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Some aspects of the spring migration of the Willow Warbler *Phylloscopus trochilus*, on the isle of Capri

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Abstract — Some aspects of the migration of the Willow Warbler *Phylloscopus trochilus* were studied on the isle of Capri in the spring of 1987. 309 individuals were captured between April 13th and May 24th. 200 m of nets were used in groups of 20-30 m each within an area covering approx. 1 hectare and made up of Mediterranean bush. The trend of the capture, which was concentrated in the second half of the month of April, did not appear to be determined simply by the different transit of males and females in the species but also by groups of different individuals. In the nominal ssp. 2 different groups of individuals were distinguished, one characterized by colour note 2, the other by colour notes 3 and 4, according to the amount of yellow streaks on the breast and belly. The study examines the migratory transit and differences in fatty deposits between males and females in the three groups. The ssp. *acredula*, which is distinguished by wing length, appears different from the nominal ssp. also in the transit period.

Introduction

The Willow Warbler *Phylloscopus trochilus* is a transequatorial migrant breeding all over Europe north of the Alpine chain, and wintering in tropical eastern, western and southern Africa (Curry-Lindhall 1981, Moreau 1972, Williamson 1976, Zink 1973).
Two subspecies are distinguished in the species, the nominal *P.t.trochilus* (Linnaeus) and the Nordic *P.t.acredula* (Linnaeus), which have different wing lengths (Fonstad and Hogstad 1981, Williamson 1976) but not a different shape of wing (Fonstand and Hogstad 1981, Tiainen and Hanski 1985).
Other differences were observed with regard to colour of plumage (Williamson 1976) and, in particular, the presence or absence of yellow streaks on the breast and belly (Hedenström and Pettersson 1984).
The two subspecies also differ as regards time of migration: in agreement with the law of Shuz (1971), the Nordic subspecies *P.t.acredula* appears to transit later than the nominal subspecies (Pettersson 1986).
There are distinct differences between males and females of both subspecies as regards wing measurements (Tiainen and Kansli 1985), migratory phenology (Norman 1983, Tiainen 1982) and ways in which energy reserves are accumulated (Hedenström and Pettersson 1986).

The present study analyses certain aspects of the different methods of transit of individuals of both sexes. Furthermore, since both subspecies transit in the central-Mediterranean area (Gustin 1985, 1989), the migratory patterns of the two subspecies have been discussed; finally, we investigated whether populations coming from different areas but belonging to the nominal subspecies followed routes along the Italian peninsula to reach their breeding destinations.

Study area and methods

309 Willow Warblers were captured on the isle of Capri (40°33'N - 13°12'E) in the spring of 1987 (April 13th - May 24th). 200 m of mist-nets were used, arranged in groups 20-30 m long each within an area covering approximatively one hectare and made up of garigue and typical Mediterranean bush with some residues of arboreal vegetation (Gustin et al. 1985).
Time of capture was examined by subdividing the period into pentads (Berthold, 1973) or tetrads when it was necessary to separate capture peaks that were very close in time.
The following parameters were recorded for each individual:

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— wing length (method 3, Svensson 1984);
— length of third primary (Berthold and Friedrich 1979);
— Index I of wing formula (Holynski 1965);
— Index II of wing formula (Busse 1972);
— Index III of wing formula (Tiainen 1982);
— colour note as regards extension of yellow streaks on breast and belly (Hedenström and Pettersson 1984);
— fat deposits in the furcula (range 0-4);
— fat deposits both in the furcula and in the belly (range 0-5) (Busse 1972);
— weight, with accuracy to a tenth of one gram.
Individuals whose wings were within the range 61-66 mm were considered to be females while those whose wings were greater than 68.5 mm were considered to be males, in compliance with data presented by various authors (Smith 1978, Williamson 1976).
As far as statistical analysis is concerned, parametric tests were used (Linear regression) (Lison 1961) as well as non-parametric ones (Siegel 1956).

