

Spring migration of Nightingale *Luscinia megarhynchos* through western Mediterranean islands: Illa de l'Aire and Columbrets

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Abstract – Spring migration of Nightingale *Luscinia megarhynchos* over the western Mediterranean has been studied using observations collected at a ringing station on the islands of Illa de l'Aire (Balearics) and Columbrets (60 km. off mainland of Levante region) in Spain. During the years 1994-2003, birds were caught, and measured, between 16th April and 15th May. The mean arrival date was three days later in second-year than in adults on Illa de l'Aire and two days on Columbrets. At the two stations long-winged individuals passed before short-winged birds, both in the case of second-year and adults. Adults were heavier than second-year and significant differences were found in body mass along the season, i.e. heavier individuals passed before lighter ones. Important differences were found on fat scores being the mean in Columbrets significantly lower than on Illa de l'Aire. Our observations suggest that those Nightingales stopping over at Columbrets islands are not really overseas migrants, as they have a coastline migration strategy despite passing over islands located 60 km offshore.

Riassunto – *Migrazione primaverile dell'usignolo Luscinia megarhynchos attraverso le isole del Mediterraneo occidentale: Illa de l'Aire e Columbrete.* La migrazione primaverile dell'usignolo attraverso il Mediterraneo occidentale è stata studiata, per un periodo decennale (1994-2003), in due stazioni di cattura (attive ogni anno dal 16 aprile al 15 maggio), site su due isole spagnole: Illa de l'Aire (Baleari) e Columbrete (60 km al largo della regione di Levante). Durante gli anni 1994-2003, fra il 16 aprile e il 15 maggio, gli uccelli sono stati catturati e misurati. Il picco delle catture e la data media di arrivo risultano tre giorni più precoci negli adulti che negli uccelli del primo anno di vita (giovani) su Illa de l'Aire e di due giorni più precoce a Columbrete. In entrambe le stazioni gli uccelli con ala più lunga, sia adulti che giovani, passano prima di quelli con ala più corta. Gli adulti sono più pesanti dei giovani e differenze significative sono state osservate col trascorrere della stagione (i soggetti di maggior peso transitano prima di quelli più leggeri). Importanti differenze sono state trovate negli indici di accumulo del grasso, essendo la media significativamente minore a Columbrete che a Illa de l'Aire. Le nostre osservazioni suggeriscono che gli usignoli che sostano a Columbrete non vi giungano direttamente dall'Africa via mare, quanto piuttosto seguano una via migratoria costiera, a dispetto del fatto che passano su isole a 60 km al largo.

Bird migration is a widespread biological phenomenon that has been considered as one of the most fascinating of all life-history traits in wildlife (Bairlein & Coppack 2006). Usually, a migrant songbird is able to cover large distances and is a must to find suitable habitats for resting and refueling all along its journey. This is equally true for fall and spring migrations; in both seasons migrants are faced with the need to find adequate food supplies and favorable weather. Spring migration involves, among others, early arrival at breeding sites to establish quality territories, that means additional pressures (Morris *et al.* 1994).

In many species of birds males precede females on spring migration (Lozano *et al.* 1996, Swanson *et al.* 1999) but less is known about the differential timing between age classes. Studies comparing age and sex differences in the stopover biology within species are scarce (e.g. Ellegren 1991, Stewart *et al.* 2002), due to the fact that in many species there are no striking differences in plumage color between yearlings and adults and between sexes.

Returning from Africa to the European breeding territories along the western axis, birds have to cross the Sahara desert and then the Mediterranean. Once the Maghreb area has been reached, there are two possible routes to follow (Spina & Pilastro 1999): crossing the short distance to the Iberian Peninsula to migrate through the continent or crossing the Mediterranean Sea. Those migrants selecting

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the sea-route have the only opportunity to stop over at islands. Several studies have been carried out in the central Mediterranean area dealing with the spring migration of songbirds (Spina & Pilastro 1999) and even with the study of the differential migration of sex and age classes (Spina *et al.* 1994), but there are some species that have not received enough attention, as is the case of Nightingale *Luscinia megarhynchos*.

In this paper we present the stopover characteristics of the Nightingales captured at two islands during their spring migration over the western Mediterranean. The main purpose of our study is to test the differences between age classes, due to the possibility of correctly assign the age-class to the individuals of this species.

Data from the Piccole Isole Project PPI (Spina *et al.* 1993) has been used to perform this analysis. Nightingale is a night-migrating passerine that breeds in western Palearctic in middle and lower-middle latitudes, and winters in Afrotropics showing, in spring migration, a broad-front passage from African territories (Snow & Perrins 1998).

