

Moult extent differs between populations of different migratory distances: preliminary insights from Bluethroats *Luscinia svecica*

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It is generally accepted that bird species/populations that migrate longer distances undertake less extensive moults than those that migrate shorter distances. First-year Bluethroats of two subspecies with different migratory distances (*Luscinia svecica namnetum* and *L. s. cyaneacula*; the latter migrating the further of the two) were captured during the autumn migration period in 2012 in northern Iberia to test whether birds with longer migratory distances display less extensive post-juvenile moults than those that migrate less far. As predicted, the *L. s. namnetum* captured displayed more extensive moult in their greater coverts than the *L. s. cyaneacula* but not in their tertials. However, due to the large degree of overlap between the two subspecies, moult extent does not seem to be a useful marker for separating these two subspecies.

Key words: Bluethroat, *Luscinia svecica*, autumn migration, moult strategies, northern Iberia.

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Moulting is a highly energy-demanding process that is normally antagonistic with other energetically costly activities such as migration and breeding (Jenni & Winkler 1994, Figuerola & Jovani 2001). Thus, boreal migrant passerine species with little time to moult usually undergo their complete post-breeding/post-juvenile moults in winter and/or only perform a partial moult in their breeding areas (Berthold 1996, Svensson 1996, Svensson & Hedenström 1999, Figuerola & Jovani 2001, Hemborg *et al.* 2001, Barta *et al.* 2008). In this latter case, in addition to body feathers, moulting normally only involves some wing feathers and is limited to the tertials, alula and/or great coverts (Jenni & Winkler 1994). Birds from populations with longer migratory distances (compared to resident birds or to short-distance migrants) have less time to moult and thus undergo less extensive moults than populations with longer breeding

periods (Hemborg *et al.* 2001, Neto & Gosler 2006, Barta *et al.* 2008).

The Bluethroat *Luscinia svecica* is a widespread songbird that breeds over much of Europe (Cramp 1988). Two subspecies, *L. s. namnetum* and *L. s. cyaneacula*, breed, respectively, along the Atlantic façade of France and in the lowlands of Europe from northern France to eastern Europe (Cramp 1988). First-year Bluethroats undergo a partial moult before autumn migration that involves all body- and some wing-coverts (including all small and median coverts), none to several greater coverts and, occasionally, the carpal covert, one to two alula feathers and/or one to all tertials (Jenni & Winkler 1994).

Individuals belonging to *L. s. namnetum* subspecies overwinter in southern Portugal and northwestern Africa, while those belonging to *L. s. cyaneacula* overwinter from southern Europe (mostly southern Iberia) to tropical

Africa (Zucca & Jiguet 2002, Arizaga & Tamayo 2013, Correia & Neto 2013). Thus, overall, *L. s. namnetum* performs shorter migrations than *L. s. cyanecula* and so we would expect first-year *L. s. namnetum* birds to have a more extensive moult than *L. s. cyanecula*.

Both subspecies are common during autumn and spring migration in Iberia (Arizaga *et al.* 2006, 2011). Using data obtained from northern Iberia during the autumn migration period, we aimed (1) to test whether the moult extent of first-year Bluethroats belonging to the subspecies migrating shorter distances (*L. s. namnetum*) is greater than that of the subspecies migrating relatively longer distances (*L. s. cyanecula*), and (2) to evaluate whether moult extent can be used as an accurate tool for separating these two subspecies.

Material and Methods

Sampling site and data collection

This study was carried out at three coastal marshes located along the coast of northern Spain (from west to east): Villaviciosa (43°31'N 05°23'W), Urdaibai (43°21'N 02°40'W) and Txingudi (43°21'N 01°49'W). Bluethroats of both subspecies stop over in these wetlands before continuing on to their wintering areas in southern Iberia or Africa (Arizaga *et al.* 2006, 2011).

During the 2012 autumn migration period (from 15 August to 30 September), Bluethroats were captured with mist nets at each sampling site. This period of time covers almost the whole autumn Bluethroat passage through northern Iberia (Arizaga *et al.* 2010). Mist-netting was carried out on a daily basis using a constant sampling effort (the same number of mist nets in the same position at each site) during a period of 4 h from dawn onwards. Once captured, each bird was ringed and its age (adults: EURING code 4; first-year birds: EURING code 3) and sex determined (Svensson 1996). We also measured wing length (maximum chord; ± 0.5 mm).