Results

Phenology of migration

Spring transit of the Willow Warbler appears to be concentrated in the period April 16th — 20th (pentad 22); there is another capture peak, numerically inferior to the previous one, during the period May 6th-10th (pentad 26) (χ^2 = 832.43) P<0.001, Fig. 1). The capture trend reveals features of bimodality which seem to suggest different transit times for males and females of the species (Hedenström and Pettersson, 1984, 1986; Norman, 1983): on the other hand, wing formula indices I, II and III vary in a statistically significant way (Index I: P<0.05; Index II: P<0.02; Index III: P<0.01; Hedenström and Pettersson 1986, Table 2); there is a slight decrease in mean values for wing length which does not appear statistically significant (Kruskal-Wallis P = 0.14, Table 2) in the period examined. This phenomenon is identical as regards measurement of the third primary (Kruskal-Wallis P = 0.78, Table 1). Since the Willow Warbler presents a difference between measurements of wing length for pointedness indices of the wings in males and females, there should be an evident decrease in mean values from the beginning to the end of the period under investigation; instead, an increase in mean values is observed in the central pentads of the monitoring period.
These data allow us to speculate that the phenologic trend of the Willow Warbler in Capri is not determined only by the transit of males and females in a homogeneous group of indivuduals, but possibly in different groups.
This hypothesis seems to be confirmed by the fact that the passage of individuals characterized by different colour notes appears to be differentiated (χ^2 = 99.07, P<0.001, Fig. 2). The Willow Warbler *acredula* (colour note 1) seems to transit almost exclusively in May, while the nominal subspecies transits prevalently in April (χ^2 = 7.12, P<0.01).
As for wing lengths, they appear to be different in the case of the *acredula* (Kruskal-Wallis P = 0.05), but appear homogeneous for all Willow Warblers in the nominal subspecies (Kruskal-Wallis P = 0.72, Table 3).
This is in accordance with results published by Pettersson (1986): since the *acredula* have a longer wing, which allows a more rapid flight, they can transit later than their con-specific similes.
With regard to the Willow Warblers in the nominal subspecies, there is a difference in transit for individuals characterized by colour note 2 and those characterized by colour note 3 (χ^2 = 39.63 P<0.001): individuals in the "2" group transit earlier than those in the "3" group; no significant differences were observed, on the other hand, between Willow Warblers characterized by colour notes 3 and 4 (χ^2 = 10.10, P = 0.18). This allows us to determine that willow warblers "3" and "4" are included in the same phenologic nucleus, while those in group "2" appear to be separate.

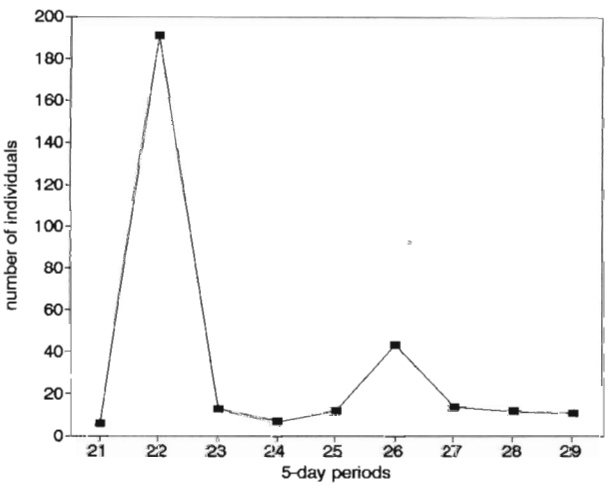

Figure 1 - Fenology of the Willow Warbler in Capri.

Rhythm of activity and accumulation strategies for energy reserves

Unlike in other Passerines species of nocturnal migrants (Spina 1986, 1988), Willow Warblers are

Table 1 - Change of wing lenght and third primary during the period considered.

