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Short communication

Northward expansion of a desert bird: effects of climate change?

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Geographical expansion of species is a common process. Environmental changes over long timescales have produced new conditions that have allowed some species, including both plants and animals, to increase their range of distribution following such changes (Blondel & Mourer-Chauviré 1998, Svenning & Skov 2004). But such modifications can also come about on shorter timescales, mainly due to the effects of human activity (Johnson 1994, Sanchez-Lafuente *et al.* 2001, Wehtje 2003). More recent changes in distribution range seem to be related to current climate change (e.g. Valiela & Bowen 2003) and some predictions for the future have been made (Peterson *et al.* 2002). Available climate data for the past century indicate an increase in mean global temperature (IPCC 2001). Such temperature increases affect living species in different ways, including physiological adaptations (Clarke 2003), changes in phenological patterns (Walkowszky 1998) and/or changes in their distribution. Studies of such effects in southern latitudes of the Northern Hemisphere are scarce (but see Peñuelas *et al.* 2002, Sanz 2002) despite the rapid alteration of Mediterranean biodiversity owing to the combination of both climate change and human pressure (Santos & Telleria 1995, Sanz 2002, Opdam & Wascher 2004). Sanz (2002) pointed out the particular interest in studying how Mediterranean species respond to climate change in order to predict likely responses to future changes in the Mediterranean region.

The Trumpeter Finch *Bucanetes githagineus* Lichtenstein 1823, a fringillid bird associated with arid habitats and hot climates, is a good model for studying the probable effects of climate change on animal populations for several reasons. The distribution of this species was originally in North Africa (Cramp & Perrins 1994), and began to expand in the middle of the 20th century, occupying areas of south-eastern Spain (Cramp & Perrins 1994). The first winter record for southeastern Spain was in 1969 (König & Cano 1971) and the first breeding record was in 1971 (García 1972). Moreover, in the second half of the 20th century, this area has undergone changes in the seasonality of precipitation (Sumner *et al.* 2001), a decrease in precipitation (Rodrigo *et al.* 2000) and an increase in temperature (Watson 1998). The aim of the current study was to investigate the influence of climate change on the recent northward expansion of the Trumpeter Finch.

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METHODS

To document the expansion of the Trumpeter Finch, we performed an extensive literature search in databases such as the ISI Web of Knowledge, Zoological Records and Basic Biosis, to obtain references to the Trumpeter Finch. Spanish ornithological journals such as *Ardeola* and *Anuarios Ornitologicos* were thoroughly reviewed as well. Additional information was found by using internet search engines. Finally, some information reached us through personal contact with ornithologists and from ringing data.

To determine the probable influence of changes in aridity in southeastern Spain on the expansion of the Trumpeter Finch, we obtained the mean annual precipitation (data from the Instituto Meteorológico Nacional) from 1947 to 2003 for the cities of Almería (36°50′N, 02°28′W) and Alicante (38°20′N, 00°29′W), which are representative of the Trumpeter Finch's area of expansion in southeastern Spain. Data for Almería could not be found for two years (1979 and 1981) in the IMN records. Sample size for this city is therefore 55. To analyse the probable trends in precipitation over the years, we used the Mann–Kendall test (Sneyers 1992). Mann–Kendall statistic calculations were made using the program developed by Salmi *et al.* (2002). The relationship between mean annual precipitation and the presence of the Trumpeter Finch was analysed by means of logistic regressions with 0 = absence and 1 = presence. Presence was considered from the first year of breeding, 1971 for Almería, 1995 for Alicante, to the present.

RESULTS

The study species has been known to be present in the Iberian Peninsula since the 19th century (López-Seoane 1861, Vayreda 1883, Arevalo y Baca 1887, Jourdain 1936), but was considered to be accidental. In the early 1970s, breeding of the species was recorded for the first time in Almería (García 1972), the southeasternmost point in Spain. Since then, the number of records has increased with the establishment of several new breeding localities along the Mediterranean coast. First records in Murcia date back to the mid 1980s (Castanedo *et al.* 1987) and there are currently several locations (most of them along the coast, but also some inland) where a small number of birds are known to breed (Manrique *et al.* 2003). Alicante was probably colonized in the second half of the 1990s, as

