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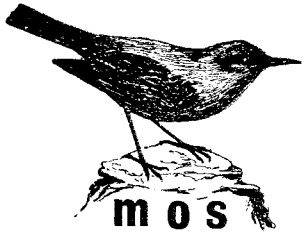

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IL-MERILL No. 20 January–December 1979

Moult of the Sardinian Warbler

CHARLES GAUCI & JOE SULTANA

Introduction

The Sardinian Warbler **Sylvia melanocephala** is a very common breeding resident in the Maltese Islands. It frequents most habitats including urban gardens. Formerly it was a winter visitor only, but became established as a breeding resident at the end of the last century (Sultana et al.1975). However, there are still indications of influxes in late autumn and winter (Sultana & Gauci 1976) and also evidence of spring passage in some years (Gauci & Sultana 1978).

Between the years 1974 and 1978, 511 moult cards (158 for adults and 353 for juveniles) were filled in by the authors for the MOS Ringing Scheme - Valletta. Moult was recorded following the criteria used in the moult enquiry of the British Trust for Ornithology, as described by Snow (1967). A score of 0 was allotted to an old feather, 1 to a feather missing or in pin, and 2, 3 and 4 to feathers up to one-third, two-thirds and nearly fully-grown respectively. New fully-grown feathers were given a score of 5. Fully-grown feathers still having a sheet of wax at the base have been scored as 4. Adult post-nuptial moult and post-juvenile moult are described separately. As will be seen later, a high percentage of adult birds were trapped when the primary score had already advanced to twenty or more. This bias is due to two factors: little ringing was done in June and July; also, birds are much less active in the early stages of moult.

Adult Post-Nuptial Moult

Sequence of Moult

The sequence of primary moult is the same as that found in most other passerines, the innermost (i.e. 1st) primary being shed first and the outermost (i.e. 10th) last - i.e. descendantly (Snow 1967). Occasionally, however, the 10th primary (which is reduced) is dropped at the same time as primary 7 or 8. Two to four (normally three) primaries are to be found moulting concurrently, but occasionally five. The first three primaries are dropped in quick succession or, much less frequently, together. Birds in the latter category were all estimated to have started moult late in the season (late July-earlyAugust). On average the entire primary moult takes place in 76 days (see below). Moult usually proceeds symmetrically on the two wings, but very occasionally a difference in score of one or two is observed.

The secondary scores are plotted against the primary scores in Fig.1. Only secondaries one to six are taken in consideration here. The others, the 'tertials', are treated separately. The outermost secondary is moulted first, when the primary score is approximately 19. As in most other species, the replacement proceeds from the outer towards the inner secondaries. When the first secondary is moulted there are four to six old primaries remaining. As in some other species, e.g. Great Tit **Parus major** and Blue Tit **Parus caeruleus** (Flegg & Cox 1969), and Tree Sparrow **Passer montanus** (Bibby 1970), secondary moult finishes some time after the termination of primary moult.

The tertials (Fig.2) start and finish earlier than the rest of the secondaries, moult commencing at an average primary score of 9, approximately at the same time as the 3rd or 4th primaries are dropped. On average they finish when

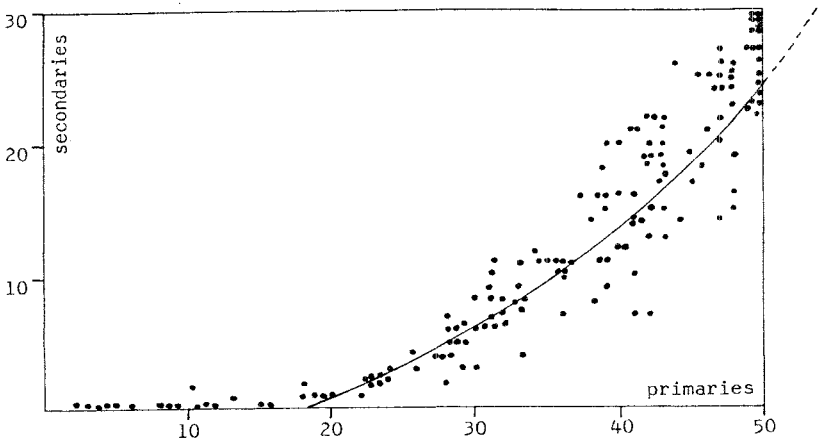

Fig.1. Secondary scores plotted against primary scores (adult Sardinian Warblers) Curve drawn by eye.

the primary score has reached 32. They are usually moulted in the order 8th-9th-7th, but very occasionally the 7th may be dropped before the 9th or both feathers are dropped simultaneously.

