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SREBARNA CASE STUDY: HABITAT CHANGES AS REFLECTED BY WATERFOWL

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ABSTRACT

The long-term observations on the waterfowl and the complex limnological situation of the lake allowed us to conclude:

1. The case of Srebarna gave an excellent example of the statement that the abundance and distribution of birds (and especially of waterfowl) depends on many different and sometimes even contradicting factors. That is why it is impossible to detect the early stages of changes in wetland habitats only by changes in bird population and colonies.

2. The waterfowl and especially the pelicans are more or less conservative element of limnological systems and their reactions to changes in the habitat quality sometimes is not so immediate. Taking in mind the nest-conservative behaviour and genetic breeding memory it is necessary to stress that the feeding activity of waterfowl (especially of fish-eating ones) is much more important indicator than their nesting.

3. According to our observations in the case of Srebarna the glossy ibises were much more sensitive to habitat changes than the other waterfowl birds. The colonies of *Plegadis falcinellus* were the first that left the lake territory. Thus, it is possible to propose that this species could provide sufficient indicative information on wetland habitat quality.

INTRODUCTION

Lake Srebarna in Bulgaria was declared as Ramsar site (1975), UNESCO biosphere reserve (1977), Monument of World Cultural and Natural Heritage (1983) and Important Bird Area (1990). The reason behind this recognition was its extremely rich ornithofauna and particularly the breeding of globally threatened species *Pelecanus crispus* and *Phalacrocorax pygmeus*. During the last years the lake ecosystem underwent significant changes toward strong eutrophication and anthropogenically speeded-up succession. The main reasons were the interrupted connection with the Danube river (because of a dyke built in 1948) together with the pumping of the underground waters, as well as the agricultural changes and activities in the watershed basin.

The case of Srebarna could be regarded as an example of the birds response to habitat changes. The problems of use the waterfowl as indicators of the wetland habitat quality are discussed.

STUDY AREA

Lake Srebarna is situated in North-Eastern Bulgaria on the right bank of the River Danuba (44° 05' n.l. and 27° 07' e.l). It is located in a karst depletion and is surrounded by three hills. Between the lake and the Danube there was a strip of arable land up to 1994. Recently Srebarna is a shallow (0.8-0.2 m depth) hypereutrophic (**Table 1**) polymiktic basin. The total reserve territory is 902.1 ha. The lake surface is about 2.4 km^2, including the open water area and the surrounding reed-belt and the volume is $0.37 \cdot 10^6$ m^{-3}. The climate in the region is continental with a temperature varying between -2.5 °C (in January) and 39 °C (in July). Annual precipitation average is 159 mm. The average ionic concentration is high (1135 mg l^{-1}) with a sulphate character, corresponding to the average conductivity of 570.0 S cm^{-1} and 6.5-7.5 pH (Michev *et al.*, 1993; Radev *et al.*, 1993). The karst sediment nowadays are covered by a 7 m thick layer of sapropel.

Table 1: Selected water quality features of the Srebarna lake

	1960	1985	1993
SO_4 (mg l^{-1})	48.1	38.1	487.3
Cl (mg l^{-1})	146.4	41.0	150.5
PO_4 (mg l^{-1})	0.02	0.20	1.14
NH_4 (mg l^{-1})	0	0.07	0.40
NO_3 (mg l^{-1})	-	1.42	2.53
EJ (mg l^{-1})	663.3	496.3	1178.3
HCO_2 (mg l^{-1})	321.9	293.6	178.3
Cond ($\mu S\ cm^{-1}$)	-	-	570.0

LAKE ECOSYSTEM UP TO 1948

During the last two centuries a regular annual intrusioof Danube waters in the lake occurred. According to the descriptions of foreign naturalist in 19th centruy the Lake of Srebarna was full of life and was called "waterfowl Eldorado". Scientific investigations have started at the end of 19th and beginning of 20th century. Data on the lower flora of the lake could be found only in the monograph by Petkoff (1911), who mentioned 15 species. The lake higher flora (47 species) and vegetation were studied in a pilot way by Petkoff (1911). Bonchev (1929) and Jordanov (1946-47). Hydrobiological and hydrochemical investigations had not been carried out in the lake. The data on the invertebrate fauna are scarce. The most thoroughly studied component of the lake ecosystem was its ornithofauna and mainly the waterfowl (Hodek, 1882; Christovich, 1890; Reiser, 1894 and Petrov, 1947). The last author mentioned especially the presence of big heron colonies (of *Egretta alba, Egretta garzetta, Ardea purpurea, A. cinerea, Ardeolla ralloides, Nycticorax nycticorax*), *Plegadis falcinellus* and *Platalea leucorodia*. According to him the pelican colony (50-60 breeding pairs) inhabited the pool "Babushko blato" and several floating reed inlets.

