Willow Warbler

Phylloscopus trochilus

Carles Barriocanal & David Robson

Range

The Willow Warbler is a polytypic species that breeds throughout C and N Europe, and eastwards to NE Siberia (Cramp, 1992). It is a long-distance migrant, wintering in most of sub-Saharan Africa as far south as S Africa (Hedenström & Petterson, 1987; Cramp, 1992). It does not breed in the study area.

Migratory route

Recoveries indicate that most birds cross NE Spain and the Balearics heading N-NE towards Central Europe and SW Scandinavia; however, birds using a more due N or even NW direction (towards UK) are not uncommon (fig. 1). In Morocco and S Spain birds show a more pronounced NE direction that avoids the most western parts of the Iberian Peninsula. In fact, as observed in many other species, spring migration through Spain takes place largely along the east coast and the Balearic Islands, but in autumn follows a much more westerly direction (Cantos, 1992). This pattern is exemplified by eight recoveries of birds trapped in the Balearics/Els Columbrets during spring and in continental Spain and Portugal, much further west, in autumn (360 to 1,140 km apart). At least some birds make clear W-E movements, apparently across the sea, as exemplified by one individual ringed near Barcelona and trapped only three days later in N Sardinia. Some birds seem to cross the Mediterranean at different places every year: for example, eight birds were trapped in different springs at sites in Spain and Italy 340 to 1,450 km apart. Likewise, two birds were trapped in the Balearics one spring and then due west in continental Spain (398 and 927 km away) in another spring.

The abundance of captures in the Balearics and on Els Columbrets suggests that this species crosses the Mediterranean along a broad front and has no qualms about flying over large stretches of sea (fig. 2). However, maximum frequencies and raw number of captures occur largely on very small islands or even on quasi-islands close to the continent (*e.g.* L'Illa Grossa and La Punta de la Banya), independently of the availability of adequate habitat. These findings suggest that these sites act as attraction points for many migrants needing to rest whilst crossing the sea.

Phenology

The first birds pass through the W Mediterranean during mid-March, giving way after a peak in April to a steady decrease in May (fig. 3). The median date of passage is somewhat earlier than that observed on Capri (29 April; Pattersson et al., 1990) and on two other Tyrrhenian islands (Spina et al., 1993). This slight difference probably reflects the greater frequency of birds of more northerly and easterly origin passing through Italy (*cf.* Spina & Volponi, 2009). Recoveries show that the further north birds are ringed/recovered, the later they pass through the study area, indicating that the northern populations delay their migration (the opposite is found during autumn migration in Spain; Cantos, 1992). This delayed migration and arrival of more northern populations (*cf.* Cramp, 1992) could thus be a response to a parallel delay in the spring availability of food in northern Europe (Schüz, 1971). Overall, passage is very similar in all three main areas: Catalonia, N Morocco and the Balearics/Els Columbrets, although on the islands birds tend to pass *c.* 5 days later than in Catalonia (as observed by Barriocanal & Robson, 2007).

The frequency distribution of third primary lengths indicates that males (distinctly larger; Cramp, 1992) migrate during March and April and females mostly from mid-April onwards (fig. a). This differential migration of sexes accounts, at least in part, for the slight bimodality of the phenological curve (fig. 3). As described in other species, males are in more of a hurry to fly ahead of females in order to increase their chances of obtaining a good territory or mate (Heddenström & Petterson, 1986).

Biometry and physical condition

Mean values for third primary lengths range from 49.4 in Las Chafarinas to 52.9 in the wet Balearics (table 1), similar values to those reported in the C Mediterranean (overall mean 50.9, n = 20,381; Messineo et al., 2001). Mean values for wing lengths vary from 66.1 on Els Columbrets to 68.4 in the wet Balearics, likewise similar to those reported in the C Mediterranean (mean 66.9, n = 12,972; Messineo et al., 2001), N Tunisia (mean 66.7, n = 132; Waldenström et al., 2004) and S Israel (mean 67.9, n = 312; Morgan & Shirihai, 1997), revealing the homogeneity in size of populations crossing the Mediterranean. The third primary decreases in size with time (fig. 6), a similar pattern to that found in the C Mediterranean (Spina et al., 1993) and a reflection of the differential migration of sexes described above.

