Diversity and seasonal dynamics of the desmid community in the qualitative sense on Vojvodina segment of the Danube basin

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Keywords: desmids, diversity, seasonal dynamics, the Danube River, Serbia

Introduction

The detailed and concrete investigations of qualitative composition of the desmid community on Vojvodina segment of the Danube River have never been performed, according to the data basis of the Institute of Botany, Belgrade. During the algological and saprobic investigations of the Danube, desmids have been rarely found and, therefore, they have not been determined and mentioned in the previous scientific articles (SENĆANSKI 1972; OBUŠKOVIĆ 1989; MILJANOVIĆ et al. 2003; STAMENKOVIĆ 2005).

The Danube water in territory of the Province of Vojvodina is slightly alkaline, with relative high concentration of mineral salts, high degree of total hardness, periodicaly enriched with various biodegradable compounds (LITHERÁTY et al. 2002) and therefore is not appropriate habitat for the development of rich desmid flora. As typical organisms of peat bogs, marshes, fens and lakes, desmids are inhabitants of predominantly acid and soft water, with low values of conductivity and low concentration of organic biodegradable compounds (RŮŽIČKA 1977).

Material and methods

The samples of water for the phytoplankton qualitative analysis and physico-chemical analysis were collected by the Republic Hydrometeorologic Service of Serbia from seven localities on the Danube River, from April 2002 to May 2003: Bezdan (1), Bogojevo (2), Bačka Palanka (3), Čenta (4), Zemun (5), Pančevo (6), Banatska Palanka (7). The locality Zemun was also included into the consideration, although officialy it does not belong to the Province of Vojvodina. The physico-chemical analysis was performed in laboratory of the Republic Hydrometeorologic Service of Serbia, Belgrade.

The samples of phytobenthos and periphyton were not collected; in that way, the diversity of desmids was certainly reduced. The samples of algae from phytoplankton were collected using the plankton net (mesh size 25 µm), and were immediately fixed in 4% formaldehyde. The taxonomical analysis of the sampled material was performed in the Institute of Botany and Botanical Garden „Jevremovac“, University of Belgrade. All the conserved samples and desmid photomicrographs are preserved at the Institute of Botany. In this paper classification of the phylum *Chlorophyta* according to BROOK & JOHNSON (2003) is accepted.

Results and discussion

In total, 70 desmid taxa were determined during the examination of samples, in keeping with relative good water quality of the Danube River. Genus *Closterium* was dominant in the qualitative sense in the desmid community (28 taxa; 40%). Subdominant genus was *Cosmarium* (22 taxa, 31,43%), whereas genus *Staurastrum* was represented with 19 taxa (27,14%). A few specimens *Euastrum spinulosum* var. *spinulosum* (1,43%) were found in Bačka Palanka site.

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The floristic list of the determined desmids in the investigated localities is given in Table 1. *Cosmarium kjellmanii* var. *kjellmanii* and *Staurastrum smithii*, which were represented with several specimens, are new taxa to the Serbian flora.

Table 1: Floristic list of the determined desmid taxa in the investigated localities on the Danube, from April 2002 to May 2003. Symbol (*) is used to present new taxa to the Vojvodina segment of the Danube River, according to the data basis of the Institute of Botany, Belgrade.

