## Biometrics of Citril Finch *Serinus citrinella* in the west Pyrenees and the influence of feather abrasion on biometric data

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Biometric data are an essential component of studies into the breeding biology of bird populations. Citril Finches *Serinus citrinella* in the Pyrenees mainly feed on pine seeds, and coniferous habitats in the west Pyrenees are of significant conservation importance. The aim of this study was to increase our understanding of morphological variation in Citril Finches breeding in the west Pyrenees, north Iberia, within a region of grasslands and woodlands of Scots pine *Pinus sylvestris*. Individuals (1,118) were mist netted, ringed and measured. Wing and tail length were influenced by feather abrasion, particularly in juvenile birds. Overall, male Citril Finches were larger than females for all structural and flight-feather measurements (wing, tail, tarsus and culmen length, bill depth and width and lower mandible length), and adults were larger than young birds (except for tail length, culmen length and bill depth). There was significant year-to-year variation for all measurements apart from tail length, but the reasons for this are unknown. Principal Components Analyses (PCA) were used to analyse wing and bill morphology. Adult birds had narrower, more pointed wings than young birds, and the wing shape in males was more pointed than in females. There were only sex-specific differences in bill morphology, with males having more robust bills. We obtained a discriminant function to classify the sex of birds before their post-juvenile moult.

The Citril Finch is an endemic songbird from the mountain ranges of the southwest Palearctic (Cramp & Perrins 1994, Baccetti & Märki 1997). The mainland population (the nominate subspecies) is fragmented into five discrete breeding nuclei: Alps and nearby mountain ranges (mainly in southeast France, Baccetti & Märki 1997), Pyrenees (south France, north Iberia), Cantabrian mountains (northwest Iberia), mountain ranges of central Iberia, and the Bethic System in south Iberia. From a global perspective, 75% of the Citril Finch populations are found in Iberia (Borrás & Senar 2003), mainly in the Pyrenees (Baccetti & Märki 1997). During the breeding season (from February to May), Citril Finches in the Pyrenees feed mainly on pine seeds (Borrás et al 2003); therefore, coniferous areas in the west Pyrenees are of significant conservation importance (Alonso & Arizaga 2004).

Biometric data from birds are vital for ornithological studies, since they allow us to describe and identify species (Svensson 1998), to distinguish discrete populations in relation to their geographical areas of origin (Walinder *et al* 1988, Wilson *et al* 2001, Onrubia *et al* 2003, Alonso *et* 

\* Correspondence author Email: jarizaga@alumni.unav.es *al* 2006), to attribute age and sex to individuals (Campos *et al* 2005) or to provide insights into predation risk or migratory behaviour (Calmaestra & Moreno 2001). Within Iberia, the paucity of biometric data on many breeding species, such as the Citril Finch *Serinus citrinella*, limits our ability to understand factors affecting breeding success and survival. Biometric studies are therefore a vital part of conservation efforts.

Currently available biometric data for Citril Finch refer mainly to populations in central Europe (including specimens from the Alps and nearby mountain ranges; Märki & Biber 1975, Brandl & Bezzel 1989), and the east Pyrenees (Borrás et al 1998). By contrast, few data have been reported from the rest of Iberia, including the west Pyrenees. In addition to problems arising from sparse data, the value of some biometric data is reduced by the phenomenon of feather abrasion. Biometric data commonly used in ornithological studies include measurements of wing and tail length (eg Cramp & Perrins 1994), and these can be badly affected by abrasion over time. For example, in late summer or autumn birds will have new flight feathers as a result of either postbreeding moult by adult birds or recent feather growth in the nest by juveniles; over the course of the winter months

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abrasion will progressively reduce the length of feathers (Ginn & Melville 1983, Jenni & Winkler 1994, Martin 1996). Therefore, birds captured in autumn should be expected to have longer flight-feather measurements than those caught in spring. The aim of this study was to describe the biometric characteristics of a Citril Finch population in the west Pyrenees (north Iberia) in relation to age and sex and to quantify the effects of feather abrasion.