The mean fat score is similar to that recorded in the C Mediterranean (Messineo et al., 2001), although birds captured on Las Chafarinas and Els Columbrets have fairly low values. Fat increases with the season in Catalonia, the wet Balearics and N Morocco, but decreases on Las Chafarinas and Els Columbrets (fig. 9). Physical condition also decreases significantly on Els Columbrets and Las Chafarinas and also in the dry Balearics, while the trend is positive in S Morocco and slightly so in Catalonia (fig. 7). Mean body mass varies from 7.4 on Las Chafarinas to 9.4 in S Morocco, decreasing markedly during the season (table 1, fig. 8). Body mass is distinctly lower on Las Chafarinas and Els Columbrets than in N Morocco, Catalonia and the dry Balearics, while the wet Balearics has the highest average outside Morocco. Average fat has a similar pattern, although the mean is slightly higher in Catalonia than in N Morocco and the dry Balearics; differences between the sites in the Balearics are inexistent. Physical condition is significantly better in N Morocco and the wet Balearics than in the dry Balearics and Catalonia, while birds on Els Columbrets and Las Chafarinas have the lowest values.

Body mass in Catalonia similar to that reported in S Britain and C Europe (means in the range 8.8-9.1; Cramp, 1992), but somewhat higher than in S Iberia (mean at Gibraltar 8.0, n = 82; Finlayson, 1981). The mean body mass in the dry Balearics and on Els Columbrets is similar to that reported in the C Mediterranean (mean 8.3, n = 20,485; Messineo et al., 2001). Smith (1979) gives similar figures to those found by this study in N Morocco for Kaifiene, also in north of this country (mean 8.9, n = 27). Surprisingly, however, mean body mass in S Morocco is generally greater than that reported in much larger datasets from the same area, with means of 7.9 at Defilia (n = 191; Ash, 1969) and 8.0 in Merzouga (n = 350; Gargallo et al., unpubl.), and also greater than birds from the W Algerian Sahara (mean 7.7, n = 187; Cramp, 1992) and the northern edge of the desert in Israel (mean 7.5, n = 312; Morgan & Shirihai, 1997). These high figures most probably reflect very unusual conditions that require further study.

Our results indicate that birds achieve some gain in body mass during their stay in N Morocco, birds being *c.* 8-17% heavier than in the south of the country (calculated using the whole dataset available for S Morocco and excluding our unusual sample). However, mean body mass in Catalonia and further north in W Europe is similar to that given for N Morocco, suggesting that once birds leave N Africa, migration through continental Europe takes places in short bouts that do not require long stopovers or marked new gains in mass (as shown below). On the other hand, the fact that mean body mass in birds trapped in the dry Balearics (mostly recently arrived birds) is similar to that of N Morocco indicates that the birds that migrate through the islands (a minimum *c.* 250 km non-stop flight) have to be heavier than average N Moroccan birds when they depart from N Africa.

It is interesting to note that birds trapped in Las Chafarinas have a significantly shorter third primary, lower body mass and fat, and poorer body condition than those from continental N Morocco. This is particularly relevant taking into account that these differences are significant when considering only data from Kerbacha, located only a few km to the south of Las Chafarinas (fig. 4). Mean values on Las Chafarinas are similarly low in all available years (2000 and 2001) and differences in fat, body mass and condition remain similarly significant when comparing data from Las Chafarinas and Sidi Bou Rhaba from 2000. A similar pattern is observed in the Balearics: birds from the dry Balearics also have significantly shorter wings, lower body mass and poorer body condition than those trapped in more suitable habitats on the larger islands (wet Balearics). Overall, these results clearly suggest that Las Chafarinas and the dry Balearics attract a higher proportion of birds in poor body condition. In the case of Las Chafarinas, this is apparently due to the fact that birds are often forced to change or reverse flight direction due to unfavourable meteorological circumstances encountered during sea crossing (this study site is a mere 4 km north of the Moroccan coast). The fact that birds trapped in these areas also have shorter wings suggests that smaller birds may be more prone to suffer from such unfavourable circumstances (particularly strong head winds; *cf.* Saino et al., 2010), or that females and younger individuals (with shorter wings) may take fewer risks (having less of a need to migrate faster and arrive earlier) and thus be more inclined to stop at suboptimal habitats or reverse migration when facing problems. On the other hand, birds stopping at wetlands may gain mass faster and include a greater proportion of larger dominant birds (*i.e.* males; the species is known to hold territories during migration and is prone to exhibit intraspecific aggressions; Cramp, 1992; Salewski et al., 2007) or of birds that have already been on land for a few days (either at the site itself or other surrounding areas; see below), which may also contribute to their overall better average body condition and the larger size of birds trapped at these sites.

On Els Columbrets, the most isolated islands and the most distant from N Africa, birds have the lowest mean levels of fat and body mass, and the poorest condition of all the W Mediterranean islands, in a clear signal of the progressive depletion of the energetic reserves during sea crossing.

