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The Ferruginous Duck *Aythya nyroca* as a potential indicator species for tracking ecological changes at the Srebarna Lake managed reserve (NE Bulgaria)

Kostanjevka *Aythya nyroca* kot potencialna indikatorska vrsta za spremljanje ekoloških sprememb v upravljanem rezervatu jezera Srebarna (SV Bolgarija)

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As the Ferruginous Duck *Aythya nyroca* has always been numerous at Srebarna Lake, it is an obvious choice as a biomonitor. Long-term data on the number of Ferruginous Ducks at Srebarna Lake has been collected since 1987. Despite much speculation on the relationship between Ferruginous Duck numbers and ecological change at Srebarna, this is the first attempt to quantify this statistically. In this paper I have tested, for correlation, the species numbers with a number of limnological parameters – water level, chlorophyll a, dissolved oxygen, zoobenthic biomass, zooplankton biomass and water transparency. Significant positive correlations were found with water level, and water transparency, and a significant negative correlation with the concentration of chlorophyll a. The significance of these correlations increased when ecological parameters were tested with the numbers of Ferruginous Ducks present in the next year. These significant correlations with changes in the ecological parameters suggest that the Ferruginous Duck could be an important indicator species for the condition of wetlands and the Srebarna Lake managed reserve in the specific case.

Key words: Ferruginous Duck, *Aythya nyroca*, Srebarna Lake, indicator species, wetland change, limnology
Ključne besede: kostanjevka, *Aythya nyroca,* jezero Srebarna, indikatorska vrsta, spremembe v mokriščih, limnologija

1. Introduction

Ferruginous Duck *Aythya nyroca* is a species of global conservation concern that was in the middle of the last century classified as Vulnerable (Collar *et al.* 1994). Following some high number counts during migration in various countries across Asia, the species was lowered to the Near Threatened category (BirdLife International 2000). However, the population decline in Europe continues (Robinson & Hughes 2003) and most of the studies on the species are focused largely on numbers and distribution, while the habitat requirements and characteristics are often neglected (Robinson 2003). All information on the habitat characteristics so far has been descriptive and no quantitative and qualitative study has been performed.

Generally it is accepted that the Ferruginous Duck inhabits shallower, well-vegetated wetlands of various kind (Cramp & Simmons 1977). The knowledge of the habitat requirements of the species is key data for motivated habitat management of breeding sites and conservation activities on the species.

Srebarna Lake is situated in northeastern Bulgaria, on the Bulgarian bank of the Danube, beside the village of Srebarna. It is the only Danube riverside lake in Bulgaria that has survived the drainage campaigns of the 20th century. It was declared as a protected area 55 years ago due to its unique bird diversity. There has been much speculation on the relationship between Ferruginous Duck numbers and ecological change at Srebarna (Stoyneva & Michev 1997), but so far no statistical relation to wetland parameters has been

established. Since 1990, various ecological parameters of the wetland ecosystem have been monitored (Vassilev 2002). The Ferruginous Duck is known to inhabit luxurious wetlands with rich biodiversity and a diversity of microhabitats (Petkov 1997). Long-term data on Ferruginous Duck numbers has been collected in a standardised fashion at Srebarna Lake for many years. Here we discuss the use of Ferruginous Duck numbers as a biomonitor for tracking ecological change in the wetland ecosystem.

2. Materials and Methods

2.1. Data collection and analysis

Ferruginous Ducks were counted on a single day between the period 15 – 20 May, i.e. once the breeding season had already started. All birds were recorded whilst walking along the southern and western banks of the wetland. Data is stored in the BSPB/BirdLife Bulgaria National Data Bank for Ornithological Information. The Laboratory of General Ecology has collected data on lake limnology since the 1990's within the project concerning the ecological monitoring of restoration of Srebarna Lake water regime. Data on nitrate, phosphate, and ammonium ions were collected from 1998 – 2001. Data on zooplankton were collected from 1998 – 2000. Water level data were collected from 1991 – 2001 using the Baltic measuring system. The data analysis and correlations between Ferruginous Duck numbers and transparency and chlorophyll a covers a period of 8 years (1988 – 1991 and 1998 – 2001).

The raw data was log transformed for normalisation before Pearson Correlation analysis was applied. Though transparency, water level and chlorophyll a are interrelated, their relationship with Ferruginous Duck numbers were tested separately for different years using the Jundel Scientific Statistical package Sigma Stat ver. 1.0.

