

## Extension of post-juvenile moult and ageing of the Cetti's warbler *Cettia cetti* in northern Italy

ANDREA PILASTRO\*, STEFANO TASINAZZO<sup>o</sup> and CARLO GUZZON<sup>s</sup>

\* Istituto Nazionale per la Fauna Selvatica, Via Ca' Fornacetta 9, 40064 Ozzano Emilia (BO) - Italy

<sup>o</sup> Gruppo Vicentino Studi Ornitologici, c/o Museo di Storia Naturale, contrà S. Corona 2, 36100 Vicenza - Italy

<sup>s</sup> via Roma 30/1, 33050 Marano Lagunare (UD), Italy

**Abstract** - The extent of the post-juvenile moult of Cetti's warbler was studied in northern Italy. Compared to previous studies, it was found to be more extended than in northern Europe populations, involving body feathers and most of wing coverts. Moreover, juvenile birds moulted rather frequently all the tertials and up to 5 inner secondaries. In 6 cases out of 102 examined (4.9%), also 2-5 primaries were moulted. Birds from first clutches moulted significantly more greater coverts than birds from second clutches. Extension of the post-juvenile moult was significantly correlated with the degree of skull pneumatization in September and October, suggesting that birds from early clutches have a more extended moult. Moreover, males moulted on average significantly more remiges and greater coverts than females. Moult limit, i.e. the contrast between moulted adult-like feathers and unmoulted juvenile feathers, was visible in all examined juvenile birds within greater coverts or, alternatively, within tertials or secondaries. Pre-nuptial moult was restricted both in terms of individuals and number of feathers involved, and never affected wing coverts or remiges. On the basis of these results, a new method for ageing Cetti's warbler, based on the contrast between moulted and unmoulted feathers, is proposed. This method allows juveniles to be told apart from adults beyond the completion of skull pneumatization, until their first complete moult.

### Introduction

Among the many characters used in the field for ageing passerine birds (Svensson 1992, Pyle *et al.* 1987), those related to differences in the moult extent between juvenile and adult birds are the most reliable, since these differences are not usually prone to change until a juvenile bird wears its first adult plumage or, more generally, until a next moult cycle (Jenni & Winkler, 1994). Cetti's warbler (*Cettia cetti*) is distributed in the southern and western part of Palearctic. In this species, as in most Passerine species living in temperate regions, juveniles undergo a partial moult which usually starts soon after fledging in summer. At the same time adults undergo their annual complete moult at the end of the breeding season (Ginn & Melville, 1984; Jenni & Winkler, 1994). Pre-breeding moult, when present, is almost invariably confined to body feathers both in adults and first year birds, but large variation between populations is reported (Cramp, 1992). Therefore, the identification of a moult limit, i.e. a contrast between juvenile (unmoulted) and adult (moulted) feathers, may allow to tell apart first year birds from older ones in the period between the completion of the post-juvenile

moult and the end of their first breeding season. So far, no reliable ageing method based on plumage character has been proposed for this species. We present here data on the extent of post-juvenile moult collected in northern Italy. On the basis of these results, a new ageing method, based on plumage and moult differences between juveniles and adults, is proposed.

### Materials and methods

During standard ringing operations 135 Cetti's warbler were mist netted and ringed in three localities of the eastern Po river lowland: Novoledo (VI), 45.33N, 11.33E, n=52 (years 1988-1989), Marano Lagunare (UD), 45.44N, 13.10E, n=29 (years 1993-1995) and Campotto (FE), 44.36N, 11.48E, n=54 (year 1995). Most of the birds were captured during the post-reproductive season, August-October, but many of them were later recaptured all year around. We determined the extension of the post-juvenile moult on the wing (upper coverts and remiges) and tail feathers (rectrices). In particular, we estimated for each bird the number of renewed marginal and median coverts, greater coverts (hereafter GC), carpal. primary