#### **METHODS**

#### Study area

Sampling work was carried out at two localities in Navarra, north Iberia, west Pyrenees, situated within 30 km of each other: Bigüézal (42°40'N 01°08'W, 1,096 m asl) and Uztárroz (42°53'N 00°60'W, 1,383 m asl). Vegetation in these areas consisted of open mountain grasslands adjacent to woodlands dominated by Scots Pine *Pinus sylvestris*.

#### **Data collection**

From 2000 to 2005, individuals were captured with mist nets placed near the edge of the forest and grasslands. In order to facilitate captures, live decoys were used (see for further details Borrás & Senar 1986) under license from the Government of Navarra. Data collection was undertaken during the breeding season from March to October (inclusive) during the period when the species was present in the west Pyrenees. Once caught, each bird was ringed and its sex and age determined using published criteria (Svensson 1998). For this study, two age categories, based on plumage features, were used: young birds (EURING age codes 3 and 5: first-year birds after their partial post-juvenile moult in autumn of their first calendar year, and first-year birds in their second calendar year before their first complete moult in late summer, respectively) and adult birds (EURING age codes 4 and 6: adults in autumn after the late-summer complete moult, and adults in spring before the complete moult, respectively). Biometric data collected from each bird included wing length (WL,  $\pm$  0.5 mm, Maximum Chord Method, Svensson 1998), tail length (TL,  $\pm$  0.5 mm), primary feather lengths (P1 to P9, numbered descendently from proximal to distal,  $\pm$  0.5 mm), tarsus length (TS,  $\pm$  0.1 mm), culmen length (CUL,  $\pm$  0.1 mm), bill width and depth (BWI and BDE, respectively,  $\pm$  0.1 mm) and lower mandible length (LML, from buccal commissure to the tip,  $\pm$  0.1 mm). All measurements were recorded by a single observer (DA), as described by Svensson (1998).

#### Statistical analysis

Only information from newly caught birds (*ie* excluding recaptures) and birds with known age and sex were included in the analyses. The software SPSS version 13.0 for Windows was used with reference to statistical procedures described by Sokal & Rohlf (1995). To determine whether or not abrasion of feathers over time had any effect on feather-length-associated measurements, we conducted a Univariate Analysis of Variance (ANOVA; data fitted the statistical assumptions adequately: for all analyses  $F_{Levene}$ , P > 0.05) on WL and TL (dependent variables) with age, sex and season (autumn - EURING age codes 3 and 4; spring – EURING age codes 5 and 6) as factors. Although year of collection may be an additional source of variation, this variable was not included in this analysis since it would have diminished the sample size too much in each category ( $N \le 10$ ; Table 1). As an alternative way to test for year-to-year variation, residuals from an initial ANOVA (ie dependent variables after removing the effects of age and sex) were used within a subsequent ANOVA with the year of collection as a factor (for similar analyses see Edelaar & Terpstra 2004, Alonso et al 2006).

The data on feather abrasion were used to inform subsequent analyses. Thus, for analyses of flightfeather biometrics, when we analysed wing-associated

Table 1. Number of captures of Citril Finches, in the west Pyrenees (Navarra, north Iberia), from 2000 to 2005.

	Juveniles				Adults			
	Mo	ales	Fem	ales	Males		Females	
	EURING3	EURING5	EURING3	EURING5	EURING4	EURING6	EURING4	EURING6
2000	3	5	2	4	-	5	-	1
2001	4	4	3	2	3	4	3	1
2002	6	40	6	16	6	109	3	33
2003	77	82	40	50	8	36	6	20
2004	64	101	48	77	13	72	5	38
2005	30	20	13	14	7	24	2	8
Total	184	252	112	163	37	250	19	101

measurements, only data for first-year birds in autumn (EURING code 3) and adults in spring and autumn (EURING codes 6 and 4, respectively) were used. In contrast, for tail length, only data for birds aged as EURING code 3 or adults of EURING code 4 (autumn) were used.