Tail moult is often difficult to record as newly grown and growing feathers tend to fall off easily when the birds are being extracted from nets or when they are put in bird bags. It starts rather early, at an average primary score of 7 and is usually completed by the time the primaries reach a score of 40. Tail feathers normally moult in pairs, starting with the innermost and proceeding outwards. However, this is not always the rule and a number of variations was recorded, some of which could be attributed to accidental feather loss.

The lesser, median, and greater coverts start moulting soon after the shedding of the first primary and are completed by the time the primaries have reached a score of 40. The first to finish are the greater, usually being renewed by the time the primary score reaches 25 - 30. The bastard wing is not renewed until late in the moult, starting after the greater coverts are completely renewed, and finishing before the primaries. The body feathers start at about the same time as the primaries, with the head the last to start. Moult of these feathers terminates shortly after the primaries, the underparts being the last to complete moult.

Duration of Moult

Assuming that the primary score advances more or less linearly with time, as has been found in other passerines (e.g. Evans 1966; Newton 1967; Buker et.al. 1975), it is possible to estimate the rate of advance of score/day from data pro-

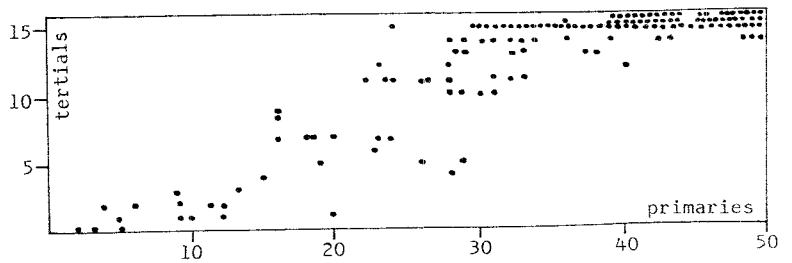

Fig.2. Tertial scores plotted against primary scores (adult Sardinian Warblers).

vided by birds examined more than once during the moult. In this study, twelve birds were caught twice and another two on three occasions. Newton (1967) showed that estimates of the rate of moult in abird made from two scores obtained less than a fortnight apart are unreliable so four of the above fourteen birds which had their moult recorded less than ten days apart are omitted. The rest are listed in Table 1.

TABLE 1 : Primary moult scores and rate of moult of birds caught two or three times.

Ring No.	Dates	Scores	Time Interval (days)	Advance of score	Rate of Advance of Score/Day
KC26051	22.7.75	22			
	24.8.75	42	33	20	0.61
KC26071	13.8.75	34			
	24.8.75	41	11	7	0.64
KC28707	1.8.76	29			
	24.8.76	43	23	14	0.61
KC29651	12.8.76	11			
	6.9.76	36	25	25	1.00
JK32742	17.8.77	32			
	28.8.77	39	11	7	0.64
	1.9.77	42	15	10	0.67
01246	17.8.77	41			
	28.8.77	47	11	6	0.55
01243	17.8.77	36			
	28.8.77	43	11	7	0.64
01228	5.8.77	16			
	28.8.77	31	23	15	0.65
	1.9.77	35	27	19	0.70
01222	4.8.77	31			
	7.9.77	48	34	17	0.50
KA95921	5.8.78	13			
	27.8.78	28	22	15	0.68
		Total	246	162	0.66

These ten birds handled twice (or three times) while in moult show a mean rate of advance of primary score of 0.66 per day (range 0.50-1.00). The birds with ring numbers 01222 and 01246 were re-caught when moult was almost complete and therefore had only the last primary in growth. KC29651, when first caught, had primaries 1 - 3 all showing a score of three; i.e. they had been dropped together. The other seven birds show a fairly uniform rate, ranging from 0.61 - 0.70/day. If the three birds not showing a uniform rate had been omitted from the analysis, the other would have shown a mean rate of 0.65/day, which is only marginally different from the rate obtained by including all birds. At a rate of advance of score of 0.66/day, the average time taken for the primaries to moult is 76 days.

As stated earlier the secondaries finish moulting after the completion of the primary moult. On average, in relation to the primaries, secondary moult finishes at a time when the primary score would have reached 53 if it had continued to this theoritical score rather than stopping at 50 (see Fig.1). This is about 4.5 days after the completion of the primary moult, assuming a rate of advance of primary score of 0.66/day. At this rate of advance of primary score, the total

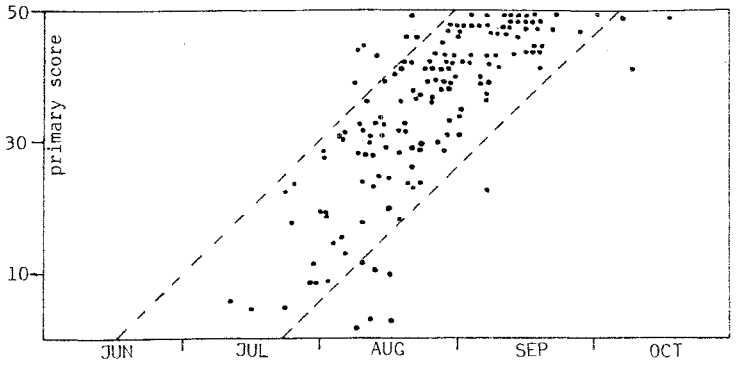

Fig.3. Primary scores plotted against date for adult Sardinian Warblers. Dotted lines show a rate of advance of score of 0.66/day and are fitted to embrace the majority of individual points.

