanothece floccosa (ZALESSKY) CRONBERG et KOMÁREK			ab	
Chroococcus limneticus LEMMERM.	ab	ab	ab	ab
Coelomoron pusillum (VAN GOOR) KOMÁREK	ab		ab	ab
Cyanocatena planctonica HINDÁK			ab	
**Cyanocatenula calyptrata* JOOSTEN			ab	
Cyanogranis basifixa HINDÁK	b	ab	ab	
Cyanogranis ferruginea (WAWRIK) HINDÁK	ab	ab	ab	ab
Cyanogranis libera HINDÁK		ab	ab	ab
Merismopedia ferrophila HINDÁK	b			
Merismopedia glauca (EHRENB.) KÜTZ.			ab	
Merismopedia tenuissima LEMMERM.	ab	ab		
Merismopedia warmingiana LAGERH.		ab	ab	ab
Microcystis aeruginosa (KÜTZ.) KÜTZ.	ab	ab	ab	ab
Microcystis flos–aquae (WITTR.) KIRCHN.		ab	ab	
Microcystis ichhtyoblabe KÜTZ.	ab	ab	ab	ab
Microcystis novacekii (KOMÁREK) COMPÈRE		ab	ab	?
Microcystis viridis (A.BR.) LEMMERM.	b	b		b
Microcystis wesenbergii (KOMÁREK) KOMÁREK	ab	ab	ab	ab
Pannus spumosus B. HICKEL	ab	ab	ab	ab
Romeria okensis (MEYER) HINDÁK	b	b	b	
Snowella atomus KOMÁREK et HINDÁK	b			

Cont. Table 3	OL	LA	DE	DY
Snowella litoralis (HÄYRÉN) KOMÁREK et HINDÁK	ab	ab	ab	ab
Woronichinia naegeliana (UNGER) ELENKIN	ab	ab	ab	ab
Oscillatoriales				
Geitlerinema sp.	ab	ab	ab	ab
Limnothrix redekei (GOOR) MEFFERT	ab	ab	ab	
Oscillatoria janus SKUJA	b	ab	ab	
Oscillatoria limosa AGARDH ex GOMONT	ab			ab
Oscillatoria tenuis C. AGARDH ex GOMONT	ab			
Planktolyngbya limnetica (LEMMERM.) KOMÁRK.–LEGN. et CRONBERG	ab	ab	ab	
Planktothrix agardhii (GOMONT) ANAGN. et KOMÁREK	ab	ab	ab	ab
Planktothrix cryptovaginata (ŠKORBATOV) ANAGN. et KOMÁREK				b
Planktothrix isothrix (SKUJA) KOMÁREK et KOMÁRKOVÁ		b		b
Pseudanabaena catenata LAUTERBORN	ab	ab	ab	
Pseudanabaena limnetica (LEMMERM.) KOMÁREK	ab	ab	ab	
Pseudanabaena mucicola (NAUMANN et HUB.–PEST.) BOURR.	ab	ab	ab	ab
Nostocales				
Anabaena circinalis RABENH. ex BORNET et FLAHAUT		a	a	
Anabaena crassa (LEMMERM.) KOM.–LEGN. et CRONBERG		ab	ab	
Anabaena compacta (NYGAARD) HICKEL		ab	ab	ab
Anabaena flos–aquae (LYNGB.) BRÉB. ex BORNET et FLAHAULT	ab	ab	ab	ab
Anabaena perturbata HILL		b		
Anabaena planctonica BRUNNTH.	ab	ab	ab	
Anabaenopsis elenkinii BRUNNTH.	ab	ab	ab	
Aphanizomenon gracile (LEMMERM.) LEMMERM.			ab	ab
Aphanizomenon flos–aquae (L.) RALFS ex BORNET et FLAHAUT	b		b	b
Aphanizomenon issachenkoi (USSACZEW) PROSHK.–LAVR.	b	b	b	b
Raphidiopsis mediterranea SKUJA		ab	ab	
RHODOPHYCEAE				
Chantransia sp.		b		
CHRYSOPHYCEAE				
Chrysococcus diaphanus SKUJA			ab	
Chrysococcus rufescens G. A. KLEBS	ab		ab	ab
Dinobryon divergens O. E. IMHOF		ab	ab	
Hymenomonas roseola F. STEIN			ab	ab
Mallomonas robusta MATVIENKO			a	
Mallomonas sp.	ab	ab	ab	ab
Ochrobium tectum PERFILIEV.			b	
Pseudokephyrion entzii W. CONRAD			ab	
Synura sp.	ab	ab	ab	
BACILLARIOPHYCEAE				
Coscinodiscales				
Acanthoceras zachariasii (BRUN) SIMONSEN	ab	ab	ab	ab
Actinocyclus normanii (W. GREG. ex GREV.) HUST.				ab
Aulacoseira ambigua (GRUNOW) SIMONSEN var. *ambigua*	ab	ab	ab	ab
Aulacoseira ambigua var. *curvata* (GRUNOW) SIMONSEN	ab	?	?	?
Aulacoseira granulata var. *curvata* GRUNOW	ab	ab	ab	ab
Aulacoseira granulata (EHRENB.) SIMONSEN var. *granulata*	ab	ab	ab	ab
Aulacoseira muzzanensis (F. MEISTER) KRAMMER	ab	ab	ab	ab
Aulacoseira subarctica (O. MÜLL.) E. Y. HAW.	ab	ab	ab	ab

