Spring Passage of Willow Warbler Phylloscopus trochilus Across the Western Mediterranean: Comparing Islands with the Mainland

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Spring passage of Willow Warbler *Phylloscopus trochilus* across the western Mediterranean: comparing islands with the mainland

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Spring migration of Willow Warbler *Phylloscopus trochilus* over the western Mediterranean was studied using observations collected at a ringing station on the mainland of Spain (Aiguamolls de l'Empordà), and at an island station (Cabrera, one of the Balearics). During the years 1993–2001, birds were caught and measured between 16 April and 15 May. The peak of captures and mean arrival date was seven days earlier on the continental station than on the island. At both stations long-winged individuals passed before short-winged birds, and birds at the continental station had longer wings than at the island. The number of recaptures was low at both locations suggesting that most birds departed at the day of arrival. The mean stopover period for recaptured individuals at the continental and island station was 2.2 and 2.6 days, respectively. Body mass remained more or less constant during this stay. Our observations suggest that subpopulations of Willow Warblers, differing both in morphology and timing of migration, have different migration routes over the western Mediterranean; one migrates over the Iberian Peninsula and another crosses over the sea.

Key words: differential timing, Mediterranean, migration, subpopulations

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INTRODUCTION

In spring, trans-Sahara migrants cross several ecological barriers to arrive at their European destinations. The Sahara desert, the Mediterranean Sea, the Pyrenees and the Alps are major obstacles that passerines have to overcome when they follow the western Mediterranean flyway. Several studies have focused on the strategy used by birds to cross the Sahara (Biebach *et al.* 1986, Biebach *et al.* 1991, Bairlein 1992, Biebach 1992, 1995, Izhaki & Maitav 1998a,b), but data is scarce on the strategy used by birds to cross the western Mediterranean Sea. Trans-Sahara migrants arriving at the Mediterranean Sea have two possibilities: either crossing the sea near the Gibraltar strait to migrate through the continent, or crossing the sea without detour. Studies carried out up to now showed that both possibilities are used. Some passerines, such as Melodious Warbler *Hippolais polyglotta* and the western subspecies of the Bonelli's Warbler *Phylloscopus bonelli*, arrive at southern and central

Europe across the Iberian peninsula (Pilastro *et al.* 1998), while species as Wood Warbler *Phylloscopus sibilatrix* tend to choose a direct crossing of the Sea (Spina & Pilastro 1999). Moreover, some species as for example Garden Warbler *Sylvia borin* use both strategies (Grattarola *et al.* 1999).

Birds that directly cross the Mediterranean Sea may benefit from islands to make a stopover. By using data from birds captured on islands and the continent, it is possible to compare strategies used and eco-physiological characteristics of the individuals. We compared the characteristics of Willow Warblers *Phylloscopus trochilus* captured during spring passage on a coastal stopover site of the Iberian Peninsula and on one of the Balearics islands. Data from the Piccole Isole Project PPI (Spina *et al.* 1993) was used to perform this analysis. The Willow Warbler is a long-distance, night-migrating passerine bird that breeds in the middle latitudes of the western Paleartic in a vast territory from Britain to the west Paleartic, extending east across Siberia to c. 180° E and north of 45°, and winters in a large part of sub-Saharan Africa (Cramp 1992). In spring, western populations migrate through the Spanish Mediterranean region (Flegg 2004).

