



Biogeography of haemo- and ectoparasites of an arid-land bird, the Trumpeter finch

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ABSTRACT

The study of biogeographical patterns is basic to understand the processes that rule the distribution of parasites and to understand the influence that they have on host population dynamics. We tested (i) whether island dwelling host populations have lower parasite richness and higher prevalence than the mainland one; and, (ii) whether an expanding host population undergoes both lower parasite richness and prevalence than the source one. For these purposes, we studied the parasite fauna (haemo- and ectoparasites) of 398 Trumpeter finches (*Bucanetes githagineus*), an arid-adapted passerine, in three regions, the Canary Islands, south-eastern Iberian Peninsula (continental expanding) and Northwest Africa (mainland, source population). We searched for blood parasites microscopically. We studied feather lice and feather mites by scanning plumage of trapped birds. Whereas we found two haemo-parasite species in the mainland/source population, one in the island and two in the expanding population, we found two ectoparasites species in the mainland/source and three both in the island and in the expanding populations. Average and total prevalence of haemoparasites were highest in the mainland/source population. Ectoparasites had the lowest prevalence in the mainland/source population. Thus, we found that blood parasites fit the biogeographical predictions whereas ectoparasites do not.

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1. Introduction

Studying the diversity of parasites is particularly relevant from an ecological, evolutionary, epidemiological and conservationist point of view (Poulin, 2004; Poulin and Morand, 2000). Current studies on parasite diversity attempt to determine which factors, host or environmental-related, are the most appropriate determinants of parasite species richness (Poulin, 1998, 2004; Poulin and Morand, 2000). Works on biogeographical patterns of parasite diversity found that, besides the influence of parasite traits (Bush et al., 2009; Malenke et al., 2011; Moyer et al., 2002a), parasite distribution and richness is also linked to the ecology (habitat, migration, geographical range) of the host (Gómez-Díaz et al., 2012; Smith et al., 2004; Spurgin et al., 2012). Both factors can interact, since whereas overall species (including potential host) richness is usually lower in arid environments compared with temperate or

tropical regions (Myers et al., 2000), water scarcity can limit the presence of both haemo- (Tella et al., 1999; Valera et al., 2003; but see Martínez-Abraín et al., 2004 for alternative explanations) and ectoparasites (Malenke et al., 2011; Moyer et al., 2002a).

Here we investigated large-scale patterns of the parasite assemblage of an arid-land passerine, the Trumpeter Finch (*Bucanetes githagineus*, Lichtenstein, 1823). This species is distributed along North Africa, from where it has recently expanded to the Iberian Peninsula (Barrientos et al., 2014, 2009a; Carrillo et al., 2007a). The species is also present in the Canary Islands, where populations occur long time ago (Barrientos et al., 2014). Following Poulin and Morand (2000) for studies of biogeographical patterns, we designed our study focussing on a subset of parasites from a limited number of regions/populations. More precisely, we compared two insular and one recently expanded populations with a continental, long established population (Barrientos et al., 2009a, 2014), as well-designed richness-based studies require the comparison of parasite assemblages with the source (or equivalent) population rather than with the whole range (Colautti et al., 2004). We considered two groups of parasites with different transmission modes, namely the haematzoa (life-cycle with intermediate vectors) and the ectoparasites (feather lice and feather mites, both with direct transmission). Specifically, we test the following

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hypotheses: i) parasite richness is expected to be lower in island-dwellers respect counterparts inhabiting mainland (Gouy de Bellocq et al., 2002); ii) on the contrary, prevalence in islands tends to be higher due to the expected higher host densities (Dobson, 1988); iii) birds from the expanding population are expected to undergo fewer number of parasite species and lower prevalence than those from the source population (Phillips et al., 2010; Torchin and Mitchell, 2004; Torchin et al., 2003).

2. Methods

2.1. Study area, host and parasite species

We studied the parasite assemblage of the Trumpeter finch, a small-bodied fringillid (c. 21g) distributed in arid regions from Pakistan to the Canary Islands (del Hoyo et al., 2010), in four breeding localities (Appendix 1, electronic version only): i) Errachidia (31°56' N, 04°25' W), placed in North Africa, representing the continental, long established population and the source for the Iberian finches (Barrientos et al., 2009a); two islands of the Canary archipelago, ii) Fuerteventura (28°35' N, 13°58' W) and iii) Lanzarote (28°54' N, 13°46' W), where the Trumpeter finch is long established (Barrientos et al., 2014). These two islands host the largest Canary populations (del Hoyo et al., 2010; Martín and Lorenzo, 2001); and iv) Tabernas (37°02' N, 02°30' W), placed in south-eastern Spain, by far the most important breeding locality in the more recently colonized Iberian Peninsula (Barrientos et al., 2014, 2009a; Carrillo et al., 2007a). The Trumpeter finch breeding season extends from January to May in the Canary Islands (Martín and Lorenzo, 2001), from February to July in continental Spain (Barrientos et al., 2007) and from February to June in Morocco (Thiévenot et al., 2003).

Our microscopy study does not allow parasite identification to the species level. Instead, we worked at the genus level. Admittedly, this approach poses some limits to the interpretation of the results. In contrast it allows meaningful comparisons with previous studies (Carrillo, 2007; Carrillo et al., 2007b; Valera et al., 2003) that, in fact, enable us to test the biogeographical hypotheses mentioned above.

