Garden Warbler

Sylvia borin

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Range

The Garden Warbler is a common trans-Saharan migrant that has been a focal species for many studies (Schaub & Jenni, 2000; Shirihai et al., 2001; Ottosson et al., 2005). Its breeding distribution extends throughout most of Europe between 37°-70°N and eastwards between 52°-64°N to western Siberia. All populations are migratory, wintering extensively in Africa south of *c.* 10°N in the west and 3°N in the east, and southwards to S Africa (Urban et al., 1997). The western nominate subspecies *borin* winters from W to E Africa and south to South Africa, occurring progressively more rarely east and southwards; eastern *woodwardi* largely predominates in E and S Africa (Urban et al., 1997). In the study area it breeds in Catalonia but not at the study sites.

Migratory route

The distribution of recoveries shows a main SW-NE direction in this species' migratory movements (fig. 1) along a fairly similar axis of movement in spring and autumn (Zink, 1973; Cramp, 1992). One bird ringed on L'Illa de l'Aire (Menorca) and recovered at Palmaria (Italy), 656 km NE, only two days later characterises perfectly this pattern of movements and suggests that some birds may cover distances across the sea of up to 656 km in a single flight (assuming no stops in between). In spring, however, birds seem to cross continental Spain following a rather narrow central path, avoiding the westernmost and north-westernmost part of the Iberian Peninsula and to a lesser extent coastal Mediterranean areas (Cantos, 1992). The few recoveries from Catalonia (n = 2), as well as the relative low raw numbers of birds trapped in this area, further supports this idea. Interestingly, recoveries are much more frequent in the Balearics/Els Columbrets (n = 18) where, moreover, birds show a significantly more due N axis of movement (mean direction 13.89°NE, instead of 36.50° from Catalonia [two individuals only] and 34.44° in the rest of continental Spain). This pattern may reflect the fact that those birds that do cross the W Mediterranean Sea tend to involve birds returning to breeding grounds along a more direct due N route, possibly including a higher proportion of delayed birds in a hurry (*cf.* Barriocanal & Robson, 2006). In fact, birds passing through the Balearics tend to pass somewhat later than those migrating through continental NE Spain (see below). In any case, the scarcity of direct recoveries and the small sample size from Catalonia (at similar longitude to the islands) prevents a more definitive analysis.

A gradual cline from west to central Mediterranean towards longer-winged birds parallels size-related differences in the breeding origin of birds and suggests that birds cross the Mediterranean and the Sahara across a quite broad front (Grattarola et al., 1999, present data;

see below). However, recoveries and the relative frequency of captures (figs. 1, 2; Grattarola et al., 1999) indicate that passage may be more intensive in areas such as central continental Spain (see above) or the C Mediterranean. In the latter area, birds could use the Italian Peninsula and adjacent islands as a bridge for reaching Europe over a more direct NNE route (*cf.* Spina & Volponi, 2009).

This warbler seems to be fairly common in Morocco in spring (Thevenot et al., 2003), when recoveries are more frequent then than in autumn (Moroccan Bird Ringing Centre, unpubl. data). Moreover, some sites in the north of the country have some of the highest relative frequencies of capture recorded in this study (fig. 2). The abundance of captures on isolated islands such as Els Columbrets and on the quasi-island of La Punta de la Banya (in the Ebro delta) suggests that these sites act as attraction points for many migrants urged to find resting areas whilst crossing the sea (a fact further supported by the poor body condition of birds trapped at these sites; see below). Independently of this attraction factor, overall figures for both frequency and the raw number of captures are quite high in the whole of the Balearics/Els Columbrets, supporting the view that large numbers of birds pass through this area.

Phenology

Passage in the W Mediterranean begins in early April and peaks by mid-May (fig. 3). The intensity of migration decreases markedly towards the end of May, but passage extends into the first half of June, outside the study period (Cramp, 1992; Telleria et al., 1999; Thevenot et al., 2003). In the Balearics/Els Columbrets the peak passage takes place 5-10 days later than in Catalonia and Morocco and on average birds pass through these islands 4 days later. The overall phenological pattern is similar to that reported in Morocco, Gibraltar and S France (Blondel & Isenmann, 1981; Thevenot et al., 2003; Finlayson, 1992). Quantitative phenological data from the C Mediterranean indicates that migration occurs there slightly later than in Morocco and continental Spain (Pettersson et al., 1990; Rubolini et al., 2005), although the differences between the C Mediterranean and the Balearics/Els Columbrets are very slight.

