

Post-nuptial moult and fat accumulation of the Ashy-headed Wagtail (*Motacilla flava cinereocapilla*) in Northern Italy

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Ashy-headed Wagtails (*Motacilla flava cinereocapilla*) studied in Val Campotto (Northern Italy) start complete moult in July, and by the beginning of September the whole wing is fully renewed. Primary moult starts with P1, ending with P10; secondaries moult from S1 to S6, tertials with T2, T1 and then T3. The last feather to be found still in growth is P9 or S6. Primaries are not dropped with a linear sequence, possibly also in relation to the onset of secondary moult; a clear difference in moult sequence is found between the 5 innermost (P1–P5) and the outermost primaries (P6–P10). The difficulties related to such non-linear patterns in the calculation of moult duration through different methods are discussed. Juveniles and adults leave the area with considerable fat depots, and adults in particular quickly accumulate energy reserves after completion of moult.

Keywords: Ashy-headed Wagtail (*Motacilla flava cinereocapilla*), moult, body mass, fat.

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1. Introduction

The Yellow Wagtail (*Motacilla flava*) is a long-distance migrant with vast wintering grounds in Africa south of the Sahara (CURRY-LINDAHL 1963, ZINK 1983). Adult birds undergo a complete post-nuptial moult, with a shorter duration in more Northern populations and apparently still to be finished in some cases when birds leave their breeding quarters (DITTBERNER & DITTBERNER 1987, GINN & MELVILLE 1983, GLUTZ VON BLOTZHEIM & BAUER 1985, HERWARD 1979). In Northern and Central Europe birds can be involved in parental cares till the last days of July (BREHM 1857, HERWARD 1979), and HAUKIOJA (1971) reports adult birds in the first stages of moult while still feeding their offspring.

Migration starts at the beginning of August, peaking between the second half of August and the beginning of September, with first year birds coming through earlier than adults in some areas of Central Europe (e.g. Col de Bretolet, WINKLER pers. comm.), while in North Africa intense southward movements are reported from early September till early October (GLUTZ VON BLOTZHEIM & BAUER 1985, HERWARD 1979). Apart from accomplishing their moult, adult birds must also put on a sufficient amount of fat for their migratory flight before departure. First year birds only have a partial moult before flying to Africa (DITTBERNER & DITTBERNER 1987). Several subspecies of *Motacilla flava* have been recorded for Italy, with *M. f. cinereocapilla* being a fairly widespread breeder (ARRIGONI DEGLI ODDI 1929). No data have been published so far on moult and fat accumulation, nor on the timing of departure from the Italian quarters. Recent information on spring migration indicates clear differences in the timing of passage of four different subspecies along the Adriatic coast (MAGNANI et al. in press).

Between 1985 and 1990, a specific effort was devoted to investigate the pre-migratory phase in a dense breeding population of *M. f. cinereocapilla* in Val Campotto, during ringing activities carried on within the EURING Acroproject (KOSKIMIES & SAUROLA 1985).

We wish to thank the Consorzio della Bonifica Renana, owner of the area, and the C.I.S.O. Ornithological Station for providing permission and accommodation facilities. We are grateful to all ringers who joined the project for their friendly support. Raffael Winkler kindly revised a first draft of the manuscript.

2. Study area

Val Campotto-Vallesanta Natural Reserve (44.35 N, 11.51 E) is a 1800 ha area of international importance under the Ramsar Convention. Detailed habitat descriptions are reported in PICCOLI (1976) and SANTUCCI (1978). The trapping site is a pure reed bed of *Phragmites australis*, in which a 300 m board walk transect has been built to set the nets; more nets were set at right angle along the edge of the reed bed (SPINA & BEZZI 1990).

3. Materials and methods

Ring activity was based on continuous and standardized mist-netting following the methods described by BERTHOLD & SCHLENKER (1975). In the different years, the trapping periods were: 1985 (1 – 20 August), 1986 (30 July – 30 October), 1987 to 1989 (30 July – 2 September), 1990 (30 July – 30 September). The presence of numerous freshly fledged Reed and Great-Reed Warblers (*Acrocephalus scirpaceus*, *A. arundinaceus*) in our ringing site till the end of July did not allow an earlier start of our activity, although post-nuptial moult in the Yellow Wagtail is reported as lasting between July 19th and August 31st (HEREWARD 1979).

