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DETERMINING THE WINTERING- AND MOULTING QUARTERS OF
MARSH WARBLERS (*ACROCEPHALUS PALUSTRIS*) WITH
REMOTE-SENSING

Thesis book

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1. INTRODUCTION

The rapid technical development of computers in the recent past made possible the widespread use of analytical methods based on remote sensing. In ecology the most expansively used dataset is the NDVI - Normalized Difference Vegetation Index (Pettorelli et al. 2005). NDVI is basically an expression of primary production, which especially in arid and semi-arid habitats strongly correlates with rainfall. It reflects vegetation greenness of a certain area.

In the last decade NDVI had shown an unforeseen success in animal ecology (Pettorelli et al. 2011), it is used at global and regional scale, too.

NDVI is generally used in bird studies, as a describer of the ecological conditions: through its strong correlation with net primary production (NPP) it expresses food abundance for herbivorous but also for insectivorous birds (Phillips et al. 2008).

In bird research it is used to study global change and species area expansions (Liu et al. 2013); habitat structure (Illera et al. 2010); habitats, diversity and species distribution (Goetz et al. 2007); avian influenza (Tran et al. 2010); climate change and fitness (Sanz et al. 2003); onset of singing (Gordo et al. 2008) etc.

In several studies it has been shown, that climatic and ecological conditions (NPP) in the wintering quarters and stopover-sites have a great impact on body condition, therefore on wintering bird survival. Through the NDVI – rainfall – NPP – food abundance relationship the winter survival of long-distance migrants often correlates with NDVI values of the wintering quarters (Grande et al. 2009). Moreover ecological conditions in wintering areas (NDVI) correlate with the timing of spring migration and arrival (Gordo & Sanz 2008), protandry, sexual selection (Møller 2004, Saino et al. 2004), timing of breeding (Both et al. 2006), clutch-size and reproductive success (Schaub et al. 2011), and with the length of feathers moulted in the wintering quarters (Saino et al. 2004).

1.1. The importance of the research of long-distance migrants – in the light of recent Climate Change

Climate Change is one of the severest problems of the present, it has several direct or indirect effects on the life-cycle of birds. Due to milder winters and warmer springs resident species, short- and medium-distance migrants can arrive and occupy territory earlier, therefore they are in competition advantage compared to long-distance migrants. Therefore Afro-Palearctic long-

distance migrants are among the most severely affected groups: their populations showed an alarming declining trend in the last decades (Vickery et al. 2014), therefore their study is essential.

1.2. New methods are needed in the research of bird migration

Despite strong ringing efforts in Europe there are few recoveries in Africa, so by the traditional ringing-recapture method there is very little information accumulated about wintering areas of different species. Thanks to rapid technical evolution there are new methods for tracking birds, but GPS data-loggers cannot be mounted on small passerines and birds equipped with geolocators must be recaptured to download data which in some species can be difficult. Moreover there can be financial limitations, too. An alternative solution can be the strong relationship between the NDVI values of wintering quarters and survival: searching the areas whose NDVI values strongly correlate with bird survival, we may identify potential wintering quarters. There are successful researches in finding wintering regions of some species/populations (Szép et al. 2006), but the calculation of survival rates needs several capture-recapture data which often are not available.

2. OBJETIVES

2.1. Testing our survival index and method –identifying wintering areas

Our main objective is to test the suitability of a simple survival index calculated from autumn migration ringing data for searching/studying wintering areas using remote sensing datasets. The leading idea of these calculations is that if survival in the wintering period has a major role in annual survival, than the fluctuation of annual survival indices will follow the year-to year fluctuation of NPP (NDVI values) on wintering quarters in the period when the studied species is present. Therefore searching for wintering regions consists in the identification of those African regions where mean NDVI values – calculated for the wintering period – on long term fluctuate with annual survival indices of birds.

2.2. Studying the connection between NDVI and wing-length – identifying moulting areas

Based on the correlations between food supply – feather growth rate (Brown & Sherry 2006), food quality – wing-length (Pehrsson 1987), and NDVI values of wintering quarters – wing length (Saino et al. 2004) we expect that the NDVI values of moulting areas will correlate with average annual wing-lengths of adult birds. We are searching for those areas, whose NDVI values fluctuate with annual wing-lengths of birds.

2.3. Searching for spring migration stop-over sites

We are searching for the African stop-over sites, important for Marsh Warblers during their spring migration. In this region we expect strong positive correlations between survival indices and African NDVI in April, respectively strong negative correlations with NDVI and wing-lengths.