The various ecological parameters were tested for correlation with Ferruginous Duck numbers, firstly using duck numbers from the same year when the ecological parameters were measured and at the second test using duck numbers from the following year (as this may better reflect the effect of any limnological change). We presumed that the effect of poor limnological conditions resulting in poorer breeding result would reflect on the next year numbers through fewer yearlings for recruitment in the breeding population and some unsuccessful breeders looking for alternative sites elsewhere.

2.2. Study area

Srebarna Lake (UTM NJ08; IBA BG033; 44°07' N, 27°04' E) is situated on the south bank of the Danube River between kilometres 393 and 391 of the river, in northeastern Bulgaria, 18 km to the west of Silistra town near the village of Srebarna. The lake is situated 12 m a.s.l., has a surface area of about 350 ha, and a depth of 0.7 – 3 m. The wetland has extensive floating reedbeds consisting of Common Reed *Phragmites australis*, some Marsh Fern *Thalypteris palustris* and Grey Willow *Salix cinerea*. It is listed as a wetland of international importance under the Ramsar Convention, World Heritage Site, Important Bird Area and Biosphere Reserve. Under the national legislation, it is classified as a managed reserve. Map and location in the country is available from Kamburova (2005).

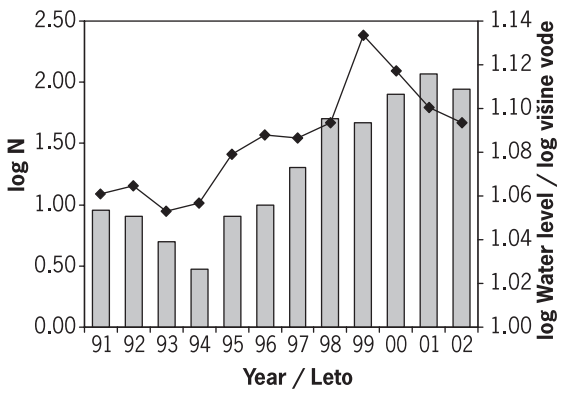

Figure 1: Trends in the Ferruginous Duck *Aythya nyroca* numbers and the water level at the Srebarna Lake managed reserve in the years 1991 – 2002 (values are log transformed)

Slika 1: Trend gibanja števila kostanjevk *Aythya nyroca* in višine vode v upravljanem rezervatu jezera Srebarna v letih 1991 – 2002 (vrednosti so logaritemsko transformirane)

The lake used to be annually flooded by the Danube, which purified the lake of detritus and mud sediments, but in 1949 it was disconnected from the river by a dike constructed to reclaim the marsh for arable land. In addition, since 1975 reed-cutting has stopped resulting in a large amount of organic material entering the ecosystem annually. In 1979, the dike was partially removed but only to the extent that very high waters of the Danube could enter the wetlands. As a result of human interference, the wetland ecosystem at Srebarna was disrupted, and the natural purification system stopped operating (Michev *et al.* 1998). A large silt layer then formed on the bottom of the lake,

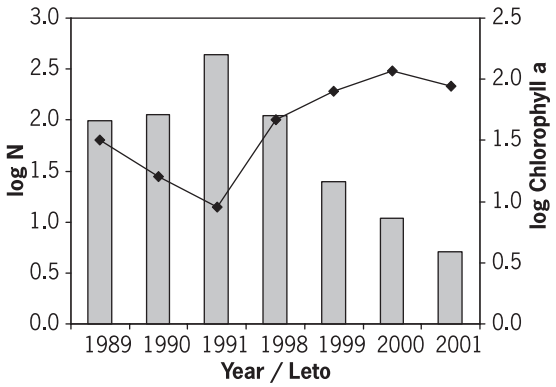

Figure 2: Trends in the Ferruginous Duck *Aythya nyroca* numbers and the chlorophyll a concentration at the Srebarna Lake managed reserve in the years 1989 – 2001 (values are log transformed)

Slika 2: Trend gibanja števila kostanjevk *Aythya nyroca* in koncentracije klorofila a v upravljanem rezervatu jezera Srebarna v letih 1989 – 2001 (vrednosti so logaritemsko transformirane)

which reduced water flow into the lake from karstic springs. These factors, combined with abstraction of water for irrigation and drainage of other parts of the Srebarna watershed, resulted in the lake gradually drying up. The last inflow of water from the Danube was in 1988, and by 1993 – 1994 the lake was only some tens of centimetres deep. The lake turned into a hypereutrophic wetland with algal blooms, this process exacerbated by input of fertilisers from surrounding agricultural land. In 1994, an artificial canal was built to reconnect the wetland with the Danube and the lake has subsequently reformed.