Each bird has been aged and measured, the main measurements being wing length (third primary, BERTHOLD & FRIEDRICH 1979, JENNY & WINKLER 1989), body mass (at 0.1 g accuracy) and fat score. Only for a small fraction of the total sample tarsus and bill lengths were recorded. As for fat score, a scale between 0 to 4, which takes into account only the furcula, has been used in the years 1985–1987; the method described by BUSSE (1974) has then been introduced since 1988. In the following analyses the more widespread Busse scale will be used, although the two methods didn't show very different correlation coefficients with body mass (BUSSE: KENDALL's Tau-B = 0.41; «furcula»: KENDALL's Tau-B = 0.38). Moult stage was recorded with reference to GINN & MELVILLE (1983), and each feather numbered accordingly.

A KOLMOGOROV-SMIRNOV goodness-of-fit test has been used to check the distributions related to the linear variables considered. Since in most cases these differed from the normal, non-parametric tests have been chosen for the analyses following SIEGEL (1956). For all tests the SPSS-PC package has been used.

4. Results and discussion

4.1. Ringing patterns

Apart from a tiny fraction, all birds were mist-netted while reaching and leaving their roosting site. A total of 2864 birds have been ringed (897 adults and 1967 juveniles) with an overall juv./ad. ratio of 2.19 (numbers of single years in Tab. 1). Only one bird was recaptured during

Table 1: Number of Ashy-headed Wagtails ringed and recaptured in Val Campotto (Ferrara, Italy) during the years 1985–1990. In brackets the number of moult cards. SS = Birds ringed in the same season; PY = birds ringed in previous years.

Tab. 1: Zahl beringter und wiedergefangener Aschköpfiger Schafstelzen von 1985–1990 im Val Campotto (Ferrara, Italien). Die Zahl in Klammern gibt die Anzahl der Mauserkarten an. SS = beringt in derselben Saison; PY = beringt in einem früheren Jahr.

	Ringed Juveniles	Adults	Recaptured	
			SS	PY
1985 (01.08/20.08)	270	150 (150)	0	1
1986 (30.07/30.10.)	413	145 (145)	0	5
1987 (30.07/02.09)	364	99 (98)	0	0
1988 (30.07/02.09)	272	146 (146)	0	1
1989 (30.07/02.09)	192	208 (197)	1	7
1990 (30.07/30.09)	456	149 (148)	0	1
Total	1967	897 (884)	1	14

the same season. Possibly also in relation to different locations of the main roosting sites within each season, as well as during the study period, significant differences in the trapping patterns have been found over the years. Nevertheless data from the 6 years have been clumped by 5-day periods (BERTHOLD 1973, Fig. 1) to analyse the seasonal pattern of moult, as well as of body mass and fat variations.

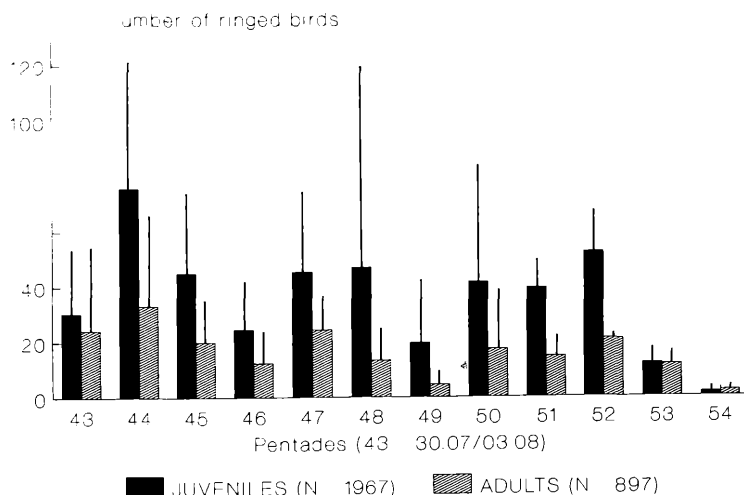


Fig. 1: Ringing pattern of Ashy-headed Wagtail in Val Campotto during the years 1985–1990 (mean number + standard deviation).

Abb. 1: Beringung von Aschköpfigen Schafstelzen von 1985–1990 im Val Campotto (durchschnittliche Pentadenwerte + Standardabweichung).