Because according to our knowledge no one has tried this before, we are testing this method on a species (Marsh Warbler - *Acrocephalus palustris*) whose wintering quarter is well known in comparison with other species, therefore with the help of literature we can test the plausibility of our results. Marsh Warblers are typical bottleneck migrants, birds from the whole breeding area migrate through a thin bottleneck near the Red-Sea, East Africa and Middle East towards their final South-African wintering quarters, where they undergo a total moult. Some individuals may overwinter in Kenya. Migrants from the western and north-western side of the distribution area are heading to south-east and they are passing through the Carpathian Basin and Hungary, hence these populations are represented in our data-base.

3. METHODS

3.1. Calculation of the survival index

We have calculated an annual survival index from the total number of adult and juvenile birds ringed during the previous and the following autumn migration:

$$Si = N_{ad(T)} / (N_{ad(T-1)} + N_{juv(T-1)})$$

where: Si - survival index; $N_{ad(T)}$ – total number of adult birds in a year; $N_{ad(T-1)}$ – total number of adults in the year before; $N_{juv(T-1)}$ – total number of juveniles in the year before.

The idea behind this survival index is that adults in a given year are the survivors from the total number of birds (adults and juveniles) from previous year.

3.2. Bird data

In our studies we have calculated survival indices (Si) from 1222 adult (annual mean: 49.42; SD: 26.07) and 3078 juvenile (annual mean: 125.21; SD: 77.74) Marsh Warblers ringed between 1984 - 2008 at Ócsa Ringing Station (Duna-Ipoly National Park - Ócsa Landscape Protected Area).

3.3. Calculation of annual mean wing-lengths

In wing length calculations only adult birds were included because their wing feathers were moulted/grown in Africa. Wing lengths of 1170 adult birds ringed between 1984-2008 were analyzed (annual mean number of adults 48.75; SD: 24.24), average of annual wing length means: 68.31 mm; SD: 0.5.

3.4. NDVI data

For our calculations we have used the NOAA AVHRR NDVI datasets. These images have a resolution of 8×8 km, every image containing 1152×1152 pixels, covering the entire African continent. This dataset has a temporal resolution of 10 days and is available for the period 1980-2008.

For every pixel we have calculated these averages for every migration/wintering season, therefore for every year we obtained a mean NDVI map for the following periods: 11th September - 20th November (main autumn migration period within northern Africa); 21st November - 20th December (a shorter and later period within the autumn migration in northern

Africa); 1st January - 31st March (main wintering period in final wintering areas) and 1st-30th April (shorter and faster spring migration period within Africa).

3.5. Calculations

From the time series of survival indices and time series of mean NDVI data Spearman's rank correlations have been calculated for each pixel of Africa and for every above mentioned period of year. Hereby every map is a result of more than 1.3 million (1152x1152) Spearman rank correlations between annual survival indices and mean NDVI pixel values for the studied time-intervals, over a time series of 24 years.

With annual wing-length averages similar calculations were done for the periods January - 31st March (moult) and 1st-30th April (spring migration).

We have illustrated on the map of Africa those pixels where the resulted Spearman's R values were greater than 0.4 and 0.5, respectively smaller than -0.4 and -0.5.

4. RESULTS and DISCUSSION

4.1. 11th September - 20th November – survival index:

Major areas with strong positive correlations are in: the Arabian Peninsula (Yemen), the eastern shores of Somalia. The area in Yemen near the coast of the Gulf of Aden may be an important stop-over and fueling site before crossing the major geographic barrier represented by the Arabian Sea.

4.2. 21st November - 20th December – survival index:

Relevant regions for Marsh Warblers with strong correlations for this period are in Southern-Ethiopia and Western-Somalia.

4.3. 1st January - 31st March – survival index:

A major Southern African patch is formed by the Southern and Eastern parts of Namibia, Botswana and the Western region of the South African Republic. A small patch also appeared near the Eastern shores of the South African Republic, in the Natal region.

Although most recoveries are from the coastal regions of South Africa, Marsh Warblers were caught also in Namibia (Becker & Lütgens 1976), so their presence is proven in our

“artificial” wintering areas. Marsh Warblers can overwinter in arid habitats far away from coastal regions. According to our theory and methods these are the main wintering quarters of those Marsh Warbler populations which migrate through the Carpathian Basin.