time taken to replace the secondaries is 51.5 days (the time in which the primaries advance from 19 to the theoritical score of 53). From a total of 58 birds caught in advanced secondary moult, 37.9% had dropped or were growing the last two secondaries simultaneously, while in 25.9% of the birds the 6th secondary had been dropped at the same time as secondaries 3 or 4. The inner half of the secondaries is thus replaced more rapidly than the outer half. This is also indicated by the small sample of retrapped birds, in which the rate of advance of score in the secondaries varied greatly, depending on the stage reached. Thus a bird with a score of 1(feather missing) on 5th August had only advanced to 2 on 27th August, but one with a score of 11(state of feathers 0 0 0 2 4 5) on 17th August had advanced to 19 (1 1 3 4 5 5) on 28th August. Fig.1 also shows that the rate of advance of secondary score is non-linear.

The entire wing moult thus appears to take an average of 80 days. Deviations from this period seem to be mainly attributable to the variation that exists in the manner of replacing the secondaries. From Fig.1 it appears that in some individuals the entire wing moult can take up to 88 days.

Relationship between Moult and Breeding Season

In Fig.3 the primary scores of adults have been plotted against date. Dotted lines, showing a rate of advance of score of 0.66/day, have been fitted to embrace the majority of individuals. These show that the bulk of the population starts to moult between mid-June and the third week in July. Very few birds are still moulting after the end of September.

From nest record cards in the files of The Ornithological Society, the fledging dates of 119 broods of Sardinian Warblers were estimated by assuming a duration of 12 days each for the incubation and fledging periods. All cards were taken into consideration, irrespective of success, failure, or unknown outcome. The Sardinian Warbler is normally double brooded, but losses are somewhat high. Birds normally start building again a few days after a failed attempt (pers.obs.). Birds fledging between June and August are thus likely to be third broods after failure of the first or second attempts, or both. In Fig.4 the percentage of broods fledging, and the percentage of adults starting moult are plotted against time of year, grouped in 10-day periods. The majority start moult between mid-June and the third week in July, which follows the peak fledging period of the second broods. The estimated dates of start of moult in males and females were compared. No variation was found to exist. This is to be expected as in the Sardinian Warbler both sexes take part in nest-building, incubation and feeding of the young.

