WHERE DOES THE MARSH SEEDEATER MIGRATE TO?

AMANDA PERIN MARCON[1]; FABIANA GONÇALVES BARBOSA[2]; RAFAEL ANTUNES DIAS[3]

[1]Universidade Federal de Pelotas, Instituto de Biologia, Laboratório de Ecologia de Mamíferos e Aves, Capão do Leão, Brasil – amandaperinmarcon@gmail.com
[2]Universidade Federal de Rio Grande, Instituto de Ciências Biológicas, Rio Grande, Brasil – fabibarbos@gmail.com
[3]Universidade Federal de Pelotas, Instituto de Biologia, Laboratório de Ecologia de Mamíferos e Aves, Capão do Leão, Brasil – rafael_antunes_dias@yahoo.com.br

1. INTRODUCTION

The conservation of migratory birds demands comprehending the dynamics of habitat use (POCEWICZ *et al.*, 2012). By relying on multiple places at different times of the year, migratory birds are especially vulnerable to climatic changes and anthropogenic alterations (KLAASSEN *et al.*, 2012). The incomplete knowledge on their spatiotemporal distribution (Wallacean deficit) is particularly challenging because it may limit the effectiveness of conservation actions (LEMES *et al.*, 2011). The distribution of migratory species can be modeled via occupancy estimation, as it provides measures of detectability and increases confidence on true absences (PETERMAN; CRAWFORD; KUHNS, 2012). Occupancy models can solve problems of imperfect detection by using the information of observations made at each site and estimating species prevalence (WELSH; LINDENMAYER; DONNELLY; 2013).

The Marsh Seedeater (*Sporophila palustris* Barrows, 1883) is a long-distance austral neotropical migrant that inhabits native grasslands with moist soil and marshes with emergent vegetation, apparently tracking the distribution of herbaceous plants on which it feeds (VIZENTIN-BUGONI *et al.,* 2013). During the breeding season, between November and February, it is found discontinuously in Uruguay, Argentina and Rio Grande do Sul, Brazil (MAURÍCIO *et al.,* 2013). It winters mainly in tropical grasslands of Central Brazil, and apparently also in northeastern Paraguay (MAURÍCIO *et al.,* 2013). With a rapidly declining population estimated between 600-1700 mature individuals, it is considered globally endangered (IUCN, 2019).

Aiming to minimize the Wallacean deficit regarding this bird's migratory system, we modeled its temporal distribution using occupancy models and circular statistics in a series of sites covering most of its breeding and non-breeding distribution. This enabled us to visualize the Marsh Seedeater's spatiotemporal distribution across South America and to infer its possible annual movements throughout the continent.

2. METODOLOGY

Occurrence data:

Data was compiled from the oldest record known up to December of 2018. We searched citizen science and photography websites (eBird, Wiki Aves, Biofaces, Eco Registros, Táxeus, Xeno-Canto, Macaulay Library, Flickr, Internet Bird Collection), online databases (Splink, Gbif, VertNet), published records and museum specimens (contacting museum curators). We checked for taxonomic synonyms (such as *Spermophila palustris* and *Sporophila zelichi*). We only used records of adult or juvenile males to avoid confusion with other members of the

genus. We compiled the locality (country, state, city and specific location), geographical coordinates and the date (day, month and year). Data was filtered to eliminate repeated records and to verify the accuracy of the coordinates (SANTANA *et al.,* 2008).

Predicted occupancy:
Aiming for a more recent distribution, we only used records between 1990 and 2018, totalizing 373 registers. We separated records by month and observed their spatial distribution. We then searched for sites that were regularly visited by birdwatchers along the year in WikiAves, eBird, Eco Registros and Táxeus in a buffer with a 50 km radius around each record. This procedure resulted in defining 11 locations containing at least five sites each were a birdwatcher had a probability in finding this species in any given week of the year if it was present. Four of these locations are in breeding areas and the remaining are in wintering areas. Single-season simple models were used to estimate the monthly occupancy for each location based on the weekly presence or absence of the species at the five sites. Since for some months we had a single presence record for a single site, we added 15 dummy sites to all locations with a checkerboard pattern of presence-absence to ensure that models would converge. Thus, occupancy estimates reflect the variation only of the real data (L. M. ROSALINO *in litt.*). Occupancy for months without any presence record was assumed to be zero. Analyses were carried out using the “unmarked” package (FISKE *et al.*, 2011) in R (R CORE TEAM, 2018). Occupancy estimates were then transferred to Oriana (version 4.02) to develop circular distribution histograms per area and to calculate data uniformity with a Rayleigh test. This test analyzes periodicity in irregular data, informing if the distribution is uniform or if it tends towards a value of the circle (JUPP, 2001).

3. RESULTS AND DISCUSSION

Monthly occupancy estimates ranged from 0.8 to 1. The Rayleigh test was significant for all 11 locations, which indicates they tend toward determined angles.

Breeding season:
Records in northeastern Corrientes, Argentina, fell between September to April. The highest occupancy was estimated from October to February and nesting was reported for December and January. In south Entre Ríos, Argentina, records are for October to March. Occupancy was highest from November to February, which corresponds to the nesting season. In southernmost Rio Grande do Sul, Brazil, records are also for October to March. Occupancy was highest in November and February, and nesting was verified for December and January. In easternmost Uruguay, however, records were for November to April. The highest occupancy was for January, February and March, which are also months with nesting activities. These results correspond to previously known breeding areas and pulses of arrival and departure for some areas (VIZENTIN-BUGONI *et al.*, 2013).

Wintering season:
Occurrence data in winter is scarce. The apparently bi-monthly occupancy predicted for southeast Paraguay and Central Mato Grosso do Sul state, Brazil, and for July and August in the Pantanal of Mato Grosso, Brazil suggests that birds might use these areas during the dry season. Records for nearly all months in south Paraguay suggests that some birds might remain in this region during the

winter. The main wintering area seems to encompass regions within the western sector of the Cerrado and the Pantanal. However, records for the eastern portion of the Cerrado are mainly from October and November.

Displacement between areas:
There are possibly two main migratory routes: one through the west via the Pantanal and the other through the east, via Minas Gerais and São Paulo, Brazil. The western route seems to be used both when moving north and returning south. As no eastern records exist from March to August, some individuals might move from the wintering areas in Mato Grosso do Sul and Paraguay to mid-eastern Brazil. Since there are no records for Santa Catarina and north Rio Grande do Sul, it is possible that individuals using the eastern route return to their breeding areas via Paraguay and Argentina.

4. CONCLUSIONS

Our results indicate birds occupy breeding areas mainly between October and February. Nesting activities occur from November to March. The westernmost wintering areas possibly comprise the main region where these birds spend the winter. The easternmost wintering areas seem to be used mainly from October to November. Individuals might migrate north and return south through a route between Paraguay and western Brazil, but others seem to travel from these western wintering areas through central Brazil until they reach the easternmost portions of the Cerrado before moving southwest before reaching their breeding areas.

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