THE DIVERSITY OF ZOOPLANKTON IN TWO RESTORED WETLANDS IN THE DANUBE DELTA

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Abstract: For both polders (Babina and Cernovca), reconnection to the Danube's flood regime implied the inundation of large areas that would correspond to the water levels of the Danube.The reestablishment of the flood regime induced a process of rehabilitation of the planktonic fauna similar to permanent eutrophic waters. There is a significant increasing of the zooplanktonic species number since the wetlands were reflooded (1994), more interesting in the last 4 years when the species number almost get doubled every year: 24 sp. – 1998, 46 sp. - 1999, 71 sp. – 2000, 189 sp. – 2001, and 87 sp. – 2003. Zooplankton is considered a good indicator of changes in water quality because the community is strongly influenced and has a fast response to changes in environmental conditions (Gannon et. Al., 1997). The community can be influenced by extreme spatial and temporal changes and a typical assemblage for all practical purposes cannot be adequately described.

Key words: re-established wetlands, species diversity, zooplankton, aquatic ecosystem function.

INTRODUCTION

A development strategy for the lower Danube and Danube Delta developed in the 1960ies proved, to have far-reaching consequences. The construction of dams and channels necessary for the establishment of agricultural polders, reed harvesting, fishing and silviculture significantly altered the network of watercourses between the main branches.

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Due to the political changes in Eastern Europe, developments and orientations regarding nature protections were given new perspectives and also provided a fresh imput to nature protection in the Danube River floodplain and delta.

In 1993 a pilot project focusing the rehabilitation of the agricultural polders Babina (2200 ha), and Cernovca (1580 ha) was initiated as part of the WWF International "Green Danube" Program.

Restoring ecosystems to some previous "natural" state is often impeded by the lack of information on what goal is to be attained (Karr, 1991; Carpenter, 1997; Haring 2000).

However, a target for restoration of ecosystems can be established by developing indicators for the assessment of biological integrity. The wetlands provided a number of essential ecological functions necessary to proceed an analysis of the ecological situation on the basis of indicator species in order to elaborate forecasts regarding the probable development of the ecosystem

Zooplankton is considered a good indicator of changes in water quality because this community structure is strongly influenced and has a fast response to changes in environmental conditions. The community can be influenced by extreme spatial and temporal changes and a typical assemblage for all practical purposes, cannot be adequately described.

Zooplankton diversity in ours case depended on the season of sampling; this case is not complete because all the sample is take in June. The number of macroinvertebrates on submerged and swimming aquatic plant species is very high in June.

The reestablishment of the flood regime induced a process of rehabilitation of the planktonic fauna similar to permanent eutrophic waters.

The most abundant taxonomic groups recorded during the study were the *rotifer* species. The *rotifer* community across all channels, lake and outlet was dominated by *Brachionus sp.* species found almost exclusively in eutrophic waters (Berzins and Pejler, 1989).

In terms of density, small herbivorous rotifers (e.g. *Keratella* and *Aschomorpha*) are the most abundant, these being a characteristic of eutrophic systems (Premazzi *et al*., 1992; Carpenter, 1997).

Wetlands restoration research has demonstrated that in many cases it is possible to change a stabile situation with turbid water and dominance by phytoplankton into an 'alternative stable state' with clear water and dominance by macrophytes (Moss *et al*., 1986; Scheffer *et al*., 1993; Hansson *et al*., 1998), with diversity in zooplankton and macroinvertebrates species.

The flooding of Babina was initiated in May 1994. After its reconnection to the Danube flood regime, the island took up its former function as a water reservoir, so that 35 million m^3 may be retained at high water level and 5 million m^3 at low water levels (Marin *et al*., 1997). The reabilitation of Cernovca was initiated with two openings in the surrounding dyke (April 1996). Its hydrological function as a water reservoir is reflected by a water retention volume of 28 million water (Marin *et al.*, 1997).