Biometry and physical condition

Mean third primary lengths range between 58.8 mm in Las Chafarinas and 61.2 mm in the wet Balearics, while mean wing length varies between 78.0 in N Morocco and 80.3 in the wet Balearics (table 1). Overall, third primary length increases slightly but significantly during the season (fig. 6). This might be related to the late passage of more northern, longer-winged birds, since this species does not have any pronounced sexual size dimorphism and both sexes tend to arrive on breeding grounds at the same time (Cramp, 1992). There is an increase in wing length with longitude, with the largest birds crossing through the most eastern part of the study area. This pattern matches the cline in wing length reported from both the breeding and wintering ranges and during migration across the W and C Mediterranean (Cramp, 1992; Grattarola et al., 1999).

Mean body mass varies from 15.7 on Els Columbretes to 18.0 in the wet Balearics, while mean fat scores range from 1.6 (Els Columbrets) to 3.6 (N Morocco). Body mass, fat and physical condition show an overall increasing trend during the season (figs. 7-9). Though the pattern is unclear in Morocco and on Els Columbrets, in the large datasets of Catalonia and the Balearics, the increase is marked and significant. An improvement in the overall condition of birds is also observed in the C Mediterranean (Spina et al., 1993) and seems to reflect progressively better conditions for feeding either en route or at fattening sites south of the Sahara, or the fact that birds leaving the wintering grounds later have more time to gain weight. In support of this, it is worth mentioning that a distinct, progressive seasonal increase in body mass is clearly observed in spring in Nigerian (Ottosson et al., 2005).

Average body mass and fat scores on the islands of the C Mediterranean (means 15.9 [n = 29,944] and 1.7 [n = 29,023], respectively; Messineo et al., 2001), are similar to those reported on Els Columbrets but lower than in the dry Balearics, reflecting the longer stretch of sea and desert crossed by birds passing through the former group of islands (see also Grattarola et al., 1999). Mean body mass in Catalonia is somewhat higher than at Gibraltar (mean 16.5, n = 48; Finlayson, 1981), but distinctly lower than in N Germany (mean 18.4, n = 27) and N Italy (18.7, n = 10) and slightly lower than in S France (17.2, n = 1,152; Bairlein, 1991). Birds trapped in N Morocco have significantly higher average body mass, fat and physical condition than in all other areas further north except the wet Balearics. Birds are distinctly heavier in Sidi-Bou Rhaba than in Kerbacha (fig. 4), differences being significant in all available years and probably reflecting the higher availability of stopover sites along the Atlantic coast when compared with the east of Morocco, where the desert or semi-desert belt extends further north (Rguibi-Idrissi, 2002). Mean body mass is *c.* 7-12% lower on Els Columbrets and in the dry Balearics, as well as in the south of the Iberian Peninsula (*cf.* Bairlein, 1991), but only 3% lower in Catalonia. Interestingly, in the wet Balearics birds have similar mean masses to that of birds from N Morocco, but significantly higher values than in the dry Balearics (9% more) and even Catalonia (4%). Data on body mass from S Morocco is scarce, but average figures are rather similar to those obtained at nearby sites by Ash (1969; 16.3, n = 17) and Gargallo et al. (unpubl.; 17.2, n = 141).

Our results show that the mean body mass in S Morocco is *c.* 4-8% lower than in the north, indicating that a certain amount of refuelling takes place after crossing the Sahara (see below). This has already been noted by Smith (1979) and in the exhaustive work of Bairlein (1991), and seems also to occur in Tunisia, since the reported average in the north of the country is also quite high (mean 18.5, n = 76; Waldenström et al., 2004). Birds are able to put on weight after reaching continental Spain and the Mediterranean islands as long as they find suitable stopover sites (see also below). As pointed out by Bairlein (1991), this mass gain is only moderate, probably due to possibilities for finding further food en route northwards. In fact, average mass increases from S Iberia to C Europe (present data; Bairlein, 1991).