coverts, remiges and rectrices. New (post-juvenile) feathers differed from the juvenile ones, the latter being reddish-brown, whereas the renewed feathers were more greenish brown. In particular, juvenile unmoulted greater coverts had a narrower reddish-brown edge, contrasting with the inner part of the feather web, which was more brown. On the contrary, moulted greater coverts had a generally more glossy coloration, characterised by a greenish-brown general tone. Moreover, the outer edge is wider than in the unmoulted GC. A similar colour pattern was observed also in carpal and alula feathers. Moulted remiges were distinctly darker and glossier than unmoulted ones. The difference between moulted and unmoulted rectrices was sometimes less evident, also because these feathers often became readily abraded. About 25% of the examined birds were scored for moult extension more than once by two different ringers or by the same ringer between October and May, after the completion of the post-juvenile moult and before the beginning of the first complete post-breeding moult. There was a high repeatability of moult scoring both between and within observers, indicating that moult limit was clearly visible through the period and that pre-breeding moult, if any, did not involve wing feathers.

If not specified, number of moulted feathers is referred to the right wing. We report here the post-juvenile moult extension only of those birds whose age was

independently confirmed by skull pneumatization stage (Svensson, 1992) or by recapture. Only birds after completion of their post-juvenile moult were considered. All year around, birds were scored for the presence or absence of growing feathers on the body (0 = no growing feathers, 1 = only a few growing feathers, 2 = intense body feather moult). Birds were sexed according to wing length (maximum chord, Bibby & Thomas, 1984; Svensson, 1992; Tasinazzo, 1993) or to the presence of brood patch and cloacal protuberance in the following breeding season.

During 1988 and 1989 breeding season 147 pulli (104 and 43 from first and second clutches respectively) were ringed at nest in the course of a study on the breeding biology near Vicenza (Tasinazzo 1993). Among these, 17 (5 from first clutches and 12 from second clutches) were recaptured later in the season, at the end of their post-juvenile moult.

## Results and discussion

Although birds started moulting soon after fledging, the post-juvenile moult period was protracted from June through October, probably due to the prolonged reproductive period (about three months and a half between the earliest and the latest clutch, Tasinazzo, 1993). Birds with traces of body feathers moult were found until December (Fig. 1). Pre-breeding moult

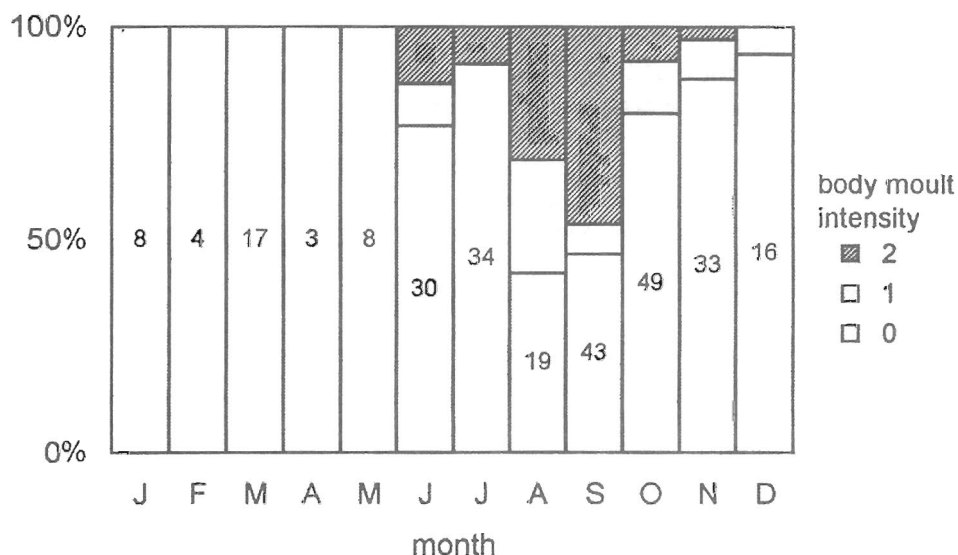


Figure 1. Frequency of first-year Cetti's warblers with moult on body (0=no moult, 1=traces of moult, 2=heavy moult) in northern Italy (n=264). Data from 5 trapping years were pooled by month of capture. Number in the bars indicates sample size.

was nearly absent in the studied populations. Among 164 birds (captures + recaptures) examined from January to May (40 first year birds, 53 adults and 71 of unknown age), only one (0.6%) showed traces of moult, limited to some contour feathers. These results confirm the observation that prebreeding moult is present only in some populations, e.g. in Great Britain (Ginn & Melville, 1983) and in the *orientalis* subspecies (Dementiev & Gladkov, 1954, cited in Cramp, 1992), but absent in Balkan countries (Stresemann, 1920) and in the *albiventris* subspecies (Williamson, 1968).

