First records on effect of renewed flooding of three wetlands from Belene Island (Lower Danube, Bulgarian stretch)

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1 Introduction

The importance and role of riparian wetlands based on their diverse functions and services were thoroughly reconsidered over the last 10-20 years. In that sense the future functions of restored wetlands on Bulgarian Belene Island are focused mainly on protecting, sustaining and developing biodiversity of this important part of the natural park. These functions have been extremely limited and even damaged by the years of permanent isolation of wetlands from the Danube River. Therefore the core of the wetland restoration is the establishment of a well functioning surface connection between marshes (floodplain) and main river, preventing wetlands from drying and securing effective flushing at times of high river levels. Only this combination of measures can provide the necessary precondition for achieving good ecological status of this wetland. Such an approach is not only supported by world-wide practice but also by monitoring restoration of another Bulgarian Danube wetland – the Srebarna Lake. Many publications dealing with ecological investigations of this lake clearly showed that the observed unstable improvement of lake status is connected with lake water level fluctuations and the thick mud layer still present on the lake bottom 15 years after its reconnection to the river (Kalchev et al. 2007, Beshkova et al. 2008, Vassilev et al. 2008, Kalcheva et al. 2008). All this is a result of ineffectively established connectivity to the river by only one inlet channel.

Therefore monitoring progress of Belene island wetland restoration is an obligatory measure, which will provide society and stakeholders with the necessary information and probable solutions in order to accelerate or correct the development of ongoing wetland restoration. This might help to avoid repetition of mistakes experienced on Srebarna Lake. The quick and reliable estimation of efficiency of the restoration process is substantially facilitated by available information for the ecology of Belene wetlands from the period before reconnection to the Danube River (Beshkova & Botev 2004, Beshkova et al. 2003).

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2 Material and methods

The Belene Island situated at Danube River km 561 -576 presently has four distinct water bodies (Fig.1).

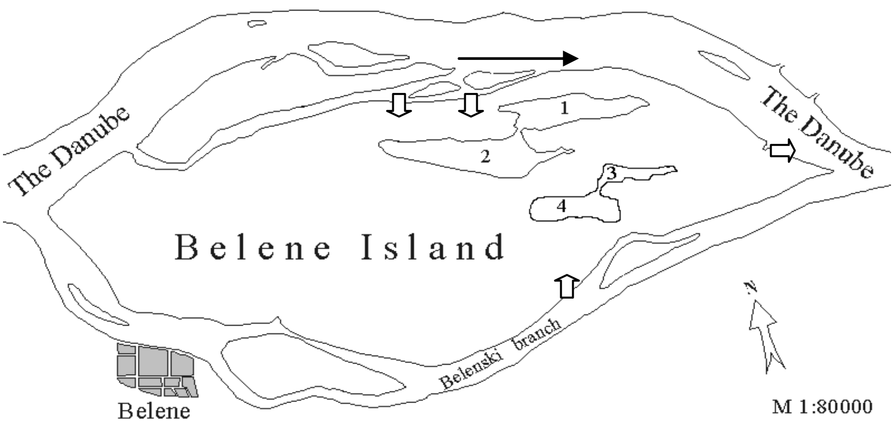

Figure 1. *Schematic map of the Belene (alias Persina) Island with localization of four marshes: Murtvo blato (1), Peschinsko blato (2), Dyuleva bara (3) and Staroto blato (4); block arrows mark places of inlet and outlet devices and line arrow indicates the river flow direction; the small-scaled network of channels crossing the island is not shown. Modified after Beshkova & Botev (2004).*

The latitude of Belene islands is about 43° 40’ N, the longitude 25° 12-15’ E and the altitude amounts to 18 m a.s.l. approximately. The total aquatic area before wetland restoration measured on topography maps amounts to 314 ha (Kalchev et al. 2010), while according to the Management Plan (MP 2006) the total area is 386 ha distributed between Peschinsko blato (182 ha), Murtvo blato (123 ha) and both Dyuleva bara and Staroto blato (81 ha). The geology of the island consists of gravels, sands and clays (alluvium), while the soil is fluvisols – calcaric (Kalchev et al. 2010). In the past all four marshes were completely isolated by dykes from the river for many years and were fed by underground waters only, thus some of them occasionally got dry and converted to temporary waters. Recently there are three inlet and one outlet devices (Fig. 1), whose function is to supply or retain the water in the marshes depending on the Danube River levels. Additionally the marshes are interconnected and the island area crossed by several draining channels built in the past with the aim to keep most of the island area dry. Now these channels are permanently full with water and part of them should serve the water circulation between the marshes. However, since the elevation of inlet and outlet devices is approximately the same there is almost no flow in the channels and, hence, no significant water exchange between marshes.