Birds trapped in the wet Balearics are significantly heavier, are in better physical condition, and have larger fat reserves and longer wings than those from more isolated and sparsely vegetated sites (the dry Balearics). These findings suggest that these latter areas attract a higher proportion of birds in poor body condition that have greater need to land. The fact that these birds also have on average shorter wings suggests that smaller size make them more prone to suffer from unfavourable meteorological circumstances (particularly strong head winds; *cf.* Newton, 2008; Saino et al., 2010), and thus are more inclined to stop at any available site, even including suboptimal or unsuitable habitats (as shown in this case by negative fuel deposition rates; see below). Birds stopping at wetlands on larger islands may also gain mass faster and involve a larger proportion of birds that have already been on land for a few days (either at the site itself or in surrounding areas), which may also contribute to the overall better average body condition at such sites.

Stopover

Birds do not tend to stay at the study sites and those that do stop stay on average only 1-2.5 days (table 2, fig. 5). Variation between areas in terms of the percentage of retraps and stopover length is small, only Els Columbrets having a distinctly lower percentage of retraps. In Catalonia, on Els Columbrets and in the dry Balearics birds that are not retrapped have significantly higher average initial body mass than those remaining for a few days. In retrapped birds, differences between body mass at initial and last capture do not differ statistically in any of the areas. However, fuel deposition rates are significantly positive in Catalonia and N Morocco, when considering retraps of more than one day. On the contrary, in the dry Balearics and on Els Columbrets birds show significant negative fuel deposition rates (when considering the full dataset of retraps). The dataset from Las Chafarinas and the wet Balearics is too small to be able to reach any definitive conclusions.

Our results indicates that in Catalonia, Els Columbrets and the dry Balearics birds in poorer body condition are more prone to stopover for some days, although only those that land in continental wetlands are able to subsequently gain mass. In N Morocco birds can also regain some mass during the stopover, although, unlike in Catalonia, birds are not necessarily forced or more inclined to stay due to poor body condition.

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

	n	Wing	Third primary	Body mass	Fat score
Catalonia	1,477	79.3 ± 2.2 (69.0-89.5)	60.5 ± 2.0 (51.0-66.5)	17.2 ± 2.0 (11.8-28.8)	2.6 ± 1.3 (0-7)
Columbrets	1,038	78.9 ± 2.6 (70.0-88.5)	60.0 ± 2.0 (50.5-66.5)	15.7 ± 2.0 (9.1-29.5)	1.6 ± 1.2 (0-7)
Balearics (dry)	5,055	79.0 ± 2.4 (67.0-89.5)	60.2 ± 2.1 (50.0-67.0)	16.5 ± 2.2 (9.0-28.8)	2.1 ± 1.4 (0-7)
Balearics (wet)	54	80.3 ± 2.3 (75.0-87.5)	61.2 ± 2.0 (56.0-66.0)	18.0 ± 2.6 (13.3-24.4)	2.9 ± 1.3 (0-6)
Chafarinas	47		58.8 ± 2.1 (52.0-63.5)	16.5 ± 1.7 (13.3-20.1)	2.8 ± 1.5 (0-6)
N Morocco	492	78.0 ± 2.3 (67.0-83.0)	59.6 ± 1.9 (49.0-64.0)	17.8 ± 2.2 (10.5-28.1)	3.6 ± 1.4 (0-7)
S Morocco	9	79.3 ± 1.7 (77.0-83.0)	59.9 ± 1.5 (58.0-63.0)	16.7 ± 2.4 (14.3-21.5)	3.2 ± 1.4 (2-6)

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	0.12 ± 0.17 (61)	-0.53 ± 0.19 (23)	-0.39 ± 0.16 (175)	0.43 ± 0.83 (2)	-0.20 ± 0.87 (4)	0.22 ± 0.43 (26)
Retraps >1 day	0.30 ± 0.15 (33)	-0.1 9 ± 0.21 (7)	-0.11 ± 0.15 (81)			0.44 ± 0.32 (12)