Pentads	N	Mean wing	S.D.	III primary	S.D.
21	6	68.88	0.6	51.10	1.3
22	191	67.21	2.9	50.33	2.5
23	13	68.11	3.4	49.69	3.0
24	7	69.29	3.0	49.90	2.8
25	12	68.08	2.9	50.02	2.3
26	43	67.63	2.7	50.16	2.5
27	14	66.89	3.5	50.83	3.4
28	12	66.37	3.0	49.57	3.5
29	11	66.09	1.7	50.00	1.5

Table 2 - Change of wing-formula indices 1, 2 and 3 during the period considered.

Pentads	N	Index 1	S. D.	Index 2	S. D.	Index 3	S. D.
22	137	0.53	0.04	36.85	5.3	5.55	1.2
23	13	0.53	0.04	39.37	5.0	5.90	1.0
24	5	0.57	0.10	40.19	12.6	7.36	2.0
25	12	0.56	0.05	41.66	4.5	6.56	1.0
26	18	0.55	0.06	39.15	6.0	5.77	1.2
27	4	0.54	0.03	37.90	3.5	5.67	0.6

Table 3 - Comparison between the wing lenght of Willow Warblers marked by the notes of colour 1, 2, 3, and 4.

Colour note	N	Mean wing	S. D.
1	18	69.92	3.8
2	122	67.09	3.0
3	95	67.10	2.6
4	54	76.49	3.0

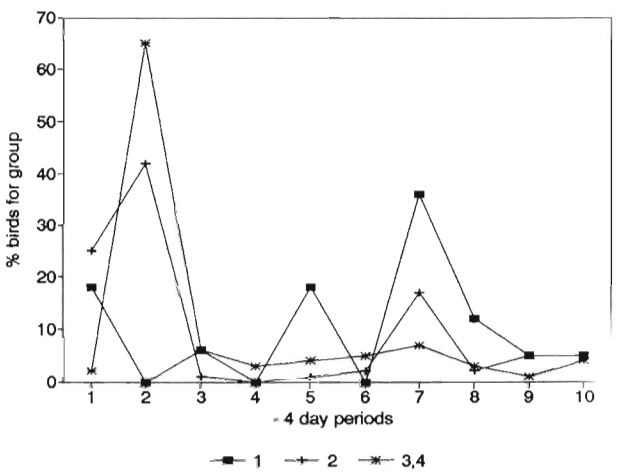

Figure 2 - Distinct movements of the populations.

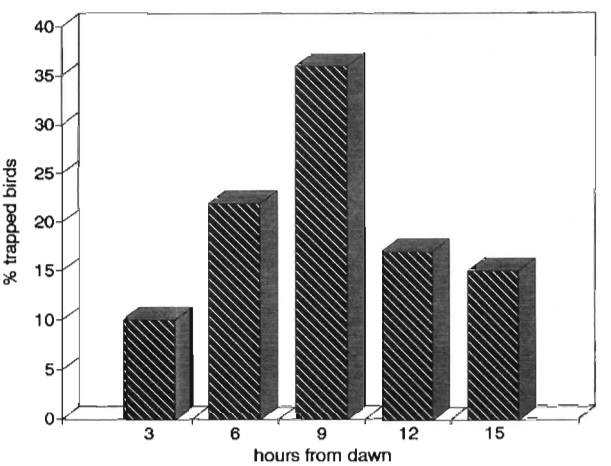

Figure 3 - Activity rhytms of the Willow Warbler in Capri.

captured mostly in the central hours of the day (χ^2 = 8.33 P<0.001, Fig. 3). It is possible that, in accordance with Riddiford and Auger's observations (1983), once the Willow Warblers have completed their nightly migratory flight, they remain inactive for several hours after dawn and only subsequently

start looking for food. During the second half of the day there was a considerable drop in the number of Willow Warblers caught; furthermore, since no re-capturing was recorded in the span of the same day, it is likely that Willow Warblers carry out short flights during the day to look for food, before the general exodus in the evening hours (Riddiford and Auger, 1983).

When the birds arrive on the island, they are never completely devoid of energetyc reserves; fat deposits in the furcula correspond to mean value 2. During the day, the Willow Warblers do not appear to increase their energy reserves (fat = -0.003* hour + 3.268); neither does the weight appear to increase significantly during the day (weight = 0.113* hour + 83.92), in accordance with data presented by Smith (1979).