Stopover

Overall birds do not tend to stay long at the study sites and have rather low mean stopover lengths (2-3 days; table 2, fig. 5). The highest percentage of recaptures occurs in N Morocco, Catalonia and the wet Balearics. Stopover length is higher in N Morocco, although differences are not statistically significant. Birds remaining in N Morocco, Catalonia and the wet Balearics tend to have higher body mass at departure than at first capture, but not significantly so. Fuel deposition rates, however, are significantly positive in Catalonia and, above all, in N Morocco (when excluding one-day retraps). On the other hand, in the dry Balearics birds lose some mass during the course of their stays and show significantly negative fuel deposition rates. Moreover, in the dry Balearics and on Els Columbrets retrapped birds have lower initial body mass than those not trapped again. These results suggest that these sites do not offer good opportunities for refuelling and that many birds unable to continue migration remain –unsuccessfully– in these areas. In Catalonia, the wet Balearics and, above all, N Morocco birds are not necessarily forced to stay due to poor body condition and can gain some mass or, at least, maintain their energetic reserves before restarting their migrations. The relevance of N Morocco as a stopover site for Willow Warblers is further supported by the relative high frequency of spring recoveries in the area (Zwarts et al., 2009). On Las Chafarinas, birds show significant positive fuel deposition rates, although the sample is too small to be conclusive.

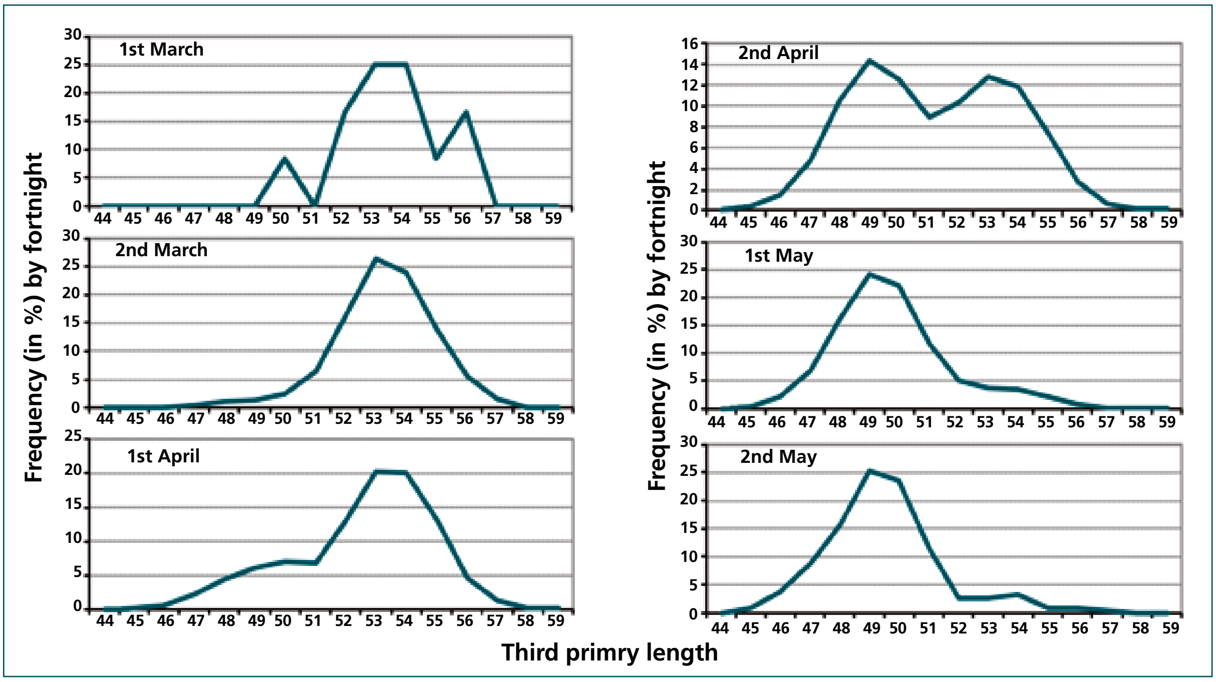


Figure a. Frequency distribution of the third primary length in fortnightly periods.

Table 1. Mean (± SD), range and sample size of main biometric parameters according to area.

	n	Wing	Third primary	Body mass	Fat score
Catalonia	8,666	67.1 ± 3.0 (57.0-76.0)	51.9 ± 2.6 (41.0-59.5)	8.7 ± 0.9 (5.3-13.5)	3.1 ± 1.2 (0-7)
Columbrets	6,728	66.1 ± 3.1 (57.0-76.0)	50.7 ± 2.6 (41.0-59.5)	8.2 ± 1.1 (5.4-14.4)	1.8 ± 1.3 (0-8)
Balearics (dry)	26,564	66.2 ± 3.1 (57.0-76.0)	51.1 ± 2.6 (41.0-59.5)	8.6 ± 1.1 (5.0-14.5)	3.0 ± 1.3 (0-8)
Balearics (wet)	363	68.4 ± 2.7 (60.0-75.0)	52.9 ± 2.3 (46.0-59.5)	9.0 ± 1.0 (6.4-11.8)	2.8 ± 1.1 (0-6)
Chafarinas	264		49.4 ± 2.0 (44.0-55.5)	7.4 ± 0.9 (5.9-11.1)	1.6 ± 1.1 (0-5)
N Morocco	526	66.2 ± 3.3 (59.0-75.0)	50.7 ± 2.6 (43.0-59.5)	8.8 ± 1.2 (6.1-14.5)	2.7 ± 1.4 (0-7)
S Morocco	91	67.6 ± 3.0 (62.0-72.0)	51.5 ± 2.5 (47.0-59.0)	9.4 ± 1.3 (7.0-14.5)	3.2 ± 1.3 (1-7)

