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Absence of insular density inflation in Corsican Finches *Carduelis* [*citrinella*] *corsicanus*

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Abstract. The insular syndrome predicts a number of differences between insular and mainland populations. One such prediction is that island populations tend to exhibit density inflation. This prediction was examined by comparing the population densities of mainland Citril Finches (central and south-west Europe) and insular Corsican (Citril) Finches (Mediterranean islands). Contrary to the hypothesis of density inflation in island populations, no indication of higher densities in Corsican Finches (0.6–2.1 pairs/10 ha) was found in comparison with Citril Finches (1.3 pairs/10 ha). In fact, population densities in the mainland population of the Catalan Pre-Pyrenees (7–10 pairs/10 ha) were extraordinarily high in comparison with all other study areas.

Key words: Citril Finch, *Carduelis citrinella*, Corsican Finch, *Carduelis corsicanus*, population density, density inflation, niche expansion, insular syndrome

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The so-called insular syndrome predicts changes in morphology (distinct plumage coloration, body size), behaviour (increased niche breadth) and demography (reproductive success, clutch size, population size) between insular and mainland populations (e.g. Blondel 2000). The reduced species richness on islands is often associated with higher population densities compared to those in similar mainland habitats (e.g. Blondel 2000). These higher densities in island populations are generally explained by the relaxation of interspecific competition on islands, niche expansion, reduced predation rate, restricted dispersal and intraspecific spill-over (George 1987, Ricklefs & Lovette 1999, Blondel 2000).

Mainland Citril Finches *Carduelis citrinella* and insular Corsican (Citril) Finches *Carduelis* [*citrinella*] *corsicanus* are appropriate model organisms to study differences between islands and mainland as imposed by the insular syndrome. Citril Finches breed in the higher mountain zones of the Iberian Peninsula, Central France, the Alps and at its northern distribution edge in the Schwarzwald (Dorka 1986, Cramp & Perrins 1994, Glutz von Blotzheim & Bauer 1997). Corsican Finches are restricted to few mountainous Mediterranean islands (Moltoni 1975, Arcamone 1993, Cramp & Perrins 1994, Baccetti & Märki 1997, Thibault & Bonaccorsi 1999). Mainland Citril Finches live in more wooded areas dominated by different pine species (especially Mountain Pines *Pinus* (*mugo*) *uncinata*, *Pinus* (*mugo*) *rotundata*), while insular Corsican Finches, use mainly the open landscape dominated by Tree Heath *Erica arborea* vegetation (Förschler & Kalko 2006b). Little information has been published about population densities of these scarcely distributed rare mountain birds. I tried to fill this gap by studying population densities in "hot spot" areas across the total range of the two (sub-) species. Main aim of this work was to find out, if insular Corsican

Finches show an extraordinary increase in population density as implicated by the hypothesis of density inflation in insular bird populations (Blondel 1985, Blondel et al. 1988, 1991, Blondel 2000).

During a study on breeding ecology of Citril and Corsican Finch (Förschler & Kalko 2006b) absolute population densities were obtained by mapping and counting nesting pairs in ten selected breeding sites between 1999 and 2003 (Table 1). Due to their typical habit of breeding in small neighbourhood groups the distribution pattern of the species is rather patchy (Förschler 2002). As population density seems to provide a good indicator for the overall quality of a habitat thus three types of population structures may be distinguished (Author's pers. obs.): 1) areas of low quality where small breeding groups and solitary pairs are spatially clearly separated from each other, 2) areas of intermediate quality where larger breeding groups are spatially separated from each other, 3) areas of higher quality where closely connected larger breeding groups are distributed more or less continuously. Because of this pattern, density measurements at study sites are strongly dependent on the size of the selected area (Luder 1981, Dorka 1986, Glutz von Blotzheim & Bauer 1997, Hölzinger 1997, Förschler 2002). Therefore I calculated densities for two spatial scales.

First, densities were obtained for large 100–180 ha sample plots. In all study plots I conducted systematic searches for all nests during the nest building period. During the time of highest nest building activity I visited the study plots continuously (10–20 days with approximately 8 hours per day in the study plots; 80–160 hours per study plot). In Citril Finches the nest searching method is more effective to calculate population densities than any other counting method. Once a nest is found it is much easier to locate the nest of neighbouring pairs of the surrounding, since nest building behaviour and breeding of neighbouring pairs is highly synchronous (Förschler 2002). The largest part of all nests was found by following the females that were engaged in nest building. Another suitable period to search for nests was during incubation, when the females were fed on the nest. Particularly during the first days of incubation, females call softly from their nest to attract their mate (pers. obs.). Finally, a few nests were found just before fledging, when young birds uttered soft calls. In total, 164 nests were detected at all study plots (see details in Förschler & Kalko

Table 1. Population densities of Citril Finches *Carduelis [citrinella] citrinella* and Corsican Finches *Carduelis [citrinella] corsicanus* in ten study plots on two spatial scales.