MATERIALS AND METHODS

Nightingales have been captured during the PPI project, that involves, during spring, several islands and mainland locations on the Western Mediterranean. In this study, the stations of Illa de l'Aire and Columbrets have been selected to study the characteristics of the stop-over. Illa de l'Aire (04°15'E-39°48'N), is located 1 km East of the Menorca Island (Balearic Islands) and has Mediterranean open-shrub vegetation with the presence of a small forest of *Tamarix*. Columbrets (00°38'E-39°53'N) are a set of volcanic islands located 60 km east of the city of Castelló de la Plana and have also Mediterranean open-shrub vegetation (Fig. 1).

We have gathered data from the ringing scheme between the years 1994-2003. Although for some years the ringing period has lasted more than one month, we have restricted the analysis to the period 16th April to 15th May to make results comparable between years.

Nightingales have been aged using the contrast between old and new greater coverts (Svensson 1992). After the post-juvenile moult, yearlings could be identified using this character that is still visible in spring and summer of the second calendar year. On the contrary, adults have these feathers similar in color and texture (Svensson 1992, Jenni & Winkler 1994).

In order to assess the mean arrival date of Nightingales and compare between islands, we have used the day of capture transformed in Julian value and Mann-Whit-

ney U-test (95% confidence interval). For each bird we recorded wing length, body mass and fat score, following the standardized PPI scheme methods (Spina *et al.* 1993). Body mass increased with wing length and was corrected using a linear regression being the wing length the independent variable (weight = $-2,892 + 0,266 * \text{wing length}$, $n = 1505$, $P < 0,0001$), and using the residuals of this regression as a size-corrected estimate of body mass. Linear regression has been used to study the wing length variation over time for each year using pentades as separated periods (Berthold 1973). Wing length, body mass and fat score differences between second-year and adults and between islands have been tested using a two-sample *t*-test.

All data was checked for normality (Shapiro-Wilk test) and no transformation was needed. Statistical analyses were carried out using version 11 of the SPSS statistical software package.

RESULTS

General aspects

The number of captures between 16th April and 15th May of the studied period (1994-2003) was 867 individuals in Illa



Figure 1. Map of the western Mediterranean showing the locations of the ringing stations used in this study – *Mappa del Mediterraneo occidentale con indicazione delle due stazioni di inanellamento dalle quali provengono i dati di questo lavoro.*

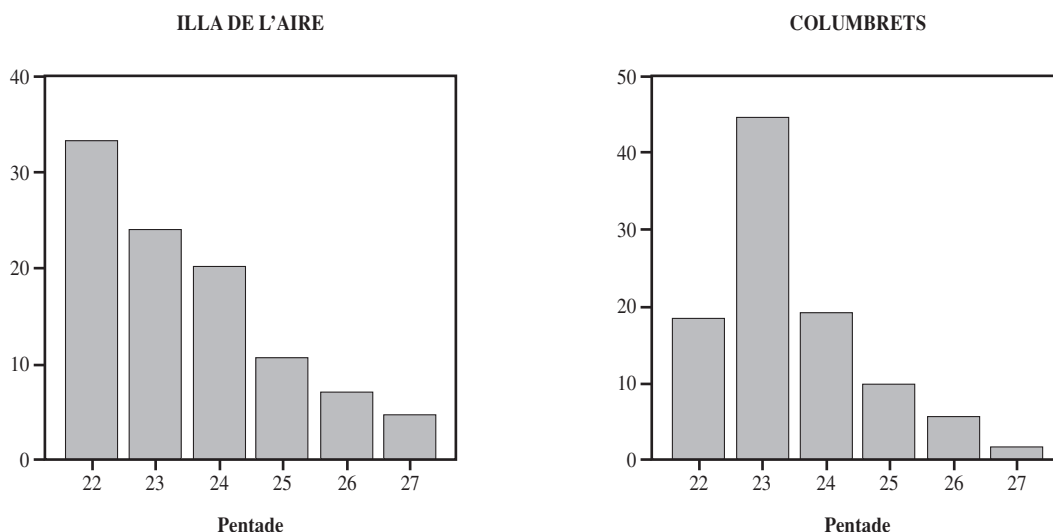


Figure 2. Percent of Nightingales captured at the islands of Illa de l'Aire and Columbrets during 1994-2003 (n = 867 and 1292, respectively) by pentades (pentade 22 is 16-20 April) – *Percentuali di usignoli catturati a Illa de l'Aire e Columbrete, per ciascuna pentade (la pentade 22 va dal 16 al 20 aprile).*

de l'Aire and 1292 in Columbrets, being the year with the maximum captures 2002 for Illa de l'Aire (162 individuals) and 1994 in Columbrets (269 individuals). On Illa de l'Aire about 95% of nightingales were correctly aged and 70% in Columbrets. The proportion of adults in relation to second-year was similar in both islands: on Illa de l'Aire 48% of the captured nightingales were adults, while at Columbrets were 45%.