3. Results

Ferruginous Duck numbers were positively correlated with water level (Figure 1 & 4; $r = 0.81$, $p = 0.001$, d.f. = 12) and water transparency (Figure 3 & 6; $r = 0.83$, $p < 0.01$, d.f. = 8), and negatively correlated with chlorophyll a (Figure 2 & 5; $r = –0.79$, $p = 0.019$). Using duck numbers from the following season in the analysis, an increase of the significance of these relationships was obtained (water level – $r = 0.87$, $p < 0.001$, d.f. = 11; water transparency – $r = 0.91$, $p < 0.005$, d.f. = 7; chlorophyll a – 0.89, $p < 0.001$, d.f. = 7; Fig. 2). All other tested parameters – nitrate, phosphate, ammonium ions, dissolved oxygen, zooplankton and zoobenthos – did not show any significant correlation.

4. Discussion

In the 19th and early 20th century, the Ferruginous Duck used to be one of the most common breeding species in Bulgarian wetlands (Petkov 1997) and has always had historically a significant breeding population in Srebarna Lake. Even when the national population began to decrease, the species in Srebarna Lake was still a common breeder (Patev 1950). The data from the National Ornithological Database with the BSPB/BirdLife Bulgaria show that since the mid-1980s the species population started to decrease dramatically. The last inflow of Danube waters was in 1989 and the Ferruginous Duck population experienced some slight increase and then around the mid-1990s, when the Lake was at its worst stage. With water depth of a few tens of centimeters, the species almost became extinct as a breeder with just single individuals still being present there. Since the restoration of the Danube River – Srebarna Lake connection through a canal, the Ferruginous Duck started a notable gradual recover (Petkov 2000). The only previous

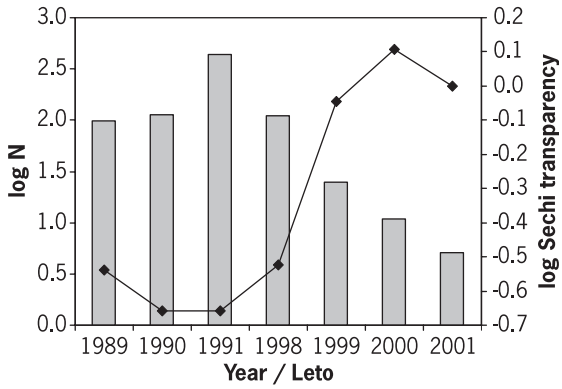

Figure 3: Trends in the Ferruginous Duck *Aythya nyroca* numbers and the Sechi water transparency at the Srebarna Lake managed reserve in the years 1991 – 2002 (values are log transformed)

Slika 3: Trend gibanja 'tevila kostanjevk *Aythya nyroca* in prozornosti vode (Sechi) v upravljanem rezervatu jezera Srebarna v letih 1989 – 2001 (vrednosti so logaritemsko transformirane)

study of waterbird numbers and wetland change at Srebarna Lake (Stoyneva & Michev 1997) did not find any significant statistical relationships. The authors suggested the Glossy Ibis *Plegadis falcinellus* as a good indicator of wetland change. This, however, was based on expert opinion rather than on solid data and statistical correlation. The results of the present

data analysis prove statistically that the changes in the Ferruginous Duck breeding population numbers reflect the ecological changes at Srebarna Lake since the 1980s. The species is totally dependent on wetlands and well-expected result for a diving duck is the fact that the water level changes influence the wetland suitability for the Ferruginous Duck. The studies of Reitan and Sandvik (1992) and Kosinski (1999) show the importance and influence of the water level on the number of *Anas* and *Aythya* species breeding pairs. The Ferruginous Duck has been recorded to abandon wetlands, which experience fluctuations in water level (Petkov 2000), especially when their preferred shallow bankside habitats disappear (Petkov 2004). Water level reduction during the breeding season also leaves many nests accessible to terrestrial predators. At Srebarna Lake, the Ferruginous Duck nests mainly on floating reedbeds or on smaller pools within the reedbeds. Ducklings may be trapped in these pools when water level falls, as happened in 2002 (Petkov

