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Demographic study of some Hungarian breeding warblers (*Sylvia* spp., *Curruca* spp. and *Phylloscopus* spp.)

Theses of doctoral (PhD) dissertation

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1. Introduction

Birds are the most abundant terrestrial vertebrates and also the most studied group; for most species their distribution, breeding range, habitat requirements, behaviour and migration routes are well known. For this reason, their role is growing in biodiversity monitoring studies as indicator species, because they indicate an environmental factor or a change in it by their absence, presence, abundance, or behaviour.

The quality of a habitat can be well characterised by the diversity or number of nesting and migratory bird species; thus, the habitat changes can be detected by changes in the number of species and individuals of birds.

The population trends of passerines show considerable variation between species and geographical scales. The annual cycle of passerines, their diet, habitat selection, migratory strategies, and environmental factors on the breeding or wintering grounds and along the whole migration route strongly determine their population dynamics. It is difficult to separate whether the cause of population changes are in the breeding grounds or out of it. We need to monitor the whole annual cycle to determine it. Population size and the number of returning adults in a given year – and thus population changes in the wintering area and during migration – can be assessed by monitoring spring migration in the stopover sites so it is easier to distinguish between changes in the wintering and the breeding area.

When considering the changes in a species' population, we need to analyse the effects on the breeding site separately, during migration routes and on the wintering grounds. Long-term changes are primarily determined by breeding success, which depends on the quality of the breeding habitat and the processes that occur in the breeding area. Wintering grounds can influence population size through survival rates. During migration there are additional losses, which should be counted to the survival rates as well. However, these losses can be compensated by higher productivity during the breeding season up to a specific limit. Weather conditions may also affect those trends locally.

In my research I have processed a long-term (15 years) data set of passerine species ringed during the breeding season. These data show the changes in local and regional population dynamics, and also allow the detecting of climatic and other environmental causes of these reasons. Furthermore, based on these data I could determine the breeding success and apparent survival rates as well.

2. Aims of the study

We now have a wide range of knowledge about birds and the various behaviours and environmental needs of different species, yet many questions remained to be answered in the light of recent major changes.

During my research, my aim was to obtain information about the population dynamics of the studied species based on bird ringing data from the CES program in Hungary between 2004-2018 and to explore the reasons for these demographic changes.

I asked the following questions:

1. Whether the population dynamics parameters (abundance, productivity) of genera *Sylvia*, *Curruca,* and *Phylloscopus* can be estimated based on long-term ringing data?

2. Are there any differences in the population changes between age classes of the studied species?

3. Are there correlations between the demographic parameters (annual captures and productivity) of each species?

4. Are there any differences in the population changes between migration strategies of the studied species?

5. Could the preferred habitat play a role in the population changes of the studied species in Hungary?

6. Are there differences in demographic trends between methods based on observation datasets (MMM) and bird ringing datasets (CES)?

7. Does the capture time of the first fledgings differ between species over the studied period?

8. Can the apparent survival and capture probabilities of the studied species and their age, sex and time dependency be estimated using long-term ringing data?

9. Can the degrees of dispersal or site fidelity be determined based on the capture and total recapture data of the studied species?

10. Are there relationships between the observed demographic trends and changes in temperature and precipitation?

3. Material and methods

In my theses, the demographic changes of the Hungarian breeding warblers (*Sylvia, Curruca,* and *Phylloscopus*) and their possible reasons were studied. Data was obtained from a CES ringing scheme using 18 ringing sites spread over Hungary (Figure 1), spanning 14 years (2004 to 2018).