Phenology

On Illa de l'Aire the peak of captures was observed on the pentade 22 (16th to 20th of April) and in the 23 in Columbrets (21st to 25th of April) (Fig. 2). Nightingales arrived as a mean the Julian day 115 in both islands (P 0,076, Mann-Whitney U-test). Adults arrived on average 3 days earlier than second-year to Illa de l'Aire (P < 0.0001, Mann-Whitney U-test), the difference ranged from 2 days in 2002 and 2003 to 6 days in 2000 although not all the years the differences were significant (Tab. 1). In 1999 both second-year and adults arrived on average the same Julian day and in 1995 second-year arrived one day earlier than adults (Tab. 1).

In Columbrets adults arrived on average 2 days earlier than second-year (P < 0.0001, Mann-Whitney U-test) the difference ranged from 1 day in 1994, 1995, 1997 and 2003 to 6 days in 1999 (Tab. 1). In 1998 both second-year and adults arrived on average the same Julian day and in two years (1996 and 2000) second-year arrived earlier than adults and those differences could be attributed to the low sample size in both islands (Tab. 1).

Wing length and data passage

In both islands adults had longer wings than second-year and we found small differences between mean value of wing length between islands either in adults as in second-year (Tab. 2) although in adults the differences were significant (t = 2.961, df = 637, P = 0.003).

Birds with long wings appeared to arrive on average earlier than short-winged individuals, both age classes on Illa de l'Aire (second-year r = 0.239, P < 0.0001, n = 374; adults r = 0.212, P < 0.0001, n = 340) and on Columbrets (second-year r = 0.121, P = 0.020, n = 366; adults r = 0.119, P = 0.035, n = 314).

Body mass and fat score at arrival

Body mass (corrected by size) of nightingales captured in both islands show a range between 17.32 and 21.31g. The differences between islands were small but significant (t = 3.367, df = 1369, P = 0.001) (Tab. 2). Differences between age-classes were also significant being adults heavier than second-year in both islands (Illa de l'Aire t = - 8.358, df = 693, P < 0.0001; Columbrets t = - 7.029, df = 671, P = < 0.0001) (Tab. 2). We have found also significant differences in weight along the season in both islands (Illa de l'Aire: r = 0.271, P < 0.001; Columbrets: r = 0.185, P < 0.001) passing the heavier ones before than lighter ones.

Fat score of captured birds show significant differences between islands (t = 8.207 df = 1366, P = < 0.0001) but no difference between age classes in both islands (Illa de

Table 1. Median trapping dates (and sample sizes) per year, of spring migrating Nightingales, second-year and adults, captured at two stopover sites located in islands of the western Mediterranean – *Date mediane di cattura (e dimensioni dei campioni), per anno e per classe di età, degli usignoli catturati in due isole del Mediterraneo occidentale.*

Location	Year	Sample size		Median trapping date (Julian days)		P	
		Second-year	adults	Second-year	adults		
Illa de l'Aire	1994	61	54	118	114	< 0,05	N.S.
	1995	35	30	116	117	0,094	
	1996	34	36	123	119	< 0,05	
	1997	44	56	114	111	< 0,05	
	1998	36	36	114	111	0,109	
	1999	54	13	117	117	0,924	
	2000	41	44	118	112	< 0,05	
	2001	34	31	120	115	< 0,05	
	2002	69	83	114	112	0,082	
	2003	22	8	116	114	0,765	
Columbrets	1994	125	84	116	115	< 0,05	N.S.
	1995	69	96	116	115	0,59	
	1996	3	4	110	116	0,114	
	1997	22	40	115	114	0,118	
	1998	38	35	117	117	0,67	
	1999	33	7	118	112	< 0,05	
	2000	12	6	127	128	0,892	
	2001	69	64	117	113	< 0,05	
	2002	105	57	116	112	< 0,05	
	2003	19	19	114	113	0,435	

l'Aire: $t = -0,173$ $df = 693$, $P = 0.862$; Columbrets $t = -0,340$ $df = 671$, $P = 0.734$) (Tab. 2). The fat score along the season does not increase in either of the islands (Illa de l'Aire: $r = 0.013$, $P = 0.734$; Columbrets: 0.008 , $P = 0.838$).