MATERIAL AND METHODS

Zooplankton sampling was collected in June from 15 stations every year (1997 – 2003).

For zooplankton sampling a vertical, conical plankton net (55 µm) was used. 30 l of water were filtered, then zooplankton was re-suspended in water and preserved with 85% alcohol in plastic bottles (100 ml). The volume of the sample is measured in the graduate cylinder. From sample is take 1ml a sub-sample with is placed in a Sedgwick-Rafter cell and identified and enumerated under a compound microscope at 100X magnification. All zooplankton samples are archived after they have been analysed.

Most of the sampling stations in Babina wetland were chosen in open-water habitats rather than in the littoral side of shallow channels (B11A, B12, B14, and B2), middle 'lake' (B5) or deep channels (about 2 m). The outlet (B4) and inlet (B16) were sampled as well (figure 1).

The interactions on zooplankton community composition were tested by principal component analysis (PCA). PCA is a relatively new and powerful approach to the analysis of multivariate response data in factorial data.

PCA was performed using the CANOCO v. 4.02 computer package (ter Braak and Smilauer, 1999) to ordination species abundance's with respect to the station.

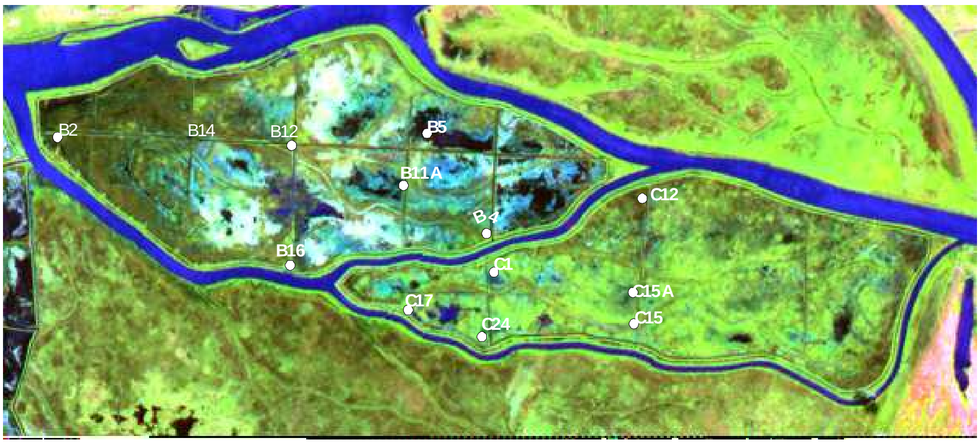

Figure 1. Satellite Image (July 1999) of Babina and Cernovca wetlands.

The sampling stations in Cernovca wetland were chosen in the littoral side of shallow channels (C1, C12, C15, and C15A), (about 1.3 m). The outlet (B24) and inlet (B17) were sampled as well (figure 1).

RESULTS AND DISCUSSION

Zooplankton is considered a good indicator of changes in water quality because the community is strongly influenced and has a fast response to changes in environmental conditions (Gannon *et al.,* 1997). The community can be influenced by extreme spatial and temporal changes and a typical assemblage for all practical purposes, cannot be adequately described. The species diversity is strongly dependent on the season. All the samples in Babina were taken in the same month (June) every year between (1993 – 2003) and for and for Cernovca samples started to collect in 1996.

The number of taxa found during the study period varied from 9 (1993) when the island was dry to 189 (2001) - (Figure 2).

There is a significant increasing of the species number since the island was flooded (1994), more interesting in the last 4 years when the species number almost get doubled every year: 24 sp. – 1998, 46 sp. - 1999, 71 sp. – 2000, 189 sp. – 2001 and 87 sp.-2003.

The lowest number of species was found in 1993 when the island was dry. The dominant genus was *Brachionus sp.*, represented by 6 taxa. After flooding the island, many species that are indicators of permanent waters occurred. The constant forms that occur every year are *Chydoridae* (*cladocera*), *Cyclopidae* (*copepoda*) and *Brachionidae* (*rotifera*). All these families occur with a frequency more than 50% in the years that follow the flooding.