Table 2. Variation in fuel deposition rate (g/day) according to area and type of retraps involved (mean ± 95% CI and sample size are given).

	Catalonia	Columbrets	Balearics (dry)	Balearics (wet)	Chafarinas	N Morocco
All retraps	-0.05 ± 0.05 (368)	-0.19 ± 0.20 (59)	-0.23 ± 0.05 (493)	0.20 ± 0.23 (19)	0.38 ± 0.12 (7)	0.03 ± 0.14 (48)
Retraps >1 day	0.08 ± 0.04 (204)	-0.17 ± 0.22 (20)	-0.08 ± 0.04 (229)	0.06 ± 0.21 (9)	0.35 ± 0.13 (4)	0.20 ± 0.11 (34)

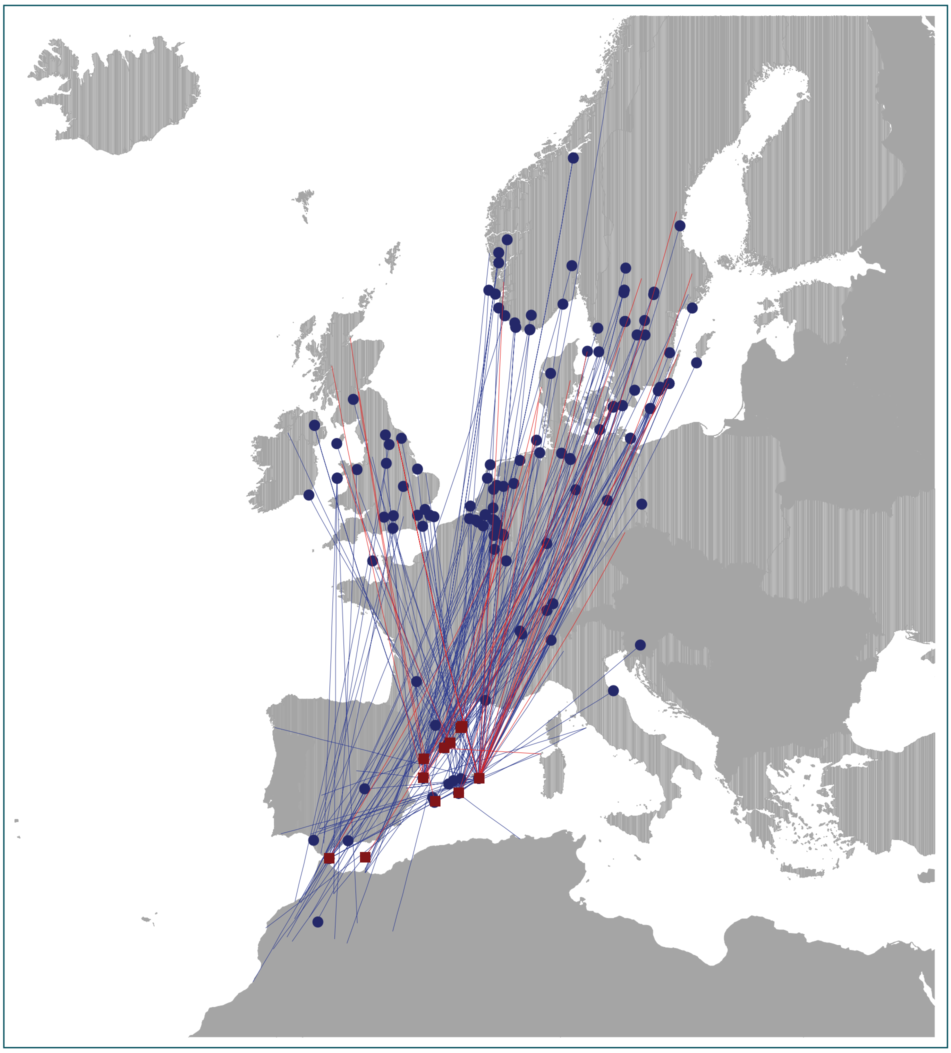


Figure 1. Map of recoveries of birds captured in the study area during the study period (March to May).