	Taxon	**New taxa to the Vojvodina segment of the Danube**	**Localities**						
	Order: **Zygnematales** Suborder: **Closteriineae** Family: **Closteriaceae**		**1**	**2**	**3**	**4**	**5**	**6**	**7**
1.	*Closterium acerosum* (SCHR.) EHR. ex RALFS var. *acerosum*						+	+	
2.	*C. aciculare* T. WEST var. *aciculare*			+					+
3.	*C. acutum* BRÉB.					+			
4.	*C. acutum* var. *linea* (PERTY) W. & G. S. WEST [= *C. linea* PERTY]	*	+	+					
5.	*C. acutum* var. *variabile* (LEMM.) KRIEG.	*				+			
6.	*C. ceratium* PERTY	*		+			+		
7.	*C. ehrenbergii* MENEGH. ex RALFS var. *atumidum* GRÖNBL.	*	+						
8.	*C. ehrenbergii* var. *ehrenbergii*		+		+				
9.	*C. gracile* BRÉB. ex RALFS var. *elongatum* W. & G. S. WEST	*					+		+
10.	*C. gracile* var. *gracile*		+	+		+	+		+
11.	*C. leibleinii* KÜTZ. ex RALFS					+			
12.	*C. leibleinii* var. *leibleinii*		+						+
13.	*C. limneticum* LEMM.				+	+	+	+	+
14.	*C. limneticum* var. *fallax* RŮŽIČKA	*	+	+	+	+	+		+
15.	*C. limneticum* var. *limneticum*		+	+	+	+	+	+	+
16.	*C. limneticum* var. *tenue* LEMM.	*	+	+		+			+
17.	*C. macilentum* BRÉB. var. *macilentum*	*			+				
18.	*C. moniliferum* (BORY) EHR. ex RALFS var. *concavum* KLEBS	*			+				
19.	*C. moniliferum* var. *moniliferum*		+	+			+		+
20.	*C moniliferum* var. *submoniliferum* (WORONICH.) KRIEG.	*	+						
21.	*C. parvulum* NÄG. var. *cornutum* (PLAYF.) KRIEG.	*						+	
22.	*C. praelongum* BRÉB. var. *brevius* (NORDST.) KRIEG.	*			+				
23.	*C. pronum* BRÉB. var. *pronum*		+						+
24.	*Closterium* NITZSCH ex RALFS *sp.*						+		+
25.	*C. strigosum* BRÉB.			+	+			+	
26.	*C. strigosum* var. *elegans* (G. S. WEST) KRIEG.	*	+						+
27.	*C. strigosum* var. *strigosum*			+	+	+	+	+	+
28.	*C. subulatum* (KÜTZ.) BRÉB. var. *subulatum*	*							+
	Suborder: **Desmidiineae** Family: **Desmidiaceae**								
29.	*Cosmarium bioculatum* BRÉB. in RALFS var. *depressum* (SCHARSCHM.) SCHMIDLE	*		+					
30.	*C. calcareum* WITTR. var. *calcareum*	*	+						
31.	*C. contractum* KIRCHN.	*							+
32.	*C. depressum* (NÄG.) LUND. var. *granulatum* TURNER	*			+		+		
33.	*C. formosulum* HOFF in NORDST.	*			+				
34.	*C. formosulum* var. *formosulum*	*			+				
35.	*C. formosulum* var. *nathorstii* (BOLDT) W. & G. S. WEST fo. *nathorstii*	*			+				
36.	*C. granatum* BRÉB. in RALFS var. *granatum*		+				+		
37.	*C. humile* (GAY) NORDST. in DE TONI var. *substriatum* (NORDST.) SCHMIDLE	*			+				
38.	*C. kjellmanii* WILLE	*							+
39.	*C. kjellmanii* var. *kjellmanii*	*	+						
40.	*C. laeve* RABH.								+