STUDY AREA AND METHODOLOGY

For this study we analyzed data from two ringing stations, one located on the northeastern coast of the Iberian Peninsula (Aiguamolls de l'Empordà Natural Park) and the other on the small island of Cabrera at the Balearic Islands (Fig. 1). The continental station of Aiguamolls de l'Empordà (42°00'N, 3°00'E) is located at a marshy area which is dominated by Common Reed *Phragmites australis*. Cabrera (39°08'N, 2°56'E) is a small island located 10 km south of the large island of Mallorca and has a Mediterranean open-shrub vegetation with a small pine forest. Contrary to the mainland station, the island does not have marshy habitats. Data from the PPI is based on continuous and standardized mist-netting on Mediterranean islands and some mainland stations (Spina *et al.* 1993). We used data collected from 1993 to 2001. Although in some years ringing periods lasted for more than one month, we restricted the analysis to the period from 16 April to 15 May to make results comparable between years. At Aiguamolls de l'Empordà a total of 180 meters of nets were used. On Cabrera, 215 meters of nets were used, but 120 meters in the last two years. Nets were checked every hour from dawn to dusk, and were closed when meteorological conditions were adverse. We used the mean values of capture date to compare continental and island arrivals. To analyse if individuals captured in the two areas came from the same breeding population, the length of the flattened wing (Svensson 1992), measured to the nearest 0.5 mm, was used. This external biometric character has been successfully used in blackcaps to segregate sedentary from migratory birds (Pérez-Tris & Tellería 2002). Several ringers collected data at each site without calibrating them against each other. Analyses of the peak of migration and wing length was performed using pentads

Figure 1. Map of the western Mediterranean showing the locations of the ringing stations used in this study.

(5-day periods) according to Berthold (1973). Other analyses were based on date of capture. To compare arrival date between locations, we used non-parametric Mann-Whitney *U*-tests. Date of capture was expressed as Julian date. Wing length, body mass and length of the stopover period at the two locations studied were evaluated by *t*-tests assuming equal variances. Stopover length was calculated as the difference between the last and first capture dates. Regression analyses were performed to investigate the relationship between wing length and day of arrival both on the continent and the island. Means are presented ± SD. Statistical significance was set at $P < 0.05$ (two-tailed). Statistical analyses were carried out using version 11 of the SPSS statistical software package.

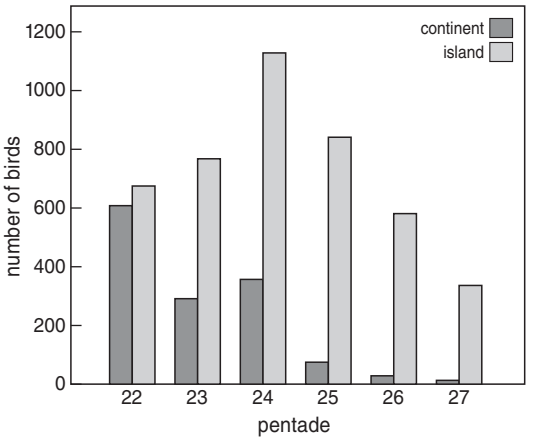

Figure 2. Numbers of Willow Warblers captured at continental and island stations during 1993–2001 (n = 1382 and 4328, respectively) by pentads (pentad 22 is 16–20 April).

RESULTS

General aspects

During the nine years of study (1993–2001) a total of 1382 Willow Warblers were captured on the continental station, ranging from 41 in 1993 to 495 individuals in 1999. On the island station of Cabrera 4328 individuals were captured, from 219 individuals in 1993 to 749 individuals in 1994.

Phenology

At the continental station a peak in captures was observed during the first pentad (pentad 22), after which the number of captures diminished, especially after pentad 24. On Cabrera the peak in captures occurred during pentad 24 (Fig. 2). Willow Warbles arrived on average 7 days earlier on the continent compared to the island station ($P < 0.0001$, Mann-Whitney *U*-test), the difference ranged from 4 days in 1997 to 9 days in 1993 and 1998 (Table 1).

Table 1. Median trapping dates (and sample sizes) of spring migrating Willow Warblers captured at two stopover sites located in the western Mediterranean.