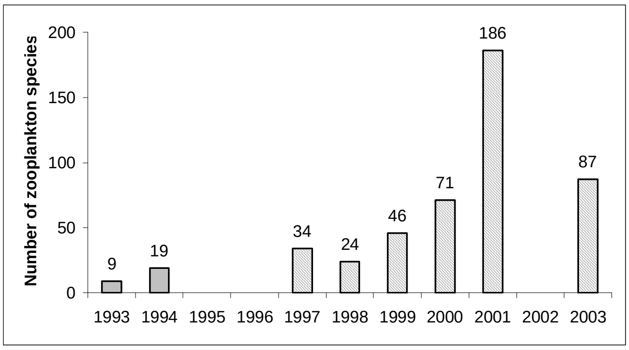

Figure 2. Evolution of zooplankton diversity in Babina wetland 1993 – 2003 (June)

All the zooplankton family found in Babina wetland in 2001-2003 is specific for permanent eutrophic water. The density dominant taxa is Rotifera.

The automatic forward selection procedure (CANOCO 4,0 ter Braak and Smilauer 1998) was used to select station in all the collected years witch contribute most to the explanation of the zooplanktonic family data set.

Multivariate analysis of the zooplankton family data was performed using direct ordination PCA = Principal Component Analysis the data (family dominant) were transformed, using correlation diversity with density.

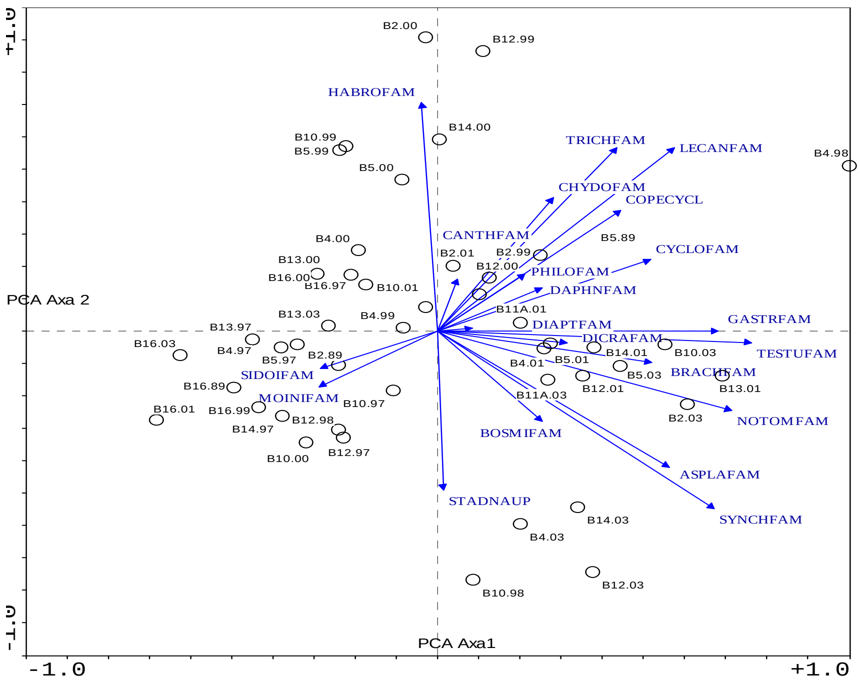

Figure 3. PCA (Principal Component Analysis) plot of the sample points based on density zooplankton families.

Arrows in the plot refer to the direction of ordination by the density zooplankton families. The distance of the large dot from the origin indicates the strength of the zooplankton variable. Underlined variables are significant, variables like - e.g. *Habrotrochidae, Moinidae, Sidoidae* family are not significant. The first two PCA axes ordination stream sites and year based on zooplankton family composition explained 80.4 % of the variance of fitted densities of zooplankton family.