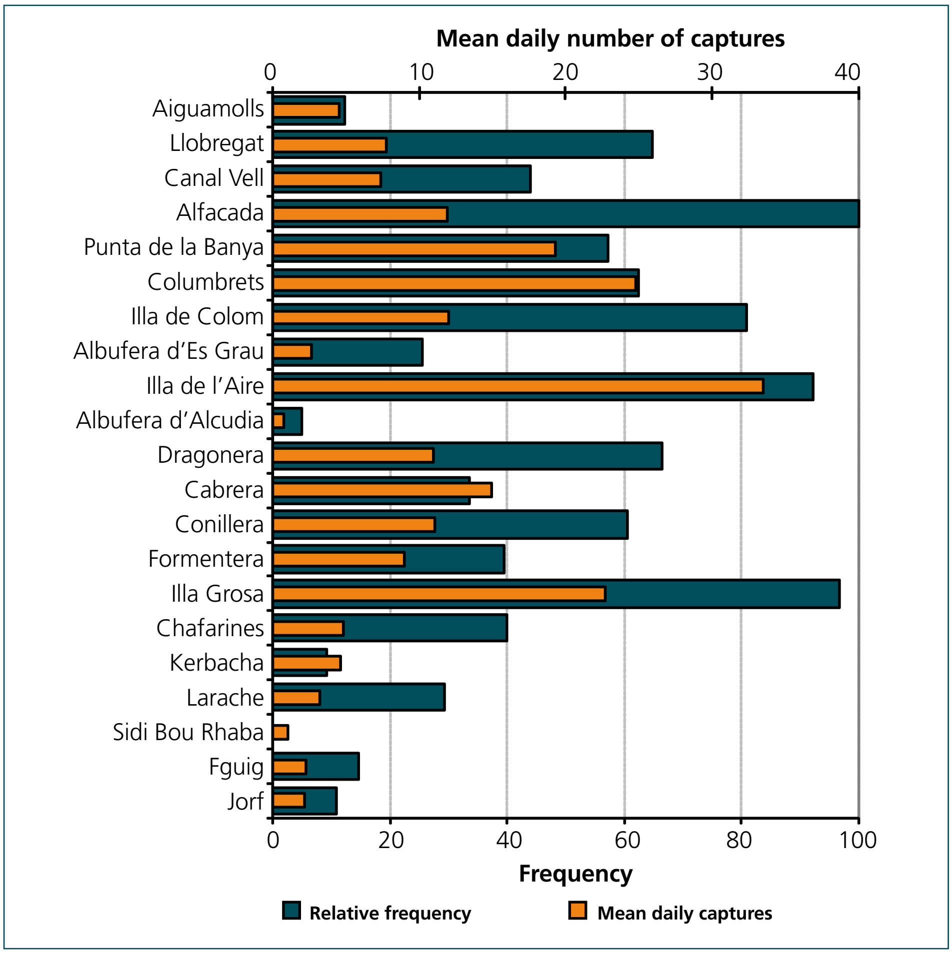


Figure 2. Relative frequency of captures and mean daily numbers according to site during the standard period (16 April to 15 May).

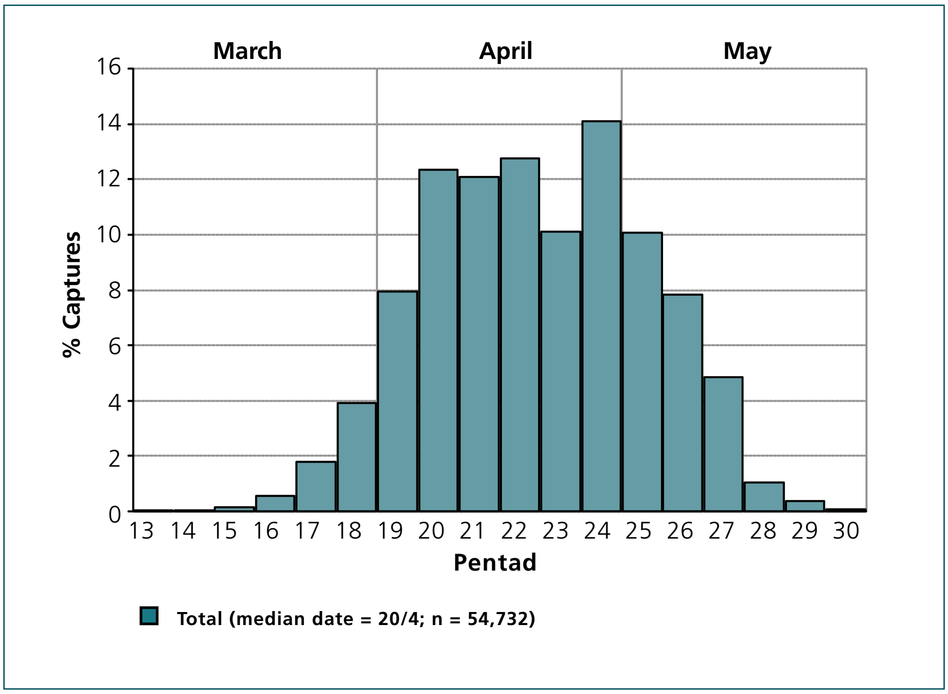


Figure 3. Frequency of captures during the study period.