Year	Sample size		Median trapping date (Julian days)		*P*
	Continent	Island	Continent	Island	
1993	41	219	113	122	<0.0005
1994	138	749	111	117	<0.0005
1995	92	759	112	117	<0.0005
1996	111	536	118	125	<0.0005
1997	231	351	113	117	<0.0005
1998	109	344	111	120	<0.0005
1999	495	447	113	119	<0.0005
2000	118	302	113	121	<0.0005
2001	47	621	111	119	<0.0005

Wing length

Wing lengths of birds captured at the island were on average shorter than those of individuals trapped at the continental station ($t = -26.834$, $df = 5231$, $P < 0.0001$), a difference that was consistent for all years (Table 2). Analysis by pentads showed significant differences in four of the six study pentads, and in almost all cases wing length was smaller in Willow Warblers captured on the island (Table 3). Birds with long wings appeared to arrive on average earlier than short-winged individuals, both on the island ($r = 0.255$, $P < 0.0001$, $n = 4078$) and on the continent ($r = 0.192$, $P < 0.0001$, $n = 1153$).

Table 2. Wing length of spring migrating Willow Warblers captured at two stopover sites located in the western Mediterranean. Data is presented as mean ± SD with sample size.

Year	Sample size		Wing length (mm)		*P*	
	Continent	Island	Continent	Island		
1993	40	218	66.1 ± 3.6	65.2 ± 2.9	0.104	NS[a]
1994	137	713	66.1 ± 3.6	65.2 ± 3.1	0.003	
1995	91	717	66.8 ± 3.1	65.5 ± 3.1	<0.0005	
1996	54	396	66.0 ± 3.6	64.8 ± 3.0	0.005	
1997	231	334	67.3 ± 3.0	65.6 ± 3.2	<0.0005	
1998	67	344	67.2 ± 2.9	65.5 ± 3.2	<0.0005	
1999	369	445	66.7 ± 2.9	65.0 ± 3.2	<0.0005	
2000	118	298	66.2 ± 2.9	65.4 ± 3.3	0.024	
2001	47	614	67.6 ± 2.4	66.0 ± 3.1	0.001	

[a]Not significant.

Table 3. Wing length of spring migrating Willow Warblers captured at two stopover sites located in the western Mediterranean. Analysis by pentads (pentad 22 is 16–20 April). Data is presented as mean ± SD with sample size.

Pentad	Sample size		Wing length (mm)		*P*	
	Continent	Island	Continent	Island		
22	556	672	67.0 ± 3.0	66.6 ± 3.4	0.033	
23	290	761	66.9 ± 2.9	65.9 ± 3.3	<0.0005	
24	186	1050	66.6 ± 3.1	65.4 ± 3.0	<0.0005	
25	77	830	64.7 ± 2.9	64.9 ± 2.7	0.717	NS[a]
26	30	526	65.1 ± 2.6	64.2 ± 2.6	0.044	
27	15	239	64.6 ± 2.7	64.0 ± 2.4	0.361	NS

[a]Not significant.

Stopover length and body mass

Body mass increased with wing length, which made it possible to correct body mass for body size using a linear regression (weight = –0.996 + 0.143 x wing length, $n = 5127$, $P < 0.0001$). At first capture, birds on the island had a body mass of 8.54 ± 0.013 g, and at the continent station a body mass of 8.35 ± 0.007 g. These differences were small but significant ($t = 12.645$, $df = 5126$, $P < 0.0001$). In general, the number of recaptured birds was low. At the island only 2.2% of the ringed birds were recaptured at least one day after initial capture, suggesting that most birds departed at the day of arrival. On the continent, 5.2% of the birds were recaptured. Mean stopover period for recaptured birds was 2.63 days at the island and 2.16 days on the continent but the difference was not significant ($t = –1.423$, $df = 162$, $P = 0.157$). Between captures, mean change in body mass was –0.043 g day^{-1} at the island, and 0.053 g day^{-1} at the continent ($t = 1.194$, $df = 162$, $P = 0.234$). These observations suggest that Willow Warblers do not refuel during the stopover period.

