Development of the zooplankton community in the Srebarna Lake (North-Eastern Bulgaria) along the process of ecosystem rehabilitation

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Keywords: zooplankton recovery, abundance and species diversity, flooding regime, Bulgaria, Danube

Introduction

The Srebarna Lake is a hypereutrophic freshwater basin situated on the right bank of the river Danube between river-km 393 and 391. Its area is about 2,5 km² with an open pool of about 1 km², surrounded by reedbeds with several smaller and more or less isolated pools within. The depth is quite variable, depending on the water influx (Pehlivanov, 2000; Pehlivanov *et al*., 2004).

In spite of its highly protected status since 1948, during the last 55 years the lake has been affected by many negative factors, but the most catastrophic one was cutting off the water exchange with the Danube as a result of embankment of the riverbank. Because of this and together with accumulation of nutrients from surrounding arable land, the ecological situation has been estimated as a disaster in the early nineties of the last century (Uzunov *et al.*, 2001).

A restoration of the aquatic ecosystem was noted after the feeding canal between the lake and the main channel of the Danube was reopened in 1994 (Hiebaum *et al.*, 2000). The investigations from 1998 to 2001 revealed recovery of the species diversity in zooplankton community and gave a reason to presume that its future development would be closely dependent on the flooding regime of the Danube (Pehlivanov *et al*., 2004)

This investigation was designed to follow the long-term changes in zooplankton composition and abundance in relation to the relevant environmental factors (i.e. flooding regime, water quality, trophic resources, and predatory pressure). Another goal of the study should be to identify the driving factors controlling the development of the zooplankton community in the wetland area during restoration.

Material and Methods

Field investigations were carried out during the ice-free periods in 2003 and 2004 by the methods used in the monitoring survey from 1998 to 2002.

Zooplankton samples were taken monthly at 5 points, selected to represent different types of habitats, Three of the sampling sites (No. 2, 4 and 5) were in the central open water body, and rest were in the adjacent pools (Fig. 1).

The samples were taken immediately under the water surface because of the small depth of the lake and the intensive mixing by wind. For quantitative sampling, 50 dm^3 of water were filtered through a plankton net (90 µm mesh size). The zooplankton samples were preserved in 4 % formaline.

The samples were processed in the laboratory. The plankton animals were sorted by species, and the specimens numbers and biomass were determined for each species. The intact body weights of plankton crustaceans were calculated according to the length to body weight

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relationships (Pavlovskiy, Zhadin, 1956). The relation between weight, body form and size was used for the rotifers (Chislenko 1968). All quantitative data refer to 1 m³.

The biomass variability index dynamics (S_t) was calculated as described by Alimov (2000). The index S_t is the ratio between the minimum and the maximum monthly total biomass of the zooplankton (S_t = B_{min}/B_{max}). It was analyzed in the course of each year, and was calculated for the whole period of investigations as the ratio between the minimum and the maximum values of the average annual biomass.

The data obtained as described above were combined with the data from the monitoring survey in 1998-2001. The joint data series was subjected to analysis of the relationship between the long-term changes in zooplankton community and some relevant biotic and abiotic environmental parameters registered in the monitoring. Correlation analysis was made by means of *Statistic 4.0 for Windows*.

