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Recovering and Succession of the Species Diversity of Macrozoobenthos in Srebarna Biosphere Reserve (North-East Bulgaria)

***Emilia D. Varadinova*[1], *Luchezar Z. Pechlivanov*[1], *Stefan A. Stoichev*[2], *Yordan I. Uzunov*[1]**

[1] Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2, Yuri Gagarin Str., 1113 Sofia,Bulgaria
[2] Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1, Tsar Osvoboditel Blvd., 1000 Sofia, Bulgaria; E-mail: emily@ecolab.bas.bg, emilia.varadinova@gmail.com

Abstract: Development of the taxonomic composition of bottom macroinvertebrate fauna in Srebarna Lake Reserve is studied with a view to the changes in the environment after its reconnection with Danube River. A regime switching in the succession of the bottom invertebrate community in Srebarna Lake occurs expressed by considerable changes of its species composition after its reconnection of the with Danube by a new canal. Higher species richness in the peripheral pools of the wetland was recorded in comparison with the main open water body. Within the wetland area the local habitat parameters (modified by the flooding regime) are the leading factor that recently directly controls the bottom community development patterns and the spatial distribution of species. Succession of the faunistic complex of secondary aquatic organisms in Srebarna Lake are considered different than these in the communities of primary aquatic species being independent of the water flow.

Key words: Srebarna Lake, macroinvertebrates, taxonomic composition, benthic community

Introduction

System benthological investigations of the bottom macroinvertebrate fauna in Srebarna Lake were initiated after the reconnection of this wetland with Danube by a canal in 1993. The most of available data from the previous period concern findings during episodic studies of the lake and some occasional samplings mainly from phytophilic biocoenoses around the lake shore (Uzunov *et al*. 2001). Furthermore some data from earlier studies concerned the registration of species from various taxonomic groups, some of them being permanent or temporary components of bottom communities (Michev *et al*. 1998). In the first recent benthosological survey (Kovachev *et al*. 1995) a total absence of macrozoobenthos was found. Later Uzunov *et al*. (2001) associated all available faunistic information with data obtained in 1997-1999 years and confirmed the forecast for gradually recovering the macrozoobenthos in the lake. General data about alterations in the species composition of the benthic invertebrate communities in Srebarna Lake for 9-year period from 1998 to 2006 were presented by Varadinova *et al*. (2009). In that work a comparison was also made with the macrozoobenthos in Danube River and Malak Preslavets Lake for the same period but without an analysis of the species composition in detail.

The aim of this work is to generalise both the recent state and the development of the taxonomic composition of bottom macroinvertebrate fauna in Srebarna Lake with a view to the changes in the environment after its reconnection with Danube.

Material and Methods

Seasonal (spring, summer and autumn) observations were made during the period from 1998 to 2006 and in 2009. The sampling points were selected with a view to be representative for the existing habitat diversity. Quantitative bottom samples have been collected by Eckmann's dredge of 225 cm^2 surface range according the Standard EN ISO 9391:1995. Throughout the period of investigations quantitative samples of macrozoobenthos where taken at five permanent points (I –V on Fig.1). Moreover, since 2003, seasonal quantitative samples were also taken in four peripheral pools (i.e., the sites: Kamaka, Kalneja, Darvoto, and Varban-Bozun, Fig. 1) as far as they were accessible. Only qualitative samples of macrozoobenthos (Standard EN ISO 7828:1994) were gathered in Dalboka site (Fig. 1) where the high density of the submerged vascular plants prevents the dredge to reach the ground.

All samples were fixed in 4% formaldehyde.

Laboratory processing included sorting by systematic groups and species determination under a light microscope. Most of the invertebrate groups are identified to species or nearest possible taxa. The wet-weighted biomass was measured as 'soft' one (excluding mollusks). The quantitative data were calculated per 1 m^2.

Sørensen similarity coefficient or Sørensen index (Sørensen 1948) was calculated for comparison of the species composition of bottom invertebrate communities in different localities.

Results and Discussion

A significant change in the species composition of the bottom macroinvertebrate community was found in comparison with the data of preceding studies (Michev *et al.*, 1998). Totally 98 taxa (species and genera) were recorded in the macrozoobenthos fauna of Srebarna lake (Table 1) what makes up about a third part of the total of taxa reported for the lake until now.

