Spatio-temporal segregation by sex of Chiffchaffs *Phylloscopus collybita* during the non-breeding period in northern Iberia

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As a contribution to the understanding of the sex-dependent spatio-temporal segregation of Chiffchaffs across their wintering range, we analysed data obtained at a ringing station in northern Iberia (Txingudi, Gipuzkoa) to test to what extent the sex composition in northern Iberia varied from the female-biased ratios detected further south in the Iberian Peninsula. The sampling period lasted for eight months from September to the following March/April (September 2003–March 2010). Wing lengths were longer in winter than in autumn and during spring migration, indicating that males were proportionally more abundant during the winter. By contrast, wing lengths did not differ between capture habitats, indicating that the sex ratio did not depend on habitat. Mean wing lengths of Chiffchaffs captured in autumn and recaptured once or more (either in autumn or later; 59.3 ± 0.7 mm) differed from the mean wing lengths of the Chiffchaffs captured in autumn that were not recaptured (57.5 ± 0.2 mm), which suggests that males were more likely to use the area than females. Although we did not estimate the sex ratios directly, we did obtain a mean wing length in winter of >59 mm. This mean is only slightly shorter than the mean wing length observed for males in France during the winter, but noticeably longer than the overall mean values reported for females. Thus, our data agree with the idea that the population of Chiffchaffs during the winter at our zone is male biased and is structurally closer to France than to regions situated further south. Thus, northern Iberia probably constitutes the southern edge of the part of the Chiffchaff's range where males are visibly more abundant than females in winter.

Key words: Chiffchaff, *Phylloscopus collybita,* differential migration, sex ratio, wing length, Txingudi.

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During the non-breeding period, sexes often segregate geographically (Gauthreaux 1978, Cristol *et al*. 1999) or locally according to habitat type (Holmes *et al.* 1989, Catry *et al.* 2004). Although this segregation is a widespread phenomenon in several bird species in both the Old and New Worlds (reviewed by Cristol *et al.* 1999), there is still a considerable gap in our knowledge of the ultimate mechanisms underlying sexual segregation during the non-breeding period (Catry *et al.* 2005b, 2007).

Sexual segregation is thought to be caused by one or more of four main mechanisms. (1) Social dominance: the dominant sex forces

the subordinate one to displace to suboptimal habitats/regions (Pienkowski *et al.* 1985). (2) Body-size interaction with local climate: the larger sex is able to live in colder environments as it has greater thermoregulation capacity (Ketterson & Nolan 1976, 1979). (3) Protandry: males overwinter closer to breeding quarters due to the potential fitness benefits of early arrival back on breeding grounds (Kokko 1999). (4) Foraging specialization: each sex is specialized in exploiting a certain habitat or region where its fitness is greater (Alves *et al.* 2013).

The Common Chiffchaff (hereafter, Chiffchaff) nominate subspecies *Phylloscopus c. collybita* breeds in central and western Europe, and its main wintering areas are found in the Circum-Mediterranean region (Cramp 1992). Iberia hosts a substantial proportion of the western European Chiffchaff breeding population that either overwinters in Iberia or passes over this region *en route* to or from Africa (Tellería *et al.* 1999). The Chiffchaff shows a sexually differentiated winter distribution, with females overwintering further south than males (Catry *et al.* 2005a). Recent studies show male-biased ratios in central and northern Europe, including northern Portugal, and female-biased ratios in the Circum-Mediterranean region (Catry *et al.* 2005a). Northern Iberia is located midway along this latitudinal gradient and so we would expect to find a slightly male-biased or possibly sex-balanced wintering Chiffchaff population in this region (sex ratios in northern Portugal were found to be male-biased; Catry *et al*. 2005).

As a contribution to the understanding of the sex-dependent spatio-temporal segregation of Chiffchaffs outside the breeding season, we analysed data obtained at a ringing station in northern Iberia to evaluate whether sex composition in this region fitted the expected latitudinal gradient.

