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SPATIO-TEMPORAL OVERLAP BETWEEN LOCAL AND NON-LOCAL REED WARBLERS *ACROCEPHALUS SCIRPACEUS* DURING THE AUTUMN MIGRATION PERIOD

SOLAPAMIENTO ESPACIO-TEMPORAL DE CARRICEROS COMUNES *ACROCEPHALUS SCIRPACEUS* LOCALES Y NO LOCALES DURANTE EL PERIODO DE PASO POSNUPCIAL

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Summary.—During the autumn migration period, northern populations commonly reach southern stopover sites where they meet conspecifics that may still be breeding or at least still at their breeding sites. Establishing whether local breeding birds overlap temporally with migrants is essential to studying the strategies adopted by the former when they have to suddenly cope with conspecific influxes. Our objectives here were (1) to establish the phenology of local and transient birds within the study area and (2) to test whether biometrics can differentiate between these two groups. Local reed warblers were observed nesting until the end of July; these birds were recaptured up to late August (although very few later than mid-August), suggesting that at least some individuals depart from the area before most non-locals arrive. Local breeding birds were found to have longer wings than non-locals. A discriminant function classified 73.4% of the non-local and local reed warblers correctly, indicating considerable morphological overlap between the two groups.

Key words: biometry, discriminant function, migration, recaptures, ringing.

Resumen.—En la migración de otoño, las poblaciones más nórdicas a menudo llegan a puntos de parada migratoria en el sur cuando las poblaciones locales aún están criando o al menos aún están en su área de cría. Comprender el posible solapamiento espacio-temporal entre estas aves locales y no locales es importante para conocer las estrategias que adoptan los locales cuando de pronto tienen que enfrentarse a la arribada masiva de migrantes. El objetivo de este estudio es: (1) establecer si existe solapamiento temporal de aves locales y no locales en el área de estudio y (2) adicionalmente, determinar si es posible emplear la biometría para distinguir estos dos tipos de poblaciones. Se observaron carriceros nidificantes locales hasta finales de julio; estas aves permanecieron posteriormente en la zona hasta el final de agosto (si bien la proporción de recapturas durante la segunda mitad de agosto fue muy baja), sugiriendo que al menos un porcentaje de la población de aves locales deja la zona antes de la arribada masiva de migrantes. Se obtuvo una ecuación discriminante que clasificó el 73,4% de las aves locales y no locales correctamente, indicando un solapamiento morfológico considerable entre estos dos grupos.

Palabras clave: análisis discriminante, anillamiento, biometría, migración, recapturas.

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INTRODUCTION

During the autumn migration period, when boreal migrants move from north to south Europe and beyond (Alerstam, 1993; Newton, 2008), they commonly reach southern stopover sites where they find conspecifics that may still be breeding or at least still at their breeding sites, for example moulting or preparing for migration (Cramp and Perrins, 1994; Andueza *et al.*, 2014a). Understanding to what extent these northern birds coexist in sympatry at stopover sites with local breeding birds is important for understanding the strategies adopted by locals when suddenly they have to cope with a wave of conspecifics competing for the same resources. This is also a question of analytical importance, since we often need to separate local breeding birds from transient ones, whether we want to focus on local breeding birds (Miles *et al.*, 2007) or active migrants (Chernetsov, 2012).

The reed warbler *Acrocephalus scirpaceus* is a widespread migratory passerine breeding across most of Europe and overwintering in tropical Africa (Cramp, 1992). Every autumn, reed warblers from western Europe migrate in a southwesterly direction to overwinter mainly in West Africa, while those breeding in eastern Europe migrate in a southeasterly direction to overwinter mainly in East Africa (Procházka *et al.*, 2008). Most reed warblers taking the southwest flyway stop-over in Iberia to build up their fuel reserves in order to be able to reach North Africa (Andueza *et al.*, 2014b). Accordingly, Iberia, with a breeding population of at least 22,000 breeding pairs (Gainzarain, 2003), receives reed warblers mostly from western and central Europe (Andueza *et al.*, 2013). These northern migrants arrive in Iberia in July and can be found until October (Cantos, 1998). At that time, reed warblers breeding in Iberia can still be found in the region, although it remains untested whether, or to what extent, a majority of these local breeders avoid extensive spatio-temporal overlap with the bulk of non-local birds.