Thus, 118 species recorded in the references were not found recently. On the other hand, in comparison with species composition registered by Michev *et al.* (1998), 57 new invertebrate taxa were reported after that in Srebarna Lake. Oligochaeta worms are represented with the most new taxa –14, followed by dipterans' family Chironomidae – 10. The order Trichoptera is consisted with 5 species, Coleoptera – 4, Heteroptera and Lepidoptera – 2 species respectively, all were entirely new for Srebarna Reserve as well.

Low similarity (QS = 0.37) was recorded between the recent species complex of the macrozoobenthos and the species composition summarized in the references until 1998 (Michev *et al.* 1998). The values of QS between these two sets varied in different taxonomic groups from 0.31 (in Oligochaeta) to 0.75 (in Gastropoda) but the most common values ranged from 0.50 to 0.58. The orders Odonata and Coleoptera were not included in the analysis as far as the species lists presented in the references are based on the adult aerial insects while the present study refers only to the aquatic larval insect stages being focused on the bottom invertebrate fauna. By this reason, the data obtained through different approaches are incomparable.

Higher species richness was registered in the peripheral pools in comparison with the main open water body that is seems related to the much more heterogeneous environment due to the expansion of aquatic vegetation. The Sørensen index (QS = 0.69) manifested a moderate similarity of the species composition of benthic communities in these both localities in general. With this, the more detailed analysis suggests quite uneven species distribution of the macrozoobenthos species at surveyed sites related also to the heterogeneity of the environmental parameters (Moskova 2005). Two different patterns of the spatial distribution of species were identified, one – in high and other – in low waters (Varadinova *et al*. 2009).

Comparative analysis of the community taxonomic species diversity shows that Diptera larvae of the family Chaoboridae (*Chaoborus crystalinus)*, larvae of Chironomidae and the aquatic oligochaetes are predominating groups by their density within the macroinvertebrate community in both the main water body (99% of benthic fauna) and the peripheral pools (90%) of Srebarna Lake (Fig. 2, 3). Percentage share increasing of the order Trichoptera, Odonata and Ephemeroptera was observed in the peripheral pools.