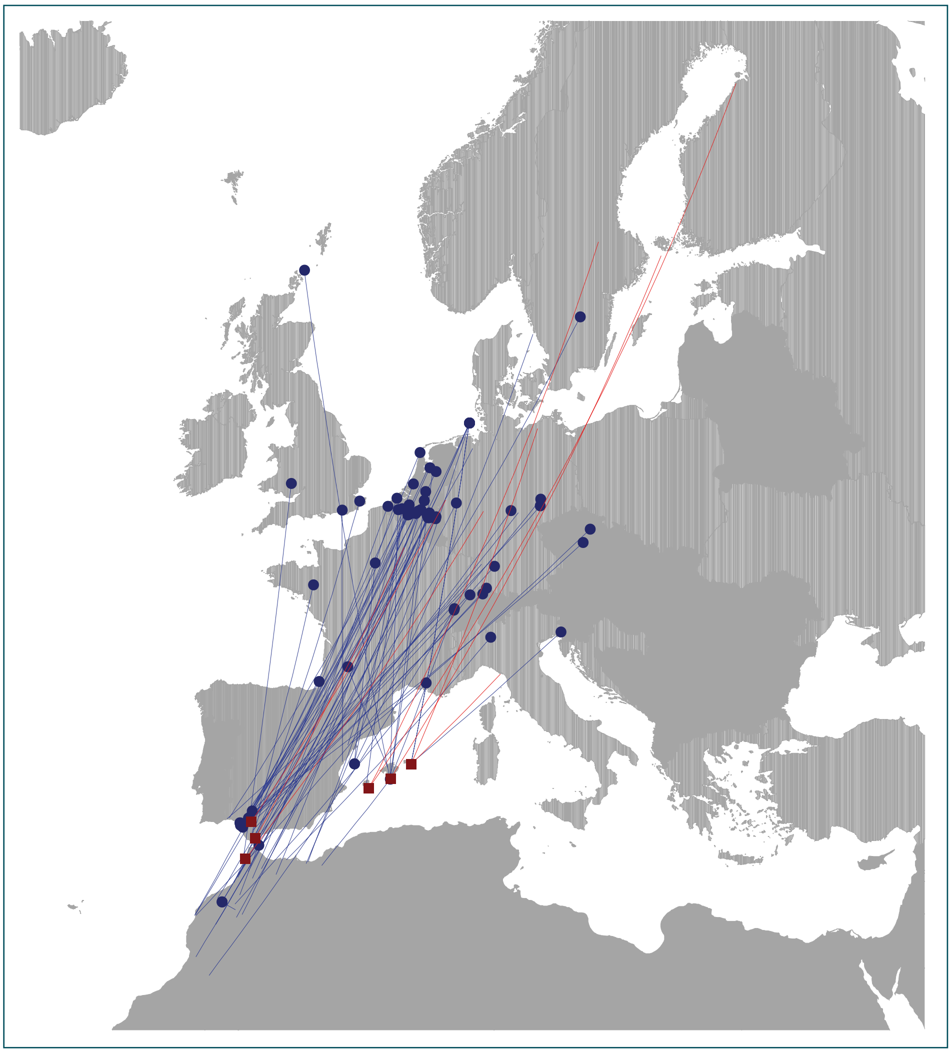


Figure 1. Map of recoveries of birds captured in the study area during the study period (March to May).