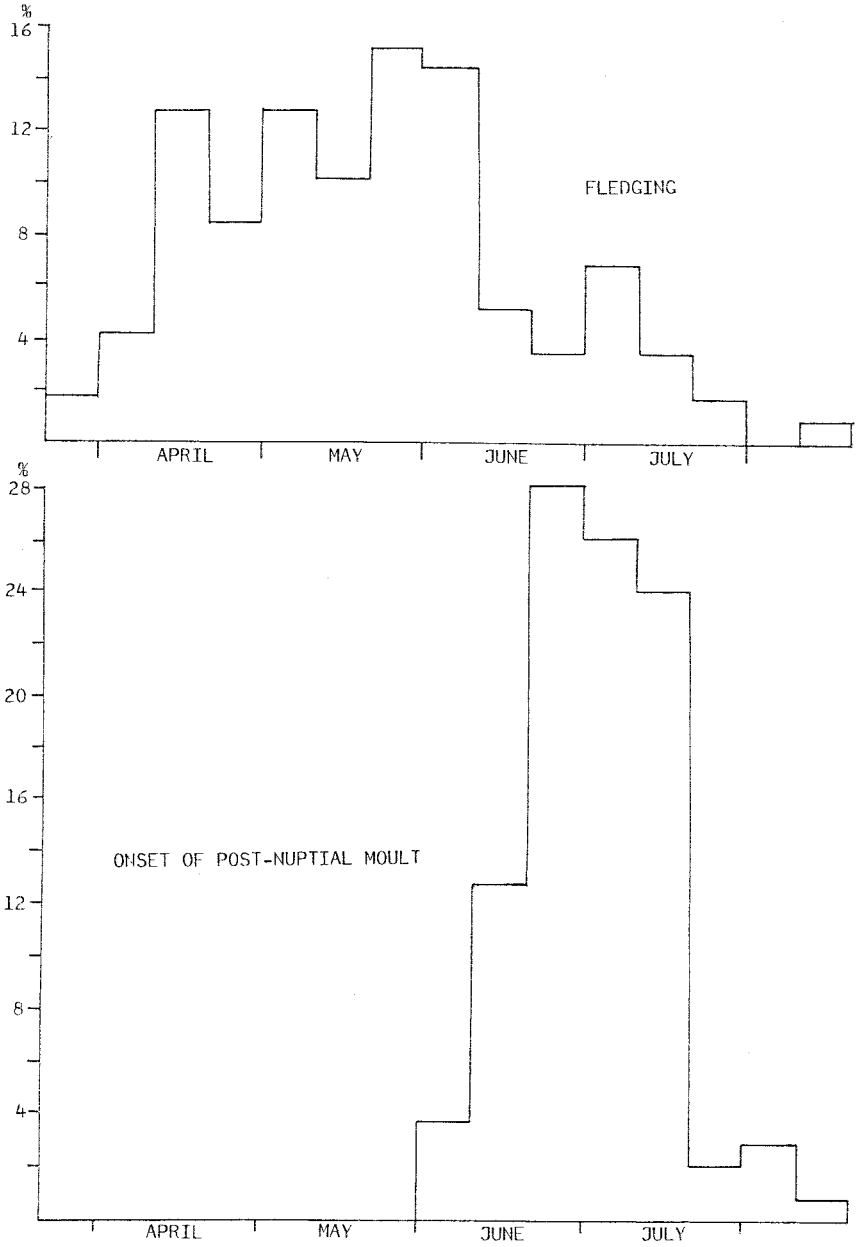

Fig.4. Estimated dates of broods fledging and onset of moult in the adult Sardinian warblers, grouped into 10-day periods.

Post-Juvenile Moult

In most species of passerine birds, post-juvenile moult is limited to body feathers, wing coverts (but not the primary coverts) and some tail feathers. Certain species of **Sylvia** warblers sometimes also moult some inner secondaries (Snow 1967). Post-juvenile moult in the Sardinian Warbler is extremely variable, ranging from a complete moult to a partial moult involving body feathers, wing coverts, bastard wing and tertials.

Complete Post-Juvenile Moult

55 out of 285 juveniles handled during moult were found to be having a complete regular moult as in adults. Most of these were caught in an advanced stage of moult, when the primaries had reached a score of 30 or more. The sequence of moult in the primaries and secondaries followed the same pattern as in adults. However, more primaries are moulted simultaneously between the scores of 11 and 45; usually three or four, but occasionally up to six. As a result, the secondary and tertial moult sequences start at a higher primary score than in adults. This is illustrated in Figs. 5 and 6, the secondaries starting at an average primary score of 25 and the tertials at an average primary score of 18 (as against 19 and 9 respectively for adults). The first secondary is usually dropped at the same time as primary 6 or 7 and the middle tertial between primaries 4 and 5. The bastard wing is renewed somewhat earlier, moult usually starting before the completion of the greater coverts.

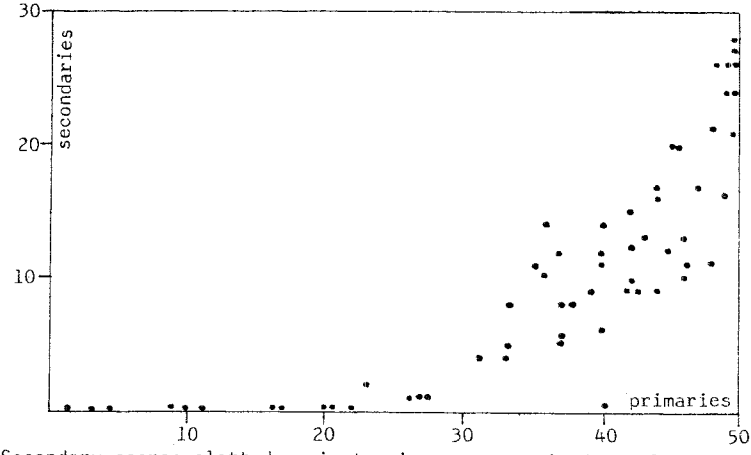

Fig.5. Secondary scores plotted against primary scores in juveniles undergoing a complete moult.

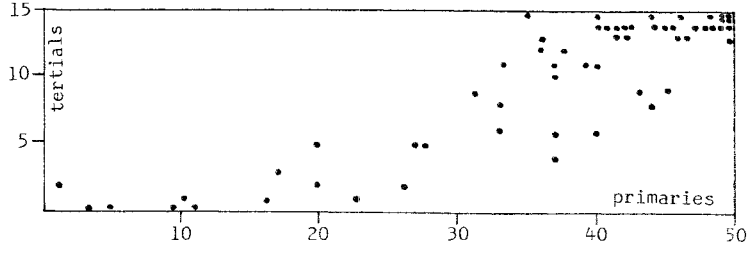

Fig.6. Tertial scores plotted against primary scores in juveniles undergoing a complete moult.