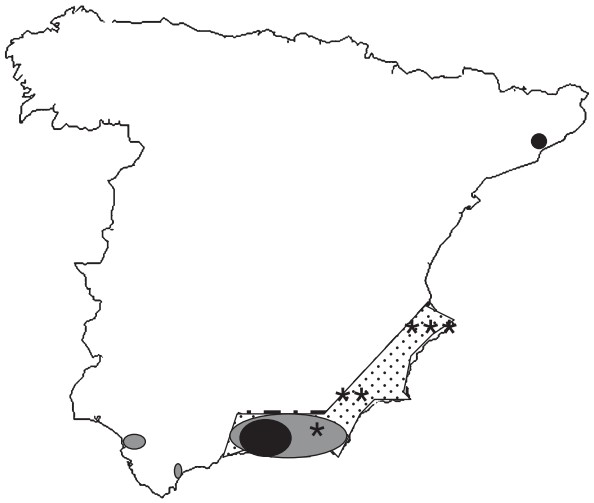

Figure 1. Distribution of the Trumpeter Finch in Spain. Asterisks show Almería (* first breeding 1971), Murcia (** 1985) and Alicante breeding localities (*** 1995). Black area = records in the 19th century; grey area = records in the 1960s; dotted area = current breeding area.

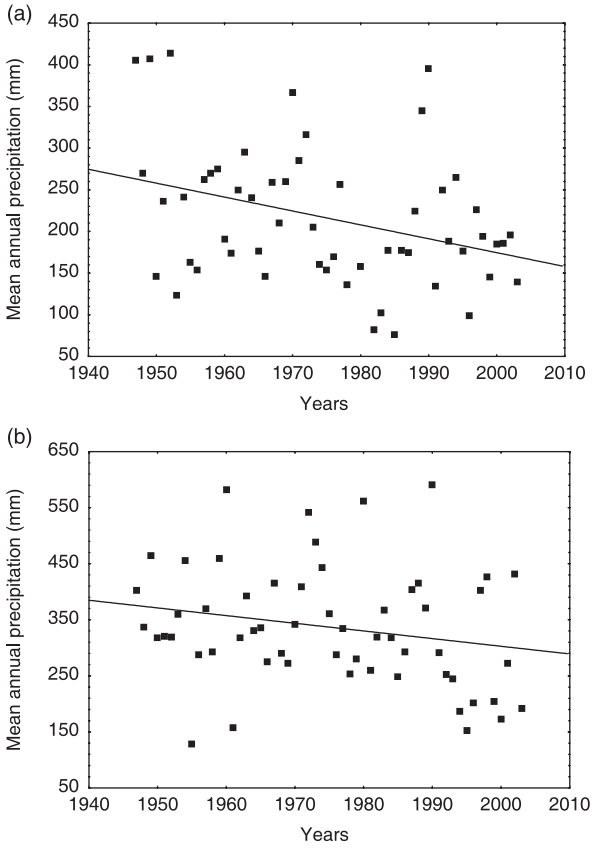

Figure 2. Variation of mean annual precipitation in the period 1947–2003 in (a) Almería and (b) Alicante.

confirmed by the finding of several old nests, and breeding was confirmed in 2000 (Manrique *et al.* 2003). There are currently two inland breeding populations, one not far from the inland location in Murcia. Additional recent non-breeding records have been cited in Granada (Fernández-Ordoñez *et al.* 2002), the Balearic Islands (De Juana 1996, De la Puente *et al.* 2003) and Valencia (De Juana 1994), and the species was recently observed as far north along the Mediterranean coast as the Camargue (Kayser *et al.* 2003). Therefore, in about 25 years, the Trumpeter Finch breeding area has spread at least 250 km further north (from Almería to Alicante) (Fig. 1). The complete list of references in which the Trumpeter Finch has been recorded is available online as supplementary material.

There is little information as to the size of the breeding populations or trends. The breeding population in Spain was estimated by Manrique and Yanes (1994) at around 100–300 pairs, most of them concentrated in Almería. These authors reported that the population in the Iberian Peninsula increased between 1970 and 1990 and that there was a decline in Almería in the early 1990s. Burfield (2004) reported a positive trend of the Spanish population in the last decade.

