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Moult and weight changes of Redpolls, *Carduelis flammea*, in north Norway

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In 1964, a party from Oxford University visited the province of Sor-Varanger, north Norway, to study small mammals and birds. During the seven weeks of the visit from 27 July to 12 September, 367 Redpolls were caught, ringed and examined by R.A.E. and G.R.S., to provide information mainly on the timing and duration of their moult, for comparison with a similar study on British Redpolls *(Carduelis flammea cabaret)* by P.R.E. (see EVANS 1966); the two populations were at latitudes of approximately 70° and 55°N respectively. The results of the Norwegian study are reported in this paper.

The taxonomy of Redpolls breeding in north Norway has been the subject of much discussion (see the review in HARRIS *et al.* 1965), and recent evidence suggests they are perhaps best considered as a hybrid swarm, as suggested earlier by PAYN (1947); the name *Carduelis flammea pallescens* has been suggested for them by HARRIS *et al.* (1965). We made no attempt to throw further light on this taxonomic problem, but, incidental to the moult study, took wing-lengths and weights, which are also reported here.

The study areas

Redpolls were trapped in three areas, Neiden, Buholmen and Lillibaeken, all within 20 km. of each other. The most profitable trapping localities were in low birch *(Betula)* scrub, where the Redpolls both fed and roosted. Mist-nets were erected along tracks through the trees, and the birds usually allowed to catch themselves, as most attempts to drive them into the nets merely made the flocks fly upwards and over the nets. Birds left their roosts and started feeding at about 0400 hrs (local time) in August, and returned to roost at about 2000 hrs. In early August, although they spent some time each day feeding on the birch catkins, they also took the seeds of grasses in the hayfields bordering the woods. In these fields they gathered in small flocks but were difficult to trap, as in most places

where mist-nets could be erected, the sky acted as a background, so that the nets were obvious to the birds; however, nets could occasionally be set near hedges, and then they proved more effective. After mid-August, although grass seeds were still available, the Redpolls fed entirely on birch catkins and were caught only in the birch woods.

Description of the moult.

In north Norway in 1964, most adult Redpolls began moult in late July, with the loss of the innermost of the nine primaries in each wing. Successive primaries were shed at regular intervals, so that on any date during moult (or at any stage of moult, as indicated by the number of full-grown new primaries),

Table 1. Variation in number of growing primaries of *Carduelis flammea* with stage of moult and date.

Stage of moult

No. of growing primaries	Sex	No. of new primaries. 0	1	2	3	4	5	6	7	8	Total for primaries 1—5 Male	Female
1	Male	2	—	2	—	—	—	—	—	2	2	5
	Female	2	—	3	—	—	2	—	—	—		
2	Male	—	—	2	—	2	1	—	6		5	10
	Female	2	2	3	1	1	4	1	4			
3	Male	3	1	—	1	4	6	10			12	14
	Female	3	1	—	3	4	6	14				
4	Male	1	1	1	1	1	9				13	11
	Female	2	—	1	2	—	8					
5	Male	—	—	—	—	—					—	2
	Female	1	—	—	—	1						
	Total no. of birds										32	42
	Average no. of growing primaries										3.12	2.81

Date (1964)

No. of growing primaries	Sex	August 1—10	11—20	21—31	September 1—10
1	Male	1	3	—	2
	Female	3	3	—	1
2	Male	2	—	2	7
	Female	2	5	4	7
3	Male	3	2	6	14
	Female	4	1	7	19
4	Male	—	3	1	10
	Female	2	1	3	7
5	Male	—	—	—	—
	Female	—	1	1	—

Note: Figures quoted in the Table are the number of birds with the given number of growning primaries (in each wing) at the given stage of moult or date.

Table 2. Variation in number of growing secondaries and tail feathers of *Carduelis flammea* with stage of moult.