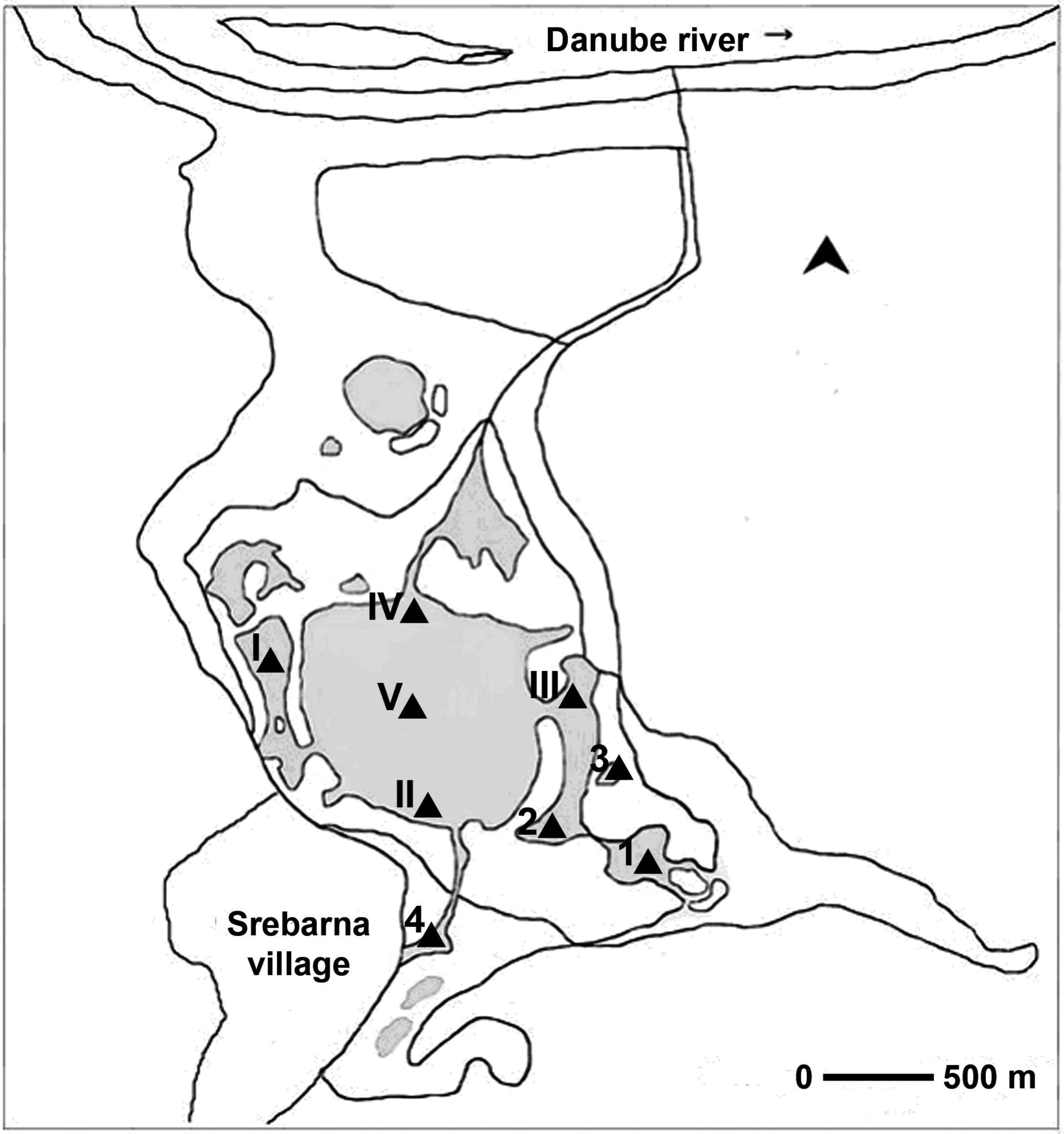

Fig. 1. Location of the sampling points. Legend: I-V – permanent monitoring sites; additional points: 1 – Kalneja; 2 – Darvoto; 3 – Dalboka; 4 – Varban-Bozun**.**

The proportion of some primary aquatic groups (such as mollusks, crustaceans, etc.) in the total numbers of the macrozoobenthos was still minimal as presence in the analysed samples. The most numerous invertebrate species on the bottom of the central open water body and also in the peripheral pools were the aquatic oligochaetes *Potamotrix hammoniensis, Limnodrilus hoffmeisteri, Limnodrilus claparedeanus, Potamothrix bavaricus* and the larvae of dipterans *Chironomus plumosus* and *Chaoborus cristalinus*. The first two species are considered typical and very common in Danube macrozoobenthos (Buijs *et al*. 1992, Uzunov, Kapustina 1993, Kusel-Fetzmann *et al*. 1998).

Varadinova *et al*. (2009) defined two potential ways for species enrichment of the lake's benthic communities: through dispersion of fringing populations and by immigration of organisms through biological drift with the water inflow from Danube. These two hypothetic ways were checked comparing the obtained data for species composition of the two most representative groups of bottom inverte-

Table1. Invertebrate bottom fauna in Srebarna Lake as recently found as recorded in the references (R); I-V – permanent sampling points, Per – additional quantitative samples from peripheral pools, Q = only qualitative samples from peripheral pools.

Taxa	**R**	**I**	**II**	**III**	**IV**	**V**	**Per**	**Q**
NEMATODA								
Dorylaimus stagnalis Dujardin	*							
Laimidorus flavomaculatus (Linstow)	*							
Monchystera stagnalis Bastian	*							
Mononchus truncatus Bastian	*							
Paractinolaimus macrolaimus (DeMan)	*							
Paradorylaimus filiformis (Bastian)	*							
Prodesmodora circulata (Micoletzky)	*							
Punctodora ratzemburgensis (Linstow)	*							
Tripyla glomerans Bastian	*							
OLIGOCHAETA								
Aeolosoma hemprichi Ehrenberg	*		*					
Allolobophora calliginosa (Savigny)	*							
Amphichaeta leydigi Tauber	*							
Aulodrilus pluriseta Piguet							*	
Aulophorus furcatus (O.F.Muller)	*							
Bimastus tenius (Eisen)	*							
Branchiura sowerbyi Beddard	*							
Chaetogaster limnaei Baer	*							
Criodrilus lacuum Hoffmeister	*							
Dero digitata (O.F.Muller)				*				*
Dero obtusa D'Udekem							*	
Eisenia rosea (Savigny)	*							
Eisenia foetida (Savigny)	*							
Eiseniella tetraedra (Savigny)	*							
Enchytraeus g.sp							*	
Homochaeta naidina Bretsher					*			*
Isochaetides michaelseni (Lastockin)	*							
Limnodrilus claparedeanus Ratzel	*						*	*
Limnodrilus hoffmesteri Claparede	*		*				*	*
Limnodrilus udekemianus Claparede	*							*
Limnodrilus sp.							*	
Lumbricus rubellus (Hoffmeister)	*							
Nais barbata O.F.Muller	*							
Nais simplex Piguet			*					*
Nais pardalis Piguet						*		
Nais variabilis Piguet			*			*	*	
Octolasion complanatum (Dugez)	*							
Octolasion lacteum (Oerly)	*							
Octolasion transpadanum (Rosa)	*							
Ophidonais serpentina O.F.Muller	*			*			*	
Potamothrix bavaricus (Oeschmann)		*	*	*		*		
Potamothrix hammoniensis (Michaelsen)	*	*	*	*		*	*	*
Potamothrix vejdovskyi (Hrabe)		*						

