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Theses of doctoral (Ph.D.) dissertation

Waterbird monitoring of the southern shore of Lake Balaton

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Introduction

Numerous ornithological papers have been published about the avifauna of Lake Balaton; however, due to the complexities of research in this area, only a few comprehensive studies have been published about population changes of local waterbirds. In the 1970's ANDRÁS KEVE, in the 1980's ATTILA BANKOVICS, and in 2008 LAJOS NAGY *et al*. summarized the status of the waterbird population on Lake Balaton.

As of the beginning of the 21st century there was no current and detailed data available for the waterbird fauna of Lake Balaton. Thus a monitoring (South Balaton Bird Monitoring) was started in 2003 with the volunteers of South Balaton Nature Conservation Group (BirdLife Hungary). Monitoring was organised by the author of the current dissertation to systematically study the waterbird population of the southern shore and the surrounding wetlands of Lake Balaton. The main objectives of the survey were to explore the local waterbird communities and follow their population changes. Additionally, information was collected about habitat utilisation of the waterbirds, about relationships between waterbird communities of Lake Balaton and fishponds of the southern shore of Lake Balaton, as well as about effects of environmental factors such as low water levels.

Material and Methods

Study area

Lake Balaton is the largest lake in Central Europe with a surface area of approximately 600 km^2. The freshwater shallow lake is a wetland of international importance – classified as Ramsar Site (3HU012), Natura 2000 (HUBF30002) Special Protection Area and Site of Community Importance; furthermore, Important Bird Area.

Most of the lake's shoreline, especially the southern shores, are artificially created. The coverage of natural or semi-natural habitats is small and can mostly be found in the northern shoreline of Lake Balaton.

Survey methods

The survey of waterbirds was carried out according to the following themes:

- Monthly surveys at the southern shore of Lake Balaton at 18 study sites, on 60 observation days in a 5 year time span (2003–2008) for a total of 1048 observations.
- Autumn migratory and wintering population census on Lake Balaton and its surrounding wetlands (fishponds, marshes).
- Survey of the breeding waterbird population on fishponds at the southern shore of Lake Balaton between April and July.

Data analysis

Data was analysed (7 orders, 12 families, 78 species, 225108 individuals, 5784 database record) with Microsoft Excel 2010 and PAST v. 2.12 softwares. The following analyses were carried out:

- Waterbird population change: population change (chain) index, linear regression; t test, one-way ANOVA, post-hoc Tukey's HSD test.
- Species richness, number of individuals, constancy-, density- and dominance values.
- Diversity (α-diversity): Shannon-Weaver, Simpson, equitability and Fisher's α indices; comparing diversities: Rényi's diversity ordering, diversity profile, bootstrapping.
- Species similarity (ß-diversity): Sørensen and Bray-Curtis indices, cluster analyses (UPGMA).
- Rank-abundance plot: log-series (Fisher) model.

- Species accumulation curve (expected number of species): sample rarefaction, Michaelis-Menten extrapolating model, individual rarefaction.
- Habitat use: comparison with χ^2 test, Levins' niche (habitat) breadth (Simpson index), niche (habitat) overlap (Renkonen index), cluster analyses (UPGMA).
- Effects of enviromental factors: principal components analysis, Pearson's correlation

Summary of scientific results, theses

1. According to the monthly surveys, which took place between 2003–2008, a total of 86 species from 16 families and 10 orders were observed at the southern shore of Lake Balaton; from this a total of 78 waterbird species from 12 families and 7 orders were selected for analysis. The main taxonomic groups of the waterbird community were: Anatidae (56.3%), Laridae (22.8%), Rallidae (11.8%), Phalacrocoracidae (5.8%), Podicipedidae (1.4%) and Sternidae (1.2%) families.

2. Data was verified by species accumulation curves (species-observation days [number of samples], species-abundance, species-area), by sample rarefaction and by the Michaelis-Menten extrapolating model, all of which indicated that the survey (sampling technique) at the southern shore of Lake Balaton was suitable for analysing the faunistic aspect of community relations for key species of the Lake Balaton.