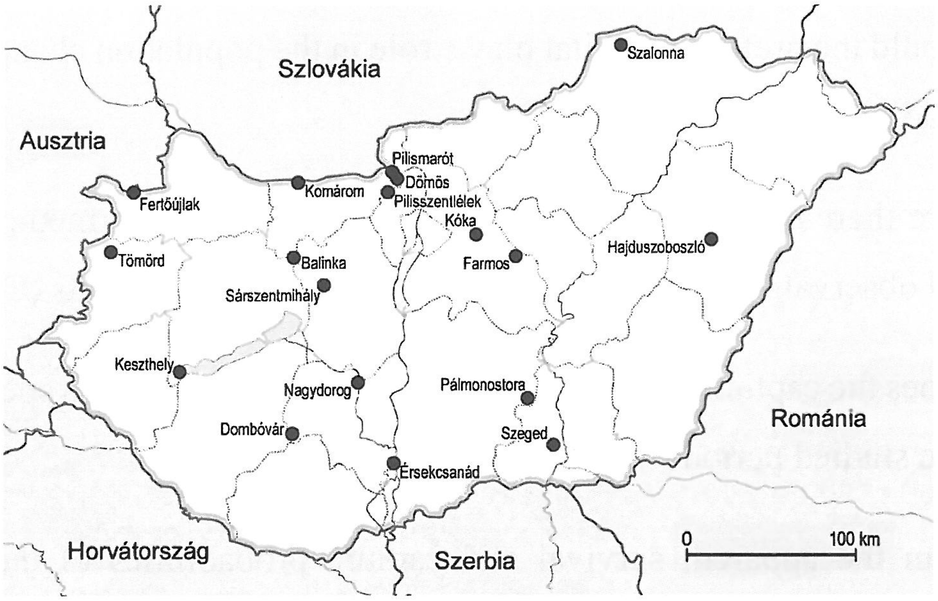

Figure 1.: Locations of the concerned ringing sites in Hungary

In this study, the capture and recapture data from Hungarian Constant Effort Sites (CES) were used. This is an international bird ringing program during the breeding season, with which we can monitor the demographics of the local breeding populations.

The Hungarian CES program was started in 2004. The purpose of the CES program is to monitor the breeding populations based on the mark-recapture standard method; the numbers, locations, types, and lengths of mist nets on a certain site were constant between years, but each site used different amounts of mist nets. The CES program covers the breeding period, which in Hungary spread out from 15 April to 13 July. There are 9 visits during the season, each separated by at least five days (*table 1.*). Ringing sessions lasted from sunrise to noon.

table 1.: The intervals of sampling periods (CES visits)

Number of visits	starting date	ending date
1.	15. April	24. April
2.	25. April	4. May
3.	5. May	14. May
4.	15. May	24. May
5.	25. May	3. June
6.	4. June	13. June
7.	14. June	23. June
8.	24. June	3. July
9.	4. July	13. July

Ringers also determined biometrics data of the ringed individuals. However, in this research, I used age and sex data of birds exclusively. In the breeding season, the age and sex in all studied species were determined based on brood patch, cloaca shape and plumage features. First year birds that hatched in the year of ringing were classified as juveniles, and signed "1y" or "1", while all older birds, that hatched in earlier years were determined as adults and signed as "1+".

Based on the obtained data, the population trends of birds ringed as juveniles or adults were determined, and their productivity considering the proportion of the first-year birds to the total captures.

The ringing data were collected from 18 CES ringing sites spread over Hungary (Fig. 1).

The ringing sites can be categorized into three main habitat types: forests, shrublands, reedbed and they can often affect more than one type.

The studied species were from genera *Sylvia*, *Curruca,* and *Phylloscopus* which are breeding in our country:

- Eurasian Blackcap - *Sylvia atricapilla* (Linnaeus, 1758)
- Garden Warbler - *Sylvia borin* (Boddaert, 1783)
- Barred Warbler - *Curruca nisoria* (Bechstein, 1792)
- Lesser Whitethroat - *Curruca curruca* (Linnaeus, 1758)
- Common Whitethroat - *Curruca communis* (Latham, 1787)
- Wood Warbler - *Phylloscopus sibilatrix* (Bechstein, 1793)
- Willow Warbler - *Phylloscopus trochilus* (Bechstein, 1793)
- Common Chiffchaff - *Phylloscopus collybita* (Vieillot, 1818)

These closely related species have similar environmental requirements, but they have very different habitat selection on breeding grounds and different migration strategies as well, so they respond differently to the change of particular environmental factors.