The average rate of primary moult, calculated from 8 retrapped birds (see Table 2), of 0.84/day is much higher than in adults. At this rate the primary moult would take an average of only 59.5 days. Allowing another 4.5 days for the termination of secondary moult (as in adults), the entire moult appears to take an average of 64 days.

The rate of 0.84/day was used to estimate the date of onset of moult in the above 55 birds. On this basis the start of moult ranged from the 19th June to 7th August with 51% starting moult between the 1st and 10th July.

TABLE 2 : Primary moult scores and rate of moult of birds caught twice (juveniles undergoing a complete post-juvenile moult).

Ring No.	Dates	Scores	Time Interval (days)	Advance of score	Rate of Advance of Score/Day
KC29637	9.8.76	31			
	18.8.76	38	9	7	0.78
KC29662	14.8.76	27			
	8.9.76	42	25	15	0.60
02289	31.7.77	23			
	22.8.77	43	22	20	0.91
01249	17.8.77	33			
	28.8.77	44	11	10	0.91
05068*	1.7.78	0			
	22.7.78	20	(21)	(20)	0.95+
05069	23.7.78	1			
	10.9.78	42	49	41	0.84
05094	22.7.78	26			
	13.8.78	46	22	20	0.91
05099	23.7.78	13			
	15.8.78	33	23	20	0.87
		Total	182	153	0.84

* Though the exact rate of advance of score/day is uncertain, the bird with ring number 05068 has been included as it shows a higher rate than the rest. If it had been omitted from the analysis the average rate of advance of score/day would have been 0.826, which is only marginally lower than the average of 0.84 calculated for all birds.

Partial Post-Juvenile Moult

The results are based on 217 moult cards for birds undergoing active partial moult and 68 cards for birds that were trapped after finishing a partial moult.

Partial moult is extremely variable. Body feathers, wing and tail coverts, and bastard wing are always renewed. In most (90%) birds all three tertials were renewed, but very occasionally only one or two were moulted. One individual moulted none. The number of secondaries and primaries moulted varied considerably, ranging from none to all. In the sample of 68 not showing active moult, 42.6% had old primaries, 29.4% had renewed 1 - 5 primaries, and the remaining 28.0% had renewed six or more primaries , at least on one wing. The Sardinian Warbler appears to be exceptional among European passerines in that juveniles also moult a variable number of primary coverts, irrespective of whether the corresponding primaries are moulted or not. Very often moult is not symmetrical on the two wings. An extreme example was one bird which moulted one tertial, three secondaries and no primaries on the right wing; and all tertials, no secondaries and six primaries on the left. Fig.7 shows which wing feathers are most frequently renewed. The figures are for the birds caught after having finished a partial moult.

In juvenile birds not undergoing a complete moult, the lesser coverts are shed first. They are usually followed by the greater and median coverts, upperparts, underparts, and one or two tail feathers. The head and bastard wing start

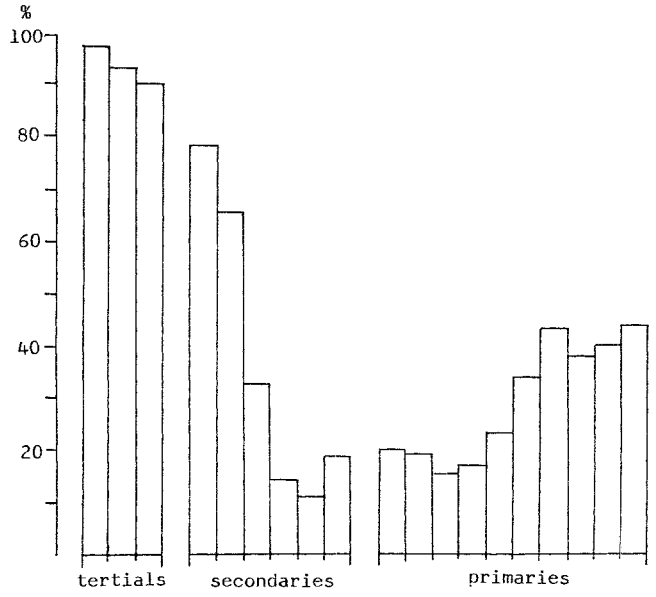

Fig.7. Percentage of wing feathers renewed in juveniles retrapped after finishing a partial moult.

immediately afterwards. Any primary coverts to be moulted, normally start at this time. The first tertial is dropped when the new greater coverts (often dropped together) have started growth. Birds which renew a number of primaries (usually the outermost four or five), start primary moult after the tertials are either fully grown, or are nearing completion. The primaries are either dropped in rapid succession or, more rarely, together. Moult on the secondaries may start soon after the new primaries begin to grow or sometimes (usually when less than three primaries are moulted) at the same time. It is thus not unusual to find up to seven feathers on one wing in active moult. Primary moult, no matter with which feather it starts, proceeds descendantly, either continuing to the outermost (10th), or being suspended before it reaches this feather. The secondaries seem to have no fixed sequence and moult can apparently proceed either way. When secondaries 5 and 6 are both renewed they are almost invariably dropped together.

