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SHORT NOTE

Does the Aquatic Warbler *Acrocephalus paludicola* show differential migration by age during the autumn in the Iberian Peninsula?

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Abstract The Aquatic Warbler *Acrocephalus paludicola* is a globally threatened European migratory songbird that passes through the Iberian Penninsula during its migration from Western Europe to Africa. The aim of our study was to determine the spatial migratory pattern of the species according to age classes during the post-nuptial passage in the Iberian Peninsula by analysing ringing data. The results confirm the existence of differential migration by age according to a longitudinal geographical gradient and suggest that the more westerly the wetlands, the smaller the proportion of juveniles that use them. Our findings also highlight the existence of a very broad migratory front. These results have implications for the conservation of different areas of migratory passage.

Keywords Migration strategy · Ringing station · Geographic segregation · Age ratio · Iberia

Zusammenfassung

Zeigen Seggenrohrsänger *Acrocephalus paludicola* im Herbst auf der Iberischen Halbinsel eine altersspezifische Differenzierung des Zugverhaltens?

Der Seggenrohrsänger *Acrocephalus paludicola* ist eine weltweit bedrohte europäische Singvogelart, die durch Westeuropa und Afrika zieht. Unser Ziel war es, durch die Auswertung von Beringungsdaten das räumliche Zugmuster der Art während des nachbrutzeitlichen Durchzugs auf der Iberischen Halbinsel nach Altersklassen zu beschreiben. Die Ergebnisse bestätigten das Auftreten altersspezifischer Unterschiede im Zugverhalten entlang eines longitudinalen geografischen Gradienten und deuten darauf hin, dass weiter westlich gelegene Feuchtgebiete in geringerem Maße durch Jungvögel genutzt werden. Dies unterstreicht außerdem das Vorhandensein einer sehr breiten Zugfront. Diese Ergebnisse haben Konsequenzen für den Schutz verschiedener Bereiche des Zugweges.

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Introduction

The Iberian Peninsula, due to its geographical location, is used as a stopover place by migratory birds during their passage from Western Europe to Africa (Newton 2008). The Aquatic Warbler *Acrocephalus paludicola* (hereafter referred to as AW), is the only globally threatened passerine species of continental Europe. Breeding populations at regularly occupied sites in Europe have been identified in only a few European countries, and its wintering areas are located in sub-Saharan Africa (Flade et al. 2011). The last two decades have seen an increase in our knowledge of

migratory routes and sedimentation sites in the Iberian Peninsula, a key area for migratory success, especially during post-nuptial passage (Atienza et al. 2001; Jubete et al. 2006; Neto et al. 2010). However, significant gaps in our understanding of basic aspects of bird migration, such as migratory strategies, still remain (Julliard et al. 2006).

Some authors have suggested the possibility of the existence of differential migration in the Iberian Peninsula, in which adult AW select a more western route during the autumn migration whereas juveniles select a more eastern one (Neto et al. 2010; Arizaga et al. 2011). However, this aspect has not yet been comprehensively analyzed. The aim of this study was to determine the spatial migratory pattern of the AW according to age classes during the post-nuptial passage across the Iberian Peninsula by analyzing data collected in ringing sites.

Methods

Data collected from 11 ringing sites located throughout Spain and Portugal were used in this analysis (Table 1), with the exception of all stations on the Mediterranean coast. Data from the latter sites were excluded because AW captures during the post-nuptial passage along the Mediterranean coast of Spain are sporadic: only five adults and 36 juveniles were captured in this area between 1980 and 2010 (e.g. between 1992 and 2010 only 3 juveniles were captured at the Ebro delta station). The 11 ringing stations/sites fulfill the requirement of being a regularly occupied site during the migration period.

For the analysis we categorized the birds into two age classes: juveniles (first year) and adults. Tape lures were used in most of the ringing sites. Two analyses were carried out, with one including all of the ringing sites ($n = 11$) and another excluding sites where tape lures were not used ($n = 9$).