No. of growing secondaries or tail feathers (pairs)	Sex	Stage of moult: No. of full-grown new secondaries (in each wing)						Stage of moult: No. of full-grown new tail feathers (pairs)					
		0	1	2	3	4	5	0	1	2	3	4	5
1	Male	12	3	—	—	—	—	—	—	—	—	—	9
	Female	15	3	—	—	—	—	3	—	—	—	—	11
2	Male	5	3	1	—	2		—	—	—	—	11	
	Female	10	3	2	—	1		1	—	—	—	12	
3	Male	2	5	—	1			—	—	—	4		
	Female	1	3	2	1			1	—	1	3		
4	Male	—	3	3				4	—	4			
	Female	—	1	6				4	—	3			
5	Male	—	1					2	—				
	Female	—	—					3	1				
6	Male	—						9					
	Female	—						14					

Note: Figures quoted in the Table are the number of birds with the given number of growing feathers at the given stage of moult.

an average of about three primaries were growing simultaneously in each wing (Table 1). Excluding data from the start and end of moult, when only one or two primaries had begun or remained to grow, the mean number of growing primaries was slightly greater for males than females (3.12 : 2.81), and in fact males completed their moult more quickly (see later).

Moult of the tertials began soon after the start of moult of the primaries, with the loss first of the middle tertial, then the inner one and finally the outer one. Of the six secondaries in each wing, the outermost (adjacent to the first primary to moult) was dropped when moult of the primaries was almost half completed. In contrast to the regularity of primary moult, more secondaries grew simultaneously at the end than at the start of their moult (Table 2), as in many passerine birds (DWIGHT 1900). The large tail feathers were shed usually in pairs, from the centre outwards, and often all six pairs were growing simultaneously (Table 2). Tail moult began when moult of the primaries was about one-third completed, and had finished shortly before the last (ninth) primary reached full length. The significance in relation to flight efficiency of the timing and simultaneous nature of tail moult in Redpolls have been considered elsewhere (EVANS 1966).

Recording and analysis of moult

As mentioned above, adult Redpolls start their moult with loss of the innermost primary; also, almost all have finished by the time the ninth primary has reached full length (though a few birds may finish moult with growth of the last secondary). Thus the stage of moult of the primaries, expressed as a primary moult score, indicates how far the complete moult of an individual has progressed. Primary moult scores were calculated for each bird on capture by scoring the growth of individual primaries as follows: 0 for an old feather; 1 for a feather in pin or missing as a

result of moult; 2, 3 and 4 for feathers up to one-third, two-thirds and almost full-grown, respectively; and 5 for a full-grown new feather. The sum of the scores for the nine primaries are believed to give for each bird an overall primary moult score which increases at a constant rate with time, as confirmed for Redpolls in Britain by EVANS (1966), and for both wild and captive Bullfinches *(Pyrrhula pyrrhula)* by NEWTON (1966, 1967). The primary moult scores of all Redpolls caught in nort Norway have been plotted against the date of capture in Fig. 1.

Since few Redpolls were caught more than once during moult, we have few direct estimates of the start and duration of their moult. However, for the sample of Redpolls examined, mean estimates of the timing and duration of moult have been obtained by means of a regression analysis of primary moult score on date for all individuals. The results are summarised in Table 3, alongside data from Northumberland, England, obtained in the same year (from EVANS 1966, where the validity of the regression analysis is discussed). As may be seen, there is good agreement between the daily increase of moult score estimated for the whole sample of birds, and the average of those for individuals, estimated from recapture data.

From Table 3, it may be calculated that males moulted on average 1.13 times faster than females. Also, from Table 1, it will be remembered that males had more primaries growing simultaneously than did females by the ratio 1.11:1 on average. Thus almost all the difference in the duration of moult between males and females resulted from variation in the number of feathers growing simultaneously, and presumably therefore *not* from variations in the rate of feather growth. A similar result was obtained for Redpolls, Bullfinches and Greenfinches