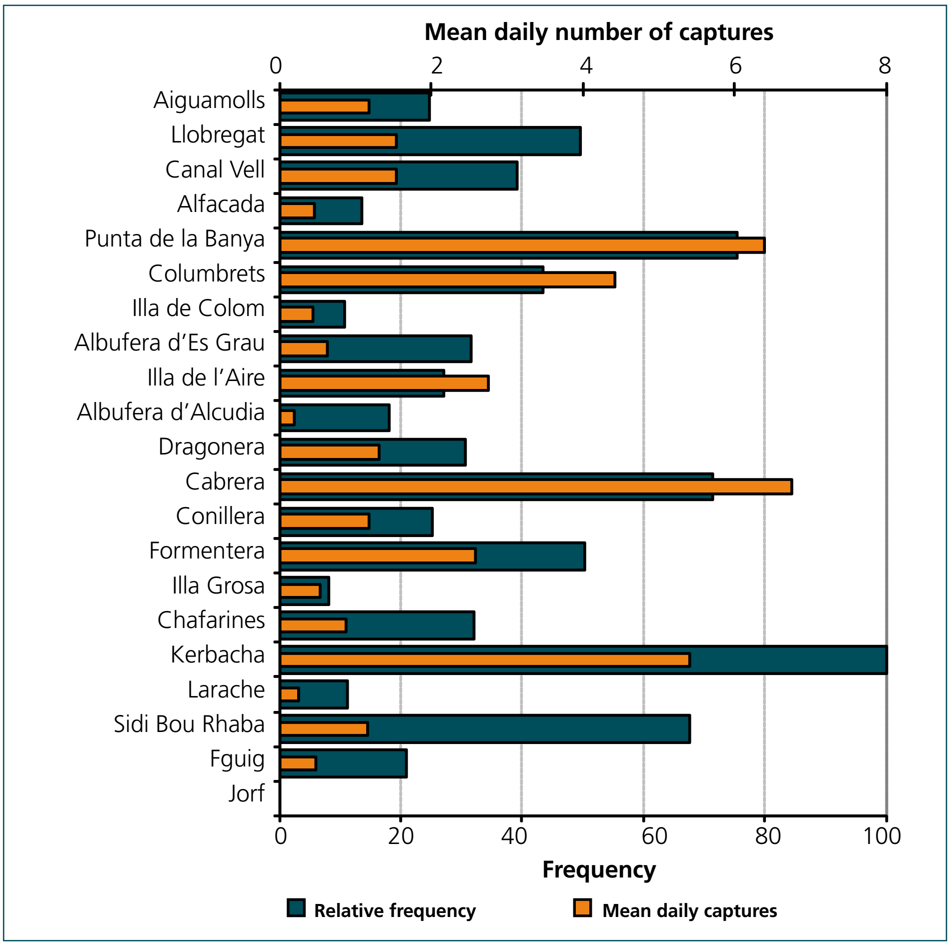


Figure 2. Relative frequency of captures and mean daily numbers according to site during the standard period (16 April to 15 May).

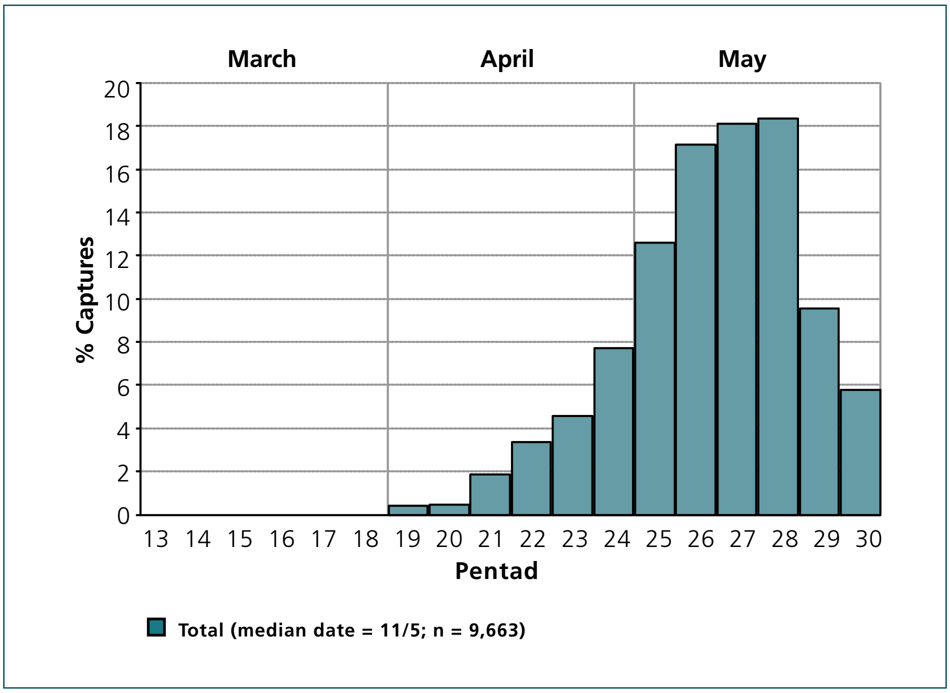


Figure 3. Frequency of captures during the study period.

