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Sexual difference and termination of growth of young Willow Warblers *Phylloscopus trochilus*

By Juha Tiainen

1. Introduction

During 1972—1978, I ringed a total of 439 successfully fledged Willow Warbler *Phylloscopus trochilus* young in the vicinity of the Lammi Biological Station (61° 03′ N, 25° 03′ E), southern Finland. The Willow Warbler is monomorphic as to plumage colouration, but it shows significant sexual size dimorphism (e. g. TIAINEN 1982). Growth of nestling Willow Warblers was described earlier on the basis of daily measurements, but without reference to the sex (TIAINEN 1978). Both the wing length and especially the weight varied interindividually considerably during the nestling period. In broods where growth was monitored for several days, the individual growth curves tended to form two groups suggesting that a sexual difference becomes evident already in an early stage of the ontogeny. The wing length reached about 70—72 % of the adult wing length until fledging at the age of 13—14 days, but the final weight was attained already on day 9.

Thirty-one of the fledged young were recaptured and sexed later after fledging during the same season or in subsequent years. This offered a possibility to study the sexual difference of the growth on the basis of data which were collected on these individuals during their nestling time. It was also possible to determine at which age the wing attains its final length. This paper describes the growth of these recaptured individuals from the day of ringing until the dispersal phase when they leave the study area.

2. Material and methods

The wing length was recorded with the maximum method (SVENSSON 1975) to the nearest 0.5 mm (nestlings and the youngest fledglings), or 1 mm (other individuals, but sometimes also to the nearest 0.5 mm), using a ruler. The weight was recorded using Pesola spring balances with an accuracy of 0.05 g (10-g balance), or 0.1 g (30-g balance). 81 measurements of the wing length, and 80 of weight, were available of the recaptured 31 individuals. 55 of these records were used for the analysis of the growth pattern in TIAINEN (1978), the rest being new measurements.

3. Results

3.1. Determination of sex of recaptured individuals

Seven of the recaptured individuals were trapped during later breeding seasons, and could easily be sexed on the basis of their behaviour, form of the cloacal region, and the bareness of the incubation patch (following SVENSSON 1975).

Twenty-four of the recaptured individuals were trapped after fledging during the same season. Sexing was based on the clear and significant sexual size dimorphism found in the breeding population studied (TIAINEN 1982; see Fig. 1). Although the frequency distribution of the wing length of adult Willow Warblers is clearly bimodal with small proportions of overlapping females (11 %) and males (2 %) at 68 mm (TIAINEN 1982 and unpubl., see also NIEMEYER 1969), the wing lengths of young Willow Warblers at an age of 21—33 days did not separate so clearly (Fig. 1). The weights of the same young did not allow any separation of sexes, neither, although the difference was clearer than in

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the wing length. In combination, both parameters, however, divided all the individuals into two groups, males above and right, and females below and left, of the diagonal from the upper left corner to the lower right corner of Fig. 1. The overlap of wing lengths in Fig. 1 is caused by the uncompleted growth (see below). Sexing of five individuals at the age of 15—16 days was also based on the size difference (cf. Fig. 2, see also TIAINEN 1978: 4—5 and Figs. 1 and 2 there).