In birds with large distribution areas or with populations with different migratory behaviour, the biometrics can differ markedly between populations (Tellería and Carbonell, 1999; Calmaestra and Moreno, 2001; Förschler and Bairlein, 2010; Arizaga and Barba, 2011). Biometric data can then be used to distinguish between migrants and local breeders when both populations overlap temporally at a given place. Body size, tail/wing ratios, wing length and morphology are among the characters frequently used to separate bird populations that have different migration distances. For example, it has been previously demonstrated that both wing length relative to body size and wing pointedness tend to increase with increasing journey distances (Mönkkönen, 1995; Fiedler, 2005).

After the breeding season, wing length and wing shape are often very useful to differentiate local and non-local individuals. For example, migrant reed warblers in Israel were observed to have consistently longer wings than local, resident breeding Clamorous reed warblers *Acrocephalus stentoreus* (Merom *et al.*, 1999). During migration periods, García-Peiró (2003) observed in the Mediterranean region that wing shape was not constant over time, suggesting that populations with different travel distances were passing through the area. Similarly, in Portugal local reed warblers are smaller than British ones (Bibby and Green, 1981). In some other areas, however, the overlap between populations with different migratory strategies is large and hence it is impossible to separate the two groups on wing length alone (Andueza *et al.*, 2013).

Our objectives here were (1) to establish the timing of the local and non-local reed warbler presence within an area used as a stopover site in northern Iberia during the autumn migration period and (2) to test whether biometrics could be used to differentiate locals and non-locals. We used data collected during eight consecutive years in a reed bed area in northern Iberia, where both local breeding and transient reed warblers are captured (Mendiburu *et al.*, 2009; Andueza *et al.*, 2014a).

METHODS

Field work was carry out at Jaizubia, Txingudi marshlands (Gipuzkoa, northern Spain), a coastal wetland located in the Bidasoa estuary at the south-eastern corner of the Bay of Biscay. The wetland complex occupies some 70 ha, of which about. 25 ha comprise the Jaizubia stream and its associated mudflats and reed beds.

Reed warblers were captured from 2007 to 2014, during May-September. Data were collected from the two ringing programmes carried out in the area every year: (1) a constant effort site oriented to catch breeding birds from May up to mid-August, with a frequency of one sampling day per fortnight (i.e., seven ringing sessions overall); (2) a constant effort site oriented to catch non-local migrant birds during August-September, when birds were captured daily. Birds were trapped with mist nets 2.5m high. Part of the net run used for the first programme was also used in the second, so the two net runs overlapped by 132 metres. Overall, we used 228 m of mist nets in the breeding season campaign and 204 m in the other. Mist-netting was carried out using a constant sampling effort protocol starting at dawn and lasting six hours (breeding programme) or four hours (migrant programme).

Once a bird was captured, it was ringed (or its ring was read if previously ringed), the age was determined (adults: EURING code 4; first-year birds: EURING code 3) (Svensson, 1996) and the following variables were measured (all in mm): head+bill length (H), tarsus length (T), wing length (method III by Svensson, 1996; W), tail length (R) and all primary feathers (numbered from innermost –P1– to outermost –P9–). Not all measurements were taken for all birds, for various reasons, so that the sample sizes for each variable were not always the same. Primary feathers were not considered separately but included within the C_2 index, which is used as an assessment of wing morphology: in this case, wing pointedness (Lockwood *et al.*, 1998). Higher values of this index show relatively more rounded wings. We also verified the presence of breeding signs on adults: brood patch (scored from 1 to 6: 1, developing brood patch; 2, almost-grown patch; 3, fully-grown patch; 4, regressing brood patch; 5, re-feathering brood patch; 6, gravid (about to lay) in females or cloacal protuberance among males (codes 7-8 after Pinilla, 2000).