Table 1. Average number of wing and tail feathers moulted by Cetti's warbler during the post-juvenile moult in northern Italy. For wing feathers means are given for right and left wing.

		mean	SD	min	max	n
alula	right	0.77	0.72	0	3	31
	left	0.67	0.70	0	3	39
carpal	right	0.70	0.47	0	1	27
	left	0.67	0.48	0	1	27
greater coverts	right	8.36	1.96	4	10	135
	left	8.36	1.93	4	10	135
tertials	right	2.16	1.21	0	3	102
	left	2.25	1.13	0	3	102
secondaries	right	0.96	1.21	0	5	102
	left	0.98	1.19	0	5	102
primaries	right	0.16	0.77	0	5	102
	left	0.16	0.74	0	5	102
rectrices		2.00	2.93	0	10	31

During their post-juvenile moult, all the examined first year birds moulted all the marginal and median coverts, but the extension of the moult of other wing feathers varied consistently between individuals (Tab. 1). The individual with the least extended moult renewed only 4 inner greater coverts, whereas outer greater coverts, primary coverts, alula, carpal, and remiges were unmoulted. On the other hand, the individual with the most extended moult was a male that renewed all the greater coverts, seven primary coverts, alula, carpal, three tertials, five inner secondaries and four primaries. About half of the individuals (53.3%) moulted all the greater coverts, three individuals out of 135 (2.2%) retained only one juvenile greater coverts, the remaining 44.5% having at least two old greater coverts. Most birds moulted one alula feather (54.8%), only one individual moulted all three alula feathers, two moulted two feathers, and 35.5% none. Tertials and secondaries were moulted almost invariably descendantly, and all individuals which moulted one or more secondaries had all tertials renewed as well. In particular, most commonly, all tertials and the innermost secondary was renewed (Fig. 2). Six individuals out of 102 (5.9%) were found with some (1-6) primaries moulted. Among these, four moulted the primaries eccentricily (primaries no. 3-8, numbered ascendantly), and the other two moulted 2-3 inner primaries. On Fig. 3 the extension of the moult of the wing feathers is summarised. Moult of wing feathers was usually symmetric. The number of moulted greater coverts differed between the two wings in 14.1% of the 135 cases examined (mean difference = 1.42, SD = 0.61, range 1-3, n=19). A more pronounced degree of asymmetry was found among the number of tertials and secondaries moulted,