Material and methods

Sampling area and protocol

Data were obtained at the Plaiaundi Ecological Park (Irún, Gipuzkoa, northern Iberia), a 24.1-ha area situated in the Txingudi marshlands (see for details Arizaga *et al.* 2007, 2010). The Chiffchaff is a non-breeding species in Txingudi that occurs mainly from September to April (Arizaga *et al.* 2010), either during autumn or spring migration or in winter, when a number of Chiffchaffs remain in the area for the entire season (Figure 1).

The sampling period during each campaign lasted eight months from September to the following April (except in the last campaign, when the sampling work finished at the end of March), from September 2004 to March 2010. Chiffchaffs were captured with mist nets four times/month (i.e. about once a week) over a period of four hours starting at dawn. Sampling was only suspended in case of adverse weather conditions. The mist nets were situated at fixed sites during each campaign. Up to March 2006, the mist nets (72 linear meters) were placed in five lines, of which some were situated in transition zones where defining a particular habitat was not possible (e.g. an ecotone between a reed bed and flooded fields). From September 2006 onwards, however, the nets (96 linear meters) were placed in four more easily identifiable habitats (24 linear m/habitat: reedbeds *Phragmites* spp.; flooded fields; an alder grove *Alnus* spp.; and a juvenile Atlantic forest of deciduous species dominated by oaks *Quercus* spp., maples *Acer* spp. and ashes *Fraxinus* spp.) (see Arizaga *et al.* 2007 for further details). The distance between the nets in one habitat type to the next was 150–350 m. The height of the vegetation was almost the same as the height of the nets in the flooded fields and the reed beds (ca. 2 m), but higher (up to 10 m) in the other two habitats.

Once captured, birds were ringed and their wing lengths measured (method III according to Svensson 1996; 0.5 mm accuracy).

Data analysis

We analysed the seasonal distribution of captures and the proportion of recaptures in order to identify passage (autumn and spring migrations) and settlement (winter) periods. We considered each bird only once (first capture event) per month, and used the campaign and months as the time units.

Chiffchaffs are sexually dimorphic, with males having longer wings than females (Svensson 1996, Catry *et al.* 2007, Rodríguez *et al.* 2013). Although differing somewhat according to the author and region, in the nominate subspecies *P. c. collybita* wings measure 53–61 mm in females and 57–64 mm in males (Svensson

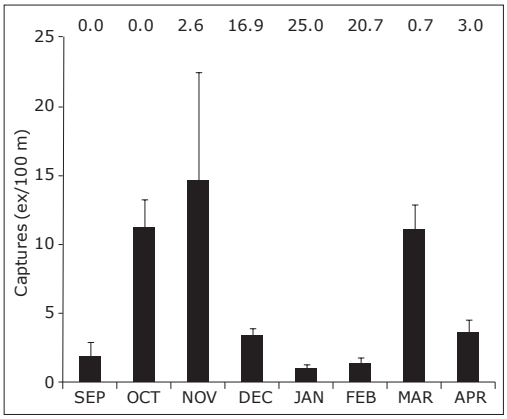

Figure 1. Standardized (captures/100 m of mist nets/4 h of sampling starting at dawn) seasonal distribution of captures (mean ± SE) and percentage of recaptures (above) of Chiffchaffs captured at Txingudi, northern Iberia. Data collected from September 2004 to March 2010. No captures took place between May and August. *Distribució estacional de captures estandarditzades (captures/100 m de xarxa/4 h de mostreig començant a l'alba) (mitjana ± error estàndard) i percentatge de recaptures (números a sobre) de mosquiters capturats a Txingudi, nord d'Ibèria. Dades recollides entre setembre de 2004 i març de 2010. No hi va haver captures entre maig i agost.*