3. Based on the national and the international conservation status (IUCN Red List, SPEC categories, Bird Directive, Bonn Convention, Bern Convention) of the observed waterbird species the southern shore of Lake Balaton proved to be a highly important bird habitat. The abundance of the Great Cormorant, Greater White-fronted Goose, Greylag Goose and the Common Goldeneye population of the Lake Balaton fulfilled the Ramsar criteria according to which the population reached the 1% threshold.

4. Population sizes of the 16 common waterbird species of the southern shore of Lake Balaton between 2003–2008 were estimated as:
4.A. Population sizes of the Little Egret and the Great Egret were under 100 individuals;
4.B. Population size was estimated to be in the 100–1000 range for the species of: Great Crested Grebe, Mute Swan, Greylag Goose, Northern Shoveler, Tufted Duck, Mew Gull, Yellow-legged/Caspian Gull and Common Tern;
4.C. For the the Great Cormorant, Mallard, Common Pochard, Common Goldeneye, Eurasian Coot and Black-headed Gull population sizes were ranged over 1000 individuals.

5. According to the earlier and recently published references the populations of Little Egret, Great Egret, Northern Shoveler, Yellow-legged/Caspian Gull and Common Tern are concentrated mostly at the southern shore of Lake Balaton; therefore, their population sizes in this region serve as adequate reference for the rest of the Balaton. In case of the other less localised bird species observational data from the southern shore of the Lake can offer suitable estimation for the entire area of Lake Balaton.

6. Analysing the short term (2003–2008) population changes of the common waterbird species:
6.A. There was a strong increase observed in case of the Great Crested Grebe (182%±50%/year, p=0.05), Eurasian Coot (104%±17%/year, p=0.05) and Great Cormorant (35%±13%/year, p=0.1);
6.B. A strong decrease was observed in the populations of Great Egret (−18%±9%/year, p=0.1), Yellow-legged/Caspian Gull (−16%±5%/year, p=0.1) and Common Tern (−15%±7%/year, p=0.1);

6.C. There were no significant changes detected in population trends for the species of the Little Egret, Mute Swan, Greylag Goose, Mallard, Northern Shoveler, Common Pochard, Tufted Duck, Common Goldeneye, Black-headed Gull and Mew Gull;
6.D. Species that showed changes in population trends in all cases differed from each other at the national level. Similarly to the southern shore of Lake Balaton population trends of the Mute Swan, Mallard, Northern Shoveler, Common Pochard, Tufted Duck and the Common Goldeneye were shown to be uncertain.
6.E. Population trends of the Great Crested Grebe and Eurasian Coot were directionally similar to international trends (AEWA); however, tendency of the trends lagged behind of those observed at the southern shore of Lake Balaton. Population trends of the Little Egret and Common Goldeneye were also deemed uncertain. In respect of other species no similarity was found in population trends.
6.F. Based on the above results, strong increase in the population of the Great Cormorant, the Great Crested Grebe and the Eurasian Coot (in the case of the latter two species, at an international level only the rate of growth); as well as, a strong decrease in the population of the Great Egret were defined as a typical local trend of the southern shore of Lake Balaton.

7. Analyses of short term (2003–2008) population changes of such scarce waterbird species as the Grey Heron (−21%±7%/year, r^2=0.73, p=0.07) and the Herring Gull (−28%±9%/year, r^2=0.74, p=0.06) of the southern shore of Lake Balaton showed a strong decreasing trend.

8. Analysis of habitat utilization by common waterbird species over the study period:
8.A. According to Levin's measure of niche breadth, the most widely utilized habitat spectrum was seen in early spring, in summer, in early autumn and in autumn by the Great Cormorant, in the spring by the Black-headed Gull, in the winter and over the entire season by the Yellow-legged/Caspian Gull.
8.B. The Greylag Goose and the Common Tern had the smallest niche (habitat) breadths in early spring, the Little Egret and the Greylag Goose in spring time, the Common Pochard in summer, the Common Pochard, the Tufted Duck, the Common Goldeneye and the Mew Gull in early autumn, the Northern Shoveler in the autumn period, the Northern Shoveler and the Tufted Duck in winter while the Mute Swan had the smallest niche (habitat) breadth over the entire season.
8.C. Based on habitat utilisation characteristics (χ^2 test, niche overlap Renkonen index) of the waterbirds, three functional groups (feeding guilds) were identified. Away from the shore-line the pelagic zone: Common Goldeneye, Great Crested Grebe, Great Cormorant, Common Pochard, Tufted Duck and Greylag Goose. Near the shore-line the littoral zone: Great Egret, Mute Swan, Mallard, Northern Shoveler, Black-headed Gull and Little Egret. The transient group included the: Eurasian Coot, Yellow-legged/Caspian Gull, Mew Gull and the Common Tern.
8.D. Comparison of habitat utilisation along the various shoreline sections showed that Bélatelep, Balatonberény and Szántód are notably different from other shore-line regions in that occurrence of waterbirds in the pelagic zone was high (>50%). Diving ducks aggregated mainly in this zone and as much as 90% of the Tufted Duck population was also observed in this pelagic zone.