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

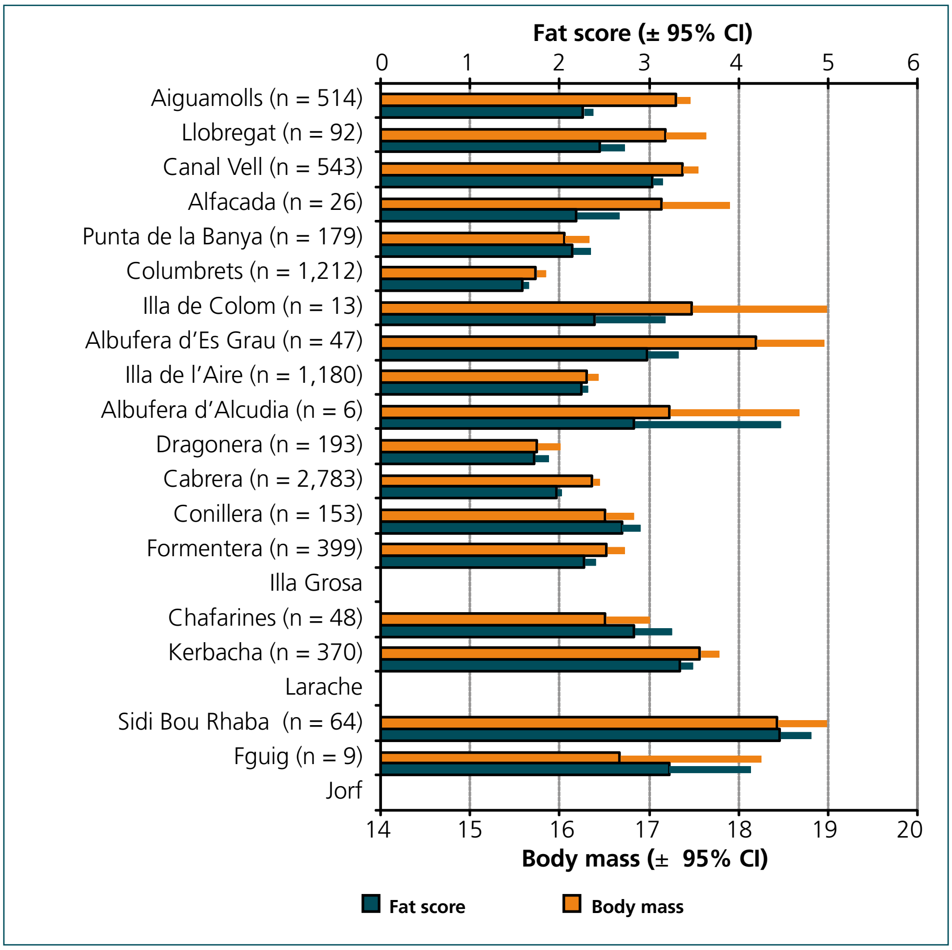
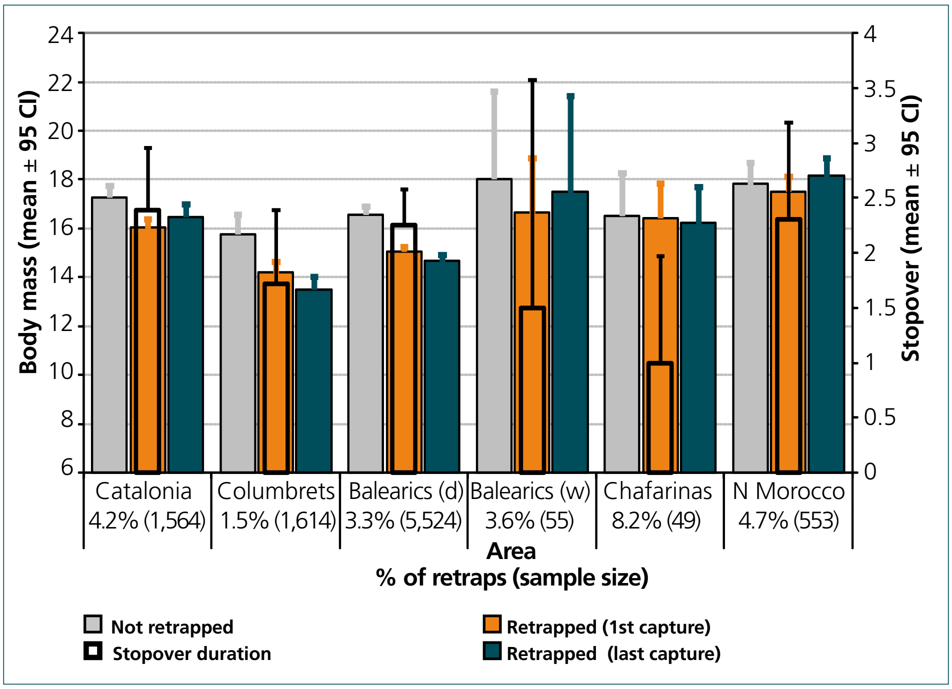


Figure 5. Variation in body mass by trapping status, minimum stopover length and frequency of retraps according to area.