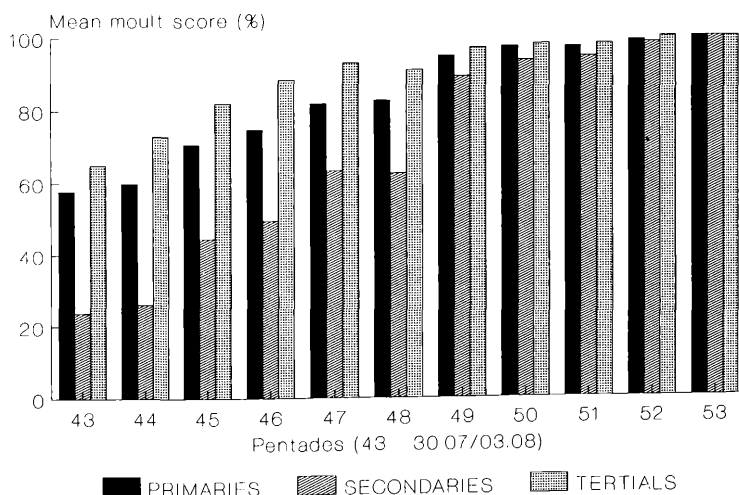


Fig. 2: Mean moult score (cf. SUMMERS et al. 1983), progress of primaries, secondaries and tertials (N = 884).

Abb. 2: Durchschnittliches Mauserstadium (vgl. SUMMERS et al. 1983), zeitliches Fortschreiten der Mauser bei Handschwingen, Armschwingen und Schirmfedern (n = 884).

4.2. Seasonal progression of moult

A total of 884 moult cards have been filled in the 6 years (Tab. 1, Fig. 2). At the beginning of August primary and tertiary moult has already more than half way progressed, while secondaries are in a less advanced stage. Moult of flight feathers regularly progresses until pentade 47 (Aug. 19th – 23d), when primaries are above 80% of their development, secondaries at approximately 70% and tertials are almost fully renewed. Mean scores for primaries and secondaries show a similar pattern during this period of fast moult. A slight decrease in moult score progression is observed in pentade 48; at the beginning of September (pentade 49), very few Wagtails are trapped (Fig. 1), suggesting that the area is abandoned by the majority of birds, and the percentage of fully moulted adults suddenly becomes the bulk of catchings (Fig. 3). No differences are observed in the seasonal pattern of moult if taking into account total mean values of primaries + secondaries and/or primaries + secondaries + tertials.

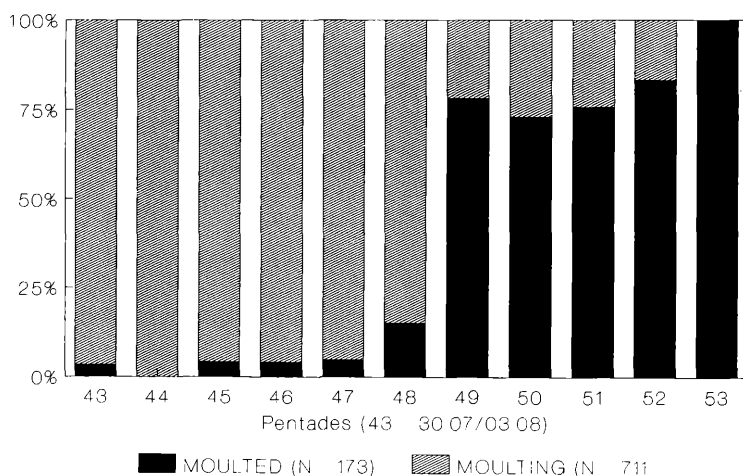


Fig. 3: Percentage of moulting and moulted adults.

Abb. 3: FlügelFederwechsel: Prozentsatz adulter Vögel in Mauser bzw. nach Abschluß der Mauser.