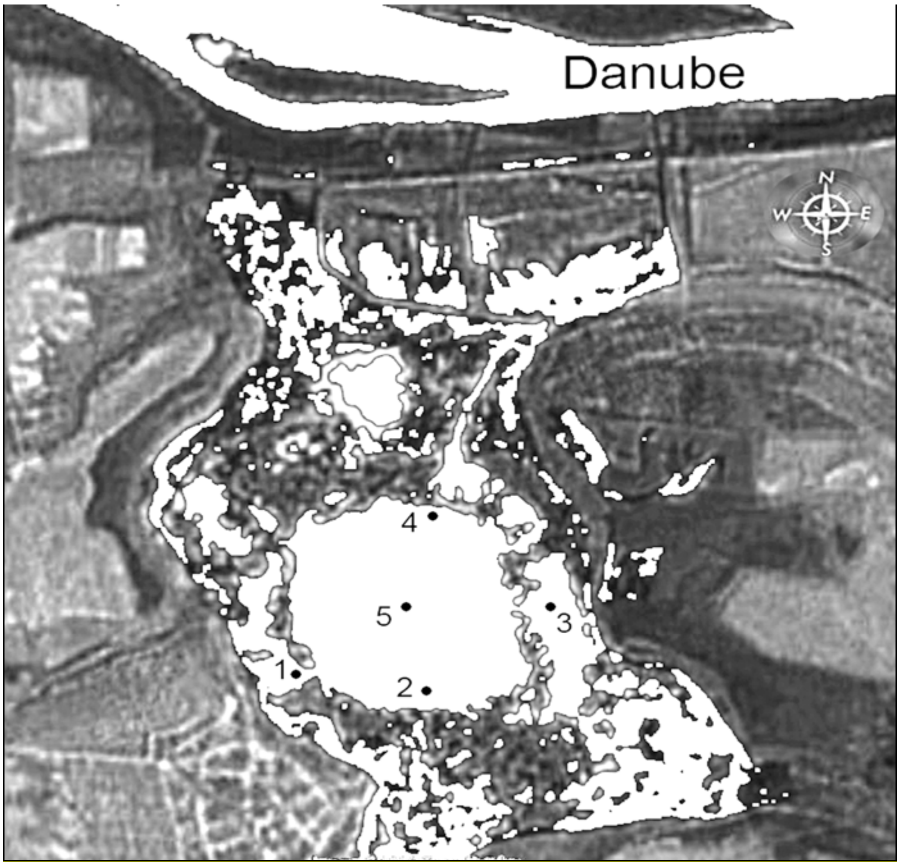

Figure 1. Scene of the Srebarna Lake. 1....5 – sampling points

Results

The metazoan plankton in the Srebarna Lake was represented mainly by eurybiotic species. The Rotatoria predominated in terms of species richness (Pehlivanov *et al.*, 2004). The total number of zooplankton taxa (at genus, species and subspecies level) displayed a tendency to increase since 1999 (Table 1).

Significant tough modest relations were proved for two of the groups between the changes in the number of species and the flooding regime as expressed by the changes of the water level in the lake. The correlation coefficient (**r**) for the cladocerans equaled to 0.5769 at critical probability (**P**) less than 0.05, and **r** was 0.5186 at **P** < 0.05 for the copepods. No such correlation was found for the rotifers.

The observed quantitative parameters of the zooplankton displayed an impressively high variability in the course of the analyzed period (Table 2).

Table 1. Changes in the number of taxa (at genus, species and subspecies level) during the analyzed period.

Zooplankton Group	Year					
	1998	**1999**	**2000**	**2001**	**2003**	**2004**
Cladocera	7	12	6	8	8	12
Copepoda	7	12	10	7	11	8
Rotatoria	36	46	56	61	53	63
Total number of taxa	50	70	72	76	72	84

Table 2. Mean values of the zooplankton quantitative parameters *per year*: N_{tot} – total numbers (x 1000); B_{tot} – total biomass (g); N_{rot}, N_{cla}, N_{cop} – numbers (x 1000) of rotifers, cladocerans, and copepods, respectively; B_{rot}, B_{cla}, B_{cop} – biomass (g) of rotifers, cladocerans and copepods; S_t –variability of the monthly dynamics of biomass.

Year	N_{tot}	B_{tot}	N_{rot}	B_{rot}	N_{cla}	B_{cla}	N_{cop}	B_{cop}	S_t
1998	238	4.077	114.1	1.66	0.5	0.004	123.3	2.42	0.034
1999	203	0.962	88.3	0.35	10.6	0.11	104.1	0.5	0.002
2001	115	0.69	42.3	0.14	4.0	0.08	68.8	0.41	0.112
2002	164	0.76	91.2	0.25	6.9	0.11	65.9	39.0	0.042
2003	297	1.12	175.5	0.46	10.1	0.09	111.4	0.1	0.217
2004	239	1.41	72.4	0.18	13.4	0.13	153.2	1.1	0.084

No statistically significant relations were found between the dynamics of water level (i.e. water influx) and the changes of either the zooplankton abundance or the community structure. At the same time, strong correlation was demonstrated of some quantitative zooplankton parameters with certain characteristics of the water quality (Table 3).

Table 3. Correlations between zooplankton parameters and water quality indicators

Zooplankton Parameter	Water Quality Parameter	R	P
Total number of zooplankton	NH_4^+ concentration	0.9135	< 0.05
Biomass of rotifers	NH_4^+ concentration	0.8522	< 0.05
Percentage of cladocerans in the total biomass of zooplankton	NH_4^+ concentration	-0.8292	< 0.05
Percentage of cladocerans in the total numbers of zooplankton	NO_3^{2-} concentration	-0.9633	< 0.01
Biomass of cladocerans	NO_3^{2-} concentration	-0.8811	< 0.05

Strong negative correlation (r = -0.9511, P < 0.05) was found between the numbers of cladocerans and the numbers of fish at CPUE (Pehlivanov et al., 2005) but no significant relations were proved between any zooplankton parameter and the fish biomass.