The most abundant taxonomic groups recorded during the study were the *rotifer* species. The *rotifers* community across all channels, lake and outlet was overwhelmingly dominated by *Brachionus sp.* >50%. These species are found almost exclusively in eutrophic waters (Berzins and Pejler, 1989). In terms of density, small herbivorous rotifers (e.g. *Keratella* and *Aschomorpha*) are the most abundant, these being a characteristic of eutrophic systems (Premazzi *et al*., 1992).

The zooplankton community in the first year of flooding (1994) was dominated by rotifers (usually belonging to few genera) who lives in shallow waters rich in aquatic vegetation (e.g. *Asplachna sp*. and *Brachionus sp*.)

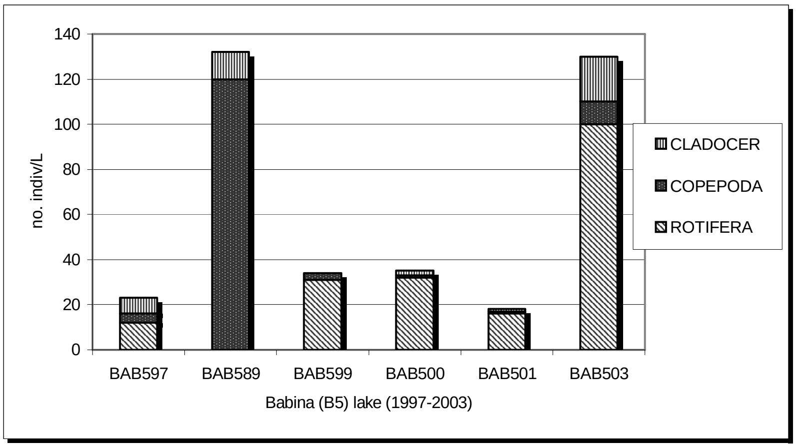

Figure 4. The distribution of zooplankton density along six years in lake form in Babina wetland [BAB597=Babina B5(map-fig1)1997]

Since 1998, when 8 families were recorded, the frequency of occurrence of the *rotifer* families increased constantly. Starting with 2000 - 2003 the zooplanktonic density it's high (hundreds ex L^{-1}). In 2001 a number of 14 families, which prefer lakes with clear water, were recorded.

In Babina wetland, *Cladocerans* from the Family *Chydoridae* and *Daphnidae* contributed significantly to the zooplankton diversity. These families were represented by herbivores species and predator species e.g. *Polyphemidae, Leptodoridae* who are living in open water around aquatic vegetation (*Nymphaea, Lemna, Ceratophyllum* and filamentous algae). These predator species are very important in the trophic chain, feeding with small size *cladocerans* (e.g. *Bosmina*); some species of *copepods* and *rotifers*, being at their turn preferred by predator fish species as pike (*Esox lucius).*

Babina lake (B5-Figure 1) is a small shallow lake on N-E Babina wetland. This lake has organic-rich substrate, high transparency and abundant aquatic vegetation typical to natural permanent shallow lake. In July 2003 in Babina Lake wen water was shallow, zooplankton density was richer than (130 no. indiv. L^{-1}) belong all three taxonomic groups Rotifers (16 species), Copepods (2 species), Cladocera (5 species). The number of pelagic cladocerans: *Daphnia* species, *Diaphanosoma* species, *Chydorus sphaericus* and *Bosmina longirostris* is comparable to the number of species found in natural shalow lake, with comparable area and depth (e.g. Cuibul cu Lebede lake) (Tudor, 2002).

Thanks to optimum condition for rotifers and crustaceans density arising form the reconection to the Danube's flood regime, a higher abundance of young fish may be observed (Tudor, 2002). This evidence leads to the assumption that a stabilization of the areas fish stands will occur to the benefit of the local population.