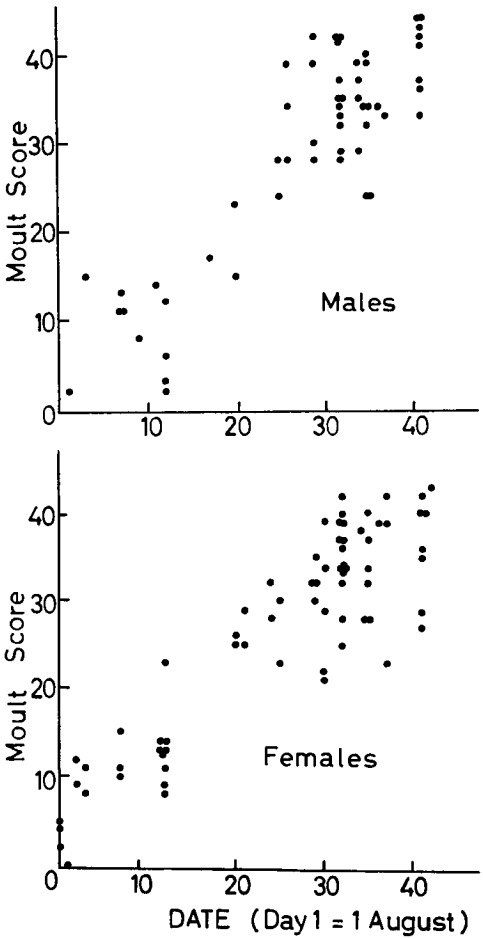

Fig. 1. Moult scores (see text) of Redpolls in north Norway on different dates in August and September 1964.

(Chloris chloris) in England (EVANS 1966, NEWTON 1966, 1967).

The average daily increase in moult score for *each* primary may be calculated as 0.30, which indicates that, as a full-grown new primary scores 5, on average each one completed growth in about 17 days, as against about 16 days in England.

Moult started slightly earlier, on average, in north Norway than in England,

Table 3. Summary of moult of the primaries of *Carduelis flammea* in autumn 1964.

Males	N. Norway	England
Daily increase of moult score	0.95 ± 0.07	0.80 ± 0.07
Daily increase from recaptures	0.95 ± 0.24 (3)	0.84 ± 0.17 (9)
Start of moult	28 July	1 August
95 % spread of start (days)	24	31
End of moult	14 September	26 September
Sample size	56	49
Regression equation	P = 0.95D + 2.56	P = 0.80D—0.61
Linearity test	$F^{15}_{39} = 1.50$	$F^{18}_{29} = 1.82$
Duration of moult (days)	48	56
Females		
Daily increase of moult score	0.83 ± 0.05	0.80 ± 0.05
Daily increase from recaptures	0.83 ± 0.26 (7)	0.83 ± 0.21 (8)
Start of moult	24 July	1 August
95 % spread of start (days)	24	22
End of moult	16 September	26 September
Sample size	70	36
Regression equation	P = 0.83D + 5.68	P = 0.80D—0.51
Linearity test	$F^{17}_{24} = 1.24$	$F^{14}_{20} = 1.00$
Duration of moult (days)	54	56

Notes: Figures in parentheses are the number of recaptures (more than 6 days after first capture) used to calculate the average daily increase in moult score given in the Table. The errors are best estimates of the standard deviation. D=date, P=primary moult score. The 95 % spread of start indicates the period during which 95 % of the sample of Redpolls examined began to moult.

and, among the males, was noticeably faster at the higher latitude (48 instead of 56 days for completion). It is believed that the start of moult reflected the time when the last brood of young reared by each pair became independent; this would suggest that adult Redpolls caught late in the moult period with moult scores markedly below average may have tried to rear unusually late broods. One female caught on 8 September had a moult score of only 18 (about 20 below average for that date), and even in late evening weighed only 11.3 gm., about 30 % below average for early September (see later), which suggests that it might have tried to rear a brood at an unfavourable time. We did in fact find a Redpoll's nest containing young which fledged as late as 10 September, and caught a few birds still in juvenile (rather than post-juvenile) plumage each day until we ceased netting (on 11 September).

Wing lengths

Measurements of Redpolls caught in west Finmark (also at 70°N, but some 250 km. west of our study area) have been published by HARRIS *et al.* (1965), and those for the alleged species and subspecies *Carduelis flammea flammea, C. f. holboelli* and *C. hornemanni exilipes* by JUNGE (1942) and WITHERBY *et al.* (1938). The measurements from Finmark were taken from live specimens, using the gently flattened chord of the wing; the rest were taken from museum specimens.