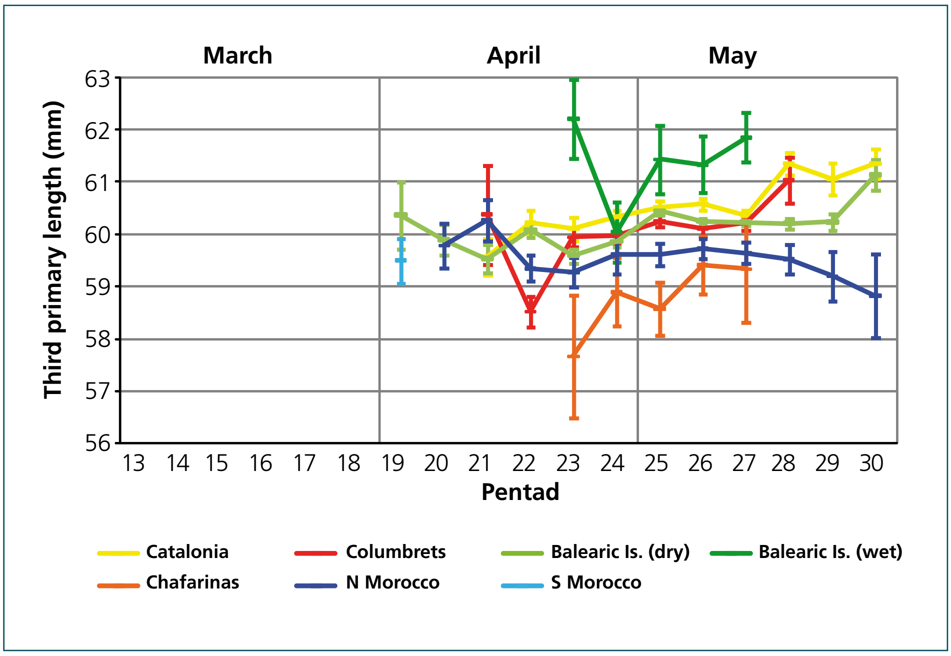


Figure 6. Temporal variation of third primary length according to area.

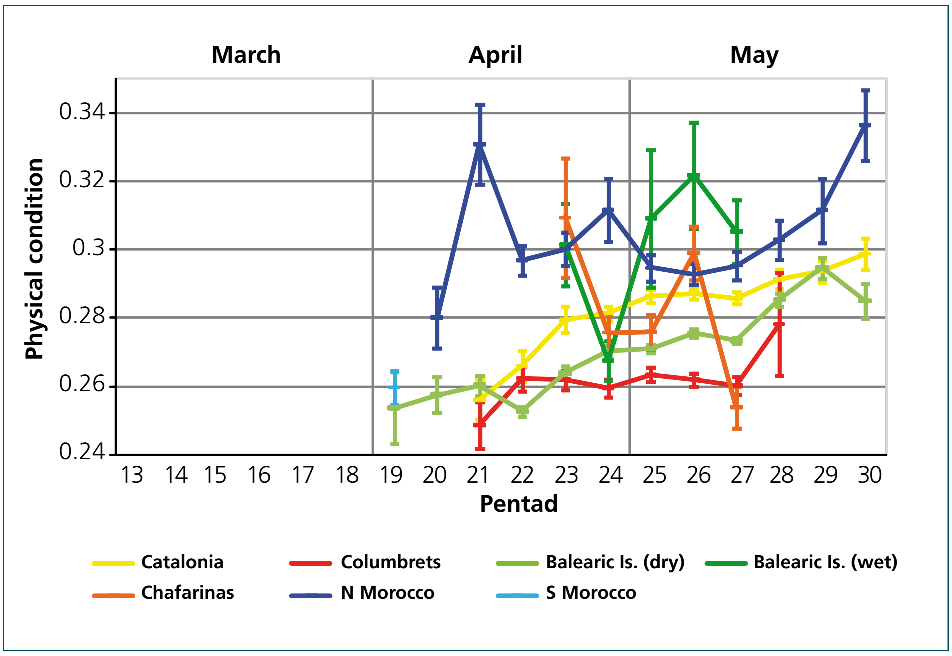


Figure 7. Temporal variation of physical condition according to area.