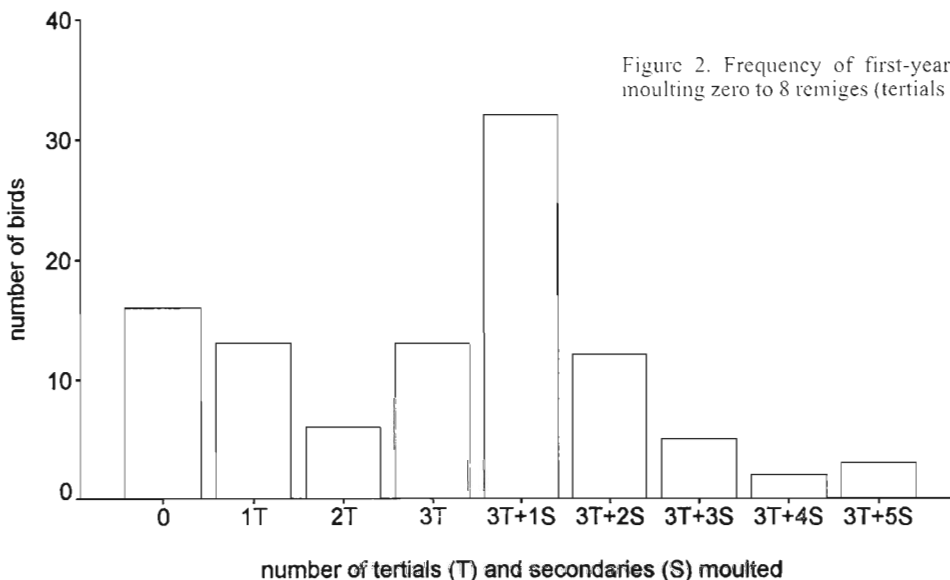


Figure 2. Frequency of first-year Cetti's warblers (n=102) moulting zero to 8 remiges (tertials and secondaries).

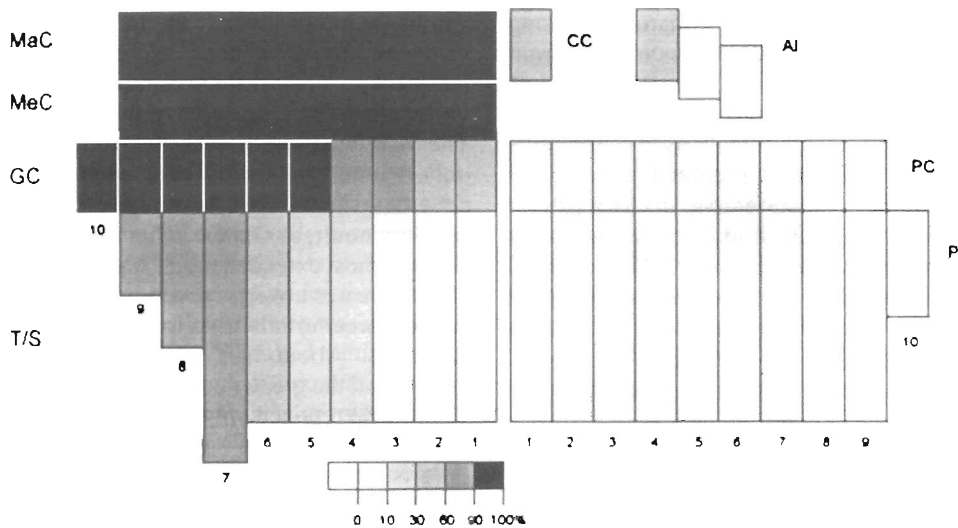


Figure 3. Extension of the post-juvenile moult of Cetti's warbler in northern Italy. The scale is referred to the frequency of moulted feathers. MaC = marginal coverts, MeC = median coverts. GC = greater coverts, PC = primary coverts, CC = carpal, AI = alula, T/S = tertials and secondaries, P = primaries.

which were different on the two wings in 30.0% of the 90 birds which moulted at least one flight feather (mean difference = 1.70, SD = 1.24, Range = 1-5, n = 27). For what primary moult was concerned, the number of primaries moulted on the two wings was always different by 1 or 2 feathers.

Moult of rectrices was rather irregular and nearly never symmetric. About half (48.4%) of 31 birds did not change any tail feather, the remaining ones moulting 1-2 rectrices (25.8%) or more than 2 rectrices (25.8%). Only two birds (6.5%) changed all tail feathers, but the fraction of birds completely renewing the tail might be underestimated. The number of rectrices renewed was correlated neither with the extension of the moult of the remiges nor with that of the greater coverts ( $r=0.11$ , n.s.,  $r=0.04$ , n.s.,  $n=31$ ).

There was a strong correlation between the number of greater coverts moulted and the number of secondaries (tertials and secondaries) moulted ( $r=0.81$ ,  $P<0.0001$ ,  $n=100$ ). In particular, nearly all those birds which moulted all the greater coverts, moulted all tertials and one or more secondaries (96.8%,  $n=85$ ), only two of them having retained one or two tertials. On the other hand, birds which did not moult any tertial always retained at least four unmoulted outer greater coverts (mean = 5.60, SD = 0.99, range = 4-7,  $n=15$ ).