Table1. Continued.

Taxa	**R**	**I**	**II**	**III**	**IV**	**V**	**Per**	**Q**
Potamothrix sp. *juv.*			*		*	*		*
Psammoryctides albicola (Michaelsen)							*	*
Slavina appendiculata (Udekem)	*							
Stylaria lacustris (L.)	*		*	*			*	*
Tubifex sp.		*	*		*	*	*	*
Tubifex tubifex (O.F.Muller)	*					*	*	*
Vejdovskyella comata (Vejdovsky)	*							
HIRUDINEA								
Erpobdella octoculata (L.)		*						
Glossiphonia complanata (L.)								*
Glossiphonia heteroclita (L.)	*		*	*				*
Glossiphonia sp.							*	
Haementeria costata (O.F.Muller)	*							
Hirudo medicinalis L.	*							*
GASTROPODA								
Acroloxus lacustris (L.)	*	*	*	*	*	*		*
Anisus leucostomus (Miller)	*							
Anisus septemgyratus (Rossmassler)	*							
Anisus spirorbis (L.)	*							
Anisus vortex (L.)	*							
Anisus vorticulus (Troschel)	*							
Bithynia tentaculata (O.F.Muller)	*		*				*	*
Galba truncatula (O.F.Muller)	*							
Gyraulus albus (O.F.Muller)	*		*					
Gyraulus crista (L.)	*		*			*		
Gyraulus laevis (Alder)	*					*		
Hyppeutis complanatus (L.)	*		*					
Lithoglyphus naticoiodes Pfeiffer								*
Lymnaea stagnalis (L.)	*		*					*
Physa acuta (L.)	*				*			*
Physa fontinalis (Draparnaud)	*					*		*
Planorbarius corneus (L.)	*	*	*	*	*	*	*	*
Planorbis carinatus O.F.Muller	*							
Planorbis planorbis (L.)	*		*	*				
Radix auricularia (L.)	*		*	*				
Radix ovata (Draparnaud)	*	*				*		*
Radix peregra (O.F.Muller)	*							
Segmentina nitida (O.F.Muller)	*			*		*		
Stagnicola corvus (Gmelin)	*							
Stagnicola palustris (O.F.Muller)	*		*					
Valvata cristata (O.F.Muller)	*		*					
Valvata piscinalis (O.F.Muller)	*	*	*	*	*	*		
Viviparus acerosus (Bourguignat)	*							
Viviparus contectus (Millet)	*							
Viviparus viviparus (L.)	*							*
BIVALVIA								

Table1. Continued.