4.3. Description of moult

Due to the already mentioned late start of our sampling period, it is impossible to give a detailed description of the very first stages of moult, and in particular cases referring to birds which still have to renew the first primary (P1) are missing. P1 is already fully renewed (stage 5) in 95.1% of cases within our sample; this feather seems to be the first one to be dropped, since no cases were recorded with other primaries being at a more advanced moult stage. The last primary to be shed is generally P10; in our sample, when considering moult cards with P9 or P10 at different moult stages with scores 0 or 1 (N = 107), 89.7% of birds had dropped P9 earlier than P10. When looking at birds with both feathers actively moulting (N = 162), P9 scored the same or higher values than P10 in 92.6% of cases; also taking into account the strong difference in length between the two feathers, this result further supports the assumption of P10 being the last primary to be dropped. The fact that P9 is much longer is most likely to be the reason why, despite the earlier start of its moult, it reaches the final stage later

than P10, being therefore the last primary to be found actively moulting. In fact, out of 80 birds with one of these two last primaries in stage 5, 98.7% had P10 already fully renewed while P9 was still growing. For further details on the progression of primary moult see "Moult dynamics".

The outermost secondary is dropped first, since no cases were found with S1 scoring less than the others. This feather is shed when primary moult has half way progressed; in particular, a fairly strong relationship is observed between the moult start of S1 and P6. In fact, when taking into account all cases with S1 in stage 1 or 2 ($N = 94$), 60.6% of birds had P6 in the same condition, with two other primaries showing some degree of similarity (i. e. P5, 10.6%; P7, 6.4%). The last secondary to be renewed is S6; when looking at birds with S5 or S6 at different stages scoring 0 or 1 ($N = 57$), in all cases the innermost secondary still had to be dropped. In the last days of secondary moult there is a strong correspondence in growth phase between S5 and S6; in 80.8% of cases with S6 scoring 4 ($N = 52$), also S5 had got the same growth stage. Out of 11 cards with only one of the two feathers in stage 5, S6 was still growing in 9 cases.

Tertiary moult starts early in the season and seems to be rather fast (Fig. 2). The median tertial T2 is the first to start moulting in 88.5% of 26 cases in which two tertials were still old. Afterwards T1 is dropped, and finally T3, with no case observed of T3 moulting earlier than T1. In 73.1% of 78 cases T2 is the first to reach full length, while the longest outer tertial is the last to get to stage 5, again presumably due to its larger dimensions with respect to T3.

No clear correlation in moult stage could be found between the tertials and any of the primaries or secondaries.

Alula is moulted very late, starting after P8 is dropped (66.2% of 65 cases in connection with P9), then regularly progressing until the very end of primary moult; 10 cases were recorded with alula still growing when all primaries were already fully renewed.

When looking at the end of wing moult, cases with a single feather still in growth have been considered ($N = 14$); out of these, P9 and S6 respectively were represented with the same frequency ($N = 7$).

4.4. Moult dynamics

As a further step in the description of primary moult, we have tried to analyse how moult dynamically progresses in the wing by considering the development stage of each single feather with respect to the others. A growth pattern which seems to be far from linear was the result of the analysis, and in particular when looking at the percentage of primaries already renewed (score 5) within the whole sample, (Fig. 4), we find a clearly different and more advanced moult stage in the five innermost primaries (P1–P5) with respect to the outermost ones, (P6–P10), the two arbitrary groupings being apparently segregated by a flex point between P5–P6. This fact might suggest a discontinuity in moult onset and progression between these two groups of primaries, the innermost five dropping at shorter time intervals with respect to the outer ones. As a matter of fact, a regular shedding of all primaries during the moult period should have produced a linearly decreasing curve. Innermost primaries that shed at shorter intervals than outer ones are also reported by WINKLER & WINKLER (1985) for Snowfinches (*Montifringilla nivalis*). It is worth noting in our case (see 4.3.), that the onset of secondary moult falls just in correspondence to the already mentioned flex point between P5–P6, suggesting that the further increase in energy demand related to this new process might be one of the reasons leading to the slowing down of primary moult.