Extension of post-juvenile moult was correlated with the degree of skull pneumatisation. Considering only the birds captured in September and October, there was a significant positive correlation between skull pneumatisation score and the number of remiges moulted ( $r=0.72$ ,  $n=33$ ,  $P<0.001$ , Fig. 4), as well as

the number of moulted greater coverts ( $r=0.55$ ,  $n=47$ ,  $P<0.001$ ). Birds that did not moult all the greater coverts and 0 to 2 tertials, were likely to be birds from second or from replacement clutches. In fact, among the 17 pulli recaptured after they had completed their post-juvenile moult, five first clutch birds had moulted all the greater coverts on the right wing, whereas two of them had retained two and three outer GC on the left wing respectively (mean fledging date = 26 May, SD = 4.02). Birds from second clutches (mean fledging date = 21 July, SD = 2.55) retained on average 4.17 GC (SD = 0.83, range = 3-5,  $n=12$ ), and the difference was statistically significant for both wings ( $z=3.27$ ,  $P=0.001$ ,  $z=2.86$ ,  $P=0.004$  for right and left wing respectively, Mann-Whitney U test). Moreover, males moulted significantly more primaries, secondaries, tertials and greater coverts than females, whereas the number of renewed rectrices did not differ significantly (Tab. 2).

Table 2. Mean number (SD) of feathers renewed during the post-juvenile moult on the right wing in male and female Cetti's warblers in northern Italy.

	males	females	n	$z^1$	P
greater coverts	8.78 (1.73)	7.93 (2.08)	129	2.34	0.019
primaries	0.18 (0.71)	0.02 (0.13)	97	1.42	ns
secondaries	1.23 (1.27)	0.65 (0.99)	97	2.66	0.008
tertials	2.48 (1.01)	1.95 (1.26)	97	2.14	0.03
rectrices	1.44 (1.88)	2.29 (3.35)	30	0.15	ns

<sup>1</sup>Mann-Whitney U test

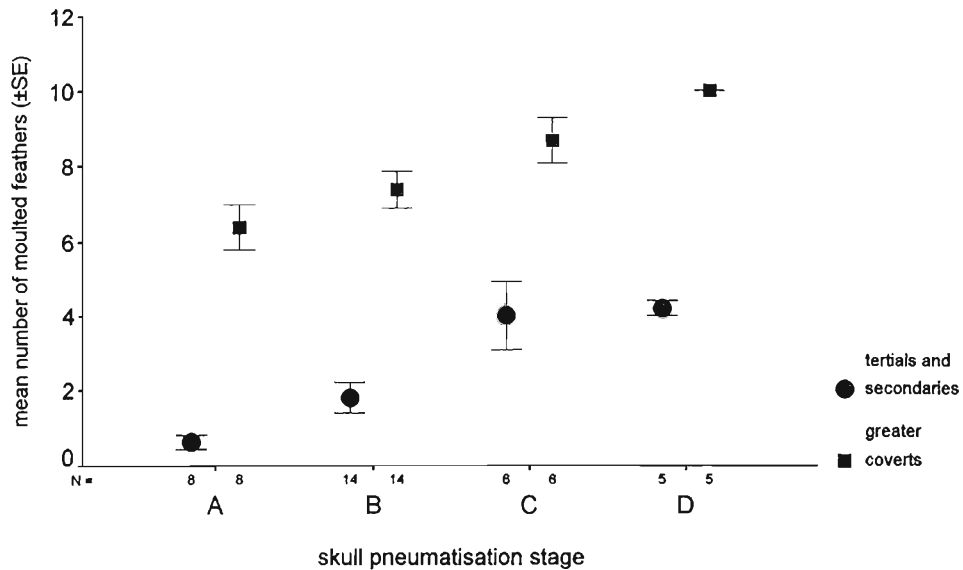


Figure 4. Mean ( $\pm$ SE) number of greater coverts and remiges (tertials + secondaries) moulted by first-year Cetti's warblers captured in September and October according to their skull pneumatisation stage (A = not pneumatised, E = completely pneumatised). Numbers above pneumatisation stage represent sample size.