Taxa	R	I	II	III	IV	V	Per	Q
Anodonta anatina (L.)	*							
Anodonta cygnaea (L.)	*							
Dreissena polymorpha (Pallas)	*	*	*	*	*	*		*
Pisidium casertanum (Poli)	*							
Pisidium personatum Malm	*							
Pisidium pseudosphaerium Schlesch	*							
Pseudanodonta complanata (Rossmassler)	*							*
Sphaerium cornem (L.)	*			*				
Unio crassus Retzius	*							*
Unio pictorum (L.)	*							*
Unio tumidus Philipsson	*							
MYSIDACEA								
Limnomysis benedeni Czerniavsky	*							
AMPHIPODA								
Gammarus arduus Karaman	*						*	
Gammarus komareki Karaman							*	
Gammarus sp.	*							*
Niphargus sp.	*							
ISOPODA								
Asellus aquaticus (L.)	*	*	*	*			*	*
DECAPODA								
Astacus leptodactylus Eschscholtz	*							*
EPHEMEROPTERA								
Caenis horaria (L.)	*							
Caenis robusta Eaton				*				*
Caenis sp.			*	*				*
Cloeon dipterum (L.)							*	*
TRICHOPTERA								
Agrypnia varia (Fabricius)				*				
Cyrnus trimaculatus Curtis					*			
Ecnomus tennelus (Rambur)			*					*
Leptocerus cf. tinneiformis Curtis			*				*	*
Limnephilus g. sp.							*	
ODONATA								
Aeschnma affinis (Linden)	*							
Aeschna mixta Latreille	*							
Aeschna isosceles (O.F.Muller)	*							
Anax imperator Leach	*							
Anax parthenope (Selys)	*							
Calopteryx splendens (Harris)	*							
Chalcolestes viridis (Linden)	*							
Coenagrion ornatum (Seles)	*							
Coenagrion puella (L.)	*							
Coenagrion pulchellum (Linden)	*							
Cordulia aenea (L.)	*							
Crocotemis erythraea (Brulle)	*							

Table1. Continued.

Taxa	R	I	II	III	IV	V	Per	Q
Enalagma cyathigerum (Charpentier)	*							
Erythromma najas (Hansemann)	*							
Erythromma viridulum (Charpentier)	*							
Hemianax ephippiger (Burmesiter)	*							
Gomphus flavipes (Charpentier)	*							
Ischnura elegans (Linden)	*							*
Iscnura pumilio (Charpentier)	*							
Lestes barbatus (Fabricius)	*							
Lestes virens (Charpentier)	*							
Lestes sponsa (Hansemann)	*							
Lestes dryas Kirby	*							
Lestes sp.			*					
Libellula depressa L.	*							
Orthetrum albistylum (Selys)	*							
Orthetrum anceps (Schneider)	*							
Orthetrum brunneum (Fonscolombe)	*							
Orthetrum cancellatum (L.)	*							
Orthetrum coerulescens (Fabricius)	*							
Platycnemis pennipes (Pallas)	*				*			*
Somatochlora metallica (Linden)								*
Sympecma fusca (Linden)	*							
Sympetrum depressiusculum (Selys)	*							
Sympetrum fonscolombei (Selys)	*							
Sympetrum meridionale (Selys)	*							
Sympetrum pedemontanum (Allioni)	*							
Sympetrum sanguineum (O.F.Muller)	*							
Sympetrum striolatum (Charpentier)	*							
Sympetrum vulgatum (L.)	*							
COLEOPTERA								
Acilius sulcatus (L.)	*							
Acilius sp.							*	
Anocaena sp.	*							
Aronia moschata (L.)	*							
Berosus sp.	*							
Chlorophorus varius (O.F.Muller)	*							
Copelatus haemmorhoidalis (Fabricius)	*							
Dytiscus marginatus L.	*							
Gyrinus distinctus L.								*
Haliplus sp.								*
Helochares sp.	*							
Helophorus sp.	*							
Hydraena sp.	*							
Hydrobius fuscipes (L.)	*							
Hydrophilus caraboides	*							
Hygrotus inaequalis (Fabricius)	*							
Ilybius sp.								*

Table1. Continued.