DISCUSSION

Birds migrating through the western Mediterranean are facing one of the last ecological barriers before reaching southern Europe. They have two possibilities to cope with the Mediterranean Sea: following the coast or crossing the sea. Species that select the direct, short route over sea may face rapid weather changes and scarcity of landing sites during passage, whereas species that select the continental route have ample opportunities to find adequate stopover sites and face less variable weather (Liechti & Bruderer 1998). This means that birds face a trade-off between time and safety when choosing the migratory route, which is solved in different ways (Spina & Pilastro 1999). Our results showed differences in migratory strategies of spring migrating Willow Warblers crossing the Mediterranean. The large numbers of birds captured at the island station compared to the mainland site could have been the result of the attraction of islands. Radar observations of nocturnal migrating passerines showed that the density of migrating birds across the Mediterranean basin between Algeria and France is two to three times lower than across the Iberian Peninsula (Bruderer & Liechti 1999). We showed that passage on the continent was earlier than at sea. These results support the idea of two different breeding populations of Willow Warblers crossing the western Mediterranean (see also Grattarola *et al.* 1999). In general, birds from northern populations migrate later in spring than southern populations possibly because food at the breeding grounds becomes available later (Schüz 1971). Following this reasoning, the later birds at our island station might belong to a northern population. If true, we would expect that birds at the island had longer wings, as generally in northern populations. However, the reverse was the case. As an alternative explanation we could think of a differential sex migration, or a differential age-related migration where young, smaller birds migrate later than adults.

We observed an earlier arrival of longer-winged individuals which means that there is a different speed of migration based on wing morphology; perhaps because adults and males were faster than juveniles and females (Hedenström & Pettersson 1986). Numbers of recaptures were low at both stopover sites. Recaptured birds showed a mean stopover period of more than two days without any clear sign of increase in body mass. This means that most individuals did not refuel during the stopover period, but rather used the sites as resting areas. The habitat quality of stopover sites may influence stopover success with the opportunity for feeding and replenishing depleted energy stores (Moore *et al.* 1990). In our case the lack of weight gain at the continental and island stopover sites suggests that foraging opportunities have no influence on the decision to land. Probably Willow Warblers captured on islands are forced to use sub-optimal sites, which do not offer adequate resources for energy storage, especially after crossing an ecological barrier such as the sea (Moore *et al.* 1990). Alternatively, the decision to land can be based on meteorological conditions (Barriocanal *et al.* 2002), or on the need to resting during the day rather than on the need to accumulate stores for the flight.

Patterns of arrival and wing morphology were clearly different for birds captured at the continental and island station. Our data suggest therefore that Willow Warblers that migrate along the coast of the Iberian Peninsula originate from a different population as birds that cross the Mediterranean Sea, having short stops at islands. Data using DNA markers (Wink 2006) could shed light on the complete migration of Willow Warbler to confirm our hypothesis.

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SAMENVATTING

Veel zangvogels die bij ons broeden, overwinteren in Afrika en doorkruisen op weg naar het noorden het Middellandse Zeegebied. Daarbij kunnen de vogels kiezen tussen een route dwars over zee of langs de kust van Afrika met een oversteek bij de Straat van Gibraltar. Tegenover het voordeel van de kortere zeeroute staan risico's van onvoorspelbaarheid van het weer en gebrek aan rustplaatsen. Te verwachten is daarom dat de keuze voor de route afhangt van bijvoorbeeld de tijdsdruk waaronder de vogels staan en de grootte van opgeslagen energiereserves. De onderhavige studie vergeleek het trekpatroon en de morfologie van Fitissen *Phylloscopus trochilus* op beide trekroutes. Dit gebeurde op basis van vangsten in het noordoosten van Spanje (Aiguamolls de l'Empordà) en op een van de Balearische eilanden (Cabrera). Vogels werden gevangen tussen 16 april en 15 mei in de jaren 1993–2001. In beide gebieden werden in de loop van het seizoen kleinere vogels, gemeten naar vleugellengte, gevangen. De doortrek van Fitissen op de vaste wal was een week vroeger dan op het eiland. Bovendien was de gemiddelde vleugellengte op de vaste wal langer dan op het eiland, hoewel het verschil klein was (1,3 mm, 2%). Er wordt verondersteld dat populaties met een verschillende geografische herkomst gebruikmaken van de twee trekroutes. (BIT)

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