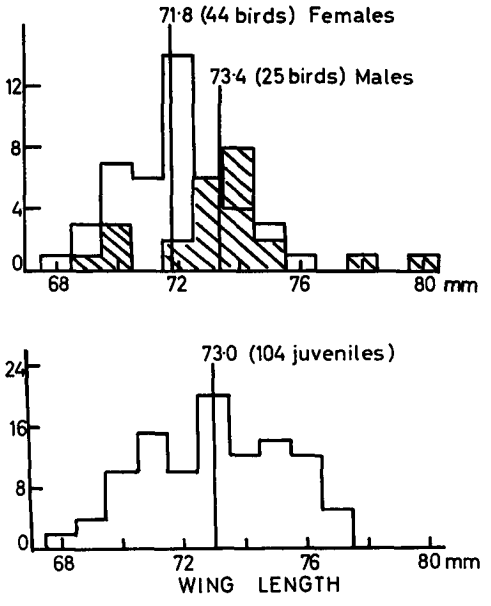

Fig. 2. Frequency distributions of wing lengths (unflattened chords) of Redpolls in north Norway. Wings of adult males and females were measured just before moult and were therefore abraded; those of juveniles were measured when their newly-grown feathers had reached full length.

Wing-lengths of the birds we caught in Sor-Varanger in 1964 were taken by measuring the *unflattened* chord of the wing, and are thus directly comparable with those published for *C. f. cabaret* (EVANS 1966), but not with those listed in the publications mentioned above. The distribution of wing-lengths of the Sor-Varanger birds is shown in Fig. 2 and summarised in Table 4. The flattened chord measurement should be slightly longer than the unflattened one; when allowance is made for this, there is no obvious difference between our measurements and those made by HARRIS *et al.* (1965), as was to be expected. As may be seen from Table 4, the sexes of Redpolls in north Norway could not be separated reliably by wing-length, as there was

Table 4. Wing lengths of *Carduelis flammea.*

	N. Norway 1964	England 1964	Average difference
All adult males			
Mean (mm)	73.4	68.3	5.1 mm.
95% Range	68.8—78.0	64.6—72.0	
Sample size	25	34	
S. Dev.	2.35	1.86	
All adult males			
Mean (mm)	71.8	66.4	5.4 mm.
95% Range	68.4—75.2	63.0—69.8	
Sample size	44	23	
S. Dev.	1.74	1.71	

Notes: Lengths are those of unflattened *abraded* wings, just before the annual moult. (Abrasion shortens the wings of *C. f. cabaret* by an average of 1 mm. during the year). S. Devs. are best estimates.

much overlap of measurements; however, Sor-Varanger birds averaged about 5 mm. longer in the wing than British birds of the same sex. The wing-lengths of about 95 % of the two populations overlapped in the ranges 69—72 mm. in the males, but only 68.5 —70 mm. in the females. Outside these limits it should be possible to allocate a Redpoll of known sex to one or other of these populations on the basis of winglength alone. However, we have no measurements of Redpolls from further south in Scandinavia; these might have wing-lengths intermediate between the British and north Norwegian birds.

Plumage

Apart from crown colour, no detailed notes were taken of the plumage of the Redpolls handled in Sor-Varanger, but birds in fresh plumage looked much paler than those in worn plumage. Presumably this arises, as in *C. f. cabaret,* through abrasion of the pale feather edgings during the year. It is clear that any attempt at racial separation by plumage characters can be justified only if the material examined consists en-