In order to compare wing length data from the west Pyrenees with the data available from other study sites in mainland Europe: east Pyrenees (Borrás *et al* 1998) and central Europe (Jura and Alps, Märki & Biber 1975, Brandl & Bezzel 1989), we used a *t*-test for each age and sex category.

A Principal Components Analysis (PCA) on standardised lengths of P1 to P9, corrected for body size and allometry (Chandler & Mulvihill 1988, Senar *et al* 1994) was used to obtain objective and quantitative indices of wing morphology. A PCA on CUL, BWI, BDE and LML was also used for analysis of bill morphology. Univariate ANOVA on PCA scores was used to investigate the effect of age and sex on wing and bill morphology.

To develop a method to discriminate the sex of fledglings in the study area, we performed a Discriminant Function Analysis (DFA) on 8 morphological measurements (WL, P8, TL, TS, CUL, BDE, BWI, LML) from a sample of birds sexed either during or just after the partial postjuvenile moult on the basis of adult-type plumage (Senar *et al* 2002, Arenas & Senar 2004).

#### RESULTS

#### Sample size

From 2000 to 2005, data on 1,118 Citril Finches were collected. Of these, 436 (almost 40%) were young males, followed by adult males and young females (287 and 275; around 25% each), and 120 were adult females (10%). This is summarised by age class, sex and year of capture in Table 1.

**Table 2.** Wing and tail length (WL and TL, respectively; mean  $\pm$  SE)variation in relation to season (autumn or spring), sex and age (adultor young). Results are derived from univariate ANOVA.

	,	WL	TL		
	F	Р	F	Р	
Sex	737.653	< 0.001	213.914	< 0.001	
Age	38.359	< 0.001	2.731	0.099	
Season	1.324	0.250	39.232	< 0.001	
Sex*age	14.451	< 0.001	2.887	0.090	
Sex*season	2.127	0.145	0.801	0.371	
Age*season	11.377	0.001	5.533	0.019	
Age*sex*season	0.720	0.509	0.059	0.808	

#### **Feather abrasion**

Variation in wing and tail lengths with respect to age, sex and seasonal effects were analysed by ANOVA. In addition to the significant effects of age and sex (Table 2), both wing and tail lengths were affected by the season of capture (autumn or spring); this is likely to result from feather abrasion (Table 2). The statistical interaction between the season and age suggested that patterns of abrasion of feathers varied between age classes. Thus, with respect to first-year birds, wing lengths (WL) and tail lengths (TL) were approximately 0.5 mm (WL) and 1.0 mm (TL) longer in autumn than in spring (Fig 1). In contrast, for adults the values for mean wing lengths and tail lengths in autumn and spring tended to be similar, with only adult males showing a significant reduction in spring tail lengths. These results were used to remove the effects of abrasion in subsequent analyses of flight-feather biometrics by only using data from birds of EURING age codes 3, 4 and 6 (wing-associated analyses) or EURING age codes 3 and 4 (tail-length analyses).

#### **Biometrics**

The biometrics of the Citril Finches caught are summarised in Table 3. All measurements except tail length, culmen length and bill depth varied in relation to age, with adults having higher mean values than first-year birds (Table 3). For each variable, differences between the sexes and two age categories were investigated by two-way ANOVA (Table 4). Sex-specific variation was observed for all measurements, with males being larger (Table 3 and 4). In these analyses,

**Table 3.** Biometrics (mean ± SE and the sample size are shown) of a breeding Citril Finch population from the west Pyrenees in north Iberia.