4.4. 1st-30th April – survival index:

The major South African wintering area is still visible but much less intense as in January-March. According to literature Marsh Warblers in April still can be in South-Africa, but all birds leave these regions by the end of the month.

In April another important positive significant area appears in Eastern Sudan, mainly overlapping with the basins of the Blue Nile, White Nile and Atbarah rivers. Marsh Warblers in March, April and May are present in the Nile System of Sudan (Hogg et al. 1984). Presumably this region is an important stop-over and fueling site for Marsh Warblers on their spring migration.

4.5. January - 31st March –mean adult wing-lengths:

When we have correlated average wing lengths with the NDVI values for January - March, on the resulted map the main regions with positive correlations were: a small, North-Eastern part of Namibia, Botswana, Southern Zimbabwe, Eastern part of the South African Republic and some of the coastal regions (near Port Elizabeth and Cape Town). According to our method these are the hypothetical moulting areas of the North-Western European Marsh Warblers sampled at Ócsa, Hungary. Comparing our results for moulting and/or wintering areas we can conclude that the studied Marsh-Warblers moult in the above mentioned regions and after completing the moult they continue their intra-continental migration towards South - South-West to final wintering quarters in South African Republic and Namibia. These movements can be interpreted also as a post-moult dispersion.

Final wintering and moulting areas partially overlap in Botswana, suggesting that for some birds beyond the moulting area this region is the final wintering quarter too, after moult these birds don't continue their intra-continental migration.

Studying the moult of other species from the *Acrocephalus* genus we can conclude that the moulting strategies of these species can be very diverse and can have even intra-specific variations. Generally we can say that the time and place of moult can differ even among the same

species, suspended moult is frequent. Most birds complete their moult in the first half of the wintering season and they migrate to a final wintering area where they stay until the onset of spring migration. Therefore it seems very plausible that not every Marsh Warbler moults on its final wintering quarters, but they undergo a fast moult in the beginning of winter, and after that they can migrate further in the African continent, as our results suggest.

4.6. 1st-30th April –mean adult wing-lengths:

With the help of survival indices, average wing-lengths and NDVI we succeeded to identify the important spring migration stop-over site for Marsh-Warblers within North-East Africa. The importance of this region is strongly underestimated, it is barely mentioned in literature.

5. CONCLUSIONS

Our results are mostly consistent with available information from literature, but they partially differ: wintering- and moulting areas emerged in regions outside the general South-African distribution of Marsh Warblers. However, there are areas where according to the literature this species is present in high numbers during winter, but do not stand out in our results.

We can conclude, that the regions highlighted in our results (wintering and moulting alike) refer to the populations from Western, North-Western parts of the species distribution area, which are sampled in Hungary. In the areas where we have found no strong correlations, but according to the literature Marsh Warblers are present, different populations from those which we have sampled might overwinter in higher proportions (birds not flying through Hungary, eg. Baltic, Eastern-European birds, etc.). According to our results Marsh Warblers overwintering and moulting in Kenya mentioned by Dowsett-Lemaire (1987) do not originate from the Western, North-Western part of the species distribution area.

We have demonstrated that the known and real winter distribution of Marsh Warblers differs, and the intensity of bird field-observations can vary strongly among regions. Hence presumably the wintering quarters of many species in literature are incomplete/imprecise.

It seems that Marsh Warbler populations migrating through the Carpathian Basin during moult and wintering equally present a geographical segregation within the species general winter-distribution:

- as final wintering quarters they rather choose the inland regions of South-Africa than the coastal regions (excepting the Natal region)
- Marsh Warblers in South Africa moult further away from the shorelines than previously thought (excepting the regions of Port Elisabeth and Cape Town)
- They do not overwinter and moult in Kenya.

With this method we could identify presumably the most important spring migration stop-over site for this species, which in literature is scarcely mentioned, its importance is strongly underestimated.

6. THE IMPORTANCE OF RESULTS

This method has proved to be usable for investigations on wintering quarters of different species. It is also suitable to spot patterns and to identify putative wintering areas of different populations within the African distribution of the given species.

In this wise we can predict regions that can be crucial in the life-cycle of long-distance migrants, hence we may contribute to their more efficient protection.

This method does not require expensive instruments (geolocators, GPS transmitters), it is independent of the birds body-size, it needs only long-term standardized data-sets, which are available in the case of many ringing-stations and ringing-centers.

It can be used on any species, not just on trans-Saharan migrants. In the case of short- and medium-distance migrants alike, based on the same principle, calculations can be performed also on NDVI values of other (eg. European) areas.

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