The Mann–Kendall test shows a significant decrease in mean annual precipitation in Almería ($Z = -2.12$, $P = 0.01$, $n = 55$; Fig. 2a) and in Alicante ($Z = -2.02$, $P = 0.01$, $n = 57$; Fig. 2b). The results of the logistic regression between the presence of the Trumpeter Finch in both Almería and Alicante and the mean annual precipitation in each location show a significant relationship for both localities, showing that the presence of the Trumpeter Finch is related to a decrease in precipitation (Almería, $\chi^2_1 = 6.17$, $P = 0.012$; Alicante, $\chi^2_1 = 3.76$, $P = 0.055$).

DISCUSSION

The results presented in this study indicate that, in the last 30 years, the area of distribution of the Trumpeter Finch has expanded along the Mediterranean coast of the Iberian Peninsula, where arid lands in Spain are best represented.

The occurrence of winter records prior to breeding in all the recently colonized locations (see Cano 1964, 1971 for Almería; Castanedo *et al.* 1987 for Murcia; Ramos 1990 for Alicante) suggests a parallel between the advance and creation of new winter quarters and the advance of breeding areas, as described for other bird species in expansion (Valera *et al.* 1993).

The precise causes of changes in the distribution ranges of species are in general difficult to determine (Bonham & Robertson 1975). Several factors such as dispersion dynamics, genetic mutation, alteration of habitat, climate

change, protection policies or re-introduction projects can explain the process of changes in the distribution area (Valera *et al*. 1993, Sanchez-Lafuente *et al*. 2001, Pacheco & McGregor 2004).

Overlap of the colonized area and the distribution of arid lands in Spain raises the question of whether the appropriate habitat was present before range expansion occurred or whether the habitat has recently changed, thus enabling birds to move into new arid habitat types. Both climate and human-related factors have acted synergistically to shape the Mediterranean (and the Iberian Peninsula) landscape, so that desertification is not new in this region (Puigdefábregas & Mendizábal 1998). The long-existing north–south aridity gradient in the Iberian Peninsula has tended to become steeper over the past 5000 years (Araus *et al*. 1997). Since 1900, a general trend of decreasing annual rainfall and increasing temperatures along with changes in land use in the southeast of the Iberian Peninsula have augmented the above-mentioned aridity gradient (Puigdefábregas & Mendizábal 1998). Thus, it is likely that an appropriate habitat for the Trumpeter Finch has existed in southeast Spain for a long time.

What then can explain the expansion of the Trumpeter Finch in recent decades? We found a negative relationship between mean annual precipitation and the presence of the Trumpeter Finch in Almería in the last 57 years. This relationship is also found in eastern Spain (Alicante) where the northernmost breeding population has recently established. Thus, current climate change in the Mediterranean area (Almarza 2000, Borén *et al*. 2000, Sanz 2002) may have favoured the presence and settlement of the Trumpeter Finch in the most appropriate parts (i.e. the most arid areas) of this region.

Of course, the expansion process could also be the consequence of climate change in other areas and/or other factors. Dramatic changes are occurring in the southwestern Mediterranean. For instance, a humid period from 1945 to 1968 was followed by a serious drought in the 1970s with serious socio-economic consequences resulting in overexploitation of the land (Puigdefábregas 1998). The Maghreb's population has increased by 300% since 1950 (Puigdefábregas & Mendizábal 1998), the area used for grain crops increased from 8.6 million ha in 1950 to 9.7 million ha in 1985, and sheep stock expanded from 18 million in 1950 to 33 million in 1984 (Le Houérou 1991).

To summarize, climate changes are known to have ecological consequences on plants and animals either directly (e.g. Peñuelas *et al*. 2002) or indirectly by promoting changes in land use and affecting human populations (Puigdefábregas & Mendizabal 1998, Puigdefábregas 1998). Such changes are likely to be more important in sensitive ecosystems such as those of arid areas. As shown for other species (Valiela & Bowen 2003), the northward expansion of the Trumpeter Finch may be a consequence of recent climate changes. What makes this species particularly interesting is that its distribution (bridging the north and southwestern Mediterranean) can make it a valuable tool for monitoring the effect of changes in sensitive areas of southern Europe and northern Africa.

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SUPPLEMENTARY MATERIAL

The following supplementary material is available as part of the online article from http://www.blackwell-synergy.com

Appendix S1: The complete list of references in which the Trumpeter Finch has been recorded.

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