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Cyclotella atomus HUST.	ab	ab	ab	ab
Cyclotella meneghiniana KÜTZ.	ab	ab	ab	ab
Cyclotella distinguenda HUST.	ab			
Cyclotella ocellata PANT.	ab	ab	ab	ab
Cyclotella pseudocomensis SCHEFFLER			ab	
Cyclotella pseudostelligera HUST.	ab			
Cyclotella quadrijuncta (SCHRÖT.) KEISSL.	ab			
Cyclotella stelligera CLEVE et GRUNOW	ab		ab	
Cyclotella stelligeroides HUST.	b	b	b	b
Cyclotella woltereckii HUST.	ab		ab	
Cyclotella sp.	a			
Cyclostephanos delicatus (GENKAL) CASPER et SCHEFFLER	ab	ab	ab	ab
Cyclostephanos dubius (FRICKE) ROUND	ab	ab	ab	ab
Cyclostephanos invisitatus (M. H. HOHN et HELLERMAN) E. C. THER., STOERMER et HÅK.	ab	ab	ab	
Melosira varians C. AGARDH	ab	ab	ab	ab
Skeletonema potamos (C. I. WEBER) HASLE	ab	ab	ab	ab
Stephanodiscus alpinus HUST.			b	
Stephanodiscus binderanus (KÜTZ.) WILLI KRIEG.	ab	ab	ab	ab
Stephanodiscus hantzschii GRUNOW f. *hantzschii*	ab		ab	ab
Stephanodiscus hantzschii f. *tenuis* (HUST.) HÅK.	ab	ab	ab	ab
Stephanodiscus sp.	ab	ab	ab	
Thalassiosira duostra PIENAAR et PIETERSE	ab	ab	ab	ab
Thalassiosira pseudonana HASLE et HEIMDAL	ab	ab	ab	
Thalassiosira weissflogii (GRUNOW) G. A. FRYXELL et HASLE			ab	
Naviculales				
Achnanthes exigua GRUNOW				ab
Achnanthes hungarica (GRUNOW) GRUNOW	ab		ab	ab
Achnanthes cf. *laevis* OESTRUP	ab			
Achnanthes lanceolata (BRÉB. ex KÜTZ.) GRUNOW var. *lanceolata*	ab	ab	ab	ab
Achnanthes lanceolata var. *rostrata* (OESTRUP) HUST.	ab		ab	
Achnanthes minutissima KÜTZ.	ab	ab	ab	
Achnanthes ploenensis HUST.			ab	ab
Achnanthes spp.	ab	ab	ab	ab
Amphora libyca EHRENB.	ab		ab	
Amphora montana KRASSKE	ab		ab	ab
Amphora ovalis (KÜTZ.) KÜTZ.	ab		ab	ab
Amphora pediculus (KÜTZ.) GRUNOW	ab	ab	ab	ab
Amphora veneta KÜTZ.			ab	
Asterionella formosa HASSALL	ab	ab	ab	ab
Caloneis amphisbaena (BORY) CLEVE		ab	ab	
Caloneis bacillum (GRUNOW) CLEVE	ab			ab
Caloneis silicula (EHRENB.) CLEVE	ab			
Cocconeis pediculus EHRENB.	ab	ab	ab	
Cocconeis placentula EHRENB.	ab	ab	ab	
Cymatopleura solea (BRÉB.) W. SM. var. *solea*	ab	ab	ab	ab
Cymbella amphicephala NÄGELI		b		
Cymbella cistula (EHRENB.) KIRCHN.			ab	
Cymbela cf. *elginensis* KRAMMER			b	

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Cymbella helvetica KÜTZ.		ab		
Cymbella minuta HILSE ex RABENH.	ab		ab	
Cymbella silesiaca BLEISCH	ab	ab	ab	ab
Cymbella sinuata W. GREG.	ab	ab	ab	
Cymbella tumida (BRÉB.) VAN HEURCK			ab	
Denticula tenuis KÜTZ.	ab		ab	
Diatoma anceps (EHRENB.) KIRCHN.	b			
Diatoma ehrenbergii KÜTZ.	ab		ab	ab
Diatoma mesodon (EHRENB.) KÜTZ.	b	b	b	
Diatoma moniliformis KÜTZ.	ab	ab	ab	ab
Diatoma tenuis C. AGARDH			b	
Diatoma vulgaris BORY	ab	ab	ab	ab
Didymosphenia geminata (LYNGBYE) M. SCHMIDT	b			
Eunotia arcus EHRENB.	b			
Eunotia incisa GREGORY	ab			
Eunotia exigua (BRÉB. ex KÜTZ.) RABENH.	ab			
Eunotia praerupta EHRENB.	ab			
Fragilaria arcus (EHRENB.) CLEVE	ab	ab	ab	
Fragilaria bicapitata MAYER	b	b		
Fragilaria brevistriata GRUNOW			ab	
Fragilaria capucina DESM. var. *capitellata* (GRUNOW) LANGE–BERT.	b			
Fragilaria capucina var. *perminuta* (GRUNOW) LANGE–BERT.	b			
Fragilaria capucina var. *vaucheriae* (KÜTZ.) LANGE–BERT.	ab	ab	ab	ab
Fragilaria construens (EHRENB.) GRUNOW				ab
Fragilaria crotonensis KITTON	ab		ab	ab
Fragilaria elliptica SCHUM.		b	b	
Fragilaria leptostauron (EHRENB.) HUST.	ab			
Fragilaria nanana LANGE.–BERT.			b	
Fragilaria nitzschioides GRUNOW			b	
Fragilaria parasitica (W. SM.) GRUNOW var. *parasitica*	ab			
Fragilaria parasitica var. *subconstricta* GRUNOW	ab		ab	
Fragilaria pinnata EHRENB.	ab		ab	
Fragilaria ulna var. *acus* (KÜTZ.) LANGE–BERT.	ab	ab	ab	
Fragilaria ulna (NITZSCH) LANGE–BERT. var. *ulna*	ab	ab	ab	ab
Frustulia vulgaris (THWAITES) DE TONI			ab	
Gomphonema acuminatum EHRENB.	b			
Gomphonema affine KÜTZ.			ab	
Gomphonema angustatum (KÜTZ.) RABENH.	ab		ab	
Gomphonema angustum C. AGARDH	ab			
Gomphonema clavatum EHRENB.	ab			
Gomphonema gracile EHRENB.			ab	
Gomphonema insigne GREGORY			b	
Gomphonema olivaceum (HORNEM.) BRÉB.	ab	ab	ab	ab
Gomphonema parvulum (KÜTZ.) KÜTZ.	ab	ab	ab	ab
Gomphonema pumilum (GRUNOW) REICHARDT et LANGE–BERT.	b	b	b	
Gomphonema tergestinum (GRUNOW) FRICKE	b	b	b	
Gomphonema truncatum EHRENB.	ab			
Gomphonema sp.	ab	ab		
Gyrosigma acuminatum (KÜTZ.) RABENH.	ab	ab	ab	ab