	Juve	eniles	Adı	ılts
	Males	Females	Males	Females
WL	79.0 ± 0.1	76.4 ± 0.1	79.9 ± 0.1	76.6 ± 0.1
	(N = 184)	(N = 112)	(N = 280)	(N = 119)
TL	$56.2 \pm 0.1$	54.1 ± 0.2	$56.4 \pm 0.3$	$53.8 \pm 0.4$
	(N = 183)	(N = 110)	(N = 33)	(N = 14)
TS	14.9 ± 0.02	14.8 ± 0.01	$15.0 \pm 0.04$	14.9 ± 0.06
	(N = 428)	(N = 268)	(N = 272)	(N = 118)
CUL	8.9 ± 0.02	8.7 ± 0.03	$8.9 \pm 0.03$	8.6 ± 0.05
	(N = 416)	(N = 257)	(N = 264)	(N = 117)
BWI	5.9 ± 0.01	5.8 ± 0.01	6.0 ± 0.01	$5.9 \pm 0.02$
	(N = 416)	(N = 256)	(N = 264)	(N = 117)
BDE	$5.8 \pm 0.01$	5.8 ± 0.01	$5.8 \pm 0.01$	$5.8 \pm 0.02$
	(N = 416)	(N = 256)	(N = 264)	(N = 117)
LML	$10.2 \pm 0.03$	9.9 ± 0.03	$10.3 \pm 0.03$	10.1 ± 0.05
	(N = 415)	(N = 257)	(N = 264)	(N = 117)



**Figure 1.** Wing and tail lengths of first-year birds (EURING age codes 3 and 5; top panels) and adults (EURING age codes 4 and 6; bottom panels) in autumn (filled bars, EURING age codes 3 and 4) and spring (open bars, EURING age codes 5 and 6). NS, non-significant; \* P < 0.05; \*\* P < 0.01; \*\*\* P < 0.001.

the interaction term (sex\*age) was statistically significant only for wing length. Thus, for measurements other than wing length, relative differences in size between the sexes were consistent in both age groups. However, for wing length, the difference between wing lengths of first-year and adult females was small by comparison with the difference in wing length between first-year and adult males. For these

**Table 4.** Univariate ANOVA on morphological measurements of a breeding Citril Finch population from the west Pyrenees. Age and sex were considered as independent factors.

	Age		S	ex	Interaction	
	F	P	F	Р	F	Р
WL	23.301	< 0.001	763.170	< 0.001	7.628	0.006
TL	0.124	0.725	60.891	< 0.001	0.954	0.329
TS	5.744	0.017	8.773	0.003	1.811	0.179
CUL	0.404	0.525	85.739	< 0.001	0.977	0.323
BWI	29.246	< 0.001	28.938	< 0.001	0.881	0.348
BDE	0.906	0.342	19.330	< 0.001	0.259	0.611
lml	24.897	< 0.001	66.480	< 0.001	0.284	0.594

males, adults had longer wings than young birds and both ages of males had longer wings than either age category of females (Table 3). With respect to year of capture, all measurements varied significantly between years except tail length (Table 5). Although ANOVA revealed significant differences for bill width, the Tukey-B test did not identify any significant differences between years (Table 5). The patterns of year-to-year variation were very different between variables.

Overall, individuals from the west Pyrenees tended to have longer wings than those from central Europe (Table 6). When compared to birds from the east Pyrenees, adult Citril Finches from the west had significantly shorter wings. With respect to first-year birds, a slight but significant difference was only found within males, where birds from the west Pyrenees had slightly longer wings (Table 6).

#### Wing shape

In relation to wing morphology, components one and two (PC1wm, PC2wm, respectively) from a PCA on standardised primary feather lengths explained 70.6% of

	F <sub>1</sub>	Р	Tukey-B					
R <sup>WL</sup>	3.925	0.002	2001°	2000 <sup>ab</sup>	2002 <sup>b</sup>	2003 <sup>b</sup>	2004 <sup>b</sup>	2005⊦
R ™	2.207	0.053	-	-	-	-	-	-
R <sup>TS</sup>	117.050	< 0.001	2004°	2005°	2002 <sup>b</sup>	2003 <sup>b</sup>	2000°	2001 <sup>d</sup>
RCUL	14.673	< 0.001	2002°	2003°	2004°	2001 <sup>b</sup>	2005⁵	2000 <sup>b</sup>
R <sup>bwi</sup>	3.098	0.009	2005°	2001°	2003°	2004°	2000°	2002°
R <sup>BDE</sup>	17.394	< 0.001	2002°	2004 <sup>b</sup>	2005 <sup>⊾</sup>	2003 <sup>bc</sup>	2000 <sup>cd</sup>	2001 <sup>d</sup>
R IML	8.362	< 0.001	2004°	2003°	2002°	2000 <sup>ab</sup>	2005 <sup>ab</sup>	2001 <sup>b</sup>

**Table 5.** Variation of residuals (R) for each measurement between years (ie. corrected for the effects of age and sex). For each measurement type, the years are ordered by the magnitude of the residuals from small to large, and years where the residuals were not significantly different (Tukey-B tests) are grouped with the same superscripts.