The data of 1997 (June), 1998 (June) and 2000 (April) characterizing the status of three wetlands in the period before restoration are derived from Beshkova & Botev (2004) and Beshkova et al. (2003). Additionally we got some data from Ninov (2008) who published information about aquatic chemistry of Peschinsko blato and Murtvo blato in June 2004.

The samplings of the period after reconnection of marshes with the Danube River were carried out in August and November 2009 within a project dealing with Danube wetland investigations funded by the National Science Fund of Bulgaria.

Despite the variety of data provided by literature and recent investigations it appears that only a limited number of characteristics are in common, allowing a comparison of wetland status before and after reconnection to the river. The set of comparable data includes measurements of pH, oxygen, NH_4-N, NO_3-N and PO_4-P concentrations, oxygen saturation of water, numerical and biomass abundance of phytoplankton and zooplankton of three marshes (Peschinsko blato, Murtvo blato and Dyuleva bara). The phytoplankton species were additionally separated into functional groups after Reynolds et al. (2002). There were no published data for Staroto blato marsh for the period before wetland restoration, which might be due to its more prolonged and probably complete drying.

Due to the limited number and partly taxonomic nature of data available we decided to apply less strict statistical approaches like cluster analyses (hierarchical, k-means clustering) and a subsequent multidimensional scaling (MDS) in order to establish the difference between the periods before and after renewed flooding of the wetland. For the sake of analysis performance and easier understanding samplings of marshes were marked by codes applied throughout the whole report. Thus a sampling of **D**yulova bara in **J**u**n**e 19**97** was indicated by DJn97 (Figs. 2-4).

3 Results and discussion

The pH values ranged from 7.2 to 8.4 only, while oxygen concentrations (Fig.2) and oxygen saturation (Fig. 3) varied on a wider scale (0.24-10.08 g m^{-3} and 2.6-126%). The occasionally discovered oxygen shortage during summer months in such eutrophic shallow waters is considered as a natural phenomenon; however, oxygen depletion in all three marshes in cold November 2009 rather presents an alarming evidence for intense processes of decomposition in the anoxic wetland sediment. With three exceptions when N:P ratios were between 23 and 48, the period June 1997 - August 2009 was characterized by an N:P ratio close to or below 10, which suggests nitrogen limitation. November 2009 was distinguished by high N:P ratios varying from 49 to 76.

Fig. 3 clearly shows that the biomasses of zooplankton and of single phytoplankton sampling (DJn98) varied within several orders of magnitude throughout the considered time span. We prefer to present these variables by biomasses instead by numbers because high zooplankton biomass values are generally caused by large sized individuals, which are more indicative for the intensity of grazing pressure of zooplankton (especially of Cladocera) on phytoplankton. The biomass of Cladocera might be influenced by fish that were introduced by reconnection to the river with all its consequences for top-down cascade effects on the pelagic food-chain down to phytoplankton. During complete isolation from the river the wetlands were extremely poor in fishes (only 8 species reported, Kalchev et al. 2010) and with one exception (DJn98) the phytoplankton biomass was always low, most probably due to high grazing pressure by zooplankton. Unfortunately this tendency seemed to continue after the renewed flooding e.g. in 2009, when in August the low biomass of Cladocera and Copepoda indicated fish pressure while in November the opposite situation occurred supposing fish absence. After unofficial communication based on visual observations of the Persina national park staff there were no indications for fish kills during the whole year. Most probably the grown up fish larvae prefer other food than zooplankton and stay in the deeper channels in autumn avoiding the shallow parts of the marshes where we took our samples. Unfortunately, for organizational reasons the start of fish samplings of the restored wetlands was postponed for the next year (i.e. 2010) and the above speculations about fish presence and absence have a conditional character.