CHANGES IN ECOSYSTEM AFTER THE DYKE-BUILDING IN 1949 (WITH SPECIAL RERERENCE TO WATERFOWL)

In 1948-49, in spite of the severe protests by scientists from Bulgarian Academy of Sciences (BASc), a dyke between the lake and the Danube river was built. Thus the previously existing connection between the lake and the Danube was interrupted. The first result was the decrease of lake surface from 5 km^2 with an open water area of 3.35 km^2, to 2.5 km^2 with an open water area of 0.6 km^2 (Modev, 1994). The water volume also decreased and the bottom rose up and the depth changed from 3.5 m to 1 m. The last even was caused mainly by the prohibited harvesting of the reed *Phragmites australis* (in 1975). This lead to the increase of the reed-bed in the lake. The previously floating *Phragmites*-inlets became anchored. They increased both in numbers and in surface area. All the events mentioned above changed the habitat features in a way that it became a wintering place for *Anser albifrons* and *Anser anser*. The first census of these geese in 1977 showed that about 10,000 individuals overwinter there. This number did not change significantly in the following years. According to our previous count-speculations it could be proposed that minimum about 1,000 kg excrements per day (about 60,000 kg per season) are involved in the nutrient cycling in the lake. The increase of dead reed material and bird excrements together with the agricultural policy to use artificial fertilizers seems to be the reason for the detected increase of SO_4, PO_4 and N (NH_4 and NH_3) in the lake waters (**Table 1**).

During the same period a decrease in the species composition of fish stocks was detected; from 19 species reported by Bulgurkov (1958), only 6 remained in the period of 1954-80 (Michev, 1968, 1981). Reptiles and amphibians were represented by 11 species (Paspaleva-Antonova, 1961; Michev - unpubl.).

There were different trends in the development of the ornithofauna during this long period (1949-1983). On one hand, at first a kind of enrichment was observed. This enrichment was due to the returning of big heron colonies to the reserve territory. The special cause for this event was not connected with the habitat changes.