In order to assess whether the increase in weight during the day is masked by the presence of individuals of different sizes, four dimensional classes were identified on the basis of wing length as discriminating parameter (Riddiford and Auger 1983). The trend of mean weight in relation to the time of day was analysed within each group. No significant increase in weight was observed, with the exception of one of the classes (Table 4).

This conflicts with observations presented by Riddiford and Auger (1983) in England, during the end stage of migration.

Differences observed in migration of males and females

Transit of Willow Warblers in Capri, concentrated in a limited time period, allows certain observations to be made on behaviour in flight of the two sexes: since males have a longer wing (Kruskal-Wallis $P<0.001$), which is also more pointed (Kruskal-Wallis $P<0.01$) as compared to that of the female, their speed during flight is likely to be greater (Hedenström and Pettersson, 1986). In fact, during the day, progressively smaller individuals were captured. This phenomenon appears very evident in the early hours of the day when the Willow Warblers arrive ($\chi^2 = 7.43$, $P = 0.02$). In the afternoon, instead, the number of presumed males and females coincides with the proportion of males and females within the entire sample group ($\chi^2 = 2.20$, $P<0.10$) (Fig. 4).

A difference was also found, moreover, between males and females in the method of accumulation of energy reserves. In the central hours of the day, when the greatest number of presumed females was captured (Fig. 4), an increase in mean weight was observed (Table 5). This indicates that females weigh more.

The distribution of fat in the furcula was considered separately in males and females: this distribution (mean value 2) does not appear to be different from a casual one in males ($\chi^2 = 4.36$, $P<0.10$); females, instead, present a prevalence of individuals with considerable deposits of fat: mean value is 3 and there is a statistically significant distribution ($\chi^2 = 21.64$, $P<0.01$). There is a statistically significant difference between the mean values of the two distributions ($P(U) = 0.02$) (Fig. 5). Analysis of fat deposits recorded both in the furcula and in the belly showed that it is not always the female Willow Warbler that has greater energy reserves. The difference between males and females is found only in the group of individuals characterized by

Table 4 - Change of weight during the day in four dimensional classes.

	Willow Warblers wing lenght to 64 mm			Willow Warbler wing lenght between 64 to 67 mm		
Hour of day	N	Mean	S. D.	N	Mean	S. D.
05-07	2	7.05	0.8	14	7.73	0.7
08-10	4	8.17	0.4	24	8.14	0.9
11-13	12	7.55	2.2	58	8.26	0.7
14-16	4	8.02	0.5	21	7.94	0.8
17-19	3	8.00	0.4	12	7.79	0.8
	Willow Warbler wing lenght between 67 to 70 mm			Willow Warbler wing lenght 70 mm		
Hour of day	N	Mean	S. D.	N	Mean	S. D.
05-07	4	7.67	0.9	11	9.16	0.6
08-10	12	8.04	1.0	27	9.21	0.8
11-13	23	8.87	0.9	21	9.70	0.7
14-16	12	9.12	0.9	15	9.22	0.8
17-19	11	8.20	0.6	16	9.02	0.8

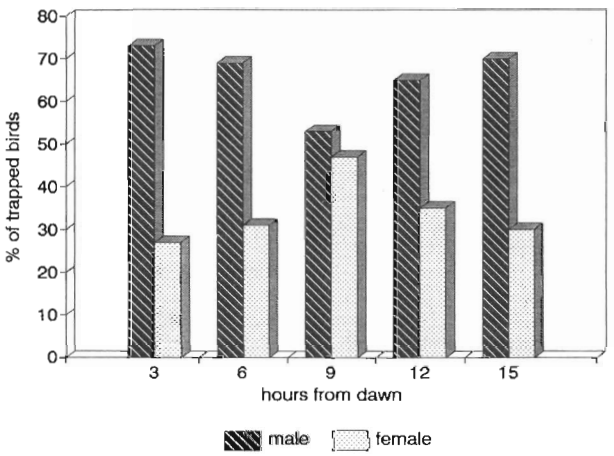

Figure 4 - Activity rhytms of males and females.