Among these species there are a few forest birds like blackcap, garden warbler, lesser whitethroat, wood warbler, willow warbler and common chiffchaff, and some agricultural species like common whitethroat and barred warbler. Moreover, two species (blackcap and chiffchaff) are short-distance migrants, the remaining species are long-distance migrants and spend the winter south of the Sahara.

In order of understanding the ornithological results, the annual capture data and productivity of each species were compared with temperature and precipitation data. These data were collected by the National Oceanic and Atmospheric Administration (NOAA) were extracted from the National Centers for Environmental Information (NCEI) system. This system can offer data by reanalysis method on the exact location of the ringing sites. I have used the annual, and the monthly (from April to July) average temperature, and total precipitation.

3.1 Data evaluation

The data had to be standardized; I calculated with 1000 m^2 net surface and 54 hours (6 hours per day for 9 days) on each site to make them comparable. The data were pulled to determine the countrywide demographic parameters of the age groups of each species.

Two age groups were used: the juveniles (the 1st year birds = ”1”) and the adults (the older individuals = ”1+”) and the productivity was determined (the rate of adults and juveniles) as well.

Linear regression was used to determine the population trends of each species, pulled all the sites and each site separately. Spearman correlation was used to investigate the relationship between the age groups.

Annual counts of birds tell us how their numbers are changing, but the capture-recapture method is needed if we want to understand the mechanism of their changes observed. Capture-recapture is an efficient way of collecting critical data on demographic parameters such as apparent survival and capture probability. To determine these demographic parameters the Cormack-Jolly-Seber (CJS) model was used in MARK program.

Based on the local recaptures, I estimated the natal-site and breeding-site fidelity and calculated the apparent survival and capture probability of each species, and, where available data allowed, the difference between age groups and sexes. I also examined species dispersal based on non-local recaptures. Then, to explore the causes of population change, I compared the bird ringing data with the weather factors for each station.

The simple linear regression was used in order of modeling the relationship between annual capture data of each age groups of species and the meteorological data.

4. Summarize of results, Theses

1. Based on the annual captures I have determined the productivity of the studied species. High average productivity was found in case of the common chiffchaff (0.55), the blackcap (0.44) and the willow warbler (0.33). Lower average productivity values were obtained for the barred warbler (0.17), the lesser whitethroat (0.19) and the common whitethroat (0.11), while the garden warbler (0.04) had a much lower productivity value compared. No productivity value could be calculated from the captured data of the wood warbler.

2. A negative linear trend was found in the total captures of barred warbler, indicating a decreasing population over the period.

   For the other species, no linear trend in annual captures could be detected, which indicates a stable population for species with higher captures (total captures > 200 individuals) (blackcap, lesser whitethroat, common whitethroat, common chiffchaff), and a low number of sample elements for species with lower total captures (garden warbler, wood warbler, willow warbler).

- In the case of the lesser whitethroat, a positive linear trend in the numbers of juveniles was observed, indicating an increase in breeding success.
- In the case of the barred warbler, a negative linear trend was detected in the numbers of adults, which could be due to increasing wintering and migration mortality.
- No significant trend in the value of productivity was detected for any species.

3. Significant correlations were detected between annual capture of each age groups and productivities in two species:
   - there is a negative relationship between the annual capture of adults and productivity, suggesting density-dependent population limitation. There is a positive relationship between the annual number of juveniles, the productivity and numbers of adult birds in the following year, indicating an increasing trend in the survival of migratory and wintering birds.
   - a positive linear relationship was found between the annual capture of adult and juvenile birds in the case of the barred warbler, which does not indicate density-dependent limitation.