Post-juvenile moult in Bluethroats includes all the lesser and median wing coverts (MiC, MeC, respectively), several greater coverts (GC) and some tertials (TT). Exceptionally, birds have been reported to moult some secondaries, primaries, or primary coverts (de Mesel 1996). We recorded the number of GC and TT moulted by each first-year

bird. Non-moulted GC or TT were identified by the presence/absence of an orange-yellowish spot at the tip of the feather; as well, non-moulted feathers are worn and browner than the greyer moulted feathers (Jenni & Winkler 1994).

Data analyses

In the analyses, we considered each individual at each site only once, i.e. recaptures within the same season were excluded to avoid pseudo-replication. No birds were recaptured at one of the other two sampling sites. Given that the post-breeding moult in adult Bluethroats is complete, we only took into account first-year birds. We used wing length to assign each bird to one subspecies or another (*L. s. namnetum* or *L. s. cyanecula*), using the criteria outlined by Neto & Correia (2012). Bluethroats were classified as *L. s. namnetum* if wing ≤ 72 mm (males) or ≤ 70 mm (females). This classification method is reported to be more accurate than formulae established on the basis of Bluethroats captured in breeding areas (Eybert *et al.* 1999), which have worn plumage (Neto & Correia 2012).

To test whether the proportion of Bluethroats with asymmetric moult limits varied according to the subspecies we ran a chi-square test on a contingency table of two variables: moult asymmetry -yes/no- and subspecies.

To test whether moult extent differed according to the subspecies, we used Generalized Linear Models (GLMs) with the number of GC or TT moulted as response variables, and the subspecies, sex, and their interaction as fixed explanatory factors. We included sex as factor since males often moult more feathers than females (Bojarinova *et al.* 1999). We used a Poisson distribution with log-lineal link function in the GLM due to the nature (counts of moulted feathers) of the response variables.

To evaluate whether moult extent can be used as a marker to separate these two Bluethroat subspecies, we conducted a Discriminant Analysis (DA) on the number of GC and TT, with subspecies as the grouping variable.

Results

We recorded the number of GC and TT replaced during the post-juvenile moult in 125 first-year

Table 1. Number of first-year Bluethroats captured at each site during the autumn migration period of 2012. Bluethroats were sexed as males, females, or unknown. *Nombre de cotxes blaves de primer any capturades a cada lloc durant la migració de tardor de 2012. Els individus es varen sexar com mascles, femelles o sexe desconegut.*

Site Lloc	<i>L. s. namnetum</i>			<i>L. s. cyanecula</i>		
	Male Mascle	Female Femella	Unknown Desconegut	Male Mascle	Female Femella	Unknown Desconegut
Txingudi	25	13	0	7	1	3
Urdaibai	22	10	1	6	3	0
Villaviciosa	14	14	1	2	3	0

Bluethroats, of which 100 were classified as *L. s. namnetum* and the rest as *L. s. cyanecula* (Table 1).

For GC, the moult limit was found to be asymmetric in 23 Bluethroats (18.4%), a proportion that did not vary with the subspecies ($\chi^2 = 0.853, P = 0.408$). For TT, however, moult limit was found to be asymmetric in only three Bluethroats (2.4%). Given the very low sample size, in the latter case we did not run any test to evaluate whether this proportion varied according to the subspecies.

We found that moult extent varied according to the subspecies for GC but not for TT (Table 2). Thus, *L. s. namnetum* moulted more GC than *L. s. cyanecula* (*L. s. namnetum*: range, 1–10; mean \pm SE, 5.2 ± 0.3 ; *L. s. cyanecula*: range, 1–9; mean, 3.8 ± 0.5 ; Figure 1). Moult extent did not differ between the sexes (Table 2). The over-dispersion (deviance/degrees of freedom) of the two models was low (GC: 1.4; TT: 1.2).