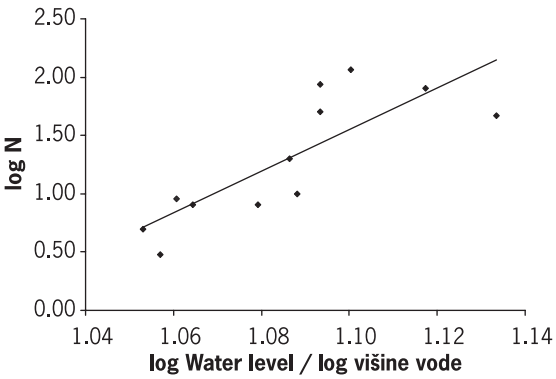

Figure 4: Correlation between water level and Ferruginous Duck *Aythya nyroca* numbers at the Srebarna Lake managed reserve in the years 1991 – 2002 (values are log transformed; r = 0.87, p < 0.001, d.f. = 11; Pearson)

Slika 4: Korelacija med nivojem vode in številom kostanjevk *Aythya nyroca* v upravljanem rezervatu jezera Srebarna v letih 1991 – 2002 (vrednosti so logaritemsko transformirane; r = 0.87, p < 0.001, d.f. = 11; Pearson)

2004). In 1999 there was a slight drop in Ferruginous Duck numbers, which might be related to the fact of too high waters that flooded the lake too late during the breeding season and might have drowned some nests. Fluctuation in numbers was obvious in the last 3 – 4 years since 2001, when subsequently with reduction in water level the numbers of the Ferruginous Duck have been decreasing, but went up again with the improvement of the water level. The influence of the water level should not be simplified just to the water depth. The influence is more complicated and related as well to the disappearance of some microhabitats in the wetland, which are important for the species as foraging or resting sites – mainly the shallow vegetated areas or mudflats on the western and south western bank of the lake (Petkov 2004). The waterbirds are influenced by water level variation both directly and indirectly. Some studies have shown that species and groups of species like grebes, diving and dabbling ducks can indicate water level changes (Frederickson & Taylor 1982, Frederickson & Reid 1988, Short 1989).

The correlation between the Ferruginous Duck numbers and chlorophyll a and water transparency (turbidity) is an indication of the influence of the trophic condition of the wetland on the species breeding population in the wetland. These influence the benthic community and submerged vegetation, both of which are a food resource for the species. Before the river connection was restored in 1994, the benthic community was totally suppressed by the hypereutrophic conditions of the wetland. The macrophyte community was in poor condition as well. The hypereutrophication has often been suggested as a reason for the disappearance of the Ferruginous Duck from various wetlands (Callaghan 2001). This is related to the benthic community that prior to the restoration of the water level and connection with the Danube River was suppressed by the hypereutrophic conditions in the wetland. Despite the fact that some researchers have suggested that Ferruginous Ducks prefer oligotrophic conditions (e.g. Zhmud 2003), most breeding habitats are found to be eutrophic wetlands (Robinson 2003). Perhaps, however, there is a eutrophic tolerance threshold of the species, related to its foraging requirements and which, if breached, the breeding population is suppressed or starts to decrease.

The increased significance of correlations using a one year time delay in Ferruginous Duck numbers suggest that though ecological parameters might have some immediate effect on the species population, there is a greater effect in the next breeding season. This may be the result of reduced breeding success in the previous year, through the effect of homing of the breeders and the recruitment of new breeders (Johnson *et al.* 1992) or improved success respectively when numbers increase. Thus when breeding success is poor there are fewer birds joining the breeding population next year (reduced recruitment) and some of the unsuccessful breeders from previous year may be looking for more suitable breeding sites in other wetlands in the region – influencing the homing of the unsuccessful breeders.

5. Conclusions

According to Kantrud & Stewart (1984), the most sensitive to changes in the wetland ecosystem are those bird species that: a) nest in the periphery of the wetlands or close to water; b) forage in mudflats; c) require structured vegetation of the wetland and certain water regime. All these are typical characteristics of the Ferruginous Duck (Cramp & Simmons 1977, Bauer & Glutz 1969, Robinson 2003). Our recent studies on the species revealed that it shows preferences for foraging areas like mudflats and requires well structured and mosaic vegetation (Petkov 2004).

The Ferruginous Duck numbers are closely related to water and limnology parameters at Srebarna Lake and reflect the ecological changes in the wetland. Long-

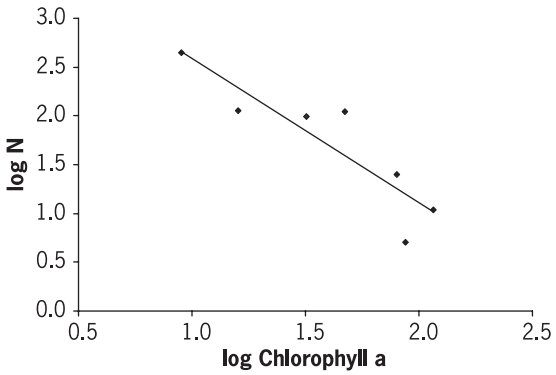

Figure 5: Correlation between chlorophyll a concentration and Ferruginous Duck *Aythya nyroca* numbers at the Srebarna Lake managed reserve in the years 1991 – 2002 (values are log transformed; r = 0.89, p < 0.001, d.f. = 7; Pearson)