DISCUSSION

In spring birds migrating from Africa to Europe have to overcome several ecological barriers being the Mediterranean Sea the last one before arriving at a continental and safety route. As stated in the introduction, some songbird species, once arrived at the north Africa, have two possibilities: to cross near the Gibraltar strait to migrate through the continent or to go across the Mediterranean Sea. The studies carried out up to now had reported a species-specific strategy. So, some species of passerines such as Melodious Warbler *Hippolais polyglotta* and the western subspecies of the Bonelli's Warbler *Phylloscopus bonelli* cross the Sahara desert and the Mediterranean Sea and arrive at southern and Central Europe across the Iberian peninsu-

la (Pilastro *et al.* 1998), while other species such as the Wood Warbler *Phylloscopus sibilatrix* tend to choose a direct crossing of the Sea (Spina & Pilastro 1999). Moreover, there are some species that could use alternatively both strategies crossing or coasting as the case of Garden Warbler *Sylvia borin* (Grattarola *et al.* 1999).

In the case of direct crossing over the Mediterranean, the presence of islands stretched over the sea gives the birds the opportunity to make stopovers. On those birds where ageing is possible, it is possible to attain additional data on the knowledge of the migration.

Previous studies had stated that adults migrate earlier than young ones (Stewart *et al.* 2002 and references therein). Moreover, older males arrive at the breeding grounds earlier and are more successful breeders than second-year (Francis & Cooke 1986). One of the hypothesis about this differential migration is related with the habitat occupancy during winter where young ones are forced to use sub-optimal habitats and get their optimal physical condition to migrate later (Marra *et al.* 1993, 1998). Moreover, if young ones could depart at the same time as adults, they

Table 2. Wing length, body mass and fat scores of spring migrating Nightingales, second-year and adults, captured at two stopover sites located in islands of the western Mediterranean (mean \pm sd and sample size are shown) – *Lunghezza dell'ala, peso, e punteggi di accumulo del grasso, suddivisi per classe d'età e per sito, di usignoli in migrazione primaverile in due isole del Mediterraneo occidentale (medie \pm sd e dimensioni dei campioni).*

Location	Wing length (mm.)		Body mass (g.)		Fat score score		Sample size	
	Second-year	adults	Second-year	adults	Second-year	adults	Second-year	adults
Illa de l'Aire	82.0 \pm 2.3	83.5 \pm 2.3	18.9 \pm 0.6	19.3 \pm 0.6	2.2 \pm 1.3	2.2 \pm 1.3	364	331
Columbrets	81.7 \pm 2.0	82.9 \pm 2.3	18.8 \pm 0.5	19.1 \pm 0.6	1.6 \pm 1.2	1.6 \pm 1.2	365	308

are not able to withstand the harsh conditions at breeding grounds during early spring (Stewart *et al.* 2002). In young males, an earlier arrival at breeding grounds means a hard fight with adults to get good territories (Sherry & Holmes 1989). Arriving later, young ones could therefore benefit from energetic costs of adult males' aggressions, together with risks associated with bad weather and scarcity of food (Hill 1989; Whitmore *et al.* 1977; Lank *et al.* 1985). The Nightingales arriving at Mediterranean islands show age differences on mean arrival, being adults earliest than young ones in both selected islands. Also, long-winged birds arrived before the short-winged. This could mean that males (i.e. longer-winged individuals) pass before the females due to the fact that arriving earlier is more important to males than to females in order to get favorable territories to attract a mate (Hedenström & Pettersson 1986).

The weight of nightingales arriving at the studied Mediterranean islands show significant differences in age classes and throughout the season. Once more, males could pass before than females as has been stated in other migrant songbirds in spring migration over Mediterranean (Spina *et al.* 1994) and these are heavier than females. Surprisingly, we have found significant differences in fat scores between selected islands but not throughout the season neither between adults nor second-year. Nightingales crossing the Mediterranean are at an intermediate stage of their spring migration from winter territories at sub-Saharan Africa to the breeding territories in Europe. Due to the possibility of finding unfavorable weather conditions during the ecological barriers crossing, fat reserves act as an insurance (Spina & Pilastro 1999). We then expect similar fat reserves in both islands due to their similar position in the sea. The distance of Columbrets islands to the mainland (c. 60 km) is too short from a bird's point of view and perhaps it doesn't act as a true island. This could explain the differences on fat score with Illa de l'Aire that could be treated as a proper island.

As has been already stated, the decision of migrants crossing the Mediterranean Sea to rest on islands, is not

explained by critical physical conditions (Spina & Pilastro 1999). Other studies dealing with stopover ecology of migrants on Balearic islands has shown no refueling there during stopover (i.e. Willow Warblers *Phylloscopus trochilus* Barriocanal & Robson 2007). Migrants stop over on islands just to rest waiting until the next night to follow the migratory program, or also the landing decision can be based on meteorological conditions such as the head winds (Barriocanal *et al.* 2002). The differences in fat score on Columbrets islands found in this study provides a new perspective to analyze migrating birds stopping at those islands that are located in the middle of the sea but relatively near to the coastline.

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