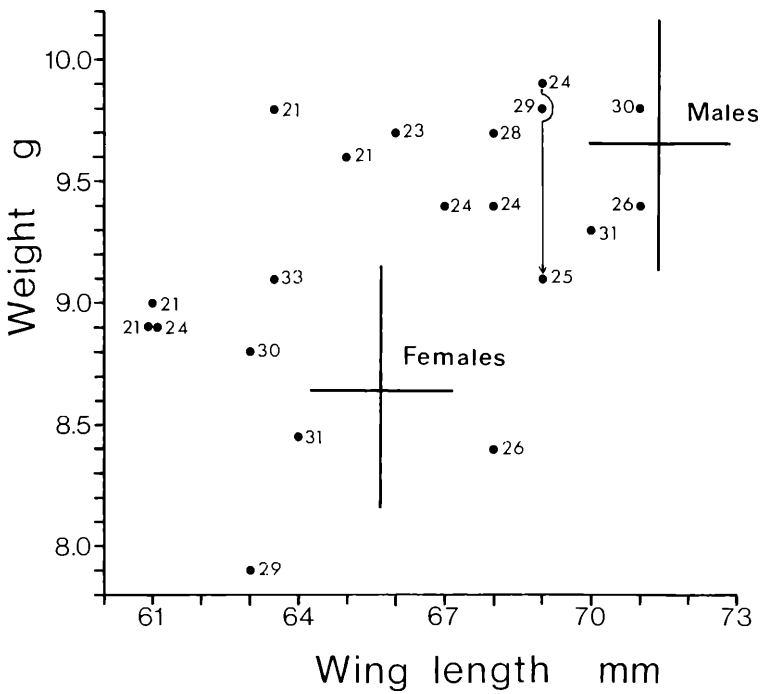

Fig. 1. Relationship between the wing length and weight of young Willow Warblers at an age of 21—33 days (numbers indicate the age of individuals; the arrow indicates two records of a single bird from two successive days). Also shown the mean ± SD of adult males and females during the breeding season excluding females with increased weight due to laying (N = 139 and 78 for weights of males and females, respectively, and 138 and 117 for wing lengths of males and females, respectively; from TIAINEN 1982).

3.2. Sexual difference of growth

The wing lengths and weights of males were at all ages (with the exception of day 12) larger than those of females (Table 1). The statistical significance of the difference could be reasonably tested (t-test) only for some ages due to the small sample sizes. The difference was significant only for the weight at the age of 8 ($p < 0.001$), 9 ($p < 0.05$), and 25—33 days ($p < 0.01$), and for the wing length at the age of 25—33 days ($p < 0.01$). During the nestling period, the means of both the wing length and weight of males almost always fell above the mean curve of the whole population, while the means of females fell below (Figs. 2 and 3).

The weights of 7, 8, 9, and 10 days old nestlings were plotted against the respective wing lengths to test whether the grouping of the records by sexes is already evident (Fig. 4). There is no clear separation but the few data suggest that this is becoming more and more distinct already at these ages. It is remarkable that the final weight is attained at

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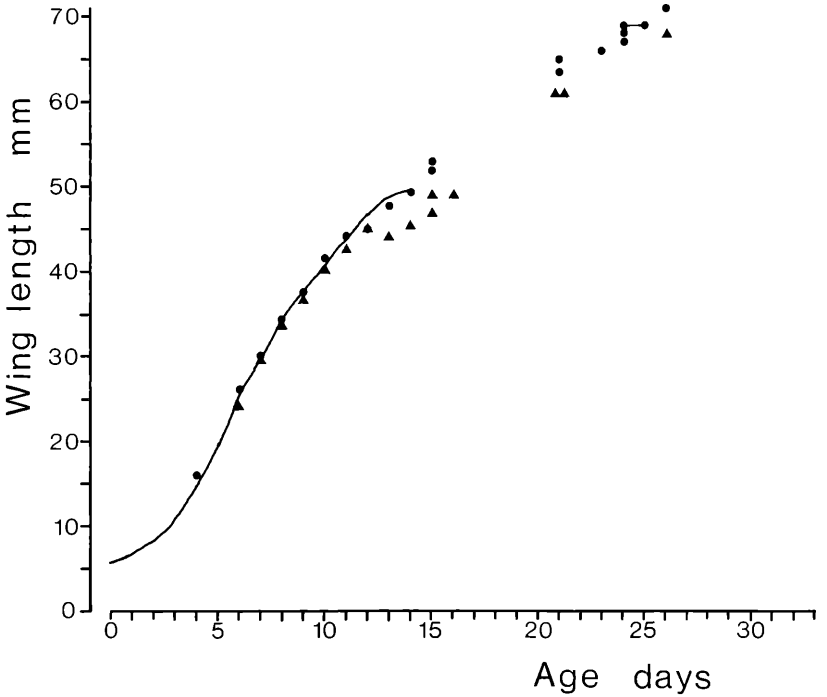

Fig. 2. Development of the wing length in young male (dots) and female (triangles) Willow Warblers (for variation and sample sizes, see Table 1). Records from a single male on two successive days connected. The solid curve was drawn through mean values at various ages and is based on a large sample (from TIAINEN 1978).