The possibility that results could be influenced by a temporal change in the proportion of juveniles due, for example, to a variation in the inter-annual productivity rate was taken into account. For this reason, data from the La Nava lagoon for 2000 and 2008 were analyzed. This is the only ringing station in the study area with a long time series and a high number of captured birds and for which data are available for most of the study period.

The relationship between the percentage of juveniles captured at each station and the geographical longitude of the capture localities was analyzed by Generalized Linear Models (GLM) with binomial error and logit-link function. The possible effect of tape lures was also determined by considering stations where they were not used in a separate analysis. The temporal evolution of the age ratio found at the La Nava lagoon site was also analyzed by GLM. All statistical analyses were performed using the software package R.

Results

A total of 1,003 AW individuals were analyzed, of whom 426 were adults (42.5 %) and 577 were juveniles (57.5 %).

Table 1 Sampling points, sampling year, use of tape lures, sample size (*n*) and proportion of Aquatic Warbler (*Acrocephalus paludicola*) juveniles in 11 regularly occupied Aquatic Warbler sites in the Iberian Peninsula during the autumn migration period

Wetland[a]	Coordinates	Study period	Use of lure	*n*	% Juvenile	References
Laguna de Gallocanta	40°58′N; 01°31′W	2010	Yes	17	82.4	Pérez Laborda pers. comm.
Ría de Txingudi	43°21′N; 01°49′W	2007–2009	Yes	29	75.9	Arizaga et al. (2011)
Humedal de Salburua	42°51′N; 02°38′W	2002–2010	Yes	64	73.4	Sáenz de Buruaga pers. comm.
Laguna de La Nava	42°03′N; 04°45′W	2000–2008	Yes	673	59.3	Jubete et al. (2006) and unpublished data
Canal de Castilla	42°02′N; 04°52′W	2007–2010	Yes	19	57.9	Zumalacárregui and Jubete pers. comm.
Ría de Villaviciosa	43°30′N; 05°23′W	2004–2010	Yes	38	36.8	González and Peón pers. comm.
Arroyo de Valcavado	42°15′N; 05°45′W	2004–2006	Yes	27	37.0	Own unpublished data
Gravera La Canterina	42°16′N; 05°49′W	2008–2010	Yes	36	50.0	Own unpublished data
Brazo de la Torre	37°04′N; 06°13′W	2005–2006	Yes	16	12.5	Arroyo unpublished data
Lagoa de Santo André	38°05′N; 08°47′W	1997–2008	No	67	49.3	Neto et al. (2010)
Estuario del Miño	41°54′N; 08°50′W	1999–2002	No	17	41.2	Robles and Arcas pers. comm.

Data include 100 % AW ringings during the post-nuptial passage from Portugal up to 2008 and 83 % of those from Spain up to 2010 (Neto et al. 2010; Spanish Migratory Species Office ringing data)

AW, Aquatic Warbler

[a] Corresponding data for the La Nava lagoon (Laguna de La Nava) did not include 2004 as the sampling campaign did not cover the complete passage period. Data for the Canal de Castilla originate from two nearby wetlands: Charcas del Cruce and Venta de Valdemudo. Data for Portugal (Lagoa de Santo André in table) actually correspond data collected at seven localities, although the geographical coordinates of Lagoa de Santo André were assigned for the statistical analyses as 87 % of the captures were made at this location and all localities have a similar geographical longitude

The proportion of juveniles in each locality varied between a minimum of 13 % and a maximum of 82 % (Table 1). The percentage of juveniles was lower than the mean in all localities west of 5°W and higher in all those east of 5°W.

A significant relationship between the percentage of juveniles and geographical longitude (GLM $b = -0.21 \pm 0.05$; $p < 0.001$) was found, i.e. the percentage of juveniles was lower in the more western Iberian localities than in the more eastern ones. This difference remained significant when the analysis was restricted to the nine stations where tape lures were used (GLM $b = -0.42 \pm 0.08$; $p < 0.001$), but the deviance ($D^2 = 69.35$) was greater in the restricted analysis than in that carried out on all stations together ($D^2 = 47.84$).