The DA showed that moult extent was not a good marker for separating the two subspeci-

es [$\lambda_{Wilks} = 0.965, P = 0.122$; discriminating function: $Y = 0.378(GC) + 0.048(TT) - 1.902$, where GC and TT are the number of moulted GC and TT; percentage of correct classifications: 53.3%].

Discussion

Bluethroats belonging to *L. s. namnetum* replaced more wing feathers than *L. s. cyanecula*, a result that agrees with the hypothesis that birds performing short migrations moult fewer feathers than those undertaking long migrations. However, caution must be taken when drawing conclusions from these results: (1) the data used in this study came from just one sampling year; (2) as only two subspecies were analyzed, this work cannot be used to test the general hypothesis stating that birds that migrate less far undertake more extensive moults than those that migrate further; (3) we have no data on moult duration and the quality of post-juvenile feathers in Bluethroat

Table 2. Results of the generalized lineal models conducted to test whether the moult extent of the greater coverts and tertials varied between the *L. s. namnetum* and *L. s. cyanecula* subspecies. *Resultats del model generalitzat lineal emprat per testar si l'extensió de la muda de les cobertores grans i les terciàries va variar entre les subespècies L. s. namnetum i L. s. cyanecula.*

Factors	Wald χ^2	df	P
Greater Coverts – Cobertores Grans			
Subspecies	4.271	1	0.039
Sex	0.377	1	0.539
Subspecies×Sex	0.638	1	0.424
Tertials - Terciàries			
Subspecies	0.933	1	0.334
Sex	1.270	1	0.260
Subspecies×Sex	0.095	1	0.758

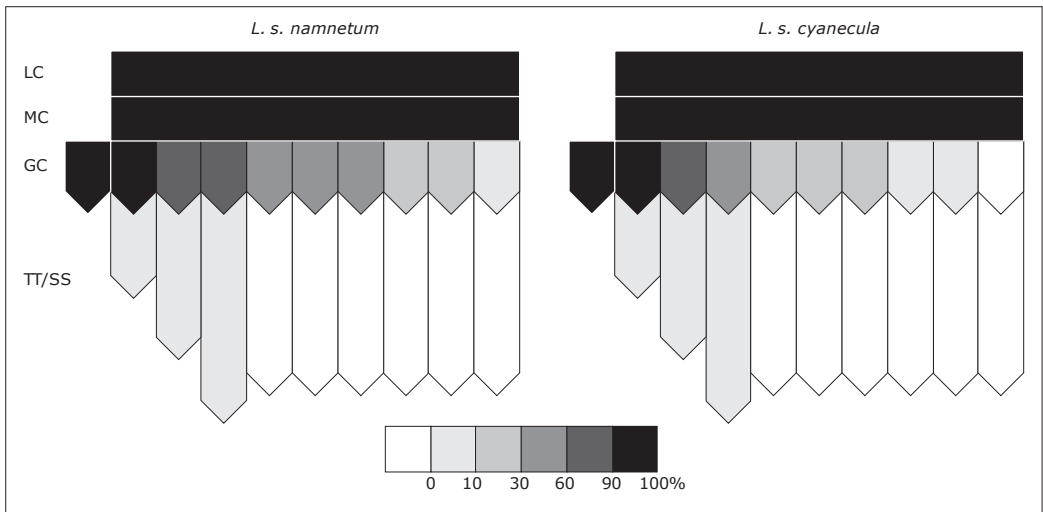


Figure 1. Post-juvenile moult extent in the two Bluethroat subspecies that pass through northern Iberia during the autumn migration period. Shades of grey indicate the frequency of feather replacement. Abbreviations: LC, MC, and GC stand for the lesser, medium, and greater coverts, respectively; TT and SS stand for the tertials and secondaries.