Local adults (females with patches 1-3 or 6 or males with protuberance –codes 7 and 8) bred mostly up to the end of July (fig. 1). Therefore, to establish when local breeding birds (i.e. local adults) left the area we calculated what proportion (%) of birds showing breeding signs until the end of July were recaptured up to the end of September. The presence of non-locals is well documented in August and September and, therefore, a high percentage of recaptures of local birds in these months would indicate high temporal overlap between locals and non-locals (Arizaga, 2010).

In addition to this analysis, we also calculated the standardised number of captures (captures/100 m mist nets) of adults. To test whether this value varied with time we used a Generalized Linear Mixed Model on the standardised number of adult captures as an object variable with fortnights (here used as a time unit) as a factor. Years were included as a random factor. The *a posteriori* analyses were done using a Tukey-B test. We used a log-linear link function with a Gamma error-based distribution.

Two-sample *t*-tests were used to determine which biometric variables varied between locals (reed warblers caught once or more up to late July, with stages 1-3 brood patches if females or cloacal protuberance if males) and non-locals (reed warblers caught with foreign rings). Non-locals mostly came from central-western European countries (Arizaga, 2010). First-year and adult reed warblers differ morphologically (Cramp, 1992; Svensson, 1996) and thus we only considered adults in this analysis. Finally, we ran a stepwise Discriminant Analysis with the aim of having an equation allowing us to separate the two bird groups by biometry. Statistical analyses were performed with SPSS (21.0) software.

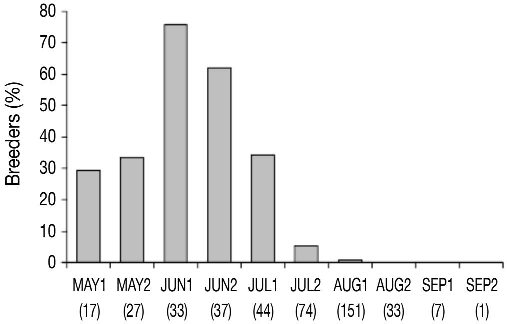

FIG. 1.—Proportion of local birds showing active signs of breeding (brood patch codes 1-3 or 6 in females and cloacal protuberance in males; see text for details) relative to all local birds which were captured with any sign of having bred within the study area during May to September (data from 2007 to 2014 pooled). The figure only includes adult birds (EURING code = 4). Sample sizes are shown in parentheses. Time unit is fortnights.
[Proporción de carriceros comunes nidificantes locales (capturados con placas incubatrices código 1-3 o 6 o protuberancia cloacal; para los detalles véase el texto) en relación con los que se capturaron como reproductores entre los meses de mayo y septiembre (datos de 2007 a 2014). Esta figura sólo incluye aves adultas (código EURING = 4). Tamaño muestral en paréntesis. Unidad temporal en quincenas.]

RESULTS

In total, 340 local-breeding adult reed warblers were identified. Local breeders were present until the end of July (captures of breeding birds in August were minimal), with a peak during the first half of June,

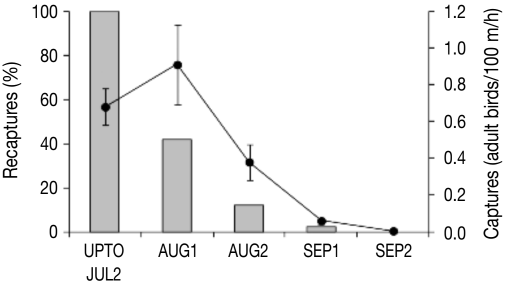

FIG. 2.—Proportion of post-breeding (August-September) recaptures of reed warblers captured with signs of having bred in the study area until the end of July (grey bars). Data from 2007 to 2014 pooled. The figure only includes adult birds (EURING code = 4). Time unit is fortnights. We also show the standardised number of captures of adults (dots; mean ± 95% confidence interval); same letters lump mean values for which there were no significant differences. The figure includes all captures of both local and non-local adult reed warblers.
[Proporción de recapturas (agosto-septiembre) de carriceros comunes capturados como nidificantes en la zona de estudio hasta finales de julio (barras grises). Datos de 2007 a 2014. Esta figura sólo incluye aves adultas (código EURING = 4). Unidad temporal en quincenas. Mostramos, además, la abundancia de adultos (puntos; media ± IC95%); la misma letra aglutina las medias para las que no se hallaron diferencias significativas. Esta última figura se ha construido considerando todas las capturas de carriceros adultos tanto locales como no locales.]