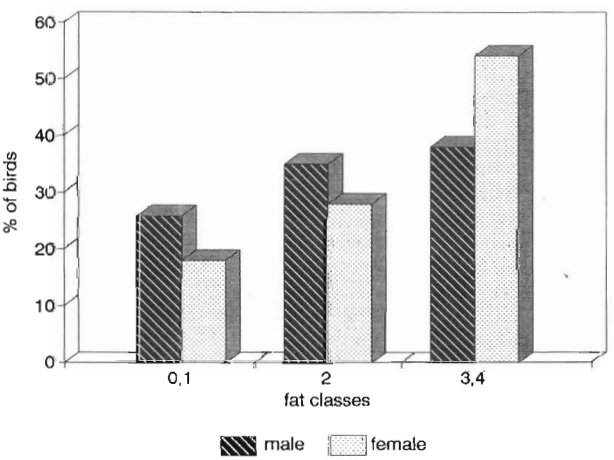

Figure 5 - Fat distribution in males and females.

Table 5 - Change of weight during the day.

Hour of day	N	Average weight	S. D.
05-06	23	8.22	1.0
07-08	19	8.09	1.1
09-10	54	8.66	1.0
11-12	68	8.60	0.9
13-14	56	8.69	1.0
15-16	35	8.61	0.9
17-18	26	8.23	0.9
19-20	15	8.67	0.8

Table 6 - Median values of fat (B = Busse) (E = Euring) in three populations.

Population	2	3	4
Sex	M/F	M/F	M/F
Median fat E	2 3	2 3	2 3
Median fat B	3 4	4 4	4 4

colour notes 3 and 4 (χ^2 = 10.14, P = 0.04); on the other hand, individuals characterized by colour note 2 did not show any significant difference in fat deposits for males and females (χ^2 = 3.87, P< 0.10) (Table 6), in contrast with observations reported by Hedenström and Pettersson (1986) in the end stage of migration.

Discussion

On the basis of data presented it is possible to conclude that the isle of Capri is an important stopping point in the spring migration of Willow Warblers. Individuals in transit are heading for the breeding areas distributed in northern Europe. Individuals of the Nordic subspecies transit later as compared to their con-specifics in the nominal subspecies, since they are faster. The Willow Warblers of the nominal subspecies all have a similar flight behaviour, but the more northern populations (colour note 2) are forced to transit earlier than the more southern populations (3 and 4), which must cover shorter routes. It is thus possible to suggest that since the females of the more southern populations have almost reached the end of their migration, they need to accumulate greater quantities of fat than the females of the more northern populations, which are still far from their final breeding destinations.

It would therefore appear possible to distinguish different groups of Willow Warblers according to morphologic, physiologic and phenologic characteristics also within the nominal subspecies.

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Riassunto — Tra il 12 Aprile ed il 24 Maggio 1987, furono catturati nell'isola di Capri 309 Luì grossi, la maggior parte dei quali in aprile (16-20). Quelli appartenenti alla sottospecie *acredula* furono tuttavia catturati soprattutto nel mese di maggio. Gli individui della sottospecie *P.t.trochilus* sono stati divisi in due differenti gruppi a seconda del numero delle strisce gialle sul petto e sul ventre: gli individui che in base al colore furono classificati come "2" sono inseriti nel primo gruppo, mentre quelli che in base al colore furono classificati come "3" e "4", sono raggruppati nel secondo. Il periodo di transito delle varie classi di colore è risultato differente: i "2" arrivano prima dei "3" e dei "4". Non è stata riscontrata una differenza nell'accumulo di grasso fra maschi e femmine della popolazione "2"; tale differenza è risultata significativa nelle popolazioni "3"e "4". La maggior parte degli individui è stata catturata nelle ore centrali della giornata. I Luì grossi non sembrano aumentare i loro contenuti di grasso sottocutaneo durante il giorno. Le femmine appaiono più pesanti dei maschi.

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