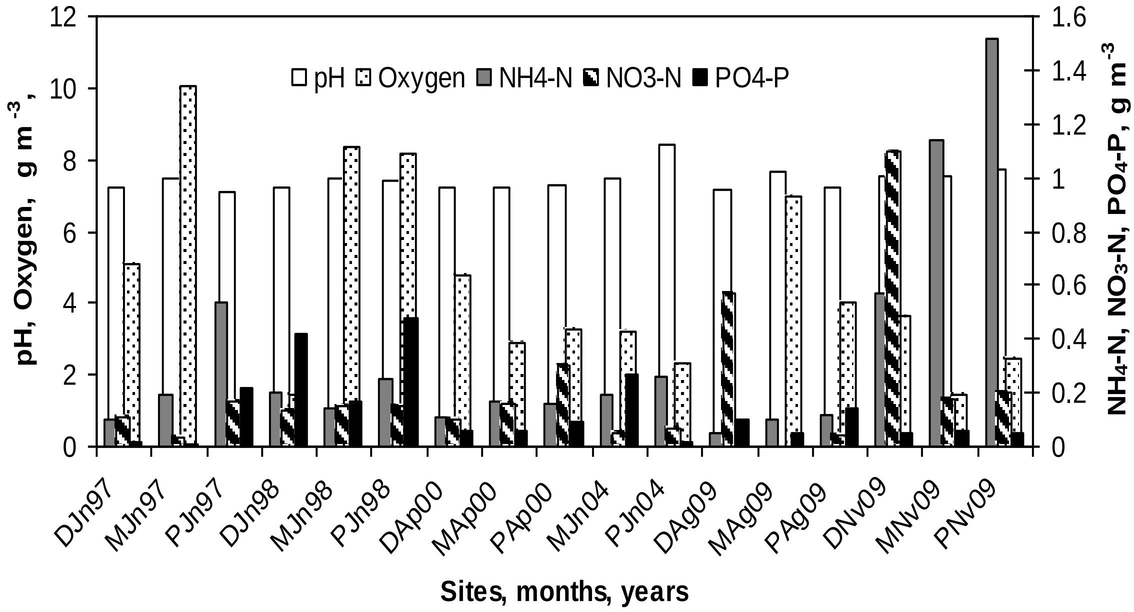

Figure 2. *Variations of pH and concentrations of oxygen and nutrients in the period before (1997-2004) and after (2009) renewed flooding of the wetlands*