Discussion

The observed tendency of the total species number to increase corroborated the suggested recovery of the zooplankton community. However, the quite variable zooplankton abundance

(Table 2) and species composition (Pehlivanov *et al.*, 2004) showed that the zooplankton community still remained rather unstable. The values of S_t reflected, according to the conclusions of Alimov (2000), the impact of a very inconstant environment within each year (Table 2), as well as during the long-term period (S_t = 0.169) at a prolonged eutrophic state of the water body.

It is well known that the succession of the aquatic communities in floodplain wetlands is closely dependent on the flooding regime (Bayley, 1991). A direct influence of flooding on the aquatic communities is manifested by the import of organisms (biological drift). The flooding exerts also an indirect effect by modifying different environmental components.

The results of this study gave a reason to suppose that the import of organisms from the Danube played a significant role as an initial incitement for the recovery of zooplankton in the Srebarna Lake. In the following years its effect on the zooplankton community reduced and caused transient changes in the species number only. Amongst all the plankton transported by the inflow, just few eurybiotic species became more or less permanent components of the zooplankton in the lake. The patterns of the community subsequent development apparently reflected mainly the indirect effect of the flooding regime by changes in different environmental components – water quality, food resources, predatory pressure of fish, etc.

The negative correlation of the numbers of cladocerans with the numbers but not the biomass of fish could be interpreted as a result of the predatory pressure of small-sized planktivorous fish which occupy the leading position in the ichthyocoenose of the Srebarna Lake (Pehlivanov et al., 2005). "Top-down" control by fish predation was suggested to be the main biotic environmental factor affecting directly both the total abundance and the structure of the crustacean plankton, and especially of the cladocerans.

Even if an expressed dynamics based on flood pulses is considered a definitive feature of such kind of ecosystems, further instability of the zooplankton community in the Srebarna Lake was found to be a result of the quite variable flow regime of the Danube.

Summary

The zooplankton community succession in the Srebarna Lake was ascertained to depend on the quite variable environment in the eutrophic situation in the water body during the period from 1998 to 2004. The import of organisms from the Danube was suggested to be an initial incitement for the zooplankton recovery. The indirect influence of the flooding regime through modifications of the environmental components could be considered the main general factor responsible for the long-term succession of the zooplankton community since 1999. Fish predatory pressure was identified as the leading biotic factor directly responsible for the changes in the structure of the zooplankton community by means of "top-down" control over the crustacean plankton.

Acknowledgements

This investigation was supported by the National Council of Scientific Research at the Bulgarian Ministry of Education and Science on Grant 1307/2003. The authors would like to thank Mrs E. Varadinova, Dr. S. Naumova and Dr V. Bisserkov for their assistance in data processing and preparing the present manuscript.

References

ALIMOV, A. F. (2000): Elements of aquatic ecosystem functioning theory. Nauka Publishing House, St. Petersburg: 147 p. (in Russian).

BAYLEY, R. (1991): The flood pulse advantage and the restoration of the river-floodplain ecosystems. Reg. Riv. Res. Manage., 6: 75-81.

CHISLENKO, L. L. (1968): Nomograms for calculation of the body mass of water organisms through body size and form.- 106 pp., (Nauka Publishing House) Moskow (in Russian).

HIEBAUM, G, T. MICHEV, V. VASILEV & Y. UZUNOV (Eds.) (2000): Management plan of the Srebarna Biosphere Reserve.- 157 pp., BAS, Central Laboratory of General Ecology, Sofia (in Bulgarian).

PEHLIVANOV, L. (2000): Ichthyofauna of the Srebarna Lake, the Danube basin: State and Significance of the Management and Conservation Strategies of this Wetland. - In: Limnologische Berichte der Donau 2000, Wissenschaftliche Kurzreferate.

PEHLIVANOV, L., V. TSAVKOVA, W. NAIDENOV (2004): The metazoan plankton of the Biosphere Reserve Srebarna Lake (North-Eastern Bulgaria). – Lauterbornia, 49: 99-105.

UZUNOV, Y., V. TZAVKOVA, I. TODOROV & E. VARADINOVA (2001): The macrozoobenthic fauna of the Biosphere reserve Srebarna Lake in North-Eastern Bulgaria.- Lauterbornia 40: 43-51.

PAVLOVSKIY, A. N., V. I. ZHADIN (eds) (1956): Life in fresh waters vol. IV, part 1.- 470 pp., (Publishing House of the Academy of Science of the USSR) Moskow-Leningrad (in Russian).

PEHLIVANOV, L., V. VASILEV, M. VASSILEV (2005): Changes in the ichthyofauna of the Srebarna Lake for the last 60 years. – In: 1st National Scientific Conference of Ecology, November 4-5, 2000, Sofia, Proceedings Volume: 265-270 (in Bulg. with Engl. Abstract).