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Gyrosigma attenuatum (KÜTZ.) RABENH.			ab	ab
Gyrosigma scalproides (RABENH.) CLEVE	ab		ab	?ab
Hantzschia amphioxys (EHRENB.) GRUNOW	ab	ab	ab	ab
Meridion circulare (GREVILLE) C. AGARDH var. *circulare*	ab	ab	ab	
Meridion circulare var. *constrictum* (RALFS) VAN HEURCK	ab	ab		
Navicula atomus (KÜTZ.) GRUNOW	a			
Navicula bacillum EHRENB.	a		a	
Navicula capitata EHRENB.	ab	ab	ab	ab
Navicula capitatoradiata H. GERM.	ab	ab	ab	ab
Navicula cincta (EHRENB.) RALFS			ab	
Navicula citrus KRASSKE			ab	ab
Navicula confervacea (KÜTZ.) GRUNOW		b	b	
Navicula contenta GRUNOW	b			
Navicula cryptocephala KÜTZ.			b	
Navicula cryptotenella LANGE.–BERT.	b		b	
Navicula cuspidata (KÜTZ.) KÜTZ.			ab	
Navicula decussis OESTRUP	ab			
Navicula elginensis (GREGORY) RALFS	b			
Navicula erifuga LANGE–BERT.			b	
Navicula goeppertiana (BLEISCH) H.L. SM.	a			
Navicula gregaria DONKIN	ab		ab	ab
Navicula halophila (GRUNOW) CLEVE		a		
Navicula helensis P. SCHULZ	b			
Navicula lanceolata (C. AGARDH) EHRENB.	ab	ab	ab	ab
Navicula medioconvexa HUST.	b			
Navicula menisculus SCHUM.	ab	ab	ab	ab
Navicula mutica KÜTZ.	ab			
Navicula nivalis EHRENB.	a	a		
Navicula placentula (EHRENB.) GRUNOW			ab	
Navicula protracta (GRUNOW) CLEVE	ab			
Navicula pupula KÜTZ.	ab		ab	ab
Navicula pygmaea KÜTZ.	ab		ab	
Navicula radiosa KÜTZ.	b			
Navicula slesvicensis KÜTZ.	ab		ab	
Navicula subminuscula MANGUIN	ab	ab	ab	ab
Navicula subplacentula HUST.			b	
Navicula tripunctata (O.F. MÜLL.) BORY	ab	ab	ab	
Navicula trivialis LANGE–BERT.	ab		ab	ab
Navicula veneta KÜTZ.	ab			ab
Navicula viridula (KÜTZ.) EHRENB. var. *linearis* HUST.	ab	ab	ab	
Navicula viridula var. *rostellata* (KÜTZ.) CLEVE				ab
Nitzschia acicularis (KÜTZ.) W. SM.		ab	ab	
Nitzschia acicularioides HUST.	a			
Nitzschia amphibia GRUNOW	ab		ab	
Nitzschia angustata (W. SM.) GRUNOW	ab			
Nitzschia calida GRUNOW			ab	
Nitzschia capitellata HUST.	ab	ab	ab	ab
Nitzschia constricta (KÜTZ.) RALFS	ab	ab	ab	ab
Nitzschia dissipata (KÜTZ.) GRUNOW	ab	ab		

Cont. Table 3	OL	LA	DE	DY
Nitzschia dubia W. SM.	b		b	
Nitzschia flexa SCHUM.			b	
Nitzschia fonticola GRUNOW	a	a	a	a
Nitzschia frustulum (KÜTZ.) GRUNOW	a	a	a	a
Nitzschia fruticosa HUST.	ab	ab	ab	
Nitzschia gracilis HANTZSCH			a	a
Nitzschia graciliformis LANGE–BERT. et SIMONSEN	ab	ab	ab	
Nitzschia hantzschiana RABENH.	ab			
Nitzschia heufleriana GRUNOW	ab		ab	ab
Nitzschia hungarica GRUNOW	ab	ab	ab	ab
Nitzschia inconspicua GRUNOW	ab		ab	ab
Nitzschia levidensis (W. SM.) GRUNOW	ab	ab	ab	ab
Nitzschia liebetruthii RABENH.			ab	
Nitzschia linearis (C. AGARDH) W. SM.	ab	ab	ab	ab
Nitzschia littoralis GRUNOW	a	a		
Nitzschia palea (KÜTZ.) W. SM.		ab	ab	
Nitzschia pusilla GRUNOW	a			
Nitzschia recta HANTZSCH	ab		ab	
Nitzschia sigma (KÜTZ.) W. SM.	a			
Nitzschia sigmoidea (NITZSCH) W. SM.	ab			
Nitzschia sinuata var. *delognei* (GRUNOW) LANGE.–BERT.			a	
Nitzschia sinuata var. *tabellaria* (GRUNOW) GRUNOW	a			
Nitzschia sociabilis HUST.			a	
Nitzschia subacicularis HUST.	ab	ab	ab	
Nitzschia tubicola GRUNOW	ab		ab	
Nitzschia umbonata (EHRENB.) LANGE–BERT.	ab	ab		
Nitzschia vermicularis (KÜTZ.) HANTZSCH	a			
Nitzschia spp.	ab	ab	ab	ab
Pinnularia borealis EHRENB.	a			
Pinnularia lundii HUST.	a			
Pinnularia microstauron (EHRENB.) A.CLEVE		ab	ab	
Pinnularia obscura KRASSKE		a		
Pinnularia subcapitata W. GREG.	a	a		
Pinnularia subrostrata (A.CLEVE) CLEVE–EULER			b	
Pinnularia sp.	ab	ab	ab	
Rhoicosphenia abbreviata (C. AGARDH) LANGE–BERT.	ab	ab	ab	ab
Stauroneis phoenicenteron (NITZSCH) EHRENB.	ab			
Stauroneis smithii GRUNOW	a			
Surirella angusta KÜTZ.	ab			
Surirella bifrons EHRENB.			b	
Surirella brebissonii var. *kuetzingii* KRAMMER et LANGE–BERT.		ab	ab	ab
Surirella capronii BRÉB.			b	
Surirella crumena BRÉB.	ab			
Surirella linearis W. SM. var. *linearis*		ab		
Surirella linearis var. *helvetica* (BRUN.) F. MESITER				a
Surirella minuta BRÉB.	ab	ab		
Surirella ovalis BRÉB.	a			
Surirella tenera W. GREG.	ab		ab	ab
Surirella terricola LANGE–BERT. et ALLES		ab	ab	
Surirella spp.	ab		ab	