4. Changes in the population dynamics of the studied species are fundamentally influenced by migration strategy. The populations of the Mediterranean overwintering Eurasian blackcap (r=-0.129,

p=0.982) and the Common chiffchaff (r=1.154, p=0.438) are stable. In contrast, the populations of long-distance migrants are mostly declining (Garden warbler r=-0.546, p=0.726; Barred warbler r=-1.700, p=0.0001; Common whitethroat r=-0.59, p=0.200; Wood warbler r=0.03, p=0.871; Willow warbler (r=-0.229, p=0.228); although the decrease was significant only in the case of the Barred warbler.

5. Changes in population dynamics of the studied species are also strongly influenced by the habitat preference of the bird species. The population of the Barred warbler, which also breeds in agricultural environments, decreased significantly (r=-1.700, p=0.0001), while the population of the forest-nesting species was stable.

6. The population dynamics results of the CES program - based on ringing data - and the MMM program - based on observational study - were similar over the study period, with possible differences due to the time period covered or be low captures in CES program. In addition, CES ringing sites are absent from a significant part of the country, e.g., eastern Hungary. However, low captures do not imply low abundance of the species, therefore it is important to analyse these results together.

7. There were differences in the fledging times of the juveniles of the studied species. In case of the short-distance migratory Eurasian blackcap and the Common chiffchaff, the first fledglings appeared in early to mid-May (3rd – 4th CES days). In the case of long-distance migrants, the first fledglings were not ringed until the end of May (5th CES day) while the latest fledglings were observed in the case of the Willow warbler, where the first fledglings appeared only in early June (6th CES day).

8. The age- and sex-dependent Cormack-Jolly-Seber models, which best fit the ringing data of the studied species, show the difference between the apparent survival and the capture probability of each age- and sex-group.
   a) In the European blackcap, the apparent survival of first years (13.6%) is significantly lower than that of second years (48.8%), and the capture probability of males is higher (21.1%) than that of females (7.3%).
   b) Based on the models of the Barred warbler, the apparent survival of males is higher (38.2%) than that of females (28%), with no significant difference in the probability of capture.
   c) In case of the Lesser whitethroat, the apparent survival of first years was also low (12.5%), compared to adult birds (35%), with no difference in the capture probability of each sex- and age-groups.

d) In case of the Common chiffchaff, the apparent survival of first-years was much lower (15.1%) than that of the same individuals at the age of two (63.5%), and the apparent survival of males was higher (36%) than that of females (20.2%). In terms of capture probability, first-years were higher (35.5%) than second-years (13.0%), and the capture probability of males were lower (26.4%) than females (40.0%).

9. In terms of site fidelity, there is a difference between the breeding site fidelity and natal site fidelity of the species included in the study. Natal site fidelity is lower for the Blackcap (5.8%), the Barred warbler (3.03%) and the Lesser whitethroat (7.9%), than breeding site fidelity (7.4%; 8.02%; 12.9%), while the natal site fidelity is higher (7.9%) for the chiffchaff compared to the breeding site fidelity (6.8%).

10. For most of the studied species, the temperature and amount of precipitation of the breeding season could influence demographic changes. The total captures of the studied species and changes in the number of individuals were affected differently by weather conditions.
    a. in case of the Blackcap, total precipitation and average temperature had a positive effect on age classes and total capture in most cases;
    b. a positive relationship was found between the number of adults and the amount of precipitation in the Garden warbler;

c. in case of the Barred warbler, the amount of precipitation had a positive effect and mean temperature had a negative effect on population change;
d. the temperature and the amount of precipitation may also have affected the Lesser whitethroat, with varying degrees at each station;
e. in case of the Common whitethroat, the temperature had a positive effect on the age classes;
f. the total number of individuals of the Wood warbler was negatively influenced by temperature;
g. the number of adults of the Willow warbler is also negatively affected by mean temperature;
h. the number of individuals of the Chiffchaff is influenced by precipitation in most cases, but the influence of temperature has also been detected.

4. Scientific publications related to the topic of the dissertation

Scientific publications in English

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