North Italian population of Cetti's warbler showed a more extended post-juvenile moult than previously reported for this species (Williamson, 1968; Flint, 1972; Sultana & Gauci, 1973; Ginn & Melville, 1983). The reason for this difference is not known, but it may be a consequence of progressively anticipated breeding seasons due to warmer winters in the recent years. Regarding this point, a significant trend was found in the number of GC moulted from 1988 to 1995 (ANOVA,  $F_{(4,130)}=5.27$ ,  $P<0.001$ ; trend analysis,  $F_{(1,130)}=14.8$ ,  $P<0.001$ ) and birds with a post-juvenile moult extending to primary feathers were found only in 1994 and 1995.

On the basis of these results, we propose here a new method for ageing Cetti's warbler, based on the plumage characteristics. First year birds usually have two (one) up to six outer GC unmoulted. In this case, a contrast is particularly visible between outer GC (more reddish brown) on the one hand, and inner GC and lesser and median coverts (more glossy greenish-brown) on the other hand. The contrast between moulted and unmoulted coverts is usually sharp and evident, particularly when the width and colour of the edge of the outer web, as well as the colour of the inner web of the coverts are carefully examined. Attention must be paid because outer greater coverts, when completely moulted as well as in the adults, are slightly more reddish than the inner ones, but the colour variation is gradual, and a clear step in coloration is lacking. In the case of juveniles with all GC moulted, these do not contrast with the lesser and

median coverts which are always renewed, but contrast with the unmoulted remiges. When all greater coverts are renewed, tertials and secondaries must be carefully examined for the presence of one, more frequently four, innermost moulted feathers, which are distinctly darker and glossier. The contrast between moulted and unmoulted feathers, in particular GC and remiges, is better visible when the wing is kept half open. At least until December, the degree of abrasion may help to tell apart moulted and unmoulted flight feathers. A difficult case would be the one of a bird having moulted all the greater coverts and none of the tertials, although it was never recorded in our sample. Molt limits were still visible until the beginning of the first complete moult, and after practising, nearly all birds can be safely aged on the basis of presence/absence of a moult limit within greater coverts, tertials/secondaries and, possibly, alula and tail feathers. The extended moult of secondary and primary feather observed in a small percentage of the birds studied here and the case of an individual with skull in stage B and almost completing its primary moult (F. Farinello, personal communication) suggest that some juvenile birds may also undergo a complete post-juvenile moult. Only a systematic control of the pneumatisation stage also in adult-looking birds may reveal how frequently this happens in southern Cetti's warbler populations.

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**Riassunto** - Si presentano i risultati di uno studio sull'estensione della muta post-giovanile in una popolazione di U'ignolo di fiume dell'Italia settentrionale. La muta post-giovanile è risultata più estesa di quanto precedentemente riportato per le popolazioni nordeuropee e coinvolge, oltre alle penne del corpo, anche le copritrici dell'ala e un numero variabile di remiganti. La maggior parte degli uccelli esaminati aveva mutato un numero di secondarie e terziarie variabile tra 1 e 8. In 6 casi su 102 sono state mutate anche 2-5 primarie. Gli uccelli provenienti dalla prima covata mutano un numero di grandi copritrici significativamente maggiore rispetto a quelli di seconda covata. Inoltre, i maschi mutano significativamente più copritrici e remiganti delle femmine. Negli uccelli catturati in settembre ed ottobre il grado di ossificazione cranica è risultato positivamente correlato con l'estensione della muta post-giovanile. Il limite di muta dovuto al contrasto tra le copritrici e le remiganti mutate durante la muta post-giovanile e quelle non mutate era sempre visibile in tutti gli uccelli esaminati. La muta prenuziale, quando presente, è risultata sempre poco estesa e limitata alle sole penne del corpo, senza mai interessare le copritrici dell'ala e le remiganti. La presenza del contrasto di muta tra penne giovanili non mutate e penne post-giovanili mutate permette quindi di distinguere gli individui di un anno dagli individui più vecchi in tutto il periodo che va dal completamento della muta post-giovanile fino alla prima muta completa post-riproduttiva. Si propone quindi un metodo che permette di attribuire l'età agli U'ignoli di fiume di un anno di età anche oltre il momento in cui si completa l'ossificazione cranica.

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