Cont. Table 3	OL	LA	DE	DY
Tabellaria flocculosa (ROTH) KÜTZ.	a			
CRYPTOPHYCEAE				
Chroomonas nordstedtii HANSG.	ab	ab	ab	
Cryptomonas compressa PASCHER	ab			
Cryptomonas ovata EHRENB.	ab	ab	ab	
Cryptomonas spp.	ab	ab	ab	ab
Rhodomonas lacustris PASCHER et RUTTNER	a			
DINOPHYCEAE				
Ceratium hirundinella (O. F. Müll.) Bergh	ab	ab	ab	ab
Gymnodinium spp.	ab	ab	ab	ab
Peridinium spp.	ab	ab	ab	ab
XANTHOPHYCEAE				
Centritractus belenophorus LEMMERM.			ab	
Goniochloris fallax FOTT	ab	ab	ab	ab
Goniochloris mutica (A.K.H. BRAUN) FOTT	ab	ab	ab	ab
Goniochloris sp.			ab	
Ophiocytium capitatum WOLLE			ab	
Pseudostaurastrum hastatum (REINSCH) CHODAT	a	a	ab	a
Tetraedriella jovetii (BOURR.) BOURR.			b	
Pseudotetraedron neglectum PASCHER			ab	
CHLOROPHYCEAE				
Volvocales				
Carteria globosa KORSHIKOV ex PASCHER			ab	
Carteria multifilis (FRESEN.) O. DILL			b	
Carteria radiosa KORSHIKOV ex PASCHER	ab	ab	ab	ab
Carteria sp.	a	a	?	a
Chlamydomonas bicocca PASCHER			a	
Chlamydomonas bilatus H. ETTL		a		
Chlamydomonas debaryana GOROZH.	b			
Chlamydomonas gloeophila SKUJA			ab	
Chlamydomonas incerta PASCHER	a			
Chlamydomonas monadina F. STEIN	ab	ab	ab	ab
Chlamydomonas pertusa CHODAT			a	
Chlamydomonas pseudolunata H. ETTL			ab	
Chlamydomonas pseudopertusa H. ETTL		ab	ab	
Chlamydomonas reinhardtii P.A. DANG.	a	a	a	a
Chlamydomonas simplex PASCHER	ab	ab	ab	
Chlamydomonas skujae PASCHER			a	
Chlorogonium elongatum P. A. DANG.		ab	ab	
Chlorogonium fusiforme MATV.			ab	
Chlorogonium minimum PLAYFAIR	a			
Chloromonas anurae (KORSHIKOV) GERLOFF et H. ETTL		a		
Eudorina elegans EHRENB.	a	a	a	
Eudorina unicocca G. M. SMITH	b	b	b	b
Gloeomonas diplochlamys (SKUJA) H. ETTL	a	a	a	a
Gloeomonas lateperforata (SKUJA) H. ETTL		a		
Gloeomonas tecta (SKUJA) H. et O. ETTL		ab		
Gonium pectorale O. F. MÜLL.		ab	ab	
Gonium sociale (DUJARD) WARM.			a	
Haematococcus buetschlii BLOCHM.			a	

Cont. Table 3	OL	LA	DE	DY
Lobomonas ampla PASCHER	ab	ab		
Nephroselmis olivacea F. STEIN			ab	
Pandorina morum (O. F. MÜLL.) BORY	ab	ab	ab	ab
Phacotus lenticularis (EHRENB.) F. STEIN	ab	ab	ab	ab
Pleudorina californica W. SHAW			ab	ab
Pseudocarteria peterhoffiensis (KISSELEV) H. ETTL	a	a	a	
Pteromonas aculeata LEMMERM.	b	b	b	
Pteromonas angulosa (H. J. CARTER) LEMMERM.	a	a	a	a
Pteromonas cordiformis LEMMERM.	ab	ab	ab	
Pteromonas limnetica HORTOB.			a	
Sphaerellopsis aulata (PASCHER) GERLOFF			ab	ab
Sphaerellopsis gloeosphaera (PASCHER et JAHODA) H. et O. ETTL				b
Tetraselmis cordiformis (H. J. CARTER) F. STEIN		ab	ab	
Tetrasporales				
Chlorangiopsis flos–aquae HINDÁK et HINDÁKOVÁ		b	b	b
Pseudosphaerocystis lacustris (LEMMERM.) NOVÁKOVÁ		a		
Stylosphaeridium stipitatum (H. BACHM.) GEITLER et GIMESI			b	
Chlorococcales				
Acanthosphaera zachariasii LEMMERM.	ab	ab	ab	ab
Actinastrum hantzschii LAGERH.	ab	ab	ab	ab
Amphikrikos nanus (FOTT et HEYNIG) HINDÁK		b		
Ankistrodesmus falcatus (CORDA) RALFS		a	a	a
Ankistrodesmus fusiformis CORDA			a	
Ankyra ancora f. *issajevii* (KISSELEV) FOTT			b	b
Botryococcus braunii KÜTZ.			ab	ab
Chlorella vulgaris BEIJ.	ab	ab	ab	ab
Closteriopsis acicularis (G.M. SMITH) J.H. BELCHER et SWALE	a			
Closteriopsis longissima (LEMMERM.) LEMMERM.		ab		
Coelastrum astroideum DE NOT.	ab	ab	ab	ab
Coelastrum microporum NÄGELI	ab	ab	ab	ab
Coelastrum polychordum (KORSHIKOV) HINDÁK			b	
Coelastrum reticulatum (P.A. DANG.) SENN	a	a		a
Coenochloris astroidea HINDÁK	a			a
Coenochloris planctonica (KORSHIKOV) HINDÁK	ab	ab	ab	ab
Coenochloris polycocca (KORSHIKOV) HINDÁK	ab	ab	ab	ab
Coenococcus planctonicus KORSHIKOV	ab	ab	ab	ab
Coenocystis subcylindrica KORSHIKOV	b		b	
Crucigenia tetrapedia (KIRCHN.) W. et G. S. WEST	ab	ab	ab	ab
Crucigeniella apiculata (LEMMERM.) KOMÁREK	ab	ab	ab	ab
Diacanthos belenophorus KORSHIKOV		ab	ab	
Dicellula geminata (PRINTZ) KORSHIKOV			b	b
Dichotomococcus curvatus KORSHIKOV		a	a	
Dictyosphaerium pulchellum H.C. WOOD			a	
Dictyosphaerium tetrachotomum PRINTZ	ab	ab	ab	ab
Didymocystis inermis (FOTT) FOTT		ab	ab	
Didymogenes anomala(G.M. SMITH) HINDÁK		b	b	
Didymogenes palatina SCHMIDLE			b	
Dimorphococcus lunatus A.K.H. BRAUN			b	
Diplochloris lunata (FOTT) FOTT			a	
Granulocystis helenae HINDÁK		b	b	