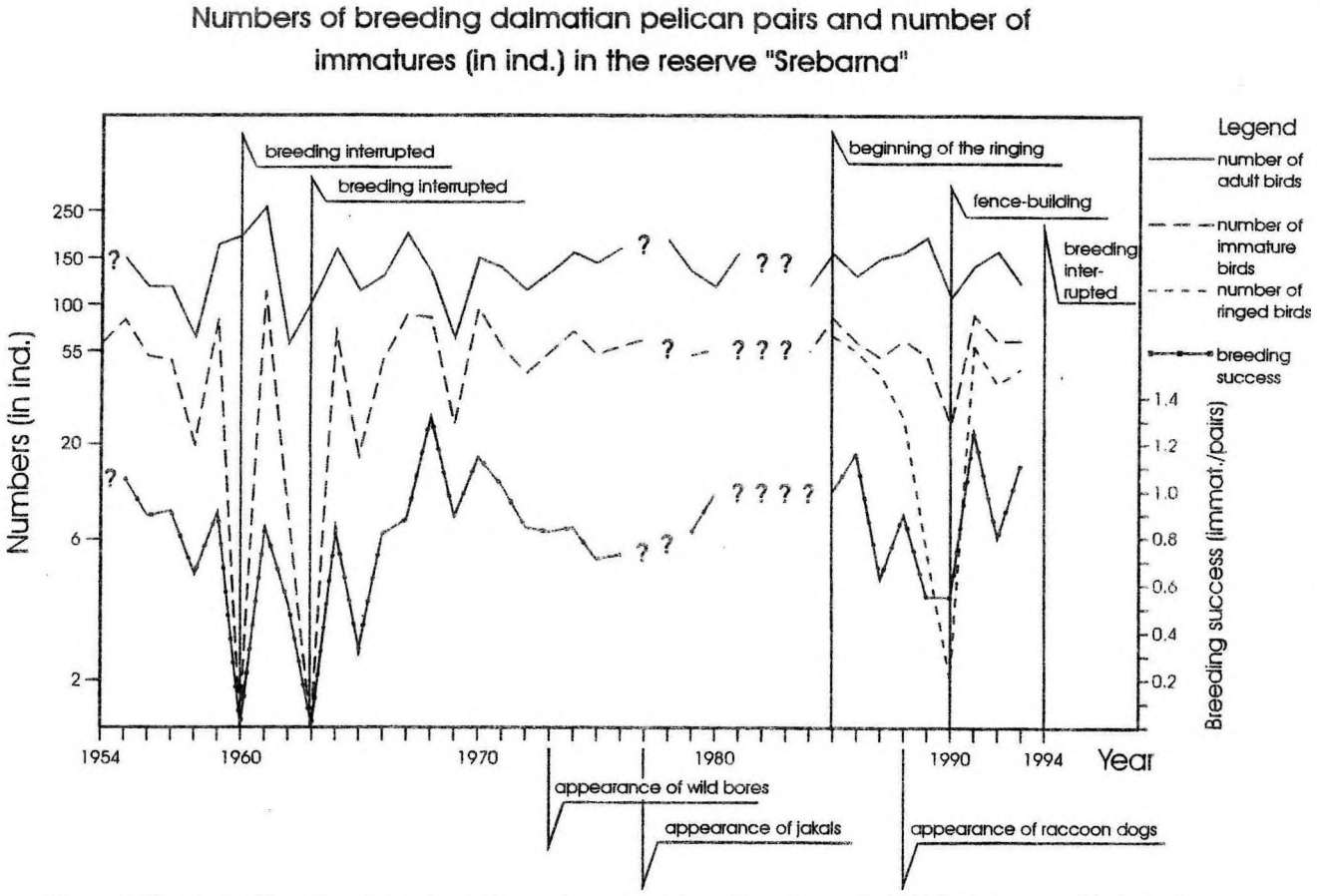

Figure 1: Numbers of breeding dalmatian pelican pairs and number of immatures (in ind.) in the reserve "Srebarna"

Such a cause was the lack of harassment of the herons after the imposed restrictions on their persecution in Bulgaria in the period 1944-1958. But afterwards, the number of species and abundance of waterfowl decreased. Paspaleva-Antonova (1961) in her list of species breeding in Srebarna (totally 33) did not include *Plegadis falcinellus* (compare with the text above). During the period 1966-67 the reserve became more important as a migration point for the waterfowl, than as a breeding place because of its changed habitat features and increased anthropogenical influence (Paspaleva, Michev, 1971). It is noteworthy to mention that the numbers of Dalmatian Pelicans varied during the period 1954-80 (Michev, 1981). He detected the interruption of their breeding in 1960 and in 1963 and increase in numbers after 1975 (**Figure 1**), when the direct anthropogenic influence was forbidden by law.

In our opinion the enrichment of species list, mainly during the period 1961-1975, could be explained with much more intensive ornithological studies carried on the reserve. I.e. Paspaleva-Antonova (1961) reported 144 psecies, whereas in the paper of Michev (1968) this number increased to 152. According to the unpublished data of the latter author the total number of bird species recorded in the reserve is 178.

The cladoceran character of the zooplankton by Naidenov (1965) was shown. The data on the lower flora of the lake from this period (Vodenicharov, 1962; Vodenicharov et al., 1971) are scarce and incomparable with the previous publication of Petkoff (1911). But it must be noted that algal blooms had not been reported. The investigations of the higher flora and vegetation (i.e. Ganchev, 1957; Vihodcevski - in Paspaleva- Antonova, 1961; Kochev, Jordanov, 1981) showed the dominance of *Phragmites australis* and existence of 67 plant species. Among them 13 were representatives of the Bulgarian Red Data Book (1984). The *Populus* plantations around the lake with their high transpiration activity have negative influence on the water regime of Srebarna since they were created.

CHANGES IN THE ECOSYSTEM AFTER DYKE REMOVAL IN 1983

The above mentioned changes in the ecological situation in the lake were the reason for the further activities of the scientists from BASc against the dyke. A lenght of 500 m was removed in 1983. During the first three years the Danube waters entered the lake and a

considerable increase of the water volume was observed and for a short period the maximum depth became again 3.5 m. This resulted in an overflow of many of the floating reed-inlets and afterward in the re-elevation of the particularly decayed dead inlets. In the same time many previously anchored inlets (including the big islet with colony of *Pelecanus crispus*) became free again and their movement and distribution in the lake followed the changes in the water level and wind direction. In this way the position of many channels in the lake were changed and the open water surfaces increased. We have to mention especially that the increase of the open water surfaces increased. Also noteworthy is that the increase of water level restored the open water surface strip between the bank and the reed-belt. Thus the nutritional basis (mainly small fish and invertebrates) for many waterfowl representatives was recovered and was available again. A re-enrichment of species composition of the birds was detected (Michev, unpubl. data) and we can only speculate that the number of bird species in this period were more or less the same as in 19th century. In the same time high concentrations of DDT in the pelican eggs were detected (Michev, Dilchev, 1985). The species composition and numbers of fish fauna increased to 9 species with large populations (Michev *et al.*, 1993). The algological investigations during this period (1982-1985) showed the specific character of the pools among the reed-belt (Stoyneva, 1991; Stoyneva and Draganov, in press). Totally 411 algal taxa (except diatoms) were recognized so far in the lake (Stoyneva and Draganov, 1994).