Plot location	Year	Predominant vegetation	Plot size (ha)	Height a.s.l.	Population densities (pairs/10ha)	Heighest densities (pairs/10ha)
		Citril Finch				
Schliffkopf, Schwarzwald, Germany	1999	*Pinus (mugo) rotundata*, *Picea abies*	180	1050	1.3	6
Vansa, Pre-Pyrenees, Spain	2002	*P. (mugo) uncinata*	150	2000	7	12
Prat de Botons, Pre-Pyrenees, Spain	2002	*P. (mugo) uncinata*, *P. sylvestris*	150	1850	10	15
		Corsican Finch				
Monte Arpagna, Capraia Island, Italy	2003	*Erica arborea*	100	350	0.6	3
Calasima, N Corsica, France	2001	*P. (nigra) laricio*, *E. arborea*	100	1100	0.8	4
Albertacce, N Corsica, France	2001	*P. (nigra) laricio*, *E. arborea*	100	1000	1.2	5
Cartalavonu, S Corsica, France	2003	*P. pinaster*, *E. arborea*	125	1100	2.1	10
Col d' Illarata, S Corsica, France	2001	*P. pinaster*, *E. arborea*	100	1100	1.9	7
Monte Limbara, N Sardinia, Italy	2003	*P. nigra*, *E. arborea*	100	1200	2.0	6
Monte Discudu, C Sardinia, Italy	2003	*Juniperus (communis) nana*	100	1500	1.0	3

2006b). All nests and nest suspicions ("territories") in the large study plots were mapped and population densities were calculated.

Second, densities were calculated for 10-ha core areas in the centres of the respective finch populations (i.e. areas with highest population density within the study plots). In these core areas, finches reach local maximum densities due to their patchy distribution, associated with good food conditions such as pine seeds or meadows and pastures with seeds of herbs and grasses (Förschler 2001, 2002, Borras et al. 2003, Förschler & Kalko 2006a). Additionally I measured the distance of nests to their nearest neighbouring nests to obtain another index for population density in these areas. For this analyses only nests were used, for which the distance to the nearest neighbours was known with certainty.

In all study plots I found the expected pattern of nesting in neighbourhood groups. Male finches showed little territoriality and defended only a small radius (about 5–10 m) around their nests and around their females (see also Förschler 2002). Of all study areas, the population at Port del Comte mountain (Vansa, Prat de Botons) in the Catalonian Pre-Pyrenees showed the highest population density (Table 1). Here densities were extraordinary elevated with 7–10 pairs/10 ha as opposed to an average of 0.6 to 2.1 pairs/10 ha in all other study areas (Table 1). In local core areas densities even reached 12 to 15 pairs/10 ha. Population density of Citril Finches in the Schwarzwald was much lower than in the Pre-Pyrenees with 1.3 pairs/10 ha and a local maximum of 6 pairs/10 ha in core areas. Accordingly, the distance to the nest of the nearest neighbouring pair was significantly higher in the Schwarzwald than in the Pre-Pyrenees (102.2 ± 50.5 vs 55.8 ± 26.1 m, Mann-Whitney U-test, T = 2588.5, $p < 0.001$).

Population density in all Corsican Finch populations was similar to the values of the Schwarzwald population with 0.6 to 2.1 pairs/10 ha (100 to 125 ha sample plot) and a local maximum of 7–10 pairs in core areas of the Massif de l' Ospedale (Cartalavonu, Col d' Illarata) in Southern Corsica. No significant difference was found in the distance to the nearest neighbour between insular Corsican Finches and mainland Citril Finches (90.9 ± 100.5 vs 77.7 ± 45.7, Mann-Whitney U-test, T = 1772, p = 0.22) as well between the three islands — Corsica, Sardinia and Capraia (60 ± 41, 127 ± 147.7 and 140 ± 127 m, respectively; Kruskal Wallis ANOVA, H = 1.36, df = 2, p = 0.5).

The insular syndrome predicts higher population densities in insular populations compared to mainland populations due to reduced competition, reduced predation, niche expansion, restricted dispersal and intraspecific spill-over (George 1987, Ricklefs & Lovette 1999, Blondel 2000). In the Silvereye *Zosterops lateralis chlorocephapha* Kikkawa (1976) found for example extraordinary high population densities with 125 pairs per 10 ha on Heron Island, Australia, compared to mainland populations of the same species. In this context I studied the expected density inflation in insular Corsican Finches versus population densities in mainland Citril Finches all over the small distribution range of these two forms (super-species *Carduelis citrinella*).