The general impression which derives from these patterns is that during the first part of moult the innermost primaries are quickly dropped and grown till a stage which guarantees

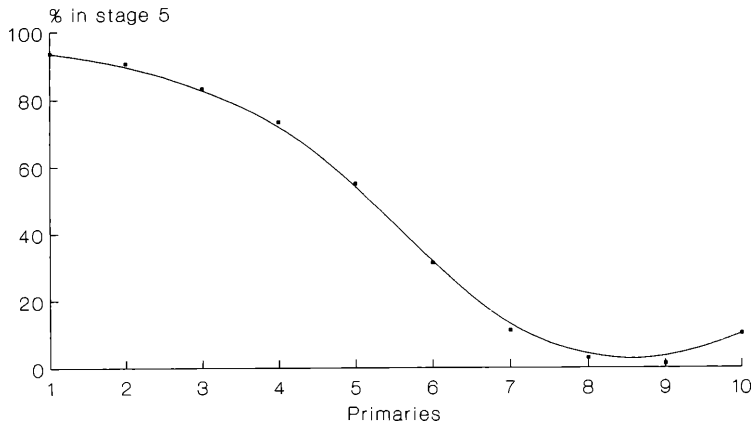


Fig. 4: Percentage of birds for each primary with moult score = 5 (i. e. fully renewed), N = 881.
 Abb. 4: Prozentualer Anteil der Vögel mit Federn des Mauserstadiums 5 (d. h. völlig ausgewachsen), aufgegliedert für die Handschwingen 1–10.

flight ability while, later on, the outer longer primaries, which have also got a more important role for flight (MILLER 1928) are renewed in a slower sequence.

4.5. Duration of moult

Complete moult in the Yellow Wagtail has been estimated by different authors as lasting 40–53 days (*M. f. flava*, East Germany, DITTBERNER & DITTBERNER 1987), 40 days (HAUKIOJA 1971, HAUKIOJA & KALINAINEN 1972, Finland), 43–45 days (*M. f. flavissima*, England, HERWARD 1979), 50 days (WINKLER in GLUTZ VON BLOTZHEIM & BAUER 1985, Camargue). In our case we could only try to assess moult duration on the basis of first captures, given the total absence of recaptures which might have supplied real quantitative information on moult progression in individual birds. Furthermore, the already mentioned lack of data from the beginning of moult causes our sample to be unevenly distributed along the whole period, which might lead to under or overestimations when trying to assess moult duration on the basis of linear regressions (UNDERHILL & ZUCCHINI 1988).

Nonetheless, also with reference to SUMMERS et al. (1983), we firstly tried to calculate a linear regression of moult score on date; the results indicated a moult duration of 93.1 days, clearly too long a period also to fit with our field observations. Similarly and inversely, the resulting estimate derived from calculating a linear regression of date on score cannot be accepted since it implies by far too short a duration of 27.9 days. The next step was to introduce power transformations of moult score to get a more linear relationship (UNDERHILL 1985; UNDERHILL et al. 1990). We have therefore tested several possible power values, and the best correlation coefficient was obtained by raising our score data to 3.5. The deriving equation indicates in this case a total duration of 61.7 days, a fairly reasonable estimate if we consider that our birds seem to start moulting in July, generally leaving the area at the beginning of September.

4.6. Body mass variations

Adult Yellow Wagtails have to get ready for the long migratory flight after having overcome the most energy demanding part of their post-nuptial moult; similarly, juveniles must put on fat once they reach full independence. We have therefore analysed the seasonal pattern in fat score and body mass values for both age classes (Fig. 5, 6).

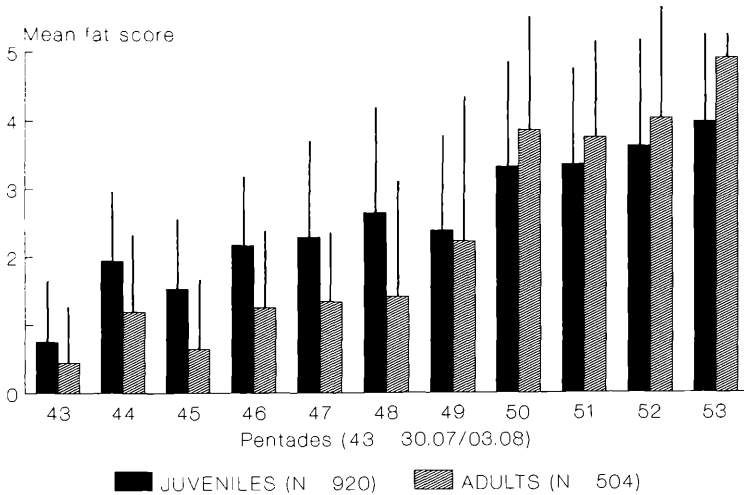


Fig. 5: Fat deposition in juvenile and adult Ashy-headed Wagtails (mean fat score + standard deviation).