Started with 1996, Cernovca polder was flooded and zooplankton composition in this period was relatively small (11 species) with 1997–2003 the density of zooplankton species (Figure 5) was characterised with planktonic forms: Rotifera and Crustaceans groups (72 species in 1997) wich are important part in trophic cascades specific natural ecosystem.

In 2003, after 8 yers of reflouted Cenovca, condition of dense vegetation and clear water coincided with a low abundance of planktonic crustaceans during the day.

High densities of *Rotifers* were found in the last years in channels. Planktonic crustaceans are dominant in shallow channels with oxygen saturation of more than 100%, dense vegetation and clear water. However, these samples were dominated by plant-associated taxa that even during the summer were rarely found outside the vegetation.

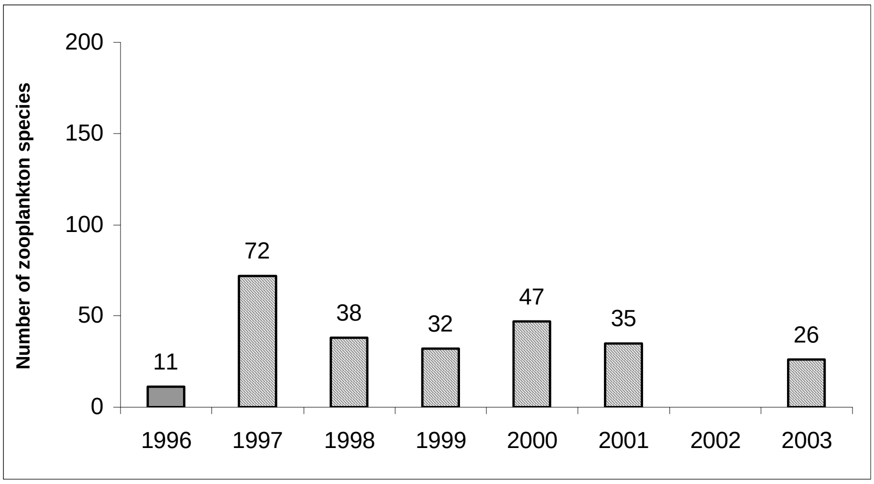

Figure 5. Evolution of zooplankton diversity in Cernovca wetland 1996 – 2003 (June).

Statistic analysis PCA ordination station from channels site and year based on zooplankton families composition explained 82.6% of the variance of fitted densities of zooplankton families (Figure 6). Zooplankton family composition in channels showed a significant channel site by year interaction. In 1997, (C1; C17) Rotifers groups assemblages were significantly different from other sites (Monte Carlo permutation test $p < 0.001$); the remaining sites were significantly different from each other (Figure 6).