The age-ratio analysis between different periods revealed that there was no significant change in the percentage of juveniles captured at the La Nava lagoon station during 2000–2008. Significantly lower values were only observed in 2002 (GLM $b = -0.53 \pm 0.23$; $p = 0.021$) and 2005 (GLM $b = -0.65 \pm 0.31$; $p = 0.035$).

Discussion

The results of our analysis of the percentage of juveniles and geographical longitude support the existence of differential migration among juveniles and adults in the Iberian Peninsula during their post-nuptial passage. This differential migration would appear to follow a longitudinal gradient, with the more westerly the location of the wetland, the larger the decrease in the number of juveniles at that site. In general, the percentages of AW juveniles in the Iberian Peninsula during the post-nuptial passage are low in comparison with those recorded in other countries on the Atlantic coast (Fig. 1).

Several authors have pointed out a decrease in the ratio juveniles: adults based on captures during the first decade of this century in Portugal (Neto et al. 2010) and at La Nava lagoon (Jubete et al. 2006). This decrease could be attributed to a possible decrease in AW productivity in breeding areas, although no accurate productivity data are available for this period. The analysis carried out in La Nava confirms that differences were not sufficiently significant to show a negative tendency.

Unlike Julliard et al. (2006), who found no significant difference in the distribution of juveniles and adults between different French sites, Le Nevé et al. (2011) propose the existence of a possible latitudinal gradient, with more adults on the central and northern coasts. This proposed latitudinal gradient coincides with the results reported by De By (1990), who observed an increase in the proportion of adult AW in southern Europe. Jiguet et al. (2011) observed a high percentage of juveniles in France and suggested that this is probably due to low juvenile mortality up to the time of the migration stopovers. However, it should not be ruled out that AW use different