Abb. 5: Fettdepot-Bildung bei juvenilen und adulten Aschköpfigen Schafstelzen (mittleres Fettdepot-Stadium + Standardabweichung).

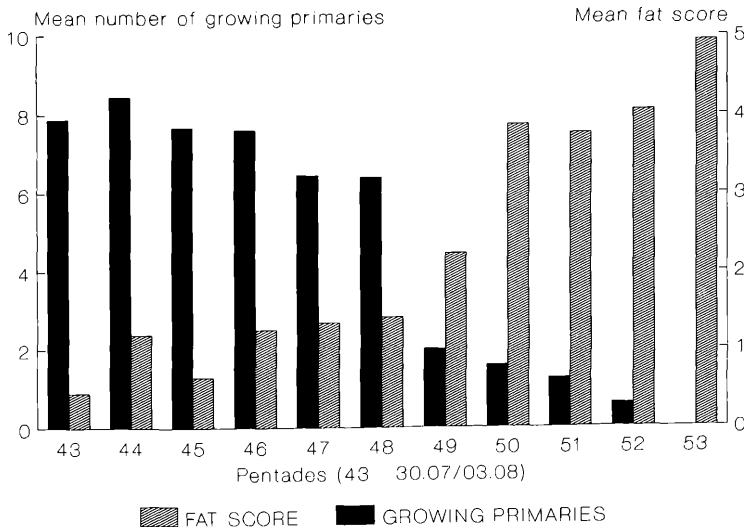


Fig. 6: Relationship between number of growing primaries and fat deposition (N = 504).

Abb. 6: Beziehung zwischen Anzahl wachsender Handschwingen und Fettdepot-Bildung.

Fat: until the end of August (pentade 48), i. e. during the most intense period of complete moult (Fig. 2), adult birds are clearly leaner than juveniles (1-tailed $p = 0.013$, WILCOXON signed-ranks test). The energetic demand related to moult is most likely to be the reason for such pattern, and in fact a strong negative correlation was found between the number of moulting feathers and fat score (KENDALL'S Tau B = -0.901 , Fig. 6). A sudden raise in fat score values for adult birds is then apparent after moult has reached its final stage, and in September adults put on fat at a much higher rate than that of first year birds, the latter showing a more linear seasonal pattern. On departure adults leave the area being on average fatter than juveniles, and with a stronger correlation in the seasonal fat increase (fat score/day, tau-B ads. = 0.47 , tau-B juv. = 0.26 , KENDALL'S CORR. COEFF.).

Body mass: until the end of August adults and juveniles have similar body mass values ($p > 0.5$, WILCOXON signed-ranks test), although the latter have already put on significantly larger amounts of fat (Fig. 7). This fact could be explained on the basis of the significantly larger dimensions and higher fat free body mass values shown by adults in our sample (Tab. 2). As a consequence of the different fattening pattern discussed above, in September adult birds quickly get higher body mass values than juveniles (1-tailed $p = 0.021$, WILCOXON signed-ranks test).

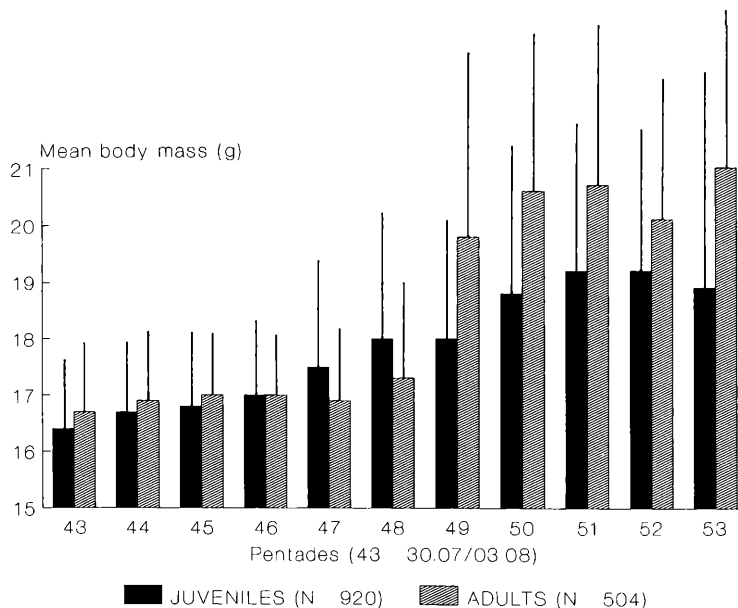


Fig. 7: Body mass increase in juvenile and adult Ashy-headed Wagtails (mean + standard deviation).
Abb. 7: Zunahme der Körpermasse bei juvenilen und adulten Aschköpfigen Schafstelzen (durchschnittliche Pentadenwerte + Standardabweichung).