**Table 6.** Wing length (mean  $\pm$  SD) of four Citril Finch populations from Europe. Within each age/sex category, comparisons between the west Pyrenees (this study) and other sites have been done using *t*-tests (*t*-test statistic, sample size and probability are shown). \*\*\* *P* < 0.001; NS, not significant.

	W Pyrenees (N Iberia)	E Pyrenees (N Iberia)	Alps (S Germany)	Jura (NW Switzerland)
Adult males	79.9 ± 1.5	80.6 ± 1.7	79.0 ± 1.5	79.0 ± 1.9
		t <sub>279</sub> = -8.251***	t <sub>279</sub> = 9.520***	t <sub>279</sub> = 9.520***
Adult females	76.6 ± 1.1	77.2 ± 1.9	77.1 ± 1.5	76.6 ± 1.9
		$t_{118} = -6.014 * * *$	t <sub>118</sub> = -5.031***	$t_{118} = -0.116^{\text{NS}}$
Juvenile males	79.0 ± 1.3	78.3 ± 1.5	77.6 ± 1.6	
		$t_{183} = 7.542 * * *$	$t_{183} = 14.669 * * *$	-
Juvenile females	76.4 ± 1.0	76.4 ± 1.7	75.9 ± 1.4	
		t <sub>111</sub> = -0.359 <sup>NS</sup>	111 = 4.933 * * *	-
Source	This work	Borrás et al 1998	Brandl & Bezzel 1989	Märki & Biber 1975

**Table 7.** Principal Components Analysis of Citril Finch wing morphology (wm). Factor loadings on standardised primary lengths P1 to P9 (numbered from innermost to outermost), corrected for body size and allometry following Senar *et al* (1994).

	PC1wm	PC2wm
P1	0.782	-0.292
P2	0.834	-0.319
P3	0.782	-0.388
P4	0.812	-0.338
P5	0.744	-0.213
P6	0.643	0.203
P7	0.726	0.501
P8	0.692	0.581
P9	0.535	0.626
Eigenvalue	4.835	1.518
Variance (%)	53.73	16.87

variance (Table 7). PC1wm (explaining 53.7 % of variance) showed positive factor loadings for all primaries, hence providing an index of wing width. Therefore, a lower value of this component should be related to a narrow wing, whilst higher values represent wider wings. In contrast,

PC2wm showed increasing factor loadings for distal primaries P6 to P9, whilst decreasing factor loadings for the innermost primaries P5 to P1; therefore PC2wm is an index of wing pointedness, with positive values representing a relatively more pointed wing, whilst negative values indicate a relatively more rounded wing. Univariate ANOVA on PC1wm demonstrated age-related variation (age:  $F_1 = 7.585$ , P < 0.001) with adults having a relatively narrower wing; there was no statistically significant variation between the sexes (sex:  $F_1 = 3.590$ , P = 0.059; age\*sex interaction:  $F_1 = 0.027$ , P = 0.869; Fig 2). With respect to wing pointedness (PC2wm), both age- and sex-related variation were detected (age:  $F_1 = 30.508$ , P < 0.001; sex  $F_1 = 8.666$ , P = 0.004; age\*sex interaction:  $F_1 = 2.167$ , P = 0.142), with males and adults having a relatively more pointed wing (Fig 2).

#### Bill morphology

For bill morphology, the first Principal Component (PC1bm) explained 44.9% of variance, whilst the second (PC2bm), with an eigenvalue near 1, explained 23.3% of variance (Table 8). PC1bm had high and positive factor loadings for each morphology-associated variable,



Figure 2. Wing morphology variation (PC1wm, PC2wm) in relation to age and sex categories. Mean ± SE and the sample size are shown.