In all study plots the birds were as previously expected not evenly distributed (see also Dorka 1986, Förschler 2002). I may assume that local variations in habitat quality lead to this unequal distribution pattern within breeding areas (Förschler et al. 2005).

In my study, the highest density was reached in the Pre-Pyrenees. Here, Citril Finches were the most abundant bird species in the higher Mountain Pine zones with 7–10 pairs per 10 ha (on 150 ha sample plots) and local maximum densities of 12 to 15 pairs per 10 ha in core areas. Port del Comte turns out to be one of the most densely settled breeding sites known so far in Spain (see also Borras & Senar 2002, Borras et al. 2005) and presumably as well in the total range of Citril Finches (Cramp & Perrins 1994). Apparently this area with its high habitat heterogeneity, including open pine forest and flower-rich meadows and pastures provides optimal conditions for the species (Borras et al. 2003, Förschler et al. 2005).

Conversely, in the Schwarzwald (Förschler 2002) and in the Cevennes (Destre et al. 2000) Citril Finches are more scarcely distributed, and their population densities over larger areas are rather low. This difference in density is probably the result of missing habitat types in the latter areas. In the northern part of the Schwarzwald, only a few areas with a combination of Mountain Pine and Spruce forest with flower rich mountain meadows and heath land above 800 m a.s.l., are suitable for Citril Finches. Additionally, a population decline was noticed in these areas over the past 40 years because of habitat loss due to changes in land use, especially the decline of traditional pasturing in forests and mountainous heath land (Dorka 1986, Hölzinger 1997, Förschler 2002, 2006, Schonhardt 2002). Similar conditions, with partial population declines leading to much lower population densities especially in lower breeding areas, have also been reported for several populations in the Alps (e.g. Luder 1981, Mingozzi & Bocca 1986, Bezzel & Brandl 1988, Kilzer & Blum 1991, Mieslinger & Schuster 1996, Glutz von Blotzheim & Bauer 1997).

In contrast to my previous expectations, population density of Corsican Finch populations (Corsica, Sardinia, Capraia) was very similar to the one of Citril Finches in the Schwarzwald (this study) and the Alps (Luder 1981, Yeatman-Bertholet 1994), but clearly lower than the one at Port del Comte (Vansa, Prat de Botons) in the Pre-Pyrenees. For Corsican Finches I found highest densities in 2001 and 2003 in the Massif de l' Ospedale (Cartalavonu, Col d' Illarata) in Southern Corsica with 1.9 to 2.1 pairs per 10 ha (on 125 ha study plots), and local maximal densities of 7 to 10 pairs in core areas. The only data that are currently available for comparison and which support my data are 0.4 to 5.3 pairs per 10 ha estimated during point censuses in Corsica (Blondel et al. 1988, Thibault & Bonaccorsi 1999). Consequently, in all seven study plots for Corsican Finches there was no evidence for higher population densities of insular Corsican Finches compared to mainland Citril Finches as predicted by the hypothesis of density inflation in insular populations (Blondel 1985, Blondel et al. 1988). In fact, as shown above, Citril Finches on the mainland showed higher densities in favourable habitat (Pre-Pyrenees) than Corsican Finches.

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STRESZCZENIE

[Zagęszczenia populacji osetnika z wysp Morza Śródziemnego i kontynentu — brak "syndromu wyspowości"]

Tak zwany "syndrom wyspowości" zakłada istnienie różnic (m. in. fenotypowych, w biologii rozrodu, zagęszczeniach itd.) pomiędzy populacjami zamieszkującymi wyspy i kontynent. Występowanie takich różnic badano w populacji osetnika zamieszkującego centralną i południowo-zachodnią Europę oraz jego podgatunku — osetnika korsykańskiego (*Carduelis citrinella corsicanus*) z wysp Morza Śródziemnego. Zakładano, że zagęszczenia populacji wyspowych będą wyższe niż na kontynencie.

Badania na 10 powierzchniach (każda 100–180 ha) przeprowadzono w Szwarcwaldzie i Pirenejach Katalońskich oraz na trzech wyspach: Korsyce, Sardynii i Capraii (Tab. 1). Liczebność ptaków ustalano na podstawie wyszukiwania gniazd. Jako, że osetniki mogą gniazdować w niewielkich grupach, a ich rozmieszczenie może być nierównomierne zagęszczenia wyliczano w dwóch skalach — całej badanej powierzchni, jak również dla 10 ha z największą liczbą gniazd.

Przeciwnie do założeń nie stwierdzono, aby badane populacje różniły się zagęszczeniami: osetnik korsykański — 0.6–2.1 pary/10 ha, osetnik — 1.3 pary/10 ha. Najwyższe zagęszczenia, 7–10 par/10 ha stwierdzono w populacji hiszpańskiej z Pirenejów Katalońskich (Tab. 1).