41.	*C. pseudopyramidatum* LUND.var. *pseudopyramidatum*	*			+				
42.	*C. punctulatum* BRÉB.var. *punctulatum*	*				+			
43.	*C. pygmaeum* ARCH. var. *pygmaeum* [= *C. schliephackeanum* GRUN.]	*	+						
44.	*Cosmarium* CORDA *sp.*							+	
45.	*C. subspeciosum* NORDST.	*							+
46.	*C. subtumidum* NORDST. var. *subtumidum*	*				+			
47.	*C. tenue* ARCH. var. *tenue*	*	+						
48.	*C. thwaitesii* RALFS var. *thwaitesii*	*			+				
49.	*C. turpinii* BRÉB. var. *turpinii*	*					+		
50.	*C. wembaerense* SCHMIDLE [= *C. laeve* RABH. var. *tumidum* GRÖNBL.]	*	+	+					
51.	*Euastrum spinulosum* DELP. var. *spinulosum*	*			+				
52.	*Staurastrum alternans* (BRÉB.) RALFS var. *alternans* [= *Cosmoastrum alternans* (BRÉB.) PAL.-MORDV. var. *alternans*]	*			+				
53.	*S. chaetoceras* (SCHRÖDER) G. M SMITH		+	+		+	+	+	+
54.	*S. cyclacanthum* W. & G. S. WEST	*					+		
55.	*S. cyrtocerum* (BRÉB.) RALFS	*			+				
56.	*S. dispar* BRÉB. [= *Staurastrum hexacerum* (EHR.) WITTR.; *Cosmoastrum dispar* (BRÉB.) PAL.-MORDV.]	*					+		
57.	*S. floriferum* W. & G. S. WEST	*							+
58.	*S. gracile* RALFS ex RALFS				+		+		
59.	*S. gracile* var. *gracile*			+	+	+	+		+
60.	*S. longipes* (NORDST.) TEIL.	*							+
61.	*S. paradoxum* MEYEN [= *Staurastrum anatinum* COOKE & WILLS f. *paradoxum* (MEYEN) BROOK]		+						
62.	*S. paradoxum* var. *paradoxum*						+		
63.	*S. punctulatum* BRÉB. ex RALFS [= *Cosmoastrum punctulatum* (BRÉB.) PAL.-MORDV.]	*						+	
64.	*S. punctulatum* var. *punctulatum*	*		+					
65.	*S. retusum* TURN. var. *retusum* [= *Cosmoastrum retusum* (TURN.) PAL.-MORDV. var. *retusum*]	*							+
66.	*S. smithi* (G. M. SMITH) TEIL.	*				+			
67.	*Staurastrum* MEYEN. *sp.*			+					+
68.	*S. sublongipes* G. M. SMITH	*						+	
69.	*S. tetracerum* (KÜTZ.) RALFS								+
70.	*S. tetracerum* var. *tetracerum* f. *tetracerum*		+	+		+		+	

Basic information of the number desmid taxa in investigated localities, from April 2002 to May 2003, as well as the qualitative dominance of genera and the facts about new taxa to the individual localities of Vojvodina segment of the Danube are given in Table 2.

Table 2: Basic information about the desmid community on each locality of Vojvodina segment of the Danube River.

Localities	**Total number desmid taxa**	**Dominance of the genera in the qualitative sense**	**New taxa to the individual localities**
1. Bezdan	21	*Closterium - Cosmarium - Staurastrum*	all taxa cited in Table 1[1]
2. Bogojevo	17	*Closterium - Staurastrum - Cosmarium*	all taxa cited in Table 1
3. Bačka Palanka	21	*Closterium - Cosmarium - Staurastrum*	all taxa cited in Table 1
4. Čenta	15	*Closterium - Staurastrum - Cosmarium*	all taxa cited in Table 1
5. Zemun	19	*Closterium - Staurastrum - Cosmarium*	all taxa cited in Table 1[2]
6. Pančevo	11	*Closterium - Staurastrum - Cosmarium*	all taxa cited in Table 1[3]
7. Ban. Palanka	25	*Closterium - Staurastrum - Cosmarium*	all taxa cited in Table 1

1 – except *Staurastrum gracile* and *S. chaetoceras*.
2 – except *Closterium acerosum*, *C. strigosum* and *Staurastrum chaetoceras*.
3 – except *Closterium acerosum*, *Cosmarium sp.* and *Staurastrum sp.*

The highest diversity of desmids was observed in summer months (June and July), when lower values of pH, conductivity, total hardness and low concentration NO_3^- in contrast to

other investigated months were noticed. During these months, frequently found desmids were *Staurastrum tetracerum* (indicator of oligosaprobic level), *Closterium limneticum*, *C. aciculare*, *Cosmarium granatum* (o–β-mesosaprobic level), *C. pronum* (β–oligosaprobic level) and *Staurastrum chaetoceras* (β-mesosaprobic level) (SEV 1977; PÁL 1998).

Periodic decreases of the water quality of the Danube (Table 3), which were particularly noticed in localities Pančevo and Zemun in August 2002 (high water temperature, high values BOD, high concentration NH_4^+, relative low values of dissolved oxygen) caused changes of the qualitative composition of the desmid flora. The qualitative impoverishment of the desmid community was noticed; also the indicators of β–α and α–β mesosaprobic level (*Closterium acutum*, *C. leiblenii* and *C. strigosum*) have appeared.