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Granulocystopsis coronata (LEMMERM.) HINDÁK	b	b	b	
Granulocystopsis elegans (FOTT) HINDÁK	b	b		
Franceia echidna (BOHLIN) BOURR.	ab	ab	ab	ab
Franceia tenuispina KORSHIKOV	ab	ab	ab	ab
Juraniella javorkae (HORTOB.) HORTOB.	ab			
Kirchneriella aperta TEILING		b		
Kirchneriella incurvata BLECH. et SWALE		ab		
Kirchneriella obesa (W. WEST) SCHMIDLE	a	a	a	a
Lagerheimia ciliata (LAGERH.) CHODAT	ab	ab	ab	ab
Lagerheimia genevenis (CHODAT) CHODAT	ab	ab	ab	
Lagerheimia longiseta (LEMMERM.) WILLE		b	b	
Lagerheimia marssonii LEMMERM.			b	
Lagerheimia quadriseta (LEMMERM.) G. M. SMITH			a	
Lagerheimia subsalsa LEMMERM.		b		
Lagerheimia wratislawiensis SCHRÖDER	b		b	
Micractinium bornhemiense (CONR.) KORSHIKOV	ab	ab	ab	
Micractinium crassisetum HORTOB.			?	a
Micractinium pusillum FRESEN.	ab	ab	ab	ab
Micractinium quadrisetum (LEMMERM.) G. M. SMITH		ab	ab	
Monoraphidium arcuatum (KORSHIKOV) HINDÁK	ab	ab	ab	
Monoraphidium contortum (THUR.) KOMÁRK.–LEGN.	ab	ab	ab	ab
Monoraphidium convolutum (CORDA) KOMÁRK.–LEGN.			ab	
Monoraphidium intermedium HINDÁK	ab	ab	ab	ab
Monoraphidium griffithii (BERKEL.) KOMÁRK.–LEGN.	ab	ab	ab	
Monoraphidium pseudobraunii (J. H. BELCHER et SWALE) HEYNIG			ab	
Neocystis diplococca (HINDÁK) HINDÁK			ab	
Neodesmus danubialis HINDÁK			b	
Nephrochlamys rotunda KORSHIKOV	b			
Nephrochlamys subsolitaria (G. S. WEST) KORSHIKOV	ab	ab	ab	
Nephrochlamys willeana (PRINTZ) KORSHIKOV	b			
Nephrocytium agardhianum NÄGELI	a		a	
Oocystella borgei (J. SNOW) HINDÁK	ab	ab	ab	
Oocystella lacustris (CHODAT) HINDÁK	ab	ab	ab	ab
Oocystella marssonii (LEMMERM.) HINDÁK	ab	ab	ab	ab
Paradoxia multiseta SVIRENKO				b
Pediastrum biradiatum MEYEN	a		a	
Pediastrum boryanum (TURPIN) MENEGH.	ab	ab	ab	ab
Pediastrum duplex MEYEN var. *duplex*	ab	ab	ab	ab
Pediastrum duplex var. *gracillimum* W. et G. S. WEST	a	a	a	a
Pediastrum simplex MEYEN	ab	ab	ab	ab
Pediastrum tetras (EHRENB.) RALFS	ab	ab	ab	ab
Planktosphaeria gelatinosa G. M. SMITH	ab	ab	ab	ab
Polyedriopsis spinulosa (SCHMIDLE) SCHMIDLE	ab		ab	ab
Pseudodictyosphaerium jurisii (HINDÁK) HINDÁK	ab	ab	ab	ab
Pseudodictyosphaerium minusculum HINDÁK	ab	ab	ab	
Pseudodidymocystis inconspicua (KORSHIKOV) HINDÁK	ab		ab	
Pseudodidymocystis planctonica (KORSHIKOV) E.H. HEGEW. et DEASON			b	b
Pseudokirchneriella contorta (SCHMIDLE) HINDÁK	ab	ab	ab	
Pseudokirchneriella danubiana (HINDÁK) HINDÁK			ab	
Pseudokirchneriella irregularis (G. M. SMITH) HINDÁK			a	

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Pseudokirchneriella roselata (HINDÁK) HINDÁK		ab		
Pseudotetrastrum punctatum (SCHMIDLE) HINDÁK	b		b	
Quadricoccus laevis FOTT	a	a		a
Quadricoccus verrucosus FOTT		b	b	
Radiococcus planctonicus J. W. G. LUND			a	
Raphidocelis sigmoidea HINDÁK			ab	
Scenedesmus abundans (KIRCHN.) CHODAT	ab	ab	ab	ab
Scenedesmus acuminatus (LAGERH.) CHODAT	ab	ab	ab	ab
Scenedesmus arcuatus (LEMMERM.) LEMMERM.	a	a	a	a
Scenedesmus armatus (CHODAT) CHODAT var. *armatus*	ab	ab	ab	ab
Scenedesmus armatus var. *bicaudatus* (GUGLIELM.) CHODAT	ab	ab	ab	ab
Scenedesmus bernardii G. M. SMITH	ab	ab	ab	ab
Scenedesmus brasiliensis BOHLIN		a	a	
Scenedesmus carinatus (LEMMERM.) CHODAT		ab	ab	
Scenedesmus communis E. H. HEGEW.	ab	ab	ab	ab
Scenedesmus denticulatus LAGERH. var. *denticulatus*	ab	ab	ab	ab
Scenedesmus denticulatus var. *linearis* HANSG.	ab	ab	ab	ab
Scenedesmus dispar BRÉB.	ab	ab	ab	ab
Scenedesmus ellipticus CORDA		b	b	
Scenedesmus intermedius CHODAT	ab		ab	
Scenedesmus longispina CHODAT	ab		ab	
Scenedesmus maximus (W. et G. S. WEST) CHODAT	ab	ab	ab	ab
Scenedesmus obliquus (TURPIN) KÜTZ.	a	a	a	a
Scenedesmus obtusus MEYEN	a	a		
Scenedesmus opoliensis P. G. RICHT.	a	a	a	
Scenedesmus pannonicus HORTOB.	ab	ab	ab	ab
Scenedesmus pectinatus MEYEN	a	a	a	
Scenedesmus raciborskii WOŁOSZ.	ab	ab	ab	ab
Scenedesmus serratus (CORDA) BOHLIN		ab	ab	
Scenedesmus subspicatus CHODAT	ab	ab	ab	ab
Scenedesmus verrucosus Y. V. ROLL	ab	ab	ab	
Schroederia robusta KORSHIKOV		b	b	
Schroederia setigera (SCHROED.) LEMMERM.		b	b	
Schroederia spiralis (PRINTZ) KORSHIKOV		ab	ab	
Selenastrum bibraianum REINSCH	ab	ab	ab	ab
Selenastrum gracile REINSCH	ab			
Siderocelopsis kolkwitzii (NAUMANN) HINDÁK	ab		ab	
Siderocelis ornata (FOTT) FOTT	ab	ab	ab	ab
Siderocelis pseudoblonga HINDÁK			a	
Siderocelis sphaerica HINDÁK			a	
Siderocystopsis fusca (KORSHIKOV) SWALE	ab	ab	ab	
Siderocystopsis irregularis (HINDÁK) HINDÁK			ab	
Tetrachlorella alternans (G. M. SMITH) KORSHIKOV	a	a	a	a
Tetrachlorella ornata KORSHIKOV		b	b	
Tetraedron caudatum (CORDA) HANSG.	ab	ab	ab	ab
Tetraedron incus (TEILING) G. M. SMITH	ab	ab	ab	
Tetraedron mediocris HINDÁK			b	
Tetraedron minimum (A.K.H. BRAUN) HANSG.	a		a	a
Tetrastrum heteraxanthum (NORDST.) CHODAT			a	
Tetrastrum komarekii HINDÁK	ab		ab	