As stated earlier, many juvenile Sardinian Warblers moult a variable number of primary coverts. In birds examined when in active moult the primary coverts (or some of them) were moulted ahead of their corresponding primaries, but sometimes at the same time. A bird which on 11th August 1976 had primary coverts 1st to 3rd in pin and 4th to 9th new but all the primaries old, later moulted all the primaries. Table 3 lists those birds caught after finishing a partial moult and in which the state of the primary coverts was recorded.

Owing to the extremely variable nature of moult in this class of juveniles, no satisfactory method could be found to estimate the rate of moult, even though

TABLE 3 : Primaries (numbered descendantly) and primary coverts moulted in 29 birds which had finished a partial moult.

	Right Wing		Left Wing	
Ring No.	pp. moulted	pc. moulted	pp. moulted	pc. moulted
JX03488	7, 8, 10	nil	7, 10	nil
JX59034	10	1-2	7, 9-10	1-2
JX03389	1, 5-10	1-9	1-2, 5-10	1-9
KA34313	1-4, 7	1-5	1-2, 7-8	1-5
KC26802	6-10	7-9	6-10	7-9
KB85500	6-10	1-3	6-10	1-3
KB85499	2	1-2	2	1-2
KC28616	6-10	1-3, 6-9	6-10	1-3, 6-9
KC26897	7-10	1-2, 8-9	7-10	1-2, 8-9
KC29858	1-10	1-4, 6-9	1-10	1-4, 6-9
KC29971	6-7	1-2	6-8	1-2
KC29973	nil	1-2	nil	1-2
00371	4-10	1-4, 8-9	2, 4-10	1-5, 8-9
KC29973	nil	1-2, 9	nil	1-2, 9
KH80795	nil	1-2	nil	1-4
JX59988	1-10	1-3	1-10	1-4
01483	1, 4, 7-10	1-5, 7-9	5, 9-10	1-5, 8-9
02437	7-10	9	7-10	9
01489	2-10	1-4, 7-9	1-2, 5-10	1-2, 4
KP63227	7	1-2	nil	1
KH82964	nil	1	3	1
02599	1-10	1-8	1-10	1-8
05278	6-10	1, 7, 9	5-10	1, 8-9
03844	nil	9	nil	9
KP64281	8-10	1-3, 9	1, 8-10	1-2, 9
00645	nil	1-4, 9	1-3, 6-7	1-7, 9
05091	nil	1-2, 4, 9	nil	1-2, 6, 9
05136	nil	1-4, 8-9	nil	1-4, 9

(8 others which did not moult any primaries renewed no primary coverts.)

a number of birds have been retrapped. The approximate dates of individual onset of moult could not therefore be calculated with the same degree of accuracy as for adults and juveniles undergoing a complete moult. The total wing score (tertials, secondaries and primaries; i.e. 95) is plotted against date in Fig.8. Those birds which had finished the partial moult when caught are also included. Not all birds showing a score of 0 are shown in the diagram; only those on which moult had started on the wing coverts. Those showing active moult and having a score of over 50 were in the process of renewing all (or most) primaries. These appear to have started moult at the same time as juveniles undergoing a complete moult, i.e. in late June or early July. Excluding these birds, the majority seem to start moult between early August and mid-September.

The Extent and Timing of Post-Juvenile Moult in Relation to Fledging

The estimated dates of fledging and onset of moult in juveniles undergoing a complete moult, as well as the total wing score of all juveniles caught in moult are plotted in Fig.8. Fig.8. also includes those birds in which moult had started on the wing coverts. Retraps of these birds indicate that wing moult starts about two weeks later.

As illustrated in Fig.8, both fledging and onset of moult show a spread of about four months each. The majority of birds undergoing a complete moult start moulting between the end of June and the end of July. Birds not undergoing complete moult but which renew a high percentage of wing feathers also seem to start at this time. Another group of juveniles start moult in August-September. These rarely renew more than half their wing feathers, usually the tertials and up to three inner secondaries.

The first birds to start moult are presumably those that have fledged from first broods. Most of these appear to have a complete moult, but a few retain up to five juvenile feathers (usually secondaries). Most birds undergoing a partial moult start between late July and late September. These are likely to be second and third brood birds.