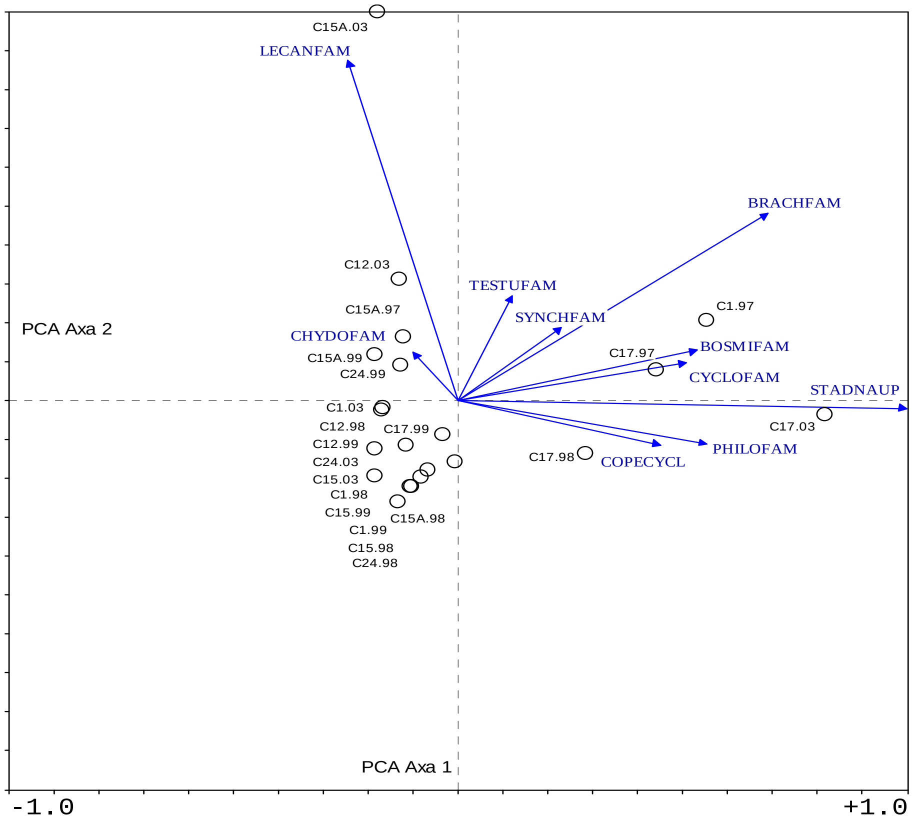

Figure 6. PCA (Principal Component Analysis) plot of the sample points based on density zooplankton family in Cernovca wetland.

CONCLUSION

The rehabilitation works may be considered as being an ecological-economical alternative to the managemnt of the unprofitable wetlands in the Danube Delta Biosphere Reserve.

After a mostly near-natural reestablishment of the hydrological regime all other ecological factors were reestablished and the natural floodplain resources could again redevelop.

The zooplankton community development indirectly reflects the length of time that has passed since the reestablishment of Babina’s hydrological regime. In comparison to Cernovca, the shorter period that has passed sine restoration was revealed in a poorer development of the submerged macrophytes within the channels of Cernovca wetland. The more of less similarly development of the submerged macrophytes within the channels of Cernovca.

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The most abundant taxonomic groups recorded during the study were the *rotifer* species. The *rotifers* community across all channels, lake and outlet was dominated by *Brachionus sp.* species found almost exclusively in eutrophic waters.

Cladocerans from the families *Chydoridae* and *Daphniidae* contributed significantly to the zooplankton diversity and were represented by herbivores and predator species e.g. *Polyphemidae, Leptodoridae* who are living in open water around aquatic vegetation (*Nymphaea, Lemna, Ceratophyllum* and filamentous algae). In 2001 the family Daphnidae is dominated by the species *Daphnia galeata* (48%) which prefers clean water with submerged vegetation.

After the flooding of Babina, *Cyclopida* occurred with a frequency of 100%. In 1999 and 2001 *Cyclopids* have became relatively frequent (62%) and other families as *Diaptomidae* (20%) and *Harpacticoidae* being recorded as well.

The reestablishment of the flood regime induced a process of rehabilitation of the planktonic fauna similar to permanent eutrophic waters.

Dominant groups of aquatic insects and mollusks are characteristic for still waters with muddy and detritus rich substrates from eutrophic and highly vegetated ecosystems.

In summary, this two wetlands reflooded, developed zooplankton communities, representing important fauna of the region. Local diversity was high and reprezented a larger fraction of regional diversity than that observed in other lentic systems of Danube Delta. The strong association between flooding and diversity suggests that flooding provides a major force for producing this diversity.

ACKNOWLEDGEMENTS

I want to thank the following individuals for assistance in collecting samples of zooplankton: Petr Obrdlik, Virgil Mitache and Marian Tudor. We also thank Varvara Suhov and Bahria Davidov for tehnical asistances. This research was funded by grants from the ''Danube Delta National Institute for Research & Development'' Tulcea – Romania and by the WWF Germany – Institute for Floodplains Ecology. Special thanks for financial support by European Commission - Center of Excellence Project.

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