9. In terms of phenology of waterbird species at the southern shore of Lake Balaton during the survey period the following observations were made:
9.A. The period between early autumn and winter is the most important as most of the bird species can be observed at this time.
9.B. The Great Crested Grebe, the Great Cormorant, the Mute Swan, the Mallard, the Common Pochard, the Black-headed Gull and the Yellow-legged/Caspian Gull were present throughout the entire year.

9.C. The maximum population sizes (MPSs) of Great Crested Grebe were in April and October, MPSs of Great Cormorant and Mallard were in December, MPS of Mute Swan was in September, MPSs of Common Pochard and Tufted Duck were in November and March; MPS of Common Goldeneye was in January and March, MPS of Eurasian Coot was in October and November, MPS of Black-headed Gull was in September and January, MPS of Mew Gull was in December and January, MPS of Yellow-legged/Caspian Gull was in August and MPS of Common Tern was in July and August.

10. Analysis of spatial distribution patterns of waterbirds between 2003–2008:
10.A. Species richness and number of individuals were highest at Szántód.
10.B. Highest abundance of waterbirds on any given day was observed at Balatonszabadi.
10.C. The Balatonszárszó and Fonyód–Balatonboglár sites were also important shore-line sections; however, Balatonmáriafürdő significantly lagged behind from other regions.
10.D. Great Crested Grebes, the Great Cormorant, the Mute Swan, the Mallard, the Common Goldeneye, the Black-headed Gull, the Yellow-legged/Caspian Gull and the Common Tern were observed at all shore sections.
10.F. Mallards had the most consistent occurrence at the shore-line sections of the southern shore of Lake Balaton.
10.G. In regards to the most notable species the site at Szántód was important for the Great Crested Grebe, the Common Pochard, the Tufted Duck, the Common Goldeneye and the Eurasian Coot (for diving ducks Bélatelep shore-line section was also essential and for Eurasian Coots Fonyód–Balatonboglár and Balatonföldvár sites were highly utilised). Balatonszárszó and Szántód sites were important for the Great Cormorant and the Yellow-legged/Caspian Gull. Fonyód site was important for the Mute Swan and the Mallard (Balatonboglár, Fonyódliget and Balatonfenyves sites were also essential for Mallards). The Balatonszabadi site was important for Black-headed Gulls and the Mew Gull (Balatonboglár, Szántód and Siófok shore section were also essential for Black-headed Gulls). Balatonszárszó site was important for the Common Tern who was also found in abundance at Fonyód and Balatonboglár.

11. Analysis of Lake Balaton's southern shore waterbird community during the study period:
11.A. Average population size of waterbirds at the southern shore of Lake Balaton was 3752 ind./day, density was 59.6 ind./km^2 and mass density was measured to be 76.18 kg/km^2.
11.B. Between 2004–2005 and 2005–2006, population size of waterbirds fell below average. There was a decreasing tendency observed in population change; however, its trend was not significant (r^2=0.24, F=0.95, p=0.40). Nevertheless significant difference was observed in population size for each year (ANOVA F=2.33, p=0.05) and there was significant difference between populations of the third study year and the first year (Q=3.84, p=0.05).
11.C. In terms of annual distribution, waterbird numbers were the lowest in February and from April to August; in December to January waterbird numbers were double of the average population size. Significant seasonal differences were found (ANOVA F=21.61, p=0.000). Lake Balaton is more important for the waterbird population during the autumn migration and winter period than it is during the breeding period. The autumn and winter periods significantly differed from the other seasons (Q=4.64–11.89, p≤0.01). Lake Balaton is less important during the spring migration period compared to the autumn migration period (between spring and early autumn Q=4.71, p=0.01).
11.D. Species richness was highest during the first observation year, and the lowest during the third year. Species composition (ß-diversity) of the first year was significantly different from those of the other years. Highest actual number of species was observed in September, but highest numbers based on the five year average of our study period were seen in November. Least number of species was recorded in June. The lower numbers of waterbird community during the breeding period can be readily separated from the migratory and wintering populations which was also confirmed by Sørensen and Bray-Curtis similarity indices.