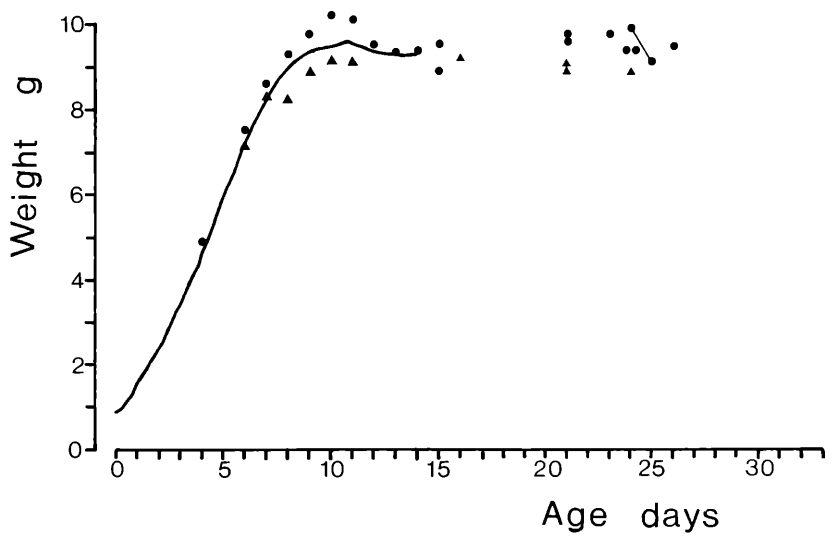

Fig. 3. Development of the weight in young male (dots) and female (triangles) Willow Warblers. Explanations like in Fig. 2.

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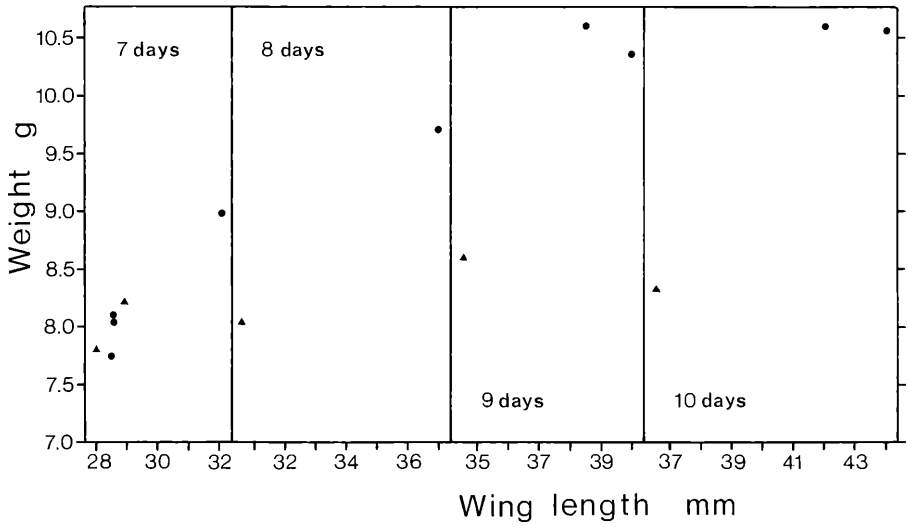

Fig. 4. Relationship between wing length and weight of male (dots) and female (triangles) Willow Warblers during four days (ages inserted) in the nestling period.

the same age in both sexes, and the weight difference is due to a faster growth rate of males (the hatching weight is less variable than the weight on day 8, before attaining the final weight level, indicating small sexual differences if there are any; see TIAINEN 1978).

3.3. Termination of growth

While the increase of the weight of young Willow Warblers has already terminated during the nestling period, the wing length is still increasing at the time of fledging. Figs. 2 and 3 and Table 1 suggest that the final length is attained at the age of 24—25 days.

4. Discussion

Sexing of full-grown Willow Warblers is possible according to the size in the population studied (TIAINEN 1982). The results presented here show that this can be made reliably already at the age of, at least, 21 days. Due to the scarceness of data between the age when the final weights are attained and day 21 (Table 1), it cannot be concluded how clear the sexual difference is at this time, although the fledglings at the age of 15—16 days could be sexed with probably fairly high security. Sexing of individual nestlings by comparing them with other individuals of the population or to the average growth curves is not possible, because many factors cause interindividual variation. The only possibility for sexing of living nestlings seems to be, besides directly using laparatomy (P. Berthold and E. Gwinner, pers. comm., see also BERTHOLD 1969), a comparison of the whole development among siblings, but the accuracy of such a practice has not until now been tested. The present data are not sufficient for such a test.

The sexual difference in the growth pattern should be significant, as the values of males were always larger than those of the females, although the means on separate days did not mostly differ significantly; this was probably only due to the small sample sizes.

How the weight developes after fledging until the age of 21 days, is not known. The four data points on day 15 would suggest a drop, but this suggestion may fail since all records come from a single late brood which was caught in the morning. The decrease of

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Table 1. Wing length (mm) and weight (g) of sexed young Willow Warblers (19 males, 12 females) during the first month after hatching. N indicates the number of measurements.