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Tetrastrum staurogeniaeforme (SCHRÖD.) LEMMERM.	ab	ab	ab	ab
Tetrastrum triangulare (CHODAT) KOMÁREK			a	
Treubaria triappendiculata C. BERNARD	a	a	a	a
Westella botryoides (W. WEST) DE WILD.	ab	ab	ab	ab
Ulotrichales				
Elakatothrix genevensis (REVERDIN) HINDÁK	a		a	a
Elakatothrix spirochroma (REVERDIN) HINDÁK			a	
Elakatothrix subacuta KORSHIKOV		a	a	a
Geminella planctonica (BOLCH.) TIVARY ET PANDEY			b	
Hortobagyiella verrucosa (HEYNIG) HINDÁK			ab	
Klebshormidium flaccidum (KÜTZ.) P. C. SILVA et al.		ab		
Koliella elongata (NYGAARD) NYGAARD			b	
Koliella longiseta (VISCHER) HINDÁK	ab		ab	
Koliella spirotaenia (G. S. WEST) HINDÁK		ab	ab	
Koliella variabilis (NYGAARD) HINDÁK			a	
Marvania geminata HINDÁK		ab	ab	
Planctonema lauterbornii SCHMIDLE			ab	
Stichococcus contortus (CHODAT) HINDÁK		ab	ab	
Stichococcus pelagicus (NYGAARD) HINDÁK		ab	ab	ab
CONJUGATOPHYCEAE				
Zygnematales				
Mougeotia sp.			ab	
Desmidiales				
Closterium acerosum (SCHROED.) EHRENB.			ab	
Closterium acutum RALFS			ab	
Closterium limneticum LEMMERM.	ab	ab	ab	ab
Closterium littorale GAY			ab	
Closterium moniliferum (BORY) EHRENB. ex RALFS	ab	ab	ab	
Closterium strigosum BRÉB.			a	
Closterium spp.			ab	
Cosmarium formulosum LUND.			b	b
Cosmarium moniliforme TURPIN EX RALFS		ab	ab	
Cosmarium pygmaeum W. ARCHER			a	
Cosmarium spp.	ab	ab	ab	ab
Staurastrum chaetoceros (SCHRÖD.) G. M. SMITH	ab	ab	ab	
Staurastrum planctonicum TEILING	ab	ab		
Staurastrum spp.	ab	ab	ab	ab
EUGLENOPHYCEAE				
Colacium cyclopicola (GICKLH.) BOURR.				ab
Colacium vesiculosum EHRENB.	b			
Euglena acus EHRENB. var. *acus*	ab		ab	ab
Euglena acus var. hyalina KLEBS			b	
Euglena agilis H. J. CARTER	ab	ab	ab	ab
Euglena caudata HÜBNER	ab	ab	ab	ab
Euglena clara SKUJA	b			
Euglena clavata SKUJA	a			
Euglena ehrenbergii G.A. KLEBS			ab	ab
Euglena ignobilis JOHNSON			b	
Euglena limnophila LEMMERM.	ab	ab	ab	
Euglena mutabilis SCHMITZ	a			

Cont. Table 3	**OL**	**LA**	**DE**	**DY**
Euglena oxyuris Schmarda			b	
Euglena rostrata Schiller	b		b	
Euglena rustica Schiller				b
Euglena spatirhyncha Skuja			b	
Euglena spirogyra Ehrenb.		ab	ab	ab
Euglena splendens P.A. Dang.			a	
Euglena texta (Dujard.) Hübner	ab	ab	ab	ab
Euglena tripteris (Dujard.) G.A. Klebs			a	
Euglena velata G. A. Klebs			a	
Euglena viridis Ehrenb.			ab	ab
Lepocinclis glabra Drezepolski		b		
Lepocinclis ovum (Ehrenb.) Minkiewicz			a	
Monomorphina pyrum (Ehrenb.) Mereschkowsky		ab	ab	ab
Phacus acuminatus Stokes			b	
Phacus caudatus Hübner	ab	ab	ab	
Phacus curvicauda Svirenko	b			b
Phacus helicoides Pochmann			a	a
Phacus longicauda (Ehrenb.) Dujard. var. *longicauda*	a	a	a	a
Phacus longicauda var. *insecta* Hub.–Pest.				b
Phacus longicauda var. *tortus* Lemmerm.			b	
Phacus orbicularis Hübner		a		
Phacus pleuronectes (Ehrenb.) Dujard.	b	b	b	b
Phacus pusillus Lemmerm.	a			
Phacus stokesii Lemmerm.			b	
Phacus triqueter (Ehrenb.) Durjadin			b	
Strombomonas eurystoma Popova			ab	
Strombomonas schauslandii (Lemmerm.) Deflandre		ab	ab	
Trachelomonas cervicula Stokes			b	
Trachelomonas hispida (Perty) Stein	a	a		
Trachelomonas irregularis Svirenko	b			
Trachelomonas intermedia Dangeard			a	
Trachelomonas nigra Svirenko	ab	ab	ab	ab
Trachelomonas oblonga Lemmerm.			ab	ab
Trachelomonas ovalis (Daday) Lemmerm.			ab	ab
Trachelomonas planctonica Svirenko	ab	ab	ab	
Trachelomonas scabratula (Playfair) Deflandre			b	
Trachelomonas volvocina Ehrenb.	ab	ab	ab	ab

Table 4. Results of forward selection procedure of partial CCA, IF – inflation factor.