Taxa	R	I	II	III	IV	V	Per	Q
Laccobius sp.	*							
Laccophilus minutus (L.)	*							
Noterus clavicornis (Degeer)	*							
Rhanthus suturalis (McLeay)	*							
HETEROPTERA								
Cymatia coleoptrata (Fabricius)	*							
Gerris argentatus Schummel	*							
Gerris lacustris (L.)	*							
Gerris thoracicus Schummel	*							
Gerris paludum (Fabricius)	*							
Hespericorixa limnaei (Fieber)	*							
Hydrometra stagnorum L.	*							
Ilyocoris cimicoides (L.)	*				*			*
Microvelia schneideri (Schneider)	*							
Nepa rubra L.	*							
Plea minutissima Leach	*							*
Plea sp. juv.		*						
Ranatra linnearis (L.)								*
Sigara falleni (Fieber)	*							*
Sigara lateralis (Leach)	*							
Sigara nigrilineata (Fieber)	*							
Sigara striata (L.)	*							
DIPTERA: CERATOPOGONIDAE								
Bezzia sp.		*	*	*	*	*	*	*
Culicoides sp.				*				
DIPTERA: CHAOBORIDAE								
Chaoborus crystallinus (Fabricius)		*	*	*	*	*		*
Chaoborus sp.		*	*	*	*	*	*	*
DIPTERA: CHIRONOMIDAE								
Camptochironomus sp.	*							
Chironomus annularius Meigen	*							
Chironomus plumosus (Linnaeus)	*	*	*	*	*	*	*	*
Chironomus gr. riparius		*	*	*		*	*	*
Chironomus sp.			*		*		*	
Corynoneura sp.	*							
Cricotopus algarum (Kieffer)			*	*			*	
Cricotopus trifascia Edwardsen	*							
Cricotopus ornatus (Meigen)	*		*					*
Cricotopus sylvestris (Fabricius)	*	*	*	*	*		*	*
Cricotopus sp.				*			*	
Cryptochironomus defectus Kieffer	*		*	*	*	*	*	*
Dicrotendipes nervosus Staeger			*		*		*	
Endochironomus sp.	*		*				*	
Eukiefferiella cf. similis Goetgh								*
Eukiefferiella grocei Edwards							*	
Glyptotendipes glaucus (Meigen)	*	*	*				*	*

Table1. Continued.

Taxa	R	I	II	III	IV	V	Per	Q
Glyptotendipes pallens (Meigen)								*
Glyptotendipes gripenkoveni Kieffer	*			*	*		*	*
Parakiefferiella bathophila (Kieffer)	*		*					
Plesctrocladius ishimicus Tschernovsky	*							
Prodiamesa olivacea Meigen							*	
Tanitarsus gregarius Kieffer							*	
DIPTERA: CULICIDAE							*	
Aedes sp.			*					*
DIPTERA: LIMONIIDAE							*	
Helobia sp.								*
Wiedemannia sp.		*						
DIPTERA: MUSCIDAE g.sp. la		*	*					*
DIPTERA: PSYCHODIDAE g.sp. la						*		*
DIPTERA: STRATYOMYIDAE g.sp. la							*	*
DIPTERA: TABANIDAE g.sp. la								*
DIPTERA indet. la		*	*					
LEPIDOPTERA								
Nimphula nimpheata (O.F.Muller)			*			*	*	*
Paraponyx stratiotata					*			
HARPACTICOIDA							*	

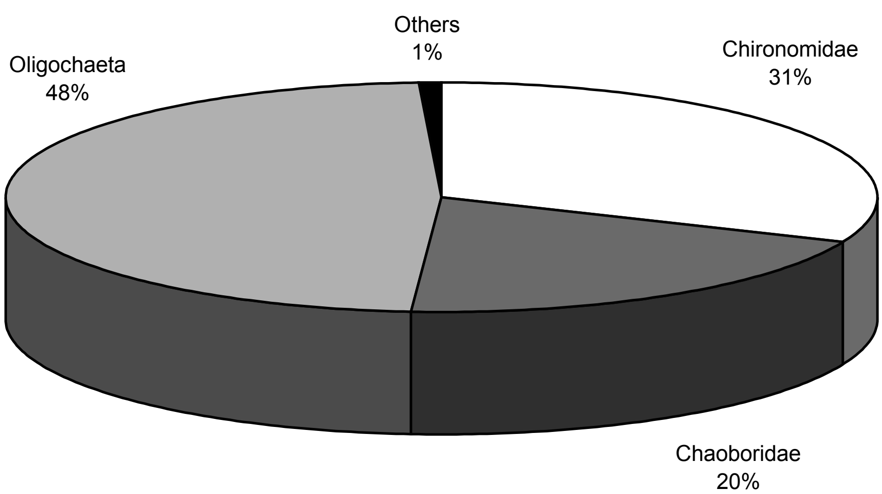

Fig. 2. Percentage proportion of the main taxonomic groups within the average macrozoobenthos density for the studied period in the main water body

brates (Oligochaeta and Chironomidae) with data for the same groups in the lower course of Danube and in other natural lakes in North-West Bulgaria. The Sørensen similarity coefficient (QS = 0.49) indicates a moderate similarity between the lake oligochaetes fauna and those in Bulgarian stretch of Danube (Uzunov, 1991) what confirms presence of interactions between the two communities. A vector of interactions obviously is the water flow from the river to the lake as far as the reverse flow recently was occurred rather as an exception.