1996). Thus, we considered that seasonal variations in mean wing length would generally indicate seasonal variations in the sex composition of the studied population (e.g. longer mean wing lengths in a particular period would be attributable to the fact that males were proportionally more abundant in that period than in other periods). Additionally, we used wing length to assign sex to each individual bird. In agreement with Catry *et al.* (2007), Chiffchaffs with a wing length ≤57 mm were identified as females and those with wings ≥60 mm as males. Intermediate wing length values were not sexed due to the biometric overlap between the two sexes (Catry *et al.* 2007). In Chiffchaffs, as in other passerine birds, adults have longer wings than first-year birds (Catry *et al.* 2005a); however, we did not attempt to include this variable in our analyses due to the difficulty of ageing birds in autumn and winter. Taking into account age in the analyses would have both decreased the sample size (a fraction of the birds were not aged) and increased the number of errors due to misclassifications. Nevertheless, age-associated wing length differences have been shown to be small (<2 mm) when compared to sex-associated differences (ca. 6 mm) (Catry *et al.* 2005a).

To analyse whether wing lengths varied between different periods (autumn, winter and spring), we conducted an ANOVA on wing length with 'period' and 'habitat' as factors. We considered each bird only once (first capture event) per period and only birds that were captured from September 2006 onwards (when the nets were placed in more clearly identifiable habitats). We also used this same data set to run a Chi-square test to check whether the proportion of sexes varied between periods.

To test whether or not males were more likely to settle in the area than females, we used a *t*-test to compare the wing lengths of Chiffchaffs captured in autumn and later recaptured with the wing lengths of Chiffchaffs captured in autumn but not recaptured.

We used SPSS version 18.0 for the statistical analyses. Unless otherwise stated, values are given as means ± SE.

Results

The distribution of captures showed peaks in November (> 15 captures/100 m of mist nets/day) and March (> 10 captures/100 m of mist nets/day) (Figure 1). As deduced from the high variance (Figure 1), the spring peak was more variable between years than the autumn peak. Between December and February, the abundance of Chiffchaffs was very low (< 5 captures/100 m of mist nets/day) but the proportion of recaptures was high, increasing from 17% in December to 21% in February. Thus, it is clear that the autumn migration period lasts from September to November, the winter period from December to February, and the spring migration period from March to April.

Mean wing lengths (each bird was only considered once per period) were longer in winter than during autumn and spring migrations (Table 1; Figure 2), suggesting that males were proportionally more abundant during the winter. By contrast, wing lengths did not differ between habitats (Table 1), indicating that the sex composition did not depend on habitat. The proportion of each sex was not constant between periods ($\chi^2 = 14.112$, $df = 2$, $P = 0.001$) as there was a much higher proportion of male Chiffchaffs in winter than in autumn and spring (Table 2).

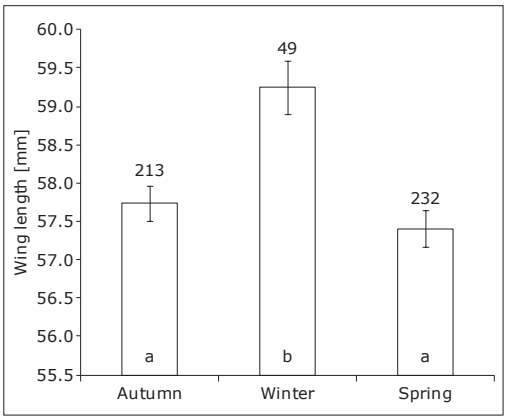

Figure 2. Mean wing length (±SE) of Chiffchaffs captured during the autumn, winter and spring at Txingudi. Also shown is sample size (above SE bars) and the results derived from an *a posteriori* test used to test for differences between periods. In this test, the same letters lump periods without significant differences.
Longitud mitjana de l'ala (± error estàndard) dels mosquiters capturats durant la tardor, l'hivern i la primavera a Txingudi. També es mostra el nombre d'individus (sobre les barres d'error) i els resultats derivats d'un test a posteriori per testar les diferències entre períodes. En aquest test, les mateixes lletres agrupen períodes sense diferències estadísticament significatives.

The mean wing lengths of Chiffchaffs captured in autumn and then recaptured either in autumn or later (59.3 ± 0.7 mm) differed from the mean wing lengths of Chiffchaffs captured in autumn but not recaptured (57.5 ± 0.2 mm; $t_{391} = 2.282$, $p = 0.023$), which suggests that males were in general more likely to be present in the area than females.