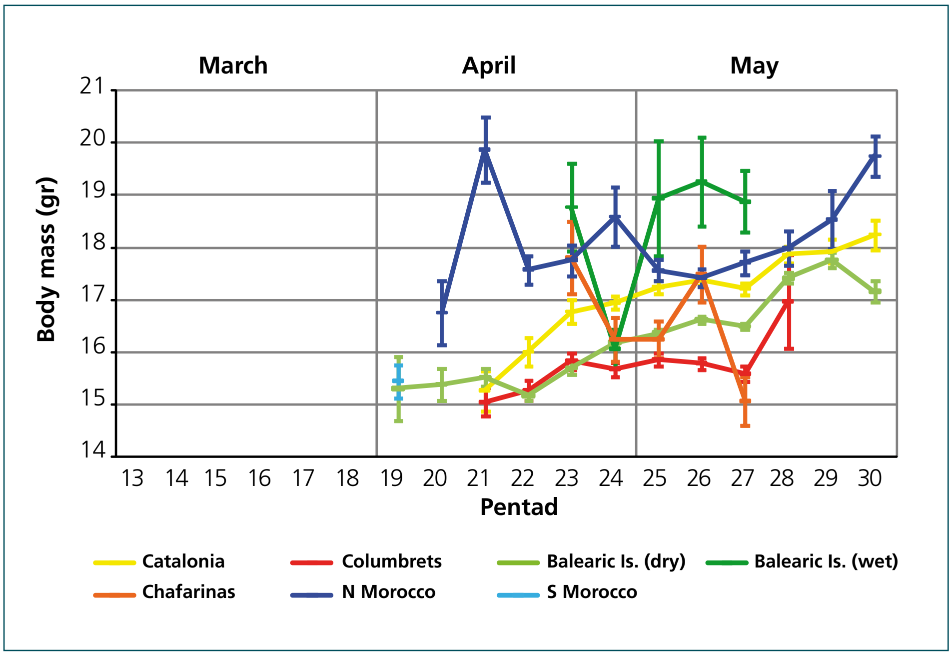


Figure 8. Temporal variation in body mass according to area.

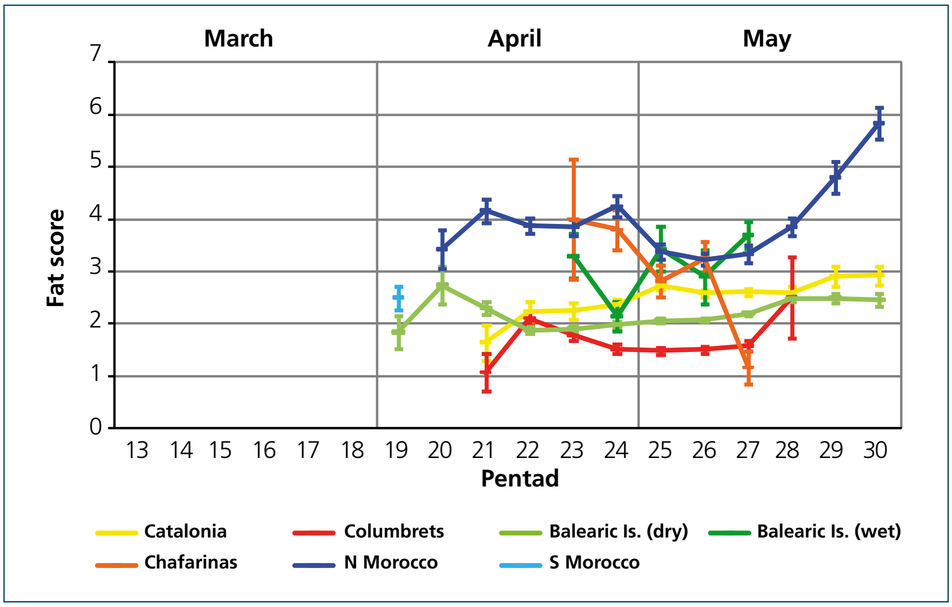


Figure 9. Temporal variation in fat score according to area.