Interlocality variation in speed of moult in the Citril Finch Serinus citrinella

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The speed of avian moult has been related to body condition, and this to habitat quality. These facts suggest a relationship between habitat quality and moult speed. We looked for evidence of such a relationship in the Citril Finch Serinus citrinella in the Pyrenees, where, because of a Mediterranean influence, there is an important bioclimatic contrast between north- and south-facing slopes of the same mountain. This contrast strongly affects the general body condition of birds there (higher body mass, fat score and survival on north-facing slopes). Citril Finches in the higher quality area moulted more rapidly (measured as residual wing raggedness) than those in the lower quality area, the two sampling localities being only 5 km apart. As the birds initiated moult at the same time in the two locations, this difference in speed cannot have resulted from a differential effect of photoperiod. This stresses the importance of habitat selection, even at very small scales, for the completion of moult.

The moult speed and extent of a bird is assumed to reflect its body condition (Jenni & Winkler 1994). For example, high-quality Barn Swallows Hirundo rustica, which display longer tail ornament, have better body condition, fewer parasites and moult more rapidly than poorer-quality birds (Møller et al. 1995). The body condition of a bird is related to the quality of its habitat (Wiens 1989). Hence we might predict that birds occupying habitats of different quality should differ in the speed at which they moult their feathers.

The Citril Finch Serinus citrinella breeds in the boreal mountain zones of western temperate Europe (Cramp & Perrins 1994), and maintains its highest densities in the Pyrenees mountains (Baccetti & Märki 1997). Here, and especially in the west, there is an important bioclimatic contrast between north- and south-facing slopes (Gutiérrez 1991). We have previously found that Citril Finches breeding on these two slopes, even when on the same mountain, differ in body condition parameters (body mass and fat score) and survival rate (Senar et al. 2002). The aim of this study is to test for a locality effect in speed of moult (residual wing raggedness) related to these differences in habitat.

MATERIALS AND METHODS
A total of 3936 Citril Finches were captured during the summer (June–September) from 1991 to 1996, during 115 trapping days; 220 of these birds were engaged in moult. Birds were captured at two localities, just 5 km apart, on Port del Comte mountain (Pyrenees, north-east Spain): Bofia (41°10′N, 1°32′E, 2050 m u.p.s.) faces south with a habitat of intermixed Mountain Pines Pinus uncinata and subalpine meadows; Vansa (41°12′N, 1°25′E, 2000 m u.p.s.) faces north and its habitat is dominated by open Mountain Pine forests. Because of a Mediterranean influence from the south, there is a high bioclimatic contrast between north- and south-facing localities (Gutiérrez 1991); this, together with additional topoclimatic factors, results in Bofia being hotter and drier than Vansa (Senar et al. 2002). Citril Finches at Vansa have a greater body mass, higher fat scores and rely more heavily on pine seeds as a (highly energetic) food source than birds at Bofia, which use a higher proportion of grass seeds (Senar et al. 2002). Vansa is consequently defined here as of higher quality than Bofia.

Age (yearlings vs. adults) and sex of the birds were determined according to Svensson (1992) and Jenni and Winkler (1994). Remex moult was recorded according to Ginn and Melville (1983). Old feathers were given a score of 0, new fully grown feathers
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a score of 5, and growing feathers a score from 1 to 4. The primary score is the sum of the scores for primaries, and the secondary score is the sum of the scores for secondaries. Raggedness is defined as the size of the gap in the wings caused by missing and growing feathers (Haukioja 1977); a raggedness score was defined as the complement of primary and secondary scores, i.e. a bird with a moult score of 4 was given a raggedness score of \((5 – 4) = 1\), and both old and new, fully developed feathers were scored as 0. The wing raggedness score is the sum of the scores for primaries and secondaries. The speed of moult was estimated as the residual from a model I linear regression of raggedness on primary moult score, according to Bensch and Grahn (1993) (taking moult scores > 5 and < 45; \(r = 0.45, F_{1,331} = 84.4, P < 0.001\)). Because moult speed did not vary across years (Vansa data, \(F_{3,153} = 1.29, P = 0.28\), controlling for age and sex), we pooled data for the different years. The timing of moult onset at the two localities was estimated according to Rothery and Newton (2002) from the probit regression (Hooke–Jeeves method & quasi Newton, implemented in the program STATISTICA) of moult state (0 = not started moult, 1 = started moult) on number of days from 1 June. Values reported are means ± se.

**RESULTS**

Adult Citril Finches moulted more quickly than yearlings (Table 1). No sex effect was detected. Locality affected moult significantly, with birds at Vansa moulting more rapidly than birds at Bofia (Table 1, Fig. 1). The date of primary-moult onset differed neither between the two localities nor between sexes (Table 2). However, on average, yearling birds started moult 1.4 days before adults (Table 2). We were unable to compare the timing of the end of primary moult between the two localities because Citril Finches desert the Bofia area before the end of moult. Taking only data from Vansa birds, we found that yearlings ended primary moult 13.6 days later than adults (Table 3). No differences between the sexes were detected (Table 3).