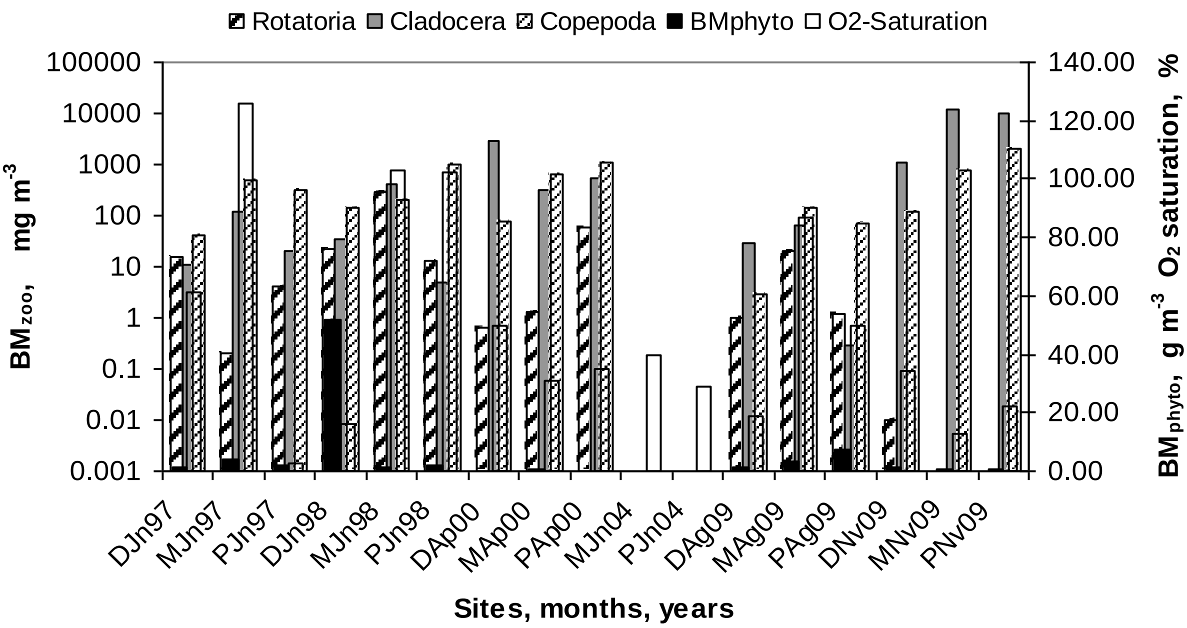

Figure 3. *Variations of water oxygen saturation, phytoplankton and zooplankton biomass (Rotatoria, Cladocera and Copepoda) in the period before (1997-2004) and after (2009) renewed flooding of the wetlands. Note the log scale on the left y-axis.*