Rather few nestling Sardinian Warblers have been ringed. The number of ringed newly-fledged birds is also low. The Ringing Scheme of the Ornithological Society keeps a retrap history of all birds ringed. An examination of these reveals that only seven Sardinian Warblers ringed as nestlings or as newly-fledged birds have been retrapped after a period of a month or more.

Two known to have fledged in mid-April (1st broods) were found to have undergone a complete moult when retrapped the following October. Three nestlings from 1978 second broods (one ringed on 24th May and two on 8th June) gave the following results. The 24th May bird had just started moulting the lesser coverts and contour feathers on 24th June. One of the 8th June birds showed no sign of moult on 10th July. The other, when retrapped in late August, was moulting the wing coverts, bastard wing and contour feathers as well as some tail feathers; whilst a month later it was renewing the tertials on both wings, secondaries 5 and 6 on the right wing and secondary 4 on the left, and had a new outermost primary on both wings. Two from a late brood (fledged early July) had not started in late August, but one of them was reported by the ringer to have started moulting two weeks later, on 9th September.

Discussion

Post-nuptial moult in the Sardinian Warbler follows the same pattern as in other small passerines studied. The peak moulting period follows closely the peak of the breeding season, moult starting soon after the fledging of the last broods. Primary moult is completed before the secondaries: this has also been observed in other species, e.g. Great Tit and Blue Tit (Flegg & Cox 1969) and Tree Sparrow (Bibby 1970). The calculated average duration of moult, 80 days, coincides with that of other sedentary species, e.g. the Bullfinch **Pyrrhula pyrrhula** and Yellowhammer **Emberiza citrinella** (Newton 1968). In migratory and also in eruptive species, moult takes place much faster and in some cases may leave birds flightless or almost so for some time, e.g. in the Bearded Tit **Panurus biarmicus** (Buker et al. 1975) and in the Redstart **Phoenicurus phoenicurus** (Snow 1969).

Some authors have described weight changes during moult. Both Bullfinches (Newton 1966) and Tree Sparrows (Bibby 1970, 1977) gain weight as moult advances. The number of adult Sardinian Warblers caught with a primary score below 25 was insufficient to permit a proper weight analysis in relation to progress of moult. There was, however, little apparent change in weight during moult. The mean weights of five score-groups (26-30, ... 46-50) were all either 11.9 g or 12 g. During the entire moult period Sardinian Warblers seem to feed mainly on fruit, mostly wild blackberries **Rubus ulmifolius** and figs **Ficus carica**, which are abun-