Table 3: Ranges of the concentrations of several nutrients in investigated localities, from April 2002 to May 2003 (RHSS 2002; RHSS 2003).

Nutrients	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**
NH_4^+ (mg/l)	0,07-0,23	0,13-0,22	0,10-0,27	0,10-0,23	0,05-0,30	0,16-0,25	0,17-0,38
NO_3^- (mg/l)	0,7-2,8	0,8-2,1	1,4-2,1	0,9-1,9	1,3-2,0	0,8-1,6	0,6-2,1
PO_4^{3-} (mg/l)	0,006-0,076	0,005-0,064	0,061-0,090	0,009-0,059	0,040-0,082	0,023-0,066	0,033-0,072
Total phosph. (mg/l)	0,100-0,205	0,101-0,129	0,101-0,215	0,076-0,118	0,094-0,104	0,103-0,140	0,097-0,162

Although the improvement of the water quality of the Danube in autumn (RHSS 2002; RHSS 2003) was noticed, lower diversity of desmids was recorded. The progressive decreases of water temperature, as well as the increases of values of conductivity, the total hardness and concentration NO_3^-, have influenced the qualitative impoverishment of the desmid community. Also, it should be taken into consideration that *Bacillariophyta* prefere cold water and increased concentration of nutrients, and therefore have greater qualitative and quantitative presence (REYNOLDS 1984) in contrast to other groups of algae. In December, under conditions of low temperature and distinct total hardness of water desmids were not found, whereas only *Closterium limneticum* var. *limneticum* was found on several localities in January 2003.

According to increases of water temperature in spring 2003, the desmid community continued to enrich in qualitative sense, although the number of the taxa was less than in summer. Low temperature of water, moderate alkaline reaction, high values of conductivity, hardness and concentrations of NH_4^+ and NO_3^- were better suited for *Bacillariophyta*, which have a competitive advantage over *Chlorophyta* in spring months. In investigated localities, the qualitative composition of desmids was unequal during examined months. This fact could be explained by the seasonal dynamics of phytoplankton community and by the high values of the Danube flow (1840 – 5715 m^3/s in investigated period). Therefore, desmids of the Danube can be considered as a part of a rheoplankton community (UHERKOVICH 1971).

There is an interesting fact that some rare desmids (e.g. *Cosmarium kjellmanii*, *C. turpinii*, *Staurastrum smithii*, *S. cyclacanthum*, *S. dispar*, *S. floriferum* and *S. retusum*) were present in investigated localities, although the Danube is not their appropriate habitat. Those desmids were represented only with a few specimens. Complete vital cycle of those species is not expected in conditions of habitat of the Danube River. There is an assumption that majority of the desmid taxa have been flushed into the Danube from tributaries, nearby lakes, marshes, fens and bogs, which represent periodic source of phytoplankton organisms. During the examination period only *Closterium limneticum* var. *limneticum* was frequently found in all the investigated localities. This taxon can be considered as a true plankton organism of the Danube River, since it is able to complete the vital cycle. As an indicator of o–β-mesosaprobic level (PÁL 1998), its presence points to a good water quality of Vojvodina segment of the Danube River.

Summary

In this paper, the results of detailed investigation of the desmid qualitative composition in the scope of phytoplankton of the Danube River, from April 2002. to May 2003, were shown. In total, 70 desmid taxa were determined. 45 taxa were new to the Vojvodina segment of the Danube River, whereas *Cosmarium kjellmanii* var. *kjellmanii* and *Staurastrum smithii* were the new taxa to the algal flora of Serbia. In all investigated localities, the domination in qualitative sense of desmid taxa, that were typical to alkaline and eutrophic ecosystems, was noticed. Also, the presence of several typical acidophilous and/or oligotrophic desmids was recorded. It was noticed the regular seasonal dynamics of desmid community in the qualitative sense, in the scope of phytoplankton of the Danube River.

Acknowledgement

This work was supported by the Ministry of Science and Environmental Protection (Contract № 1538).

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