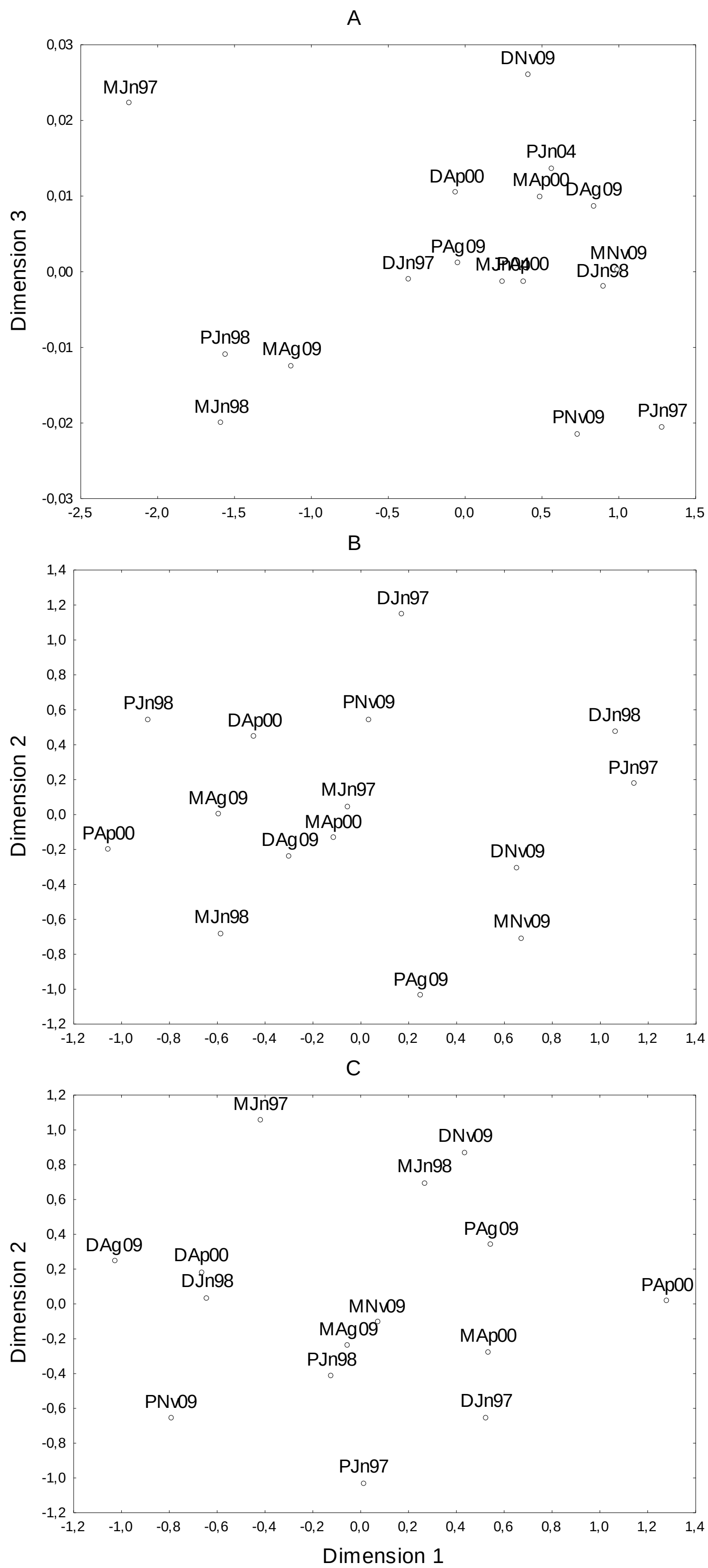

Figure 4. *The ordination diagram of samplings by MDS based on (A) squared Euclidian distance index of 6 environmental variables presented in Fig.1 and 2; (B) Chi-squared index calculated with numerical abundance of 162 phytoplankton species separated in 22 functional groups; (C) Bray-Curtis non-metric index of 100 zooplankton species.*

The taxonomic and functional group structure of phytoplankton and zooplankton communities offers further opportunities to evaluate the supposed differences between two periods of wetland development. As mentioned in the methodological part we applied various indices for clustering all 15 to 17 samplings available in order to test their separation in a meaningful way. Unfortunately, the cluster analyses and the subsequent MDS deliver either a clump of samplings with few outliers scattered around or more or less distinct separation of samplings without clear cluster differentiation. Even if we assume to have discovered some separate clusters soon we noticed that they all consist of mixture of samplings representative for both periods before and after reconnection (Fig. 4 A-C). Obviously the lack of separation between the periods before and after the wetland restoration is due to the small number of analyzed samples; however, the considerable spatial fragmentation causing heterogeneity of chemical and biological parameters typical of wetlands makes such a comparison difficult.

However, the presented data and analyses clearly confirm the first impression from the times of wetland visits. In summer most of the aquatic area was covered by floating-leaved macrophytes, which indicates long lasting absence of substantial water movement. In autumn there were no macrophytes and no single fish could be noticed in the clear water. However, the surrounding water body got easily turbid by touching the loose dark colored muddy often covered with numerous plant rests sediment, whose thickness seems to vary between 0.2-0.3 m. The staff in charge of in- and outflow water regulation put much efforts and succeeded in keeping enough water in the marshes the whole year around. However, according to unofficial statements, due to rapid fluctuations of Danube water levels and similar elevation of inlet and outlet devices a true flushing effect could not be realized and the mud accumulated in the marshes during their isolation from the river in the past could not be removed. These rapid changes in river level were produced by Iron Gate reservoir operation. The final result is that all in- and output devices connecting marshes with the river function, when opened, either as inlets or as outlets only. Thus a substantial flushing effect could not be achieved.

4 Conclusions

Unfortunately the first records on the effect of wetland restoration on Belene Island let us conclude that the result is rather negative, still far away from expectations. Despite the provision of enough water and avoiding the danger of wetland drying, the ecological status of the marshes has not changed substantially after renewed flooding. The restoration of marshes on Belene Island seems to share the fate of another Bulgarian Danube wetland “restored” recently - the Srebarna Lake. Inadequate hydrological measures led to an insufficient connectivity between the stagnant waters and the main river in both cases. The improvement of hydrological connectivity of these wetlands to the river seems the only possible solution for restoration. Sediment dynamics and formation are natural processes that need to be reactivated. The sediments of Belene Island are not toxic but moderately contaminated with wastes from farming and cattle breeding practiced on the island; hence, by flushing there is no danger to severely pollute the Danube River. Sediment removal by dredging is not recommended due to the high protection status of the area. Moreover, such a large-scale engineering solution will not remove the cause of mud accumulation and after a short period of improvement the old problems will emerge again. The presented research program was recently extended by additional chemical analyses, primary production, bacteria, macrozoobenthos, macrophyte and fish samplings. This will provide a more detailed picture of wetland status and will help to direct efforts of the limited resources of Persina national park staff to monitoring the most critical parameters for wetland development.

Acknowledgments

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