Discussion

Overall, males were found to be proportionally more abundant in winter than during the two migration periods. This result agrees with the fact that females overwinter further south than males and the existence of differential winter distributions between sexes on a large geographic scale (Catry *et al.* 2005a). With ca. 70% of the abundance, the proportion of males found during the winter in our area does not differ from that reported in France and is about 10% lower than in England, but is higher than the ca. 50% observed in northern Portugal and the <40% reported for the Circum-Mediterranean region (Catry *et al.* 2005a). Thus, our data support the idea that the population of Chiffchaffs during the winter in our zone is male biased, and that this zone is structurally closer to France than to more southerly regions (Mediterranean region in Iberia and Africa). Therefore, northern Iberia is likely to constitute the southern edge of the part of the Chiffchaff's range where males are more abundant than females in winter.

Northern European Chiffchaffs have longer wings than those breeding in areas further south (Cramp 1992). Thus, our findings are also compatible with the hypothesis that the studied winter population may be composed of a greater proportion of northern European Chiffchaffs. Although we cannot confirm this hypothesis using our data, leapfrog migration is common in many European passerines, i.e. northern breeding populations may in fact winter further south than more southerly breeding populations (Newton 2008). This hypothesis has not specifically been tested for Chiffchaffs and ring-recovery data provide no support for it, since northern birds seem to overwinter either in the same areas or even further south than more southerly breeders (Cramp 1992). Thus, the longer mean wing length in winter is probably attributable to the presence of a greater number of males (Catry *et al.* 2005a, 2005b, 2007).

We observed that Chiffchaffs captured in autumn and then recaptured had longer wings than those that were captured only once. This suggests that the Chiffchaffs that arrived in the

Table 1. ANOVA used to test whether average wing lengths varied in relation to the period and zone in which birds were captured (each bird was only considered once per period).
ANOVA per testar si la longitud mitjana de l'ala va variar en relació al període i l'hàbitat on les aus es van capturar (cada exemplar només es va considerar un cop en cada període).

Variable	SS	*df*	*F*	*p*
Period / *Període*	105.2	2	4.528	0.011
Zone / *Hàbitat*	29.7	3	0.852	0.466
Period×Zone	49.4	6	0.709	0.643
Error	5717.1	492		

Period *Període*	Female (%) *Femelles (%)*	Male (%) *Mascles (%)*	Sample size *Nº individus*
Autumn / *Tardor*	55.9	44.1	188
Winter / *Hivern*	29.5	70.5	44
Spring / *Primavera*	60.7	39.3	191

Table 2. Sex proportions during the autumn, winter and spring at Txingudi (northern Iberia). Sexes determined by wing length (Catry *et al.* 2007). Each bird was only considered once per period.
Proporció de sexes durant la tardor, hivern i primavera a Txingudi (nord d'Ibèria). Sexes determinats per longitud alar (Catry et al. 2007). Cada exemplar es va considerar només un cop per període.

area in autumn and then overwintered were mostly males, while females continued their migration southwards, where competition against males is less or, more likely, they find habitats that guarantee greater fitness and/or survival benefits (Catry *et al.* 2007).

We detected no differential distribution of sexes between habitat types, which suggests that competition for habitat – if it exists – is weak and probably biologically non-significant (Catry *et al.* 2003).

In conclusion, in contrast to autumn and spring migration periods, during the winter proportionally more male than female Chiffchaffs were captured at a locality in northern Iberia. In addition, the male bias in the birds captured in autumn and then recaptured indicates that more males than females overwinter in the area.