Age (days)	Wing length				Weight			
	Males		Females		Males		Females	
	x̄ ± SD	N	x̄ ± SD	N	x̄ ± SD	N	x̄ ± SD	N
4	16.0	1	—	0	4.90	1	—	0
6	26.13 ± 2.511	4	24.0	1	7.35 ± 0.520	4	6.60	1
7	30.00 ± 1.315	10	29.60 ± 1.335	5	8.59 ± 0.539	13	8.26 ± 0.777	5
8	34.27 ± 1.354	13	33.56 ± 1.725	7	9.28 ± 0.539	13	8.22 ± 0.571	7
9	37.50 ± 1.299	9	36.50 ± 2.449	4	9.76 ± 0.582	9	8.84 ± 0.191	4
10	41.50 ± 2.020	6	40.17	3	10.20 ± 0.373	6	9.13	3
11	44.00	3	42.50	2	10.10	3	9.10	2
12	45.0	1	45.0	1	9.50	1	8.20	1
13	47.5	1	44.0	1	9.35	1	8.30	1
14	49.25	2	45.5	1	9.38	2	8.15	1
15	52.50	2	46.50	2	9.20	2	8.00	2
16	—	0	49.0	1	—	0	9.2	1
21	64.25	2	61.00	2	9.70	2	8.95	2
23	66	1	—	0	9.7	1	—	0
24	68.00	3	61	1	9.56	3	8.9	1
25—33	69.80 ± 1.458	5	64.30 ± 2.358	5	9.60 ± 0.262	5	8.53 ± 0.506	5

weights after days 10—11 is due to a decrease in water contents of the body, and at the time of fledging the dry matter contents seem still to be increasing; no analyses of the body contents were made at the age of 21 days or later (TIAINEN 1983 a).

After fledging, the young move high in the foliage, and cannot be reached with normal mist-nets. At the time when they can again be trapped, they are probably already independent, although they still can be seen with their parents (unpubl.). No Willow Warblers ringed as nestlings in the study area were recaptured after the age of 33 days. At the same time many immigrants were caught, and it seems plausible that the offspring of the local population has dispersed away from the study area already about one week after the termination of growth of wing feathers (TIAINEN 1983b). At the same time a second set of the plumage is growing. GWINNER (1969) found that this set began to grow on about day 17 and was completed on about day 45 in four hand-raised Central European Willow Warblers (subspecies *trochilus* in contrast to my *acredula;* the first set was completed already during the nestling period). Thirteen hand-raised juveniles of GWINNER (1969) began their partial moult at the age (± SD) of 37 ± 6.0 days.

5. Summary

According to a small number of young Willow Warblers *Phylloscopus trochilus,* which were sexed after fledging and for which data on growth during the nestling period were available (19 males and 12 females), the males grow faster than the females in a local population in southern Finland. In this breeding population both the wing length and the weight of adult males and females are significantly different. A significant sexual difference could be shown for the weight in nestlings at the age of 8 and 9 days, but not on day 7, or for the wing length. Due to great interindividual variation, the nestlings cannot be sexed directly from their size, although this is possible at least from the 21st day. Sexing of nestlings may, however, be possible by comparing growth curves of siblings over several days during the nestling period. While the final weight is attained already in the nest at the age of about 9 days, the growth of the wing length is completed not before the age of 24—25 days.

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6. Zusammenfassung

Geschlechtsdimorphismus und Beendigung des Wachstums junger Fitisse *(Phylloscopus trochilus)*

31 Fitisse (19 ♂, 12 ♀) einer südfinnischen Population, deren Körperentwicklung als Nestlinge untersucht worden war, konnten später wiedergefangen und ihr Geschlecht bestimmt werden. In der untersuchten Population unterschieden sich alte ♂ und ♀ signifikant in Flügellänge und Gewicht. Männliche Jungvögel wuchsen schneller als weibliche. Nestlinge zeigten einen signifikanten Geschlechtsunterschied im Gewicht am 8. und 9. Lebenstag, nicht aber am 7., während Unterschiede in der Flügellänge nicht zu sichern waren. Wegen der großen Streuung können Nestlinge anhand der Größe nicht direkt gesext werden. Dies ist ab dem 21. Tag möglich. Ein Vergleich der Wachstumsraten von Nestgeschwistern über mehrere Tage kann eine Geschlechtsbestimmung der Nestlinge erlauben. Das Endgewicht erreichen Nestlinge mit dem 9. Lebenstag, während das Flügelwachstum nicht vor dem 24.—25. Lebenstag abgeschlossen wird.

7. Acknowledgements

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