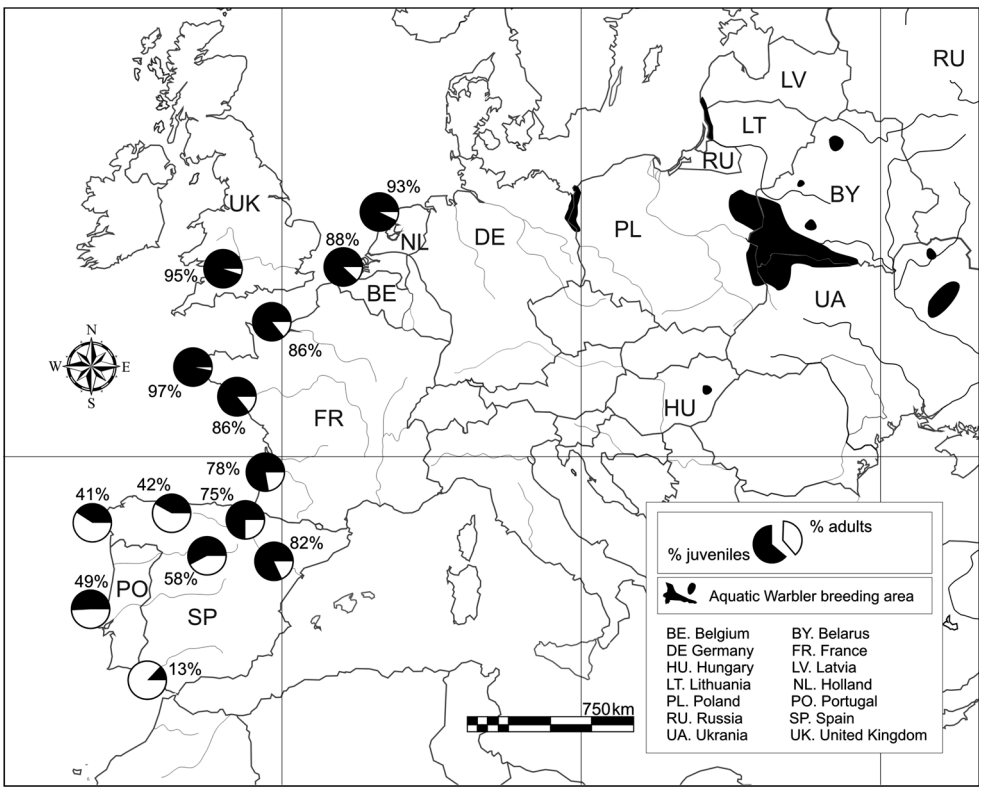

Fig. 1 Age ratio (juvenile vs. adult birds, given as a percentage) of Aquatic Warbler (*Acrocephalus paludicola*) during the autumn migration in Western Europe. For France, the percentages are from 2008–2009 (Le Nevé et al. 2011): in the northeast, $n = 445$; in Finistère, $n = 200$; in the centre of the Atlantic coast, $n = 448$; in wetlands on the southeast coast ($n = 232$). In The Netherlands, the percentages are from 1977–2005 ($n = 137$) (Boele and van Winden 2006). In Belgium, the percentage is from 1986–2006 ($n = 1{,}247$) (van Hove et al. 2011). The percentage of juveniles in the UK and Ireland are from 2006–2011 ($n = 37$) [British Trust for Ornithology (Thetford, Norfold, UK) ringing data]

migration strategies that are age dependent and that the composition of populations in different areas, such as overwintering sites, may depend on the geographical origin of the breeding populations (Pain et al. 2004). There could also be differences in migration strategy in terms of stopover site (Jiguet et al. 2011) or the distance that each age class can cover between stopover areas. Also, there could be a higher or lower number of stopover areas on the different migratory routes, as well as differences in the quality of each place.

Differences in the age ratio might be related to migratory strategy rather than the migratory route itself. In this respect, Jiguet et al. (2011) suggest that adult AW have a different migration stopover system than juvenile AW, with shorter times at each site or fewer sites. Possible explanations for this difference include adults having a long-distance migratory strategy and making fewer stops, adults being more experienced than juveniles in selecting adequate and high-quality stopover sites and adults having greater orientation skills (Newton 2008). For example, Julliard et al. (2006) indicate that body weight and fat score are higher in adults, i.e. they are in better condition for long-distance flying.

The use of tapes lures and other types of visual or sound decoys can influence the composition of captures and produce biases in the capture data in terms of age and sex distribution, physical condition of the birds or the time of the year (Mukhin et al. 2008). Jiguet et al. (2011) suggested that adult AW have a lower capture probability than juveniles in France because they are less attracted to tape luring. In our study, we found a positive relationship between longitude and the percentage of juveniles both when data from the stations using tape lures were analyzed and when the data from all stations were analyzed together. Nevertheless, the model fit was higher when the data from the only two stations not using tape lures were excluded from the analysis.

The high number of juvenile birds migrating along the French Atlantic coast may enter the Iberian Peninsula west of the Pyrenees, which could explain the high percentage of juveniles in the eastern ringing stations of our study, although this explanation does not clarify the passage through the Pyrenees and the arrival of adults in Iberia. Salewski et al. (2013) suggest that a small Ukranian population of AW uses the Atlantic coastal strip of the Iberian Peninsula. However, these authors propose a route entering the Iberian Peninsula via the Mediterranean Sea from Italy. Based on our results and those from sporadic captures along the Mediterranean coast, we believe that this new route is not used by the majority of European AW.

The detection of a longitudinal gradient during the postnuptial passage in the Iberian Peninsula indicates the existence of a very wide migration front and questions previously described routes, which are very distinct and confined to specific areas on the the Atlantic Cantabrian coast and in the Duero and Ebro river valleys (Atienza et al. 2001; Jubete et al. 2006; Julliard et al. 2006). The results of our study have clear implications for the conservation of the different migratory passage areas in the Iberian Peninsula and for the conservation of this globally threatened species, as they show differences in the spatial migratory strategy of the two age groups during a key period of their life cycle and in a geographical area of fundamental importance for migration.

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