		Marginal effects			**Conditional effects**		
	IF	**Lambda 1**	**F**	**P**	**Lambda A**	**F**	**P**
Conductivity	1.37	0.19	1.78	0.008*	0.19	1.78	0.008*
Temperature	1.35	0.18	1.61	0.020*	0.15	1.43	0.182
pH	1.36	0.11	0.93	0.580	0.07	0.65	0.744

Table 5. Number of taxa identified in the Morava and Dyje Rivers in May and August 2006.

Groups	May					August				
Locality	OL	LA	DE	DY	total	OL	LA	DE	DY	total
CYANOPHYCEAE	**24**	**33**	**36**	**20**	**45**	**33**	**36**	**42**	**26**	**53**
Chroococcales	12	18	20	13	24	18	19	25	15	30
Oscillatoriales	9	8	8	4	10	10	9	8	6	12
Nostocales	3	7	8	3	9	5	8	9	5	11
RHODOPHYCEAE	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**
DINOPHYCEAE	**0**	**0**	**0**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
CRYPTOPHYCEAE	**2**	**3**	**3**	**1**	**4**	**4**	**3**	**3**	**1**	**4**
CHRYSOPHYCEAE	**8**	**6**	**7**	**1**	**10**	**3**	**4**	**8**	**3**	**9**
BACILLARIOPHYCEAE	**118**	**115**	**86**	**87**	**171**	**134**	**80**	**133**	**66**	**189**
Coscinodiscales	19	23	24	19	30	27	21	28	20	32
Naviculales	99	92	62	68	141	107	59	105	46	157
XANTHOPHYCEAE	**2**	**0**	**1**	**0**	**3**	**2**	**2**	**7**	**2**	**8**
CHLOROPHYCEAE	**80**	**93**	**103**	**51**	**144**	**80**	**97**	**125**	**59**	**148**
Volvocales	14	17	24	8	32	10	14	20	8	26
Tetrasporales	1	0	0	0	1	0	2	2	1	3
Chlorococcales	65	71	72	42	99	69	76	94	49	109
Ulotrichales	0	6	7	1	11	1	5	9	1	10
CONJUGATOPHYCEAE	**5**	**3**	**2**	**4**	**9**	**6**	**7**	**12**	**4**	**13**
EUGLENOPHYCEAE	**17**	**16**	**15**	**3**	**29**	**15**	**13**	**29**	**17**	**41**
Σ	**256**	**269**	**253**	**169**	**417**	**280**	**246**	**362**	**181**	**468**

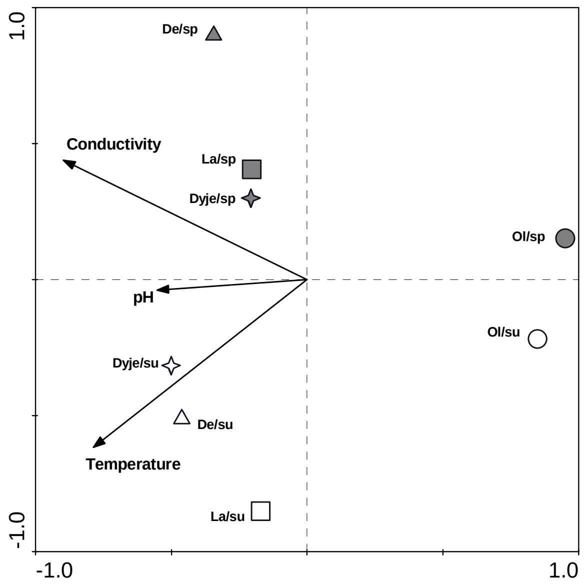

Fig. 4. Joint biplot diagram of samples vs. environmental variables (CCA): Ol – Morava at Olomouc, La – Morava at Lanžhot, De – Morava at Devín, Dyje – Dyje at Pohansko, sp – May sampling, su – August sampling.

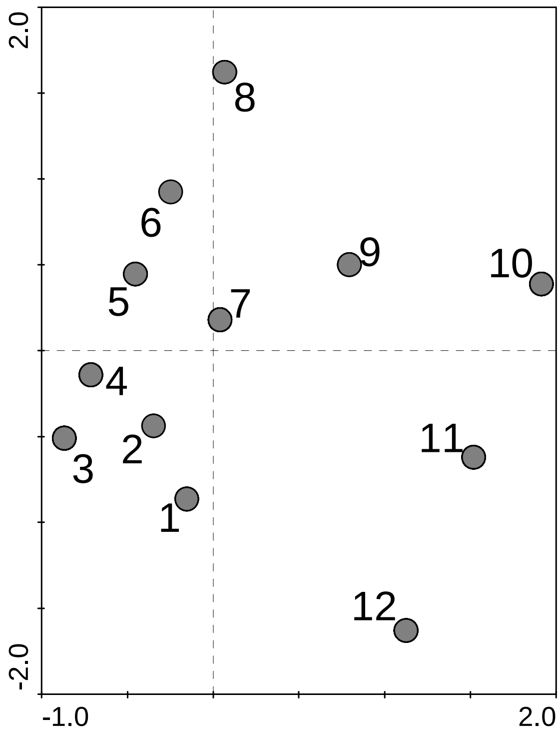

Fig. 5. Joint scatter plot of species (CCA): each number contains cluster of cyanobacteria and algae (Species Fit Range from 50 to 100%);

Species occurring at Olomouc more frequently than in the lower Morava stretch (species score 9–11): *Achnanthes laevis*, *Gomphonema acuminatum*, *G. clavatum*, *Navicula atomus*, *Eunotia exigua*, *Fragilaria parasitica*, *Surirella ovalis*, *Pinnularia borealis*, *Chlamydomonas debaryana*, *C. incerta*, *Chlorogonium minimum*, *Euglena clara*, *E. clavata*, *Phacus pusillus*, *Trachelomonas irregularis*;

Species commonly occurring at Lanžhot and Devín in spring (species score 5–6): *Anabaena circinalis*, *Aphanocapsa parasitica*, *Chlamydomonas bicocca*, *C. bilatus*, *C. pertusa*, *C. skujae*, *Chloromonas anurae*, *Gloeomonas lateperforata*, *Gonium sociale*, *Haematococcus buetschlii*, *Pteromonas limnetica*, *Euglena splendens*, *E. tripteris*, *E. velata*, *Lepocinclis ovum*, *Phacus orbicularis* and *Trachelomonas intermedia*;