Figure 3. Bill morphology variation (PC2bm) in relation to sex categories. Mean  $\pm$  SE and the sample size are shown.

**Table 8.** Factor loadings of a Principal Component Analysis on fourbill measurements (CUL, culmen length; BWI, bill width; BDE, billdepth; LML, lower mandible length), used to assess bill morphology(bm).

	PC1bm	PC2bm
CUL	0.728	-0.424
BWI	0.618	0.491
BDE	0.601	0.553
LML	0.724	-0.451
Eigenvalue	1.798	0.930
Variance (%)	44.92	23.25

**Table 9.** Classification matrix provided by the Discriminant Function Analysis on a Citril Finch sample of young birds (EURING 3) from a population from the west Pyrenees. Correct classifications in bold.

	Males	Females	Correct classifications (%)
Males (N = 177)	168	9	94.9
Females ( $N = 106$ )	8	98	92.5

which might be related to body size, rather than to bill morphology. In contrast, PC2bm represented an axis of increasing bill length (positive factor loadings in CUL and LML) and decreasing bill width and depth (negative factor loadings in BWI and BDE), so positive values of PC2bm represented a relatively thinner, slender bill, whilst negative values represented a more conical, robust bill. Thus, we used PC2bm as an index of bill morphology. Male Citril Finches had relatively deeper, wider bills than females (age:  $F_1 = 1.697$ , P = 0.193; sex:  $F_1 = 6.162$ , P = 0.013; sex\*age interaction:  $F_1 = 0.312$ , P = 0.572; Fig 3).

# Sexing juvenile Citril Finches before the partial post-juvenile moult

Morphological measurements (WL, P8, TL, TS, CUL, BDE, BWI, LML) on a sample of birds, sexed either during or just after the partial post-juvenile moult on the basis of adult-type plumage, were used to develop a method for sexing fledgling or juvenile Citril Finches. A Discriminant Function Analysis (DFA) provided a significant discriminant function ( $\lambda_{Wilk} = 0.471$ , canonical correlation r = 0.727, P < 0.001), y = 0.26 CUL + 0.149 LML + 0.05 BWI + 0.21 BDE – 0.07 TS + 0.75 WL + 0.05 TL + 0.003 P3 – 65.45, in which juvenile birds were males when y > 0, and females when y < 0. This DFA correctly predicted the sex of 94% of birds in the sample (94.9% of males, 92.5% of females, Table 9).

#### DISCUSSION

For this sample of Citril Finches from the west Pyrenees, wing and tail lengths changed, in the absence of moult, from autumn to spring, particularly among first-year birds. This was presumably due to the effect of feather abrasion, producing mean reductions of approximately 0.5 mm in wing length and 1.0 mm in tail length. Juvenile feathers seemed to show a higher degree of abrasion than those from adults and this may be due to juvenile flight feathers being of lower quality and more vulnerable to wear (Jenni & Winkler 1994). In addition, since juvenile flight feathers are not moulted during post-juvenile moult in this species, these feathers will be older than in adults and exposed to a greater amount of wear (Martin 1996).

Significant differences between the sexes were detected for all measurements, as well as between age classes (although with respect to age there were no significant differences in tail length, culmen length and bill depth), with larger mean values in males and adult birds as documented in many other species (Cramp & Perrins 1994, Svensson 1998), including the Citril Finch (Brandl & Bezzel 1989, Cramp & Perrins 1994, Borrás *et al* 1998). Tail length varied only between the sexes, with males having longer tails, which might be associated with courtship flight behaviour (Cramp & Perrins 1994), as also suggested by Borrás *et al* (1998) with respect to wing morphology. In contrast, the lack of significant differences between age classes may be an adaptation to maintain high manoeuvrability. Of the skeletal measurements, tarsus length varied between sex and age categories, with greater lengths in adults and males (Pascual & Senar 1996, Senar & Pascual 1997). This also suggests that, in addition to some sex-related size differences, tarsus lengths increase beyond the first year of life.