Danube waters did not enter the lake any more after 1988. Together with the pumping-out of the ground waters this lead to drastic changes in the total lake ecosystem. First of all the water level was diminished and a shallowing was detected. (The depth of the water column decreased to 15 cm in 1993 - Michev *et al*, 1993; Stoyneva, 1994). Again, the surface and the thickness of the floating reed-inlets increased and the nesting habitats of many waterfowl species became available for jackals, foxes, raccon dogs (a new species in the mammal fauna of the lake) and wild boars. They destroyed the nests and eggs of many species. The counts from these period showed the drastic decrease in species numbers and abundance of the birds. Only pelicans (with nutritional basis in Romania) and several trivial species (*Acrocephalus scirpaceus, A. arundinaceus, Gallinula chloropus, Fulica atra, Anas platyrhynchos, Pica pica*) remained in the lake. The numbers of pelican birds and of breeding pairs increased after 1990 because of the especially built Danube island wich recently (1994) is included in the

reserve territory. Another, additional reason for the decrease of species composition and abundance of the birds was the elimination of many vineyards and orchards in the western part of tha lake in 1983. This became very damaging because of the heavy rains and storms in this part of Bulgaria. Large amounts of soil masses were carried into the lake and on the background of the diminished water quantity this became one of the most important reasons for the strong eutophication and speeded-up succession of Srebarna. The eutrophication was detected by chemical analyses (Michev *et al.*, 1993 and Radev *et al.*, 1993, Table 1) and changes in zooplankton and zoobenthos communities towards decrease in species composition and abundance (Kraeva, 1992; Radev *et al.*, 1993) as well as by a shift in algal communities and appearance of blue-green algal blooms (Stoyneva, 1994). A strong pyrrhophyte bloom was detected also in 1993 (Michev *et al.*, 1993 - manuscript). Changes appeared in the species composition and abundance of higher flora and vegetation of Srebarna: the number of species decreased (from 157 in 1975-1989 to 136) and some of the rare and threatened species disappeared (i.e. *Aldrovanda vesiculosa*, *Stratiotes aloides*, *Carex disticha*, *Nuphar lutea*) or diminished their populations (i.e. *Nymphaea alba*), whereas for other trivial species (mainly *Phragmites australis* and *Typha angustifolia*) an "offensive" was detected (Baeva, 1992). *Phr. australis* showed pronounced morphometrical changes (diminished sizes) in the last years (Baeva, 1994). Many animal species disappeared from the reserve territory. The globally threatened *Astacus astacus*, *Hirudo medicinalis* and *Lutra lutra* among them.

CHANGES IN THE ECOSYSTEM AFTER THE BUILDING OF A NEW CANAL BETWEEN THE LAKE AND THE DANUBE RIVER IN 1994

All the events mentioned above were the reason to alarm the Ramsar Bureau and with its help and with the financial support of the World Bank a new canal between the lake and the Danube was built in May 1994. The most important change observed was the increase of water volume (depth of 1 m) and observed appearance of zoobenthos and of some representatives of the charophycean algae in the phytobenthos of the lake. A complex monitoring program started (October 1994) and it is possible to predict that hte regular entrance of Danube waters would stop the enforced succession of the lake. In this way we expect the returning of the

colonies of the waterfowl representatives which recently breed on the neighbour Danube islands.

CONCLUSIONS

The long-term observations of the waterbirds and the complex limnological situation of the lake allowed us to conclude:

1) The case of Srebarna gave an excellent example of the statement that the abundance and distribution of birds (and especially of waterbirds) depends on many different and sometimes even contradicting factors. That is why it is impossible to detect the early stages of changes in wetland habitats only by changes in bird populations and colonies.

2) The waterbirds and especially the pelicans are more or less conservative element of limnological systems and their reaction to changes in the habitat quality sometimes is not so immediate. Taking into consideration the nest-conservative behaviour and genetic breeding memory it is necessary to stress that the feeding activity of waterbirds (especially of fish-eating ones) is much more important indicator than that of their nesting.

3) According to our observations in the case of Srebarna the Glossy Ibises were much more sensitive to habitat changes than the other waterfowl birds. The colonies *of Plegadis falcinellus* were the first that left the lake territory. Thus, it is possible to propose that this species could provide sufficient indicative information on wetland habitat quality.

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