A low similarity (0.38) was found (Moskova 2005) in comparison with the oligochaetes fauna in both Danube Delta and the adjacent water bodies (Uzunov 1983; Shelyag-Sosonko 1999), although many standing water basins within Danube Delta are similar to Srebarna Lake by morphological and hydrological parameters (Shelyag-Sosonko 1999). The

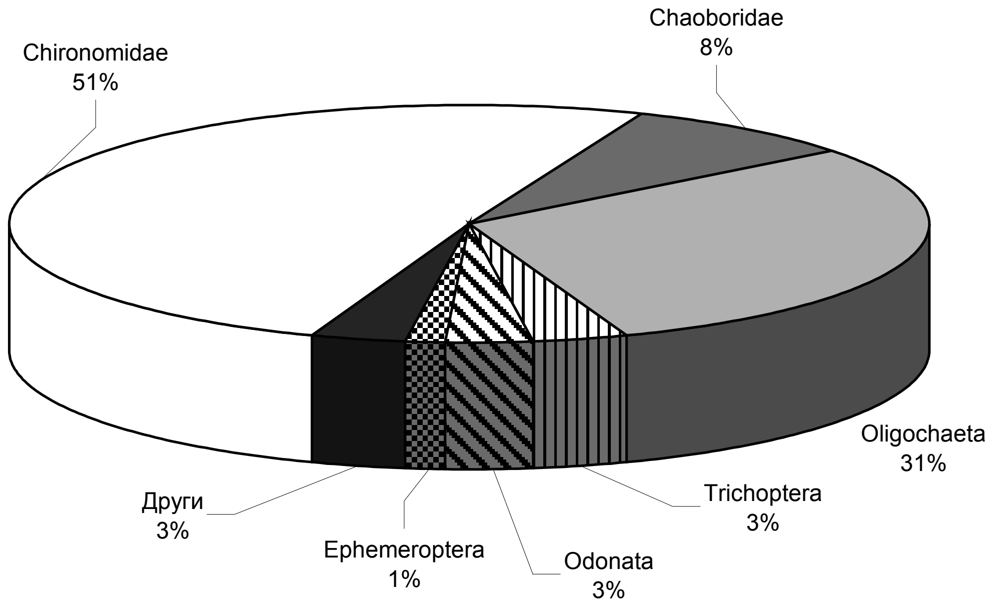

Fig. 3. Percentage proportion of the main taxonomic groups within the average macrozoobenthos density for the studied period in the peripheral pools.

low similarity between the oligochaetes of Srebarna and these of Danube Delta can be assumed as indirect evidence that the interactions between the river communities and the standing water ones concern mainly the close adjacent areas.

The moderate but not high similarity, despite the opportunities for direct interaction, suggests that the biological drift has limited effect on the lake oligochaetes community. Probably it initialized the recovering of community in the lake after its reconnection with Danube. Recently the direct effect of the biological drift apparently is limited to accidental replenishment with single eurybiotic species.

Low similarity (QS = 0.27) was found in family Chironomidae between the lake and the river communities. However, much higher similarity was found between the community in Srebarna and those in Shabla-Ezerets lake complex on Black Sea coast (Stoichev 1998), the values of QS changing from 0.44 in 1997-1999 to 0.69 in 2003-2004. This result could be explained with the fact that the dispersion of dipterans is not necessarily conditioned by water flow and is mainly carried out by air.

Conclusion

After the reconnection of Srebarna Lake with Danube by a new canal a regime switching in the succession of the bottom invertebrate community in Srebarna Lake occurs expressed by considerable changes of its species composition. The water inflow from Danube through the new canal was a ‘trigger’ factor initializing the community recovering but recently provides rather indirect than direct influence over the succession of the macrozoobenthos through modification of the environmental parameters. Within the wetland area the local habitat parameters (modified by the flooding regime as well) are considered the leading factor that recently directly controls the bottom community development patterns and spatial distribution of species.

Recently in Srebarna Lake a succession of a limnophylous bottom invertebrate community less dependent on Danube biota occurs. The secondary aquatic species still predominate in the bottom macroinvertebrate community structure over the primary aquatic ones obviously due to the unfavorable conditions near the lake bottom.

Succession patterns of the faunistic complexes of secondary aquatic organisms in Srebarna Lake being independent of the water flow are other than these in the communities of primary aquatic species.

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