All measurements except tail length and bill width showed significant year-to-year variations. Observerassociated errors as a source of these differences were unlikely since data were taken by a single author (DA). Differences in food availability between years or differential mortality of some morphotypes (Nowakowski 2000) are factors which could explain morphological variability between years. An alternative explanation is that there may be local or regional differences in food supply leading to a variable influx of birds from elsewhere (Borrás & Senar 1991), as has been observed in other coniferous-dependent birds such as crossbills Loxia spp. (Newton 1972). However, data for variation in food abundance over time, as well as recoveries of individuals ringed abroad (with the exception of some from Catalonia, northeast Iberia, and one from central Iberia, Alonso & Arizaga 2004), are not available for the west Pyrenees. In addition, the different patterns of yearto-year variation between structural measurements makes interpretation difficult and further studies are required to elucidate the cause of this variation.

On average, individuals from the Pyrenees had longer wings than those from central Europe, as also found by Borrás et al (1998) for the east Pyrenees. Although Gosler et al (1998) suggested that wing length works well as an estimator of body size within a particular population, other reports suggest that body size is best estimated with skeletal measurements, such as keel or tarsus (Pascual & Senar 1996, Senar & Pascual 1997). Nevertheless, on the basis of wing length, data from the Pyrenees and central Europe could be interpreted as a north-to-south gradient in body size as has been observed for seven types of crossbills in N America (Groth 1993). Alternatively, ecological factors such as diet or habitat quality (Borrás et al 1998) may have an important influence on wing length. Within the Pyrenees, adults from the east had longer wings than those from the west, whilst for first-winter males birds from the west Pyrenees were larger. These observations suggest the need for studies to investigate the relationships between nutrition, morphology and survival within different areas of the Pyrenees.

Wing morphology is associated with flight performance (Mönkkönen 1995, Calmaestra & Moreno 2001). Thus, a narrower, more pointed wing allows higher flight efficiency as well as faster flight speeds (Norberg 1990), whilst a more rounded wing improves manoeuvrability. In this study, adult Citril Finches had a narrower, more pointed wing than young birds. These results might be explained by differential migratory behaviour in relation to age (eg Senar et al 1994), with adults migrating further away. Although Citril Finches from the west Pyrenees are migratory, moving up to 500 km between their breeding and wintering areas (Alonso & Arizaga 2004), detailed data on wintering areas in relation to age are not available. Alternatively, since inexperience makes juvenile birds more vulnerable to predators than adults, a more-rounded wing imparting greater manoeuvrability in young birds might help them to escape from predators more successfully (Pérez-Tris & Tellería 2001).

In relation to sex, the wing shape in males tended to be more pointed than in females. Although, wing pointedness is usually related to migratory strategy, this sex-related difference in Citril Finches could be associated with courtship flight behaviour, as suggested by Borrás *et al* (1998), rather than to differences between males and females with respect to migratory distance or speed. Bill morphology also differed between the sexes, with males having relatively deeper and wider bills. This suggests that there may be differences between males and females with respect to feeding ecology, perhaps in relation to the sizes of seeds on which birds feed, as shown by Newton (1972).

It is difficult to determine the sex of fledglings or juveniles of many species of finch (Borrás *et al* 1993, Cramp & Perrins 1994, Svensson 1998). In a population of Citril Finch in the east Pyrenees, Borrás *et al* (1993) correctly assigned the sex of 69% of fledglings using DFA based on plumage coloration and this was increased to 97% when biometric data were included in the analysis. The present study shows that 8 morphological variables can be used to sex a comparable proportion of juvenile birds from the west Pyrenean population, and this emphasises the potential of morphological traits for distinguishing the sex of birds before their post-juvenile moult.

The results of this study demonstrate the value of biometric data in raising questions about the foraging and migratory ecology of birds at different stages of the life cycle and in the two sexes. Further studies are needed to investigate the relationships between wing structure, food supply and migratory behaviour, and the effects on morphology and variation in food supply on age- and sexspecific survival rates.

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