Table 2: Biometrical differences between juveniles and adults.

Tab. 2: Biometrische Unterschiede zwischen juvenilen und adulten Vögeln.

	Juveniles	Adults	p (M-W test)
Wing length (3rd primary)	Mean = 61.12 S. D. = 2.00 N = 1831	Mean = 62.18 S. D. = 2.49 N = 224	$p < 0.0001$
Body mass (fat score = 0)	Mean = 16.35 S. D. = 1.20 N = 290	Mean = 16.67 S. D. = 1.23 N = 234	$p = 0.0017$

5. Discussion

Our study shows that Ashy-headed Wagtails in Northern Italy start their complete moult in July, and the whole wing is fully renewed by the beginning of September, when breeding quarters are abandoned by the majority of birds.

Primaries seem not to be dropped in a linear sequence along the season, possibly also in relation to the onset and progression of secondary moult.

Despite the large sample of moult cards, absence of recaptures makes the calculation of the duration of moult very difficult. The simplest approach of calculating linear regressions of moult score on date or the opposite produces clearly misleading results (i. e. too long or too short periods). The introduction of exponentials seems to give a better idea at least of the period within which most of the population undertakes moult, although it is difficult to judge whether the resulting duration can also be referred to the single individual. Non linearity in the sequence of feather dropping and renewal is another factor which adds further difficulties in the calculation of moult duration in the absence of recaptures during the study period; this aspect should always be seriously taken into account before trying to assess moult duration by models based on the assumption of linear sequences (UNDERHILL 1985; UNDERHILL & ZUCCHINI 1988; UNDERHILL et al. 1990). For the same reason, also the use of recaptures for the calculation of moult duration, in the presence of patterns which may be characterized by variable moult speed in different phases of feather renewal, might produce contrasting results depending on the moment in which recapture data are collected. New models which take into account also the dynamic progression of moult in the wing might help overcoming these difficulties.

Both juveniles and adults deposit considerable amounts of fat before leaving the area. Adults in particular show very clearly how the energy demanding phase of feather renewal does not allow the birds to fatten until moult is almost completed, and afterwards the rate at which they put on fat is much faster than that of juveniles, suggesting higher foraging efficiency by more experienced birds.

6. Zusammenfassung

Postnuptiale Mauser und Fett-Akkumulation bei der Aschköpfigen Schafstelze (*Motacilla flava cinereocapilla*) in Nord-Italien.

Nach Untersuchungen im Norden Italiens beginnt bei der Aschköpfigen Schafstelze im Juli die Vollmauser, und Anfang September ist das Großgefieder des Flügels komplett erneuert. Der deszendente Handschwingenwechsel beginnt mit P1 und endet mit dem Ausfall von P10; die Armschwingen mausern von S1 nach S6, die Schirmfedern in der Reihenfolge T2, T1, T3. Mit dem Auswachsen von P9 oder S6 wird die Flügelmauser beendet. Der Wechsel der Handschwingen erfolgt nicht in linearen Zeitabständen, was möglicherweise im Zusammenhang mit der Armschwingenmauser steht. Zwischen dem Wechsel der inneren Handschwingen P1–P5 und dem der äußeren (P6–P10) ergab sich ein deutlicher Zeitintervall-Unterschied. Schwierigkeiten, die sich aus dem nicht linearen Mausermodus für die Kalkulation der Mauserdauer mit Hilfe verschiedener Methoden ergeben, werden diskutiert. Juvenile und adulte Schafstelzen verlassen die Untersuchungsregion mit beträchtlichem Fettdepot; vor allem adulte Vögel akkumulieren nach Beendigung der Mauser schnell Energiereserven.

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