TABLE 1

Mean ± SE (sample sizes in brackets) of local-breeding adult and non-local reed warblers captured. Samples were compared with a two-sample t-test. Variables in mm (except C_2). All measurements are of adult birds (EURING code = 4).

[Media ± SE (tamaño muestral en paréntesis) de carriceros comunes locales y no locales. Las muestras se compararon mediante un test de t. Variables en mm (excepto C_2). Todas las medidas son de aves adultas (código EURING = 4.]

Variable	**Locals**	**Non-locals**	***t***	***df***	***P***
Head+bill length	33.3 ± 0.1 (58)	33.7 ± 0.2 (15)	1.634	71	0.107
Tarsus lenght	22.3 ± 0.1 (98)	22.6 ± 0.2 (19)	1.222	115	0.224
Wing length	64.0 ± 0.2 (164)	66.0 ± 0.4 (20)	4.335	182	< 0.001
Tail length	51.4 ± 0.3 (61)	51.6 ± 0.7 (15)	0.277	74	0.783
C_2 index	0.77 ± 0.03 (23)	0.72 ± 0.03 (16)	1.047	37	0.302

when some 75% of captures showed signs of breeding (fig. 1). No local breeding birds were caught after mid-August.

The proportion of local breeding adults recaptured either in August or September was relatively low (fig. 2). Reed warblers that had bred within the area were recaptured up to mid-September. No local bird was recaptured during the second half of September (fig. 2). The standardised number of captures of adults varied across the season ($F = 17.705$, $df = 4$, $P < 0.001$), with more captures up to the end of August than during the second half of September. Captures during the first half of September showed intermediate values (fig. 2). Year of capture did not have a significant effect on the number of captures ($P > 0.05$).

Two-tailed *t*-tests showed that locals and non-locals only differed in wing length (table 1). Non-locals had longer wings than local birds (table 1). A stepwise Discriminant Analysis showed that wing length is useful for separating the two categories (locals vs. migrants; $\lambda_{\text{Wilks}} = 0.642$, $df = 1$, $P < 0.001$). Nevertheless, the discriminating function ($Y = -34.928 + 0.54W$, where W is wing length) only classified 73.4% of reed warblers correctly, indicating considerable morphological overlap between the two groups. According to this function, birds with wings > 64.9 mm will be migrants.

DISCUSSION

The breeding period of reed warblers in a reed bed area at Jaizubia (Txingudi marshlands, northern Iberia) extended mostly up to the end of July. Presence of these birds after this date was extremely low, suggesting that local birds leave the area before most non-local individuals arrive there (Arizaga, 2010). Further investigation is needed to establish whether this applies generally to populations breeding in northern Iberia or whether it is just a local strategy in a relatively small reed bed.

Local-breeding reed warblers differ slightly biometrically from non-local birds originating further north. The mean wing length of transient birds was longer, although the overlap was large and the discriminating function only classified < 75% of reed warblers correctly. This result highlights that biometry cannot be used to separate local breeders and non-local birds with high accuracy in our region (Bibby and Green, 1981).

The longer wing observed in transient birds conforms with the rule that individuals from northern populations tend to be longer-winged than those breeding in southern regions, in part since the former must travel further on migration. Migration distance is known to drive selection for longer wings. In particular, Andueza *et al*. (2013) reported that reed warblers migrating through Iberia in autumn tend be longer-winged in relation to longer migration distances between their breeding sites in northern Europe and Iberia.

In conclusion, a fraction of the population of reed warblers breeding in a coastal wetland in northern Iberia departed from the area before the bulk of non-local birds arrived during the autumn migration period, which could suggest a partial overlap-avoidance strategy. Biometrically, local breeders were found to be shorter-winged than transient individuals. However, the discriminant function obtained for these birds was not 100% successful for classification purposes, indicating considerable morphological overlap between the two groups.

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