Figure 4. Variation in body mass and fat score according to site during the standard period (16 April to 15 May).

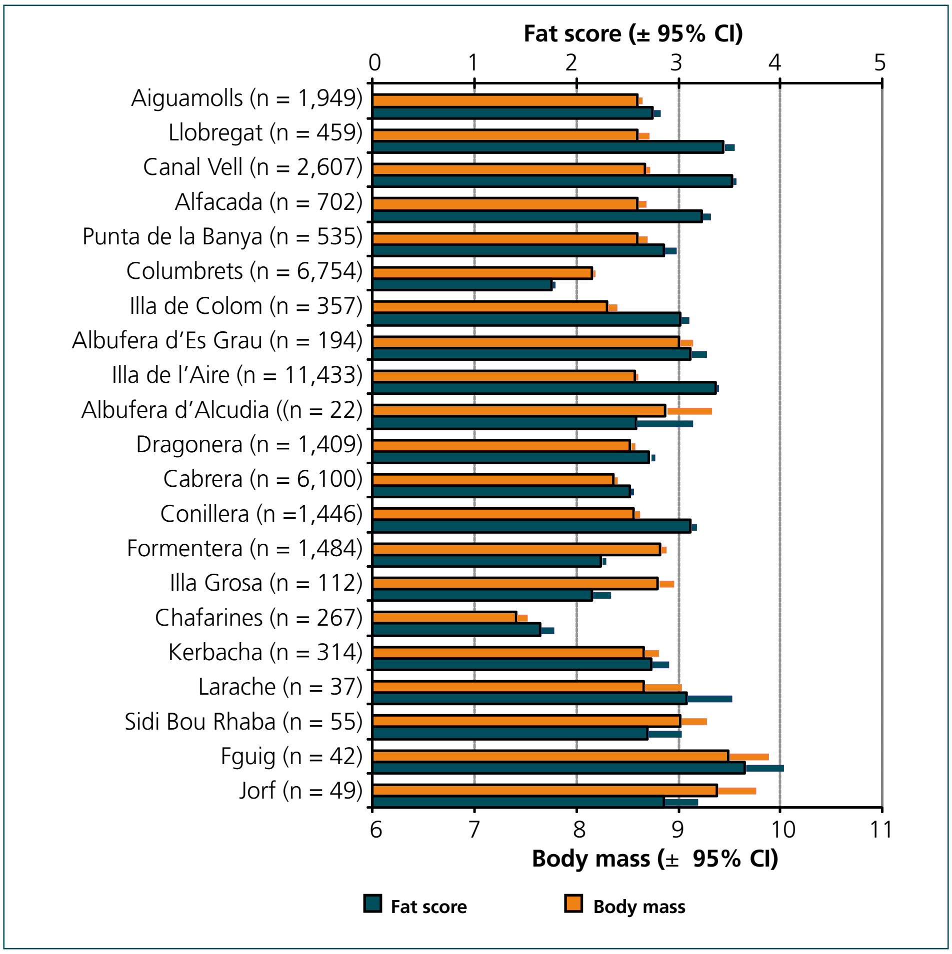
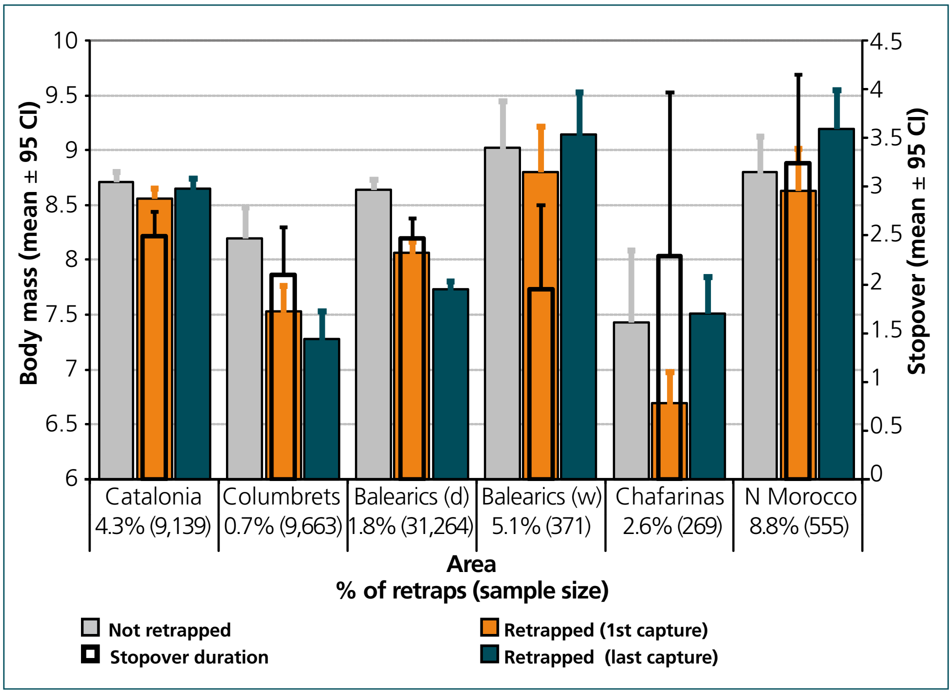