**DISCUSSION**

Because of an associated reduction in wing area, moult typically impairs flight ability and increases predation risk (Swaddle et al. 1996, 1999, Swaddle & Witter 1997). We should therefore expect birds to increase moult speed in order to reduce the moult–ing period. Given that moult is energetically highly demanding (Walsberg 1983a, 1983b), we should also expect birds in higher quality areas to moult more rapidly than birds in lower quality areas. Our data on the Citril Finch clearly support this relationship between moult speed and habitat quality: birds at Vansa, a high-quality area (Senar et al. 2002), moulted more quickly than birds at Bofia, just 5 km away. This difference cannot have resulted from a differential effect of photoperiod (Morton & Morton 1990, Dawson 1994, 1998, Dawson et al. 2000), because birds at the two localities started to moult more or less simultaneously.

A prediction from this relationship between habitat quality and speed of moult is that birds should select ‘good’ areas in which to moult. This is well known to be so in geese, ducks and waders (Salomonsen 1968, Jehl 1990, Kjellén 1994), but it has increasingly been found in recent years that some long-distance migrating passerines may also gather at special areas to moult (Ellegren & Staav 1990, Thompson 1991, Young 1991). Given that differences in habitat quality, which affect moult,
may occur very close together, as found in our study, we should also expect habitat selection in relation to moult to appear in non-migratory but non-territorial species, such as cardueline finches (e.g. Nakamura 1979). We believe that this merits further research.

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### REFERENCES


### Tables

#### Table 2. Timing of the start of primary moult according to locality (Bofia vs. Vansa), sex and age (yearlings vs. adults). Comparison tests, locality: $P = 0.24$, sex: $P = 0.73$, age: $P = 0.01$. $N$: sample size, $a$: intercept and $b$: slope for the probit regression model relating presence/absence of moult for each bird to number of days from 1 June, according to Rothery and Newton (2002).

<table>
<thead>
<tr>
<th>Locality</th>
<th>$N$</th>
<th>$a$</th>
<th>$b$</th>
<th>Days from 1 June (se)</th>
<th>Start date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bofia</td>
<td>714</td>
<td>−4.53</td>
<td>0.085</td>
<td>53.4 (11.8)</td>
<td>24 July</td>
</tr>
<tr>
<td>Vansa</td>
<td>1273</td>
<td>−3.99</td>
<td>0.076</td>
<td>52.7 (13.2)</td>
<td>23 July</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>1208</td>
<td>−4.07</td>
<td>0.076</td>
<td>53.3 (13.1)</td>
<td>24 July</td>
</tr>
<tr>
<td>Females</td>
<td>773</td>
<td>−4.59</td>
<td>0.086</td>
<td>53.1 (11.6)</td>
<td>24 July</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearlings</td>
<td>1189</td>
<td>−4.56</td>
<td>0.088</td>
<td>52.1 (11.4)</td>
<td>23 July</td>
</tr>
<tr>
<td>Adults</td>
<td>783</td>
<td>−4.09</td>
<td>0.076</td>
<td>53.5 (13.1)</td>
<td>24 July</td>
</tr>
</tbody>
</table>

#### Table 3. Timing of the end of primary moult according to locality (only data from Vansa are provided because birds desert the Bofia area before the end of moult), sex and age (yearlings vs. adults). Comparison tests, sex: $P = 0.35$, age: $P < 0.0001$. $N$: sample size, $a$: intercept and $b$: slope for the probit regression model relating presence/absence of moult for each bird to number of days from 1 June, according to Rothery and Newton (2002).

<table>
<thead>
<tr>
<th>Locality</th>
<th>$N$</th>
<th>$a$</th>
<th>$b$</th>
<th>Days from 1 June (se)</th>
<th>End date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vansa</td>
<td>454</td>
<td>8.43</td>
<td>−0.065</td>
<td>129.9 (15.4)</td>
<td>8 October</td>
</tr>
<tr>
<td>Sex (Vansa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>219</td>
<td>9.29</td>
<td>−0.072</td>
<td>129.8 (14.0)</td>
<td>8 October</td>
</tr>
<tr>
<td>Females</td>
<td>231</td>
<td>8.45</td>
<td>−0.066</td>
<td>128.5 (15.2)</td>
<td>7 October</td>
</tr>
<tr>
<td>Age (Vansa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearlings</td>
<td>144</td>
<td>8.30</td>
<td>−0.059</td>
<td>140.3 (16.9)</td>
<td>19 October</td>
</tr>
<tr>
<td>Adults</td>
<td>299</td>
<td>10.35</td>
<td>−0.082</td>
<td>126.7 (12.2)</td>
<td>5 October</td>
</tr>
</tbody>
</table>
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