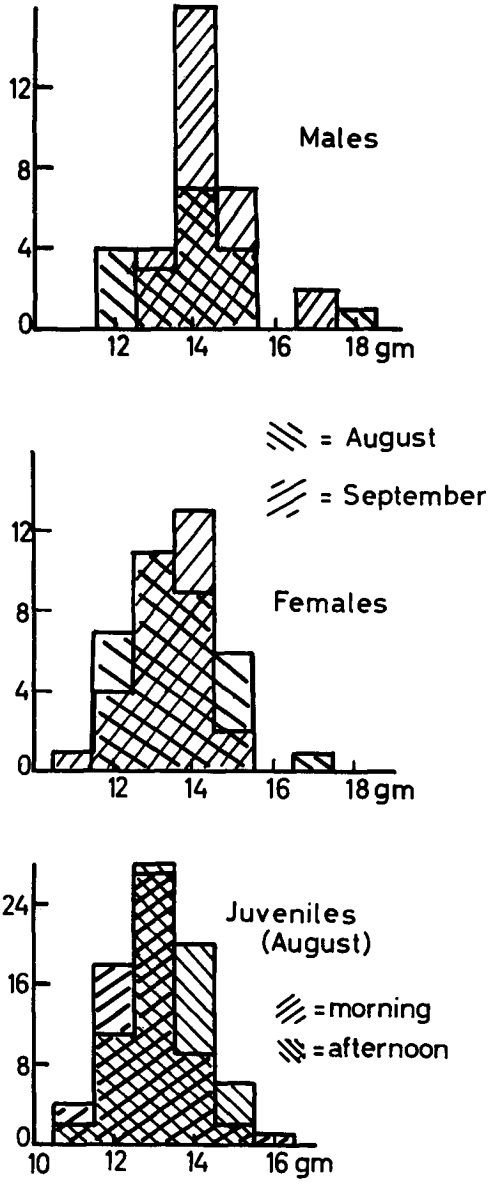

Fig. 3. Frequency distributions of weights of Redpolls in north Norway. The upper diagrams show the weights of adult males and females in August and September; all weights were taken after noon. The lowest diagram compares the weights of juveniles in August before and after noon.

tirely of freshly-moulted specimens (or, less satisfactorily, of specimens collected at the same time of year).

More Norwegian Redpolls had golden, rather than red, crowns than is usual in Britain. Such colour variants were found in 8 of 66 adult females and 1 of 52 males examined in Sor-Varanger, but in only 3 of 51 females and none of 74 males in Northumberland, England. The difference in incidence of golden crowns between the sexes suggests that more than dietary deficiencies are involved.

Weights

Most of the Redpolls handled in Sor-Varanger weighed around 13—14 gm., about 2 gm heavier than *C. f. cabaret* at the same time of year. Many of the birds were caught in the afternoon and evening, but some (notably juveniles in August) in the early morning. In the analysis which follows, weights taken before and after noon are treated separately; the weight distributions are shown in Fig. 3 and summarised in Table 5.

The division of weight data into separate groups for August and September allows a comparison to be made between the weights of adults in the early and late stages of moult, respectively. While the mean weight of males was higher in September than in August, that of females was lower, but a feature common to both sexes was a decrease in the scatter of weights about the mean in September, because there were fewer unusually high and low weights. As may be seen from Fig. 3, there was no marked increase in the proportion of very heavy birds in September as against August, as might have been expected if birds had layed down considerable quantities of fat prior to migration. Also, the weights of the few individuals caught more than once during moult showed little change (when

Table 5. Weights of *Carduelis flammea* in north Norway.

	August	September
After 1200 hrs. Local Time		
Males		
Mean	13.92±1.30	14.30±0.90
Sample	19	29
Females		
Mean	13.57±1.10	13.38±0.87
Sample	43	31
Juveniles		
Mean	13.23±0.95	14.05±1.09
Sample	67	109
Before 1200 hrs. Local Time		
Juveniles		
Mean	12.82±0.95	14.03±1.50
Sample	61	16

Note: Errors quoted are best estimates of the standard deviation.

weighed and reweighed at the same hour of the day). Unfortunately, we cannot exclude the possibility that fat deposition might have occurred only *after* completion of the moult, for we have no weights of birds then, as we left Norway before most Redpolls had finished moult.

Among the juveniles in August, birds were on average lighter before than after noon, as might be expected, and Fig. 3 shows that this was the result of a genuine shift in the weight distribution to heavier weights in the afternoon. The difference between the mean weights, 0.41 gm, is of course much less than the weight change to be expected of an individual Redpoll between early morning and late evening; to judge from a few juveniles weighed and reweighed at times of day differing by more than 12 hours, a diurnal weight variation of over 1.5 gm. is likely.