Figure 5. Variation in body mass by trapping status, minimum stopover length and frequency of retraps according to area.



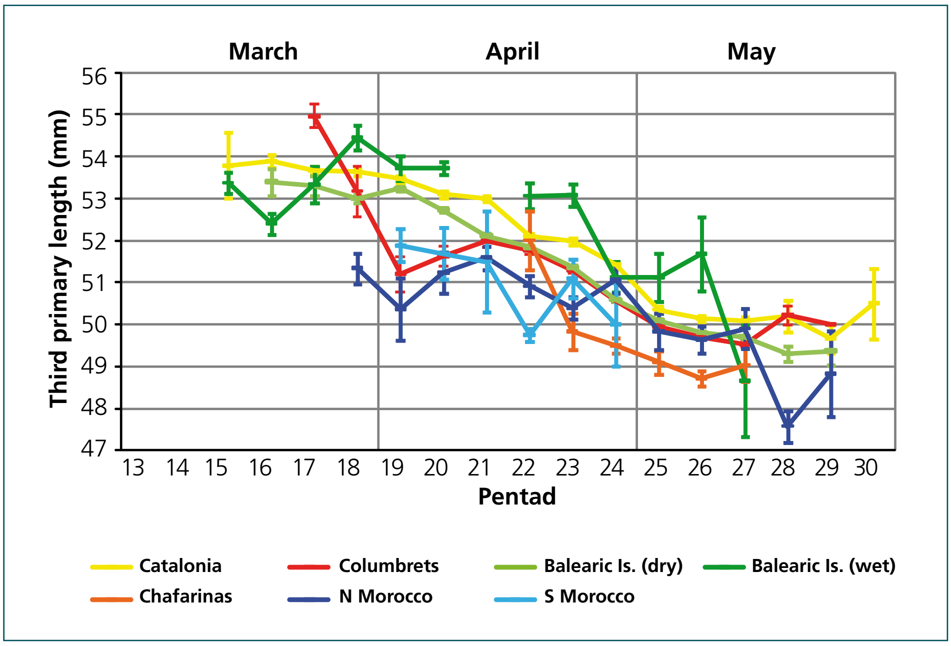


Figure 6. Temporal variation of third primary length according to area.

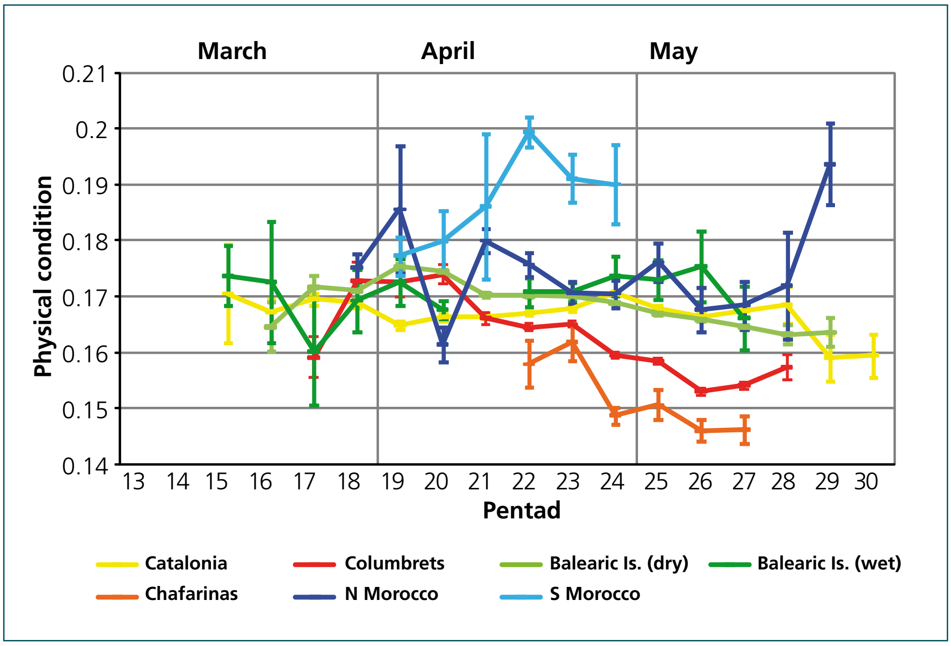


Figure 7. Temporal variation of physical condition according to area.