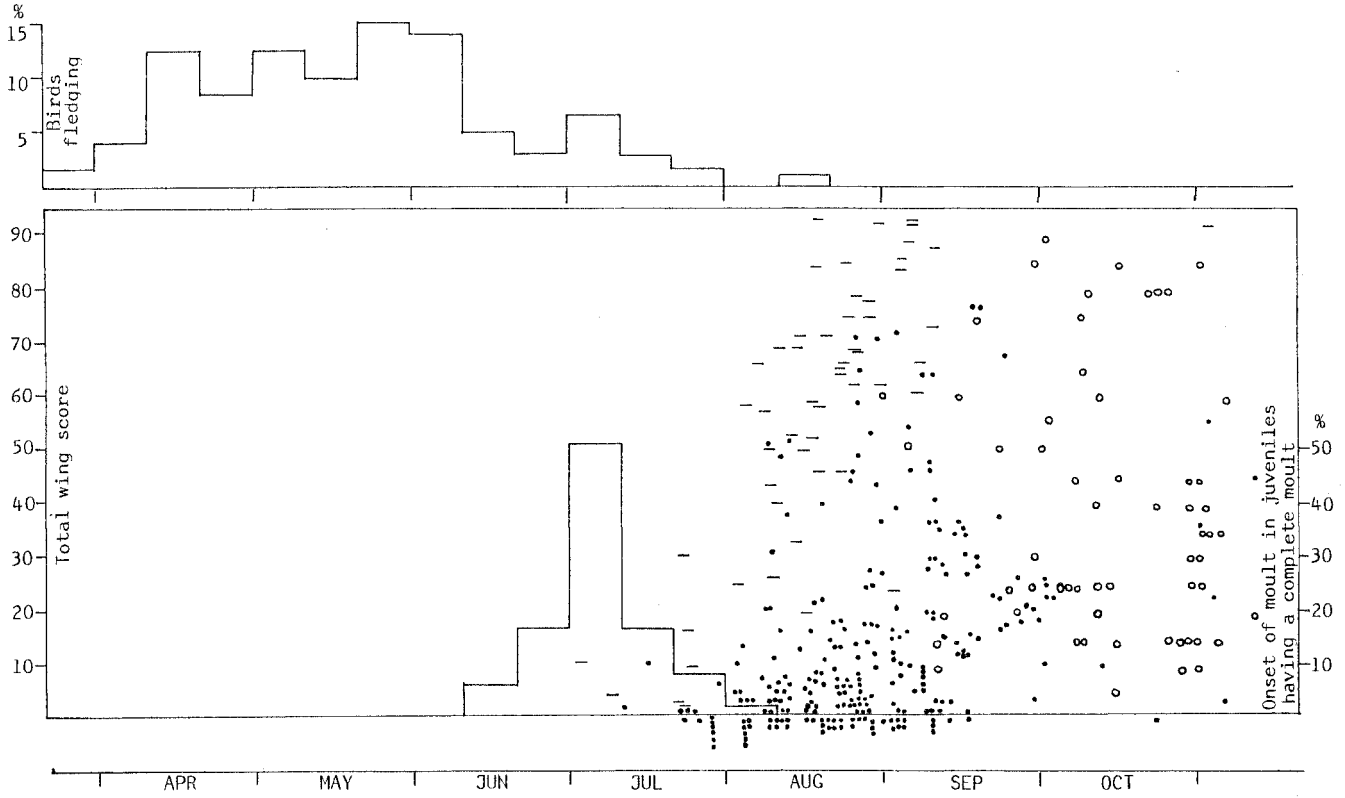

Fig.8. Dates of fledging (grouped in 10-day periods) and individual wing scores of all juveniles in moult. Since moult is often irregular, the total wing score has been adopted. where moult was not symmetrical on the two wings, only that wing showing the highes score has been included. Dashes represent scores of juveniles known to be undergoing a complete moult, solid dots juveniles having a partial moult and open circles juveniles trapped after finishing a partial moult. The percentage of onset of moult in juveniles having a complete moult is also shown - grouped in 10-day periods (see text).

dant at that time of the year. Migrant **Sylvia** warblers passing through Malta at the same time of year gain weight rapidly feeding on the same fruits.

There seems to be enough evidence showing that the extent of post-juvenile moult in the Sardinian Warbler is related to the time of fledging. In migrant **Sylvia** warblers breeding in Europe, the first fledglings are unlikely to be out of the nest before mid-June, except for some species (e.g. Subalpine Warbler **Sylvia cantillans**) in the extreme south. In these, post-juvenile moult is restricted to body plumage, some (or all) greater coverts, some inner secondaries (usually tertials only) and occasionally some tail feathers (Snow 1967). **Sylvia** species which are mainly sedentary in southern Europe may have a more extensive post-juvenile moult, having fledged earlier. Williamson (1964) records specimens of the Cyprus Warbler **Sylvia melanothorax** as having an incomplete post-nuptial moult (3 specimens examined in July, as well as two others in March-April showing a similar partial moult). These birds show the same type of moult found in juvenile Sardinian Warblers which have probably fledged from second broods, i.e. in May-June, and could well be first-year birds and not adults. Dartford Warblers **Sylvia undata** (winter visitor in small numbers to Malta) trapped for ringing also show a mixture of new and old wing feathers (pers. obs.), suggesting a similar post-juvenile moult. Some juvenile Subalpine Warblers on passage through Malta in autumn are sometimes found moulting one half of their tail, but in spring many show a clear mixture of old and new flight feathers, suggesting a similar partial moult in winter quarters (Gauci & Sultana 1976).

Juvenile Sardinian Warblers undergoing a complete post-juvenile moult are inseparable from adults (on plumage characteristics) after finishing moult. It seems likely that because of this, ringers have been incorrectly ageing a number of males when referring to Svensson (1975), who refers to adult males only as having the wings fresh and dark grey from September onwards. Similarly it is unsafe to age females on the clarity and extent of white on the outer tail feathers, since almost all juveniles also renew their tail.

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Summary

This paper reports on the sequence, rate and timing of moult in the Sardinian Warbler. Post-nuptial moult and post-juvenile moult are described. The sequence of moult in adults is the same as that found in most other passerines, Primary moult takes place in 76 days on average, but the entire moult takes an average of 80 days, as the secondaries finish moult after the primaries. Most adults start moult between mid-June and the third week of July, soon after the fledging of the last broods. Post-juvenile moult is variable. Some birds undergo a complete moult. In this category of juveniles, the secondaries and tertials start to moult at a later stage than in adults. Most start moult in July. Other juveniles moult the body feathers, wing coverts and usually the tertials and tail, plus a varying amount of primaries and/or secondaries. Juveniles undergoing partial moult may also renew a varying number of primary coverts, irrespective of whether the corresponding primaries are moulted or not. This phenomenon has not apparently been met with among other European passerines. Birds undergoing partial moult have been caught between late July and November. It seems that juveniles undergoing a complete moult are those which fledged in the earlier part of the season (late March-April); those undergoing partial wing moult fledged from second broods (May-June) and those showing moult on body feathers, wing coverts, alula and tertials only belonged to late replacement clutches (July-August).

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