Species commonly occurring at Lanžhot and Devín in summer (species score 1–4): *Aphanocapsa grevillei*, *A. minima*, *Aphanothece bachmanii*, *Fragilaria nanana*, *Gomphonema insigne*, *Navicula erifuga*, *N. subplacentula*, *Surirella bifrons*, *Chlorangiopsis flos–aquae*, *Stylosphaeridium stipitatum*, *Coelastrum polychordum*, *Dicellula geminata*, *Didymogenes anomala*, *D. palatina*, *Granulocystis helenae*, *Tetrachlorella ornata*, *Koliella elongata*, *Euglena ignobilis*, *E. spatirhyncha*, *Lepocinclis glabra*, *Trachelomonas cervicula* and *T. scabratula*;

Group of commonly occurring species (species score 7–8 and species under Fit Range 50%): *Chroococcus limneticus*, *Cyanogranis ferruginea*, *Microcystis aeruginosa*, *M. ichtyoblabe*, *Snowella litoralis*, *Woronichinia naegeliana*, *Planktothrix agardhii*, *Anabaena flos–aquae*, *Acanthosphaera zachariasii*, *Actinastrum hantzschii*, *Chlorella vulgaris*, *Coelastrum astroideum*, *C. microporum*, *Coenochloris planctonica*, *Coenococcus planctonicus*, *Crucigeniella apiculata*, *Dictyosphaerium tetrachotomum*, *Franceia echidna*, *F. tenuispina*, *Monoraphidium contortum*, *Oocystella lacustris*, *Pediastrum boryanum*, *P. duplex*, *P. simplex*, *Planktosphaeria gelatinosa*, *Scenedesmus* spp., *Siderocelis ornata*.

Discussion

A wide spectrum of cyanobacteria and algae was identified during our study on the main parts of the Morava River and the most important right–side tributary the Dyje River. As follows from previous studies (HINDÁK & HINDÁKOVÁ 1997, 1998, 2004, MARVAN et al. 2004) phytoplankton of the Morava River has been changing. In 1950´s, when organic pollution developed, high biomass and waterbloom of *Microcystis* spp. occurred, while at present time the amount of cyanobacteria is not so high. Thus, we did not record dense waterbloom, even if 53 species of cyanobacteria were found through investigated sites. According to HINDÁK´s study (2004) in the lowermost Morava River stretch at Devín in 2003 was found 42 species of cyanobacteria, which is similar to our investigations. However, a significant influence on biomass and diversity of cyanobacteria have had Nové Mlýny dams, which usually produce a strong population of *Microcystis* species and recently recorded in the end of 1990´s. According to HINDÁKOVÁ (1994) the most abundant species of centric diatoms were found in the lowermost Morava River stretch *Aulacoseira granulata*, *Cyclotella meneghiniana* and *Stephanodiscus binderanus*. We found at sampling site at Devín 28 species of centric diatoms, while in 1994 had been determined only 18 species. In case of pennate diatoms, we recorded 110 species in contrast to Hindáková who had determined 117 species. With respect to summer flood in the beginning of August 2006 the diversity of pennate diatoms increased in Olomouc and Devín as benthic species were drifted. Number of chlorococcal algae, as found in 2006, was lower than in 2003. High instantaneous discharge in the investigated rivers caused dilution of phytoplankton and consequently lacking of rare species. As follows from previous HINDÁKs´ studies (1977, 1980, 1984, 1988, 1990) such ŕare species of green algae as *Danubia ansa* and *Crucigeniopsis divergens* were not confirmed. On the other hand, *Coenochloris astroidea* was recorded at Devín, but at Olomouc was found for the first time.

With respect to last investigation on the phytoplankton of the Morava River in autumn 2005, which was identically sampled, the species diversity is different to our study and moreover strongly influenced by sampling period (HINDÁK et. al 2006). The diversity of 346 species and infraspecific taxa had been found in the Morava and Dyje Rivers, while at the same localities in summer 2006 were recorded 468 species. A discernible pattern of changes in the phytoplankton structure is possible to see in diatoms, which frequently occurred in spring 2006 and autumn 2005, while cyanobacteria and green algae dominate summer 2006. Diversity among other groups both Euglenophyceae and Conjugatophyce incresed with higher temperature in summer, while low temperature in autumn 2005 caused loss of diversity. The rest of algal flora containing groups such as Chrysophyceae, Cryptophyceae, Dinophyceae, Xanthophyceae and Ulotrichales did not show any marked changes of spieces richness amon sampling sites during our study as well as in the autumn phytoplankton. As follows from previous paper (Hindák et al. 2006) and with respect to findings the Morava River forms two major parts concerning the lowermost and middle stretch (from Lanžhot to Devín) and the upper stretch (at Olomouc), which is more similar to the Dyje River near its confluence with the Morava at Pohansko. Such measured environmental variables as temperature, conductivity and average discharge have markedly influenced structure and abundance of phytoplankton than pH or dissolved oxygen. The species richness in the Dyje River as a typical regulated lowland river is strongly influenced by Nové Mlýny dams and so we found lower diversity similar to this at Olomouc than at Lanžhot or Devín. Thus, there is no doubt that the large reservoirs significantly change phytoplankton structure of rivers with respect to former state. It means that we should not expect similar data to less or no influenced rivers in the same area.

Generally, with respect to our analysis of phytoplankton the Morava River seem to be rich in diversity of algae and especially in the lower river stretch. Wide research on phytoplankton has been actually made in the main Slovak rivers concerning the Danube, Váh, Hron, Ipeľ and Slovak part of the Morava, which were found to be an important source of algal biodiversity in the territory of Slovakia (HINDÁK et al. 2002). Similar to our investigation, in the main Slovak rivers such species of cyanobacteria and algae as *Microcystis aeruginosa*, *Planktothrix agardhii*, *Anabaena flos–aquae*, *Chrysococcus* spp., *Mallomonas* spp., *Cyclotella meneghiniana*, *Cyclostephanos dubius*, *Stephanodiscus hantzschii*, *Thalassiosira pseudonana*, *T. weissflogii* were recorded as well as *Carteria globosa*, *C. radiosa*, *Chlamydomonas incerta*, *Chl. monadina*, *Actinastrum hantzschii*, *Micractinium* spp., *Pediastrum* spp. or *Scenedesmus* spp. etc. In Czech Republic the Lužnice River was investigated by PITHART et al. (1996) who found lower diversity in the phytoplankton but with frequent occurrence of species as mentioned from Slovak rivers. The broadest research on phytoplankton in the whole Europe was undoubtedly made in the Danube River from Germany to Ukraine and five to ten times higher biodiversity through the all taxonomic groups was observed (KUSEL–FETZMANN 1998).

Summarizing all known data, the Morava River belongs to the most important river systems in the Czech and Slovak Republics concerning unique spectrum of cyanobacteria and algae.

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