Extensió de la muda de dues subespècies de Cotxa blava que passen pel nord de la península Ibèrica durant la migració de tardor. La gradació de grisos indica la freqüència de recanvi de les plomes. Abreviatures: LC, MC i GC es refereixen a les cobertores petites, mitjanes i grans; TT i SS són les terciàries i secundàries, respectivament.

subspecies, or (4) on other factors that might also affect moult extent (e.g. food availability in each population's breeding quarters, climatic conditions, hatching date, etc.) (Bojarinova *et al.* 1999, Figuerola & Jovani 2001, Barta *et al.* 2008). The ultimate causes explaining why migrants performing longer migrations moult fewer feathers than those that migrate less far are still poorly known in most species (Barta *et al.* 2008). In our two Bluethroat subspecies, it is possible that *L. s. namnetum*'s more precocious breeding period allows it to moult more extensively (i.e. it has more time to moult) than *L. s. cyanecula*. Most *L. s. namnetum* Bluethroats arrive in their breeding sites in France in March and leave in July or August (Cramp 1988). *L. s. cyanecula* birds, however, reach their breeding sites later (mostly in April) and also depart in July or August (Cramp 1988). Apparently, therefore, *L. s. namnetum* birds have more time to moult. However, we have no detailed data on breeding behaviour (breeding period, occurrence of multiple clutches, etc.) for either two subspecies and so it is impossible affirm that the more extensive moult in *L. s. namnetum* is directly associated with its longer breeding period. In addition, moulting tends to take place more quickly if

there is less time to breed (e.g. de la Hera *et al.* 2009); thus, much still remains to be learnt about the relationship between these factors in the Bluethroat.

Together with other traits such as biometry (Förschler & Bairlein 2010, Arizaga & Barba 2011) and stable isotopes (Hobson & Wassenaar 1997, Hobson *et al.* 2004) that can be used to assess the origin of a bird (at least over broad geographic areas), moult extent could be used as a proxy of bird origin, especially when it varies latitudinally or longitudinally (but see Hemborg *et al.* 2001). Although *L. s. namnetum* was found to replace more wing feathers (greater coverts) than *L. s. cyanecula*, the overlap between the two subspecies was very high. Indeed, we should bear in mind that, despite not being recorded at our study sites, some first-year *L. s. cyanecula* birds moult all their GC and hence the moult limit must be looked for in the TT (R. Aymí, pers. comm.). Thus, moult extent (at least if used exclusively) cannot be used as a good marker to separate these subspecies of Bluethroats. Our results highlight that moult extent in Bluethroats (at least in *L. s. namnetum* and *L. s. cyanecula*) cannot be used as an additional complementary tool in studies on connectivity.

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Resum

L'extensió de la muda difereix entre poblacions amb diferent distància migratòria: resultats preliminars en la Cotxa blava *Luscinia svecica*

Està àmpliament acceptat que les espècies o poblacions d'aus amb distàncies de migració més llargues presenten una muda menys extensa que aquelles amb migracions més curtes. Es van capturar cotxes blaves de dues subespècies amb diferents distàncies de migració (*Luscinia svecica namnetum* i *L. s. cyanecula*, l'última amb major distància migratòria) durant la migració de tardor de 2012 al nord de la península Ibèrica per provar si les aus amb distància de migració més llargues tenen una extensió de muda postjuvenil més gran que les que migren menys. D'acord amb la predicció, *L. s. namnetum* va mostrar una major extensió de muda a les cobertes grans, però no a les terciàries. No obstant això, l'extensió de la muda no va ser útil per identificar ambdues subespècies a causa del fort solapament dels patrons de muda de les dues subespècies.

Resumen

La extensión de la muda difiere entre poblaciones con diferente distancia migratoria: resultados preliminares en el Pechiazul *Luscinia svecica*

Está ampliamente aceptado que las especies o poblaciones de aves con distancias de migración más cortas presentan una muda más extensa que aquellas con migraciones más largas. Se capturaron pechiazules de dos subespecies con diferentes distancias de migración (*Luscinia svecica namnetum* y *L. s. cyanecula*, el último con mayor distancia migratoria) durante la migración otoñal de 2012 en el norte de la península Ibérica para probar si las aves con distancia de migración más largas tienen una extensión de la muda posjuvenil mayor que aquellas que migran menos. De acuerdo con la predicción, *L. s. namnetum* mostró una mayor extensión de muda en las coberteras mayores, aunque

no en las terciarias. Sin embargo, la extensión de la muda no fue útil para identificar ambas subespecies debido al fuerte solapamiento de los patrones de muda de las dos subespecies.

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