In consequence, we searched for the three genera of haematzoa detected to date in the Trumpeter finch: two apicomplexan, *Leucocytozoon* sp. and *Plasmodium* sp., and one microfilaria, tentatively identified as *Eufilaria* sp. We also searched for apicomplexan *Haemoproteus* sp. and euglenozoan *Trypanosoma* sp. as these parasites have been detected in several bird species following our same methodology (Valkiūnas, 2005). The genera *Leucocytozoon*, *Plasmodium* sp. and *Haemoproteus* have complex life cycles in which diptera (simuliids for the two former parasites and ceratopogonids and hippoboscids for the latter) are the main vectors (Valkiūnas, 2005). *Trypanosoma* species have also complex life-cycles and they are transmitted by a variety of simuliids (Scheuerlein and Ricklefs, 2004). *Eufilaria* species are nematodes living in the peritoneal cavity of many vertebrates that release microfilariae into the blood. They are transmitted by simuliids, ornithophilic ceratopogonids and haematophagous culicids (Anderson, 2000).

To our knowledge, the ectoparasites described for the Trumpeter finch to date are two chewing lice genera (Carrillo, 2007;

Carrillo et al., 2007b), which were considered as two single taxa for the analysis purposes. *Philopterus* sp. and *Brueelia* sp. (Phthiraptera: *Ischnocera*) live in the host plumage and only leave it to transfer directly among hosts (see Carrillo et al., 2007b for details). We also searched for feather mites (Astigmata), which are permanent ectoparasites, although some authors suggest that they are symbiotic rather than parasite taxa (Blanco and Frías, 2001; Blanco et al., 2001). They have direct transmission mode whose acquisition likely occurs during periods of high host gregariousness (e.g. Blanco and Frías, 2001).

2.2. Bird sampling and parasite survey

We sampled Trumpeter finches in Fuerteventura in February 2005 (breeding), in Lanzarote during April 2005 (breeding) and in Errachidia in July 2006 (post-breeding). In Tabernas, sampling was carried out from May to September in 2004 and from May to July 2005. Haemoparasites data from Tabernas come from Carrillo (2007) and lice data from the same population come from Carrillo et al. (2007b). All birds were ringed and aged as either juveniles (first calendar year) or adults (second calendar year or more). Adult birds were sexed on the basis of plumage colouration. As parasite prevalence or load can vary between breeding and post-breeding season (Carrillo et al., 2007b), we also included this variable (breeding vs. post-breeding) in the analyses when appropriate.

We took blood samples by brachial venipuncture using a heparinized capillary tube. Blood was smeared immediately, air dried, and fixed with absolute ethanol. Smears were stained with Giemsa at the lab. A $\times 400$ lens was used to look for extra-cellular parasites on all the surface of blood smears following the methodology described in Valera et al. (2003). We used the illustrations from Valkiūnas (2005) and Clark et al. (2009) to identify blood parasites. When a potential intracellular stage of haematzoa was detected, we used $\times 1000$ to confirm or discard it. Although molecular methods have been recommended over the use of smears (e.g., Belo et al., 2012), for the aim of our comparative approach, the smear scanning method seems to be suitable because the potential biases in parasite detection are likely the same in all the studied populations. Furthermore, microscopy is essential to detect mixed infections (Valkiūnas et al., 2006).

We studied louse species following the scanning method fully described in Carrillo et al. (2007b). Basically, two persons looked for parasites and their eggs on each bird for about 5 min by examining the breast, belly, lower back, rump, head, neck and throat. Adult and eggs from *Philopterus* sp. and *Brueelia* sp. are easily distinguishable on the basis of their body size and shape (Carrillo et al., 2007b). Furthermore, they show high specificity in the places where they are found, as *Philopterus* sp. are found in the head and *Brueelia* sp. are placed in the belly or rump (Carrillo et al., 2007b). Finally, we searched for mites in every wing and tail feather. We consecutively extended wings and tail and we counted all the mites by placing the bird against the light (see Blanco and Frías, 2001 for a similar methodology).

Overall, we searched for haemoparasites in 366 Trumpeter finches (35 in each island, Fuerteventura and Lanzarote, 276 in

Table 1
Haemoparasite prevalence in Trumpeter finches from the three studied populations. Sample sizes are shown in brackets and 95% confidence intervals in square brackets. Since there were no differences (host sex or age, season, year or island) within populations we pooled data to obtain a single value per population. Data from Tabernas are from Carrillo (2007).

	<i>Leucocytozoon</i> sp.	<i>Haemoproteus</i> sp.	<i>Trypanosoma</i> sp.	<i>Eufilaria</i> sp.
Canary Islands ($n = 70$)	0.0% [0.0–5.1]	1.4% [0.0–7.7]	0.0% [0.0–5.1]	0.0% [0.0–5.1]
Errachidia (North Africa) ($n = 20$)	0.0% [0.0–16.9]	0.0% [0.0–16.9]	5.0% [0.1–24.9]	50.0% [27.2–72.8]
Tabernas (Iberian Peninsula) ($n = 276$)	0.4% [0.0–2.0]	0.0% [0.0–1.3]	0.0% [0.0–1.3]	0.7% [0.1–2.6]

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