11.E. Mallards were observed in the highest numbers and Mute Swans had the highest mass density value. In terms of number of individuals, Black-headed Gull, Eurasian Coot and Common Goldeneye were subdominant; Common Pochard, Yellow-legged/Caspian Gull, Great Cormorant, Mute Swan, Greylag Goose, Tufted Duck, Great Crested Grebe, Mew Gull and Common Tern were accidental species while 65 bird species classified as rare were also observed in the area. In terms of dominance relations, Mallards were the dominant species for most of the year, except during the summer period. In early spring Common Goldeneye and Common Pochard were present in highest proportions, in summer Black-headed Gull and Yellow-legged/Caspian Gull were in largest numbers, in early autumn the Mallard and Black-headed Gull had the highest presence in the region; whereas, in autumn the Eurasian Coot occurred in the highest numbers.

12. By comparing waterbird communities of Lake Balaton to fishponds and marshlands of southern Lake Balaton, differences were not found in population sizes of the autumn migration and wintering periods (t test $t=0.79–1.83$, $p=0.07–0.43$); however, significant differences were found in population sizes of the nestling period (t test $t=2.19–3.92$, $p\leq0.03$). The two areas were characterized by unique species composition which was even more prominent during the nestling period. Fishponds and marshlands along southern Lake Balaton are also important international wetland habitats which also play an essential role regionally in the autumn migration and wintering of birds; as well as, it has key importance during the breeding period.

13. Conclusions about the effects of environmental factors on waterbird populations:
13.A. Environmental factors had the greatest impact during nestling periods. The effects of environmental factors were found to be lowest in the winter; whereas, temperature rise was the only factor to have a positive influence on waterbird population size.
13.B. In terms of impact on the waterbird population temperature change played the most important role, followed by water level changes and lastly atmospheric pressure of least importance.
13.C. Temperature change had significant influence on the populations of Great Crested Grebe, Great Cormorant, Egrets, Mute Swan, Mallard, diving ducks (Common Pochard, Tufted Duck, Common Goldeneye), Eurasian Coot, Yellow-legged/Caspian Gull and the Common Tern. The correlation was negative in the breeding period of Great Crested Grebe and in the migration period of Great Cormorant and diving ducks ($r=-0.5–0.7$, $p\leq0.03$); in other cases the correlation was positive ($r=0.5–0.7$, $p\leq0.03$).
13.D. Water level changes had positive influence on the population size of Yellow-legged/Caspian Gull ($r=0.5$, $p=0.02$), but had negative influence on the population size of Mute Swans, Mallards, Black-headed Gulls, Common Terns, Egrets, dabbling ducks and shore birds ($r=-0.4–0.8$, $p\leq0.05$).
13.E. Atmospheric pressure had a significantly negative impact on the population of the Great Crested Grebe and the Great Cormorant ($r=-0.5–0.6$, $p\leq0.03$).

14. Unique habitats such as sand grits; which were created by lower water levels, had a positive effect on the bird community of Lake Balaton. In the breeding period a negative correlation was found between water levels and number of waterbird species; as well as with number of individuals, also a negative correlation was found between water levels and the population size of Mute Swans, Mallards and the Common Tern ($r=-0.4–0.6$, $p\leq0.05$). During the migration period, a strong significant correlation was found: (1) between water levels and number of waterbird species; as well as, number of the individuals of waterbirds and (2) between water levels and the population size of Mallards, Black-headed Gulls and Yellow-legged/Caspian Gulls ($r=-0.7–0.8$, $p\leq0.002$). Lower water levels had a positive effect on the occurrence of Egrets, dabbling ducks ($r=-0.6$, $p\leq0.000$) and shore birds ($r=-0.4$, $p=0.05$) over the five year study period.

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