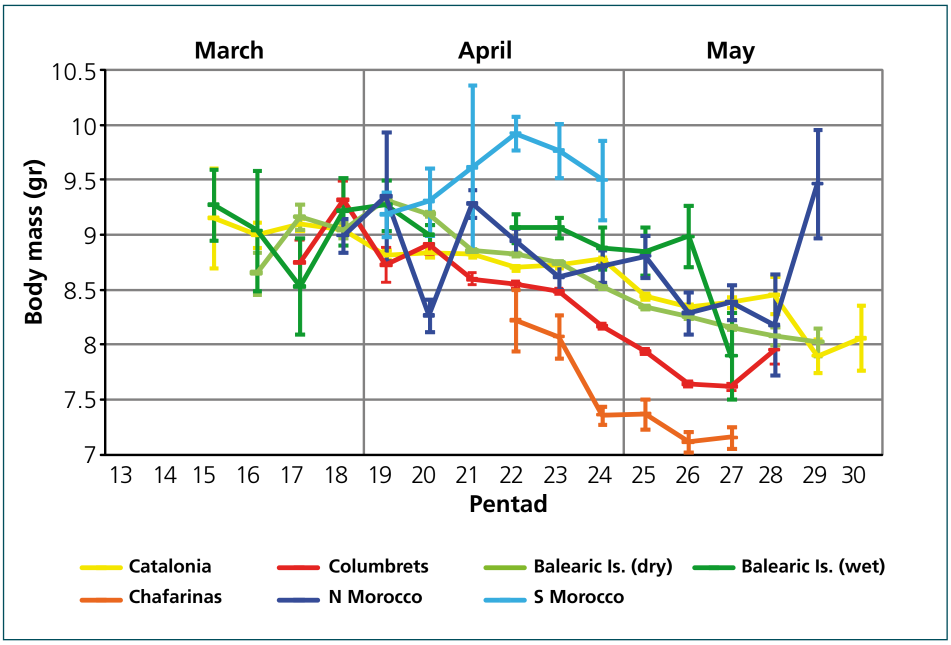


Figure 8. Temporal variation in body mass according to area.

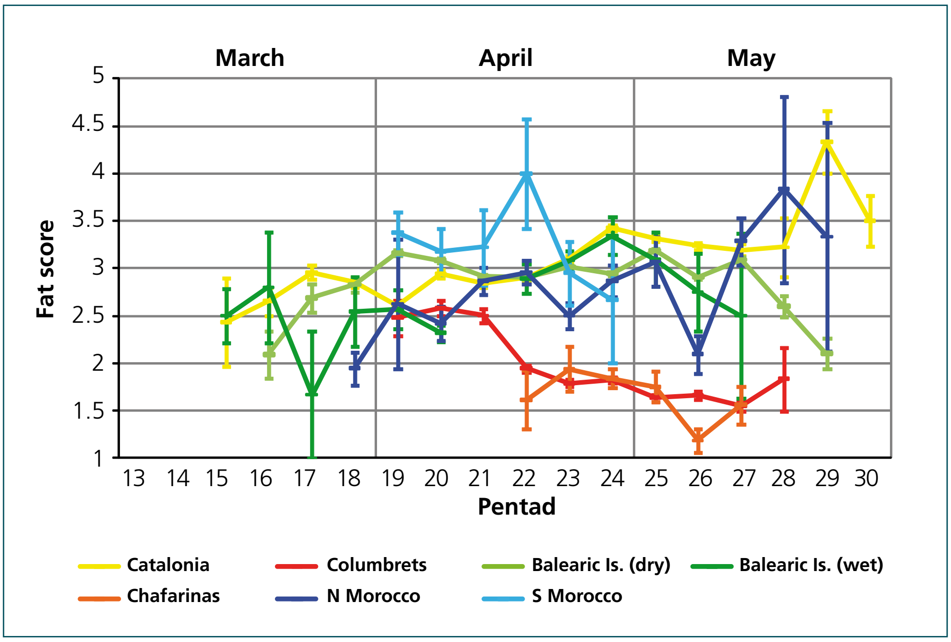


Figure 9. Temporal variation in fat score according to area.