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Resum

Segregació espaciotemporal per sexes en el Mosquiter comú *Phylloscopus collybita* durant el període no reproductor al nord d'Ibèria

Amb l'objectiu d'entendre la segregació espaciotemporal depenent de sexe en el Mosquiter comú fora de l'època no reproductora, es van analitzar les dades obtingudes en una estació d'anellament del nord d'Ibèria (Txingudi, Guipúscoa) per tal de comprovar en quina mesura la proporció de sexes al nord d'Ibèria varia significativament respecte les proporcions esbiaixades de femelles detectades en altres zones del sud de la península Ibèrica. El període de mostreig va durar vuit mesos de setembre a març/abril de l'any següent, començant el setembre de 2003 fins al març de 2010. La longitud de l'ala va ser major a l'hivern que durant la migració de tardor i primavera, el que indicaria que els mascles van ser proporcionalment més abundants durant l'hivern. Per contra, la longitud de l'ala no va diferir entre els hàbitats de captura, de manera que la proporció de sexes no va dependre d'aquest factor. La longitud de l'ala dels mosquiters capturats a la tardor i recapturats després una o més vegades (ja sigui a la tardor o més tard; 59,3 ± 0,7 mm) va diferir significativament de la longitud mitjana de l'ala dels mosquiters capturats a la tardor i que mai no van ser recapturats (57,5 ± 0,2 mm), el que suggereix que els mascles van ser més propensos a assentar-se a la zona que les femelles. Encara que no hem calculat la proporció de sexes directament, hem obtingut una longitud alar mitjana a l'hivern > 59 mm. Aquesta mitjana és només lleugerament inferior a la longitud de l'ala dels mascles observats a França durant l'hivern, i notablement més gran que els valors mitjans publicats per a les femelles en conjunt. Per tant, les nostres dades estan d'acord amb la hipòtesi que la població dels mosquiters comuns durant l'hivern a la nostra zona d'estudi està esbiaixada cap als mascles, ja que estructuralment la nostra població és més propera a les de França que a les de regions ibèriques situades més al sud. Per tant, el nord d'Ibèria potser constitueix el límit sud del rang de distribució on els mascles són més abundants que les femelles a l'hivern.

Resumen

Segregación espacio-temporal por sexos en el Mosquitero común *Phylloscopus collybita* durante el periodo no reproductor en el norte de Iberia

Con el objetivo de entender la segregación espacio-temporal dependiente de sexo en el Mosquitero común fuera de la época reproductora, se analizaron

los datos obtenidos en una estación de anillamiento del norte de Iberia (Txingudi, Gipuzkoa) con el fin de comprobar en qué medida la proporción de sexos en el norte de Iberia varía significativamente respecto a las proporciones sesgadas de hembras detectadas en otras zonas del sur de la Península Ibérica. El periodo de muestreo duró ocho meses de septiembre a marzo/abril del año siguiente, empezando en septiembre de 2003 hasta marzo de 2010. La longitud del ala fue mayor en invierno que durante la migración de otoño y primavera, lo que indicaría que los machos fueron proporcionalmente más abundantes durante el invierno. Por el contrario, la longitud del ala no difirió entre los hábitats de captura, por lo que la proporción de sexos no dependió de este factor. La longitud del ala de los mosquiteros capturados en otoño y recapturados después una o más veces (ya sea en otoño o más tarde; 59,3 ± 0,7 mm) difirió significativamente de la longitud media del ala de los mosquiteros capturados en otoño y que nunca fueron recapturados (57,5 ± 0,2 mm), lo que sugiere que los machos fueron más propensos a asentarse en la zona que las hembras. Aunque no calculamos la proporción de sexos directamente, hemos obtenido una longitud alar promedio en invierno > 59 mm. Este promedio es sólo ligeramente inferior al observado en machos en Francia durante el invierno, y notablemente mayor que los valores medios publicados para las hembras en conjunto. Por lo tanto, nuestros datos están de acuerdo con la hipótesis de que la población de mosquiteros comunes durante el invierno en nuestra zona de estudio está sesgada hacia los machos, ya que estructuralmente nuestra población es más cercana a las de Francia que a las de regiones ibéricas situadas más al sur. Por lo tanto, el norte de Iberia quizás constituya el límite sur del rango de distribución en donde los machos son más abundantes que las hembras en invierno.

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