Slika 5: Korelacija med koncentracijo klorofila a in številom kostanjevk *Aythya nyroca* v upravljanem rezervatu jezera Srebarna v letih 1991 – 2002 (vrednosti so logaritemsko transformirane; r = 0.89, p < 0.001, d.f. = 7; Pearson)

term data sets exist for the species and an effective monitoring scheme has already been established. The numbers of the Ferruginous Duck at Srebarna Lake mirror the development of the lake ecosystem from the second half of 20th century. The high correlation with important limnology parameters suggests that the Ferruginous Duck is sensitive to wetland conditions. Thus we recommend it be used as a biomonitor for the long-term monitoring programme at Srebarna Lake. Data on the species numbers should be collected using the same route, methods and time period (15 – 25 May) as this study. The sensitivity of the species to limnological change may be a reason for its decline throughout Europe. The importance

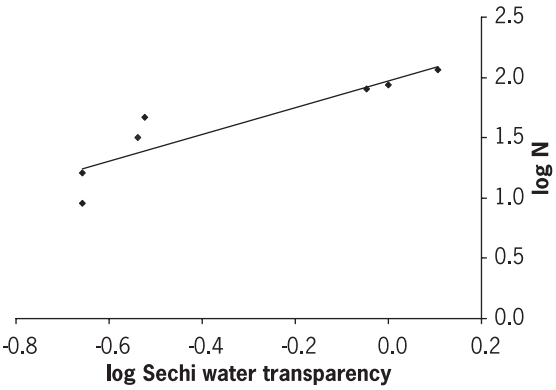

Figure 6: Correlation between Sechi water transparency and Ferruginous Duck *Aythya nyroca* numbers at the Srebarna Lake managed reserve in the years 1991 – 2002 (values are log transformed; r = 0.91, p < 0.005, d.f. = 7; Pearson)

Slika 6: Korelacija med prozornostjo vode (Sechi) in številom kostanjevk *Aythya nyroca* v upravljanem rezervatu jezera Srebarna v letih 1991 – 2002 (vrednosti so logaritemsko transformirane; r = 0.91, p < 0.005, d.f. = 7; Pearson)

of the Ferruginous Duck as an indicator of biological change should be explored further through an analysis of bird numbers and limnological parameters at other sites where sizable breeding populations of the species exist.

So far there has been no proof that a single bird species can indicate the integrity of a wetland ecosystem, but species with specific ecological requirements regarding their habitats can be used for bioindication purposes (Adamus 1996). It is very well possible that the specific habitat conditions in the wetland that favour the breeding requirements of the Ferruginous Duck – fairly large expanses of reedbeds, mosaic vegetation etc. to be favorable for other breeding species as well and thus the changes in the Ferruginous Duck population may indicate problems for other breeding species, which are more difficult to record and assess or have smaller populations.

6. Povzetek

Glede na dejstvo, da je bila kostanjevka vselej številna ptičja vrsta na jezeru Srebarna, se je zdela nadvse primerna za izbor kot indikatorska vrsta. Podatki o številu kostanjevk *Aythya nyroca* na jezeru Srebarna se v Bolgariji zbirajo že od leta 1987. Kljub precejšnjim špekulacijam o razmerju med številom kostanjevk in ekološkimi spremembami na Srebarni je to vendarle prvi poskus, da se to razmerje izmeri statistično. V pričujočem članku avtor ugotavlja korelacijo med

številom kostanjevk in več limnološkimi parametri, in sicer višino vode, klorofilom a, raztopljenim kisikom, zoobentoško biomaso, zooplanktonsko biomaso in transparentnostjo vode. Precejšnjo pozitivno korelacijo je ugotovil z višino vode in njeno transparentnostjo, precejšnjo negativno korelacijo pa s klorofilom a. Pomen korelacij se je povečal, ko so bili ekološki parametri primerjani s številom kostanjevk v naslednjem letu. Te precejšnje korelacije s spremembami v ekoloških parametrih namigujejo, da bi kostanjevka lahko bila pomemben kazalec razmer v mokriščih in, konkretno, v upravljanem rezervatu jezera Srebarna.

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