Comparison of the mean afternoon weights of juveniles between August and September suggests an average increase of 0.7 gm in the later month, but this is in fact largely spurious, and results from the inclusion of a few individuals of unusually high weight in the September average. These individuals were simply very large birds; 8 had wing-lengths between 75—77 mm., at the higher extreme of the wing-length range of young birds, shown in Fig. 2. Thus in juveniles, as in the adults, there was no evidence of marked weight increase which might have been associated with preparation for migration. However, recent work has shown that certain species of migrants deposit fat in autumn while simultaneously reducing their lean body weight, so that their total weight shows only minor fluctuations (DOLNIK 1963, KING *et al.* 1965). This applies to Redpolls in Britain (EVANS, *in prep.)* and may also apply to Redpolls in north Norway, but for the latter we have neither visual estimates nor extracts of any fat deposits in the body to test this.

Postscript

Although this study covered almost the whole of the moult period of Redpolls in Sor-Varanger in 1964, it would be extremely valuable to have similarly detailed studies in future years, as it is likely that the timing of moult varies considerably from year to year in north Norway; certainly the start of the breeding season depends both on the severity of the spring weather, the presence or absence of heavy spruce seed crops, and the habitat in which the birds breed (PEIPONEN 1957, 1962); hence the start of moult may also vary in parallel. Certainly moulting birds caught at 70°N in 1963 moulted much earlier than our birds also at 70°N in 1964 (see EVANS 1966). Further observations are needed.

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Dr. Ian Newton kindly criticized and improved the first draft of this paper.

Selostus: Urpiaisen sulkasadosta ja painon vaihtelusta Pohjois-Norjassa

Tutkimus on tehty 27.7.—12.9.1964 Etelä-Varangissa, Pohjois-Norjassa. Yhteensä 367 urpiaista pyydystettiin ja tutkittiin. Sulkasato alkoi useimmilla vanhoilla linnuilla heinäkuun lopussa sisimmistä käsisulista ja jatkui siten, että keskimäärin 3 sulkaa oli samanaikaisesti kasvamassa kussakin siivessä. Koirailla samanaikaisesti kasvavien käsisulkien lukumäärä oli hieman suurempi kuin naarailla (taulukko 1, yläosa). Kyynärsulat alkavat vaihtua uloimmasta lähtien käsisulkien uusiutumisen ollessa puolivälissä. Samanaikaisesti kasvavien kyynärsulkien määrä on suurempi uusiutumisen lopussa kuin alussa (taulukko 2). Pyrstösulat uusiutuvat pareittain keskeltä lähtien ja usein kaikki kuusi paria ovat kasvamassa samanaikaisesti (taulukko 2). Pyrstösulkien vaihtuminen alkoi, kun kolmannes käsisulista oli uusiutunut ja päättyi ennen kuin viimeinen käsisulka oli täysin kasvanut.

Sulkasadon aste kaikissa käsisulissa yhteensä on laskettu antamalla kullekin 9 sulasta jokin kerroin nollasta viiteen sen mukaan, kuinka pitkälle sulan uusiutuminen on edistynyt, ja laskemalla luvut yhteen. Kuvassa 1 on esitetty käsisulkien sadon edistyminen verrattuna aikaan elokuun alusta lähtien. Käsisulkien vaihtumisen ajoittumista ja kestoa on tutkittu regressioanalyysillä sekä useampaan kertaan pyydystettyjen urpiaisten avulla. Tulokset on esitetty taulukossa 3 yhdessä englantilaisen vertailuaineiston kanssa. Koiraiden sulkasato on keskimäärin 1.13 kertaa niin nopea kuin naaraiden, mikä ei johdu sulkien nopeammasta kasvusta vaan siitä, että koirailla useampia sulkia kasvaa samanaikaisesti. Kunkin käsisulan uusiutuminen kestää noin 17 päivää. Englannissa sulkasato alkaa myöhemmin ja on koirailla selvästi hitaampi. Sulkasadon alku riippuu ilmeisesti siitä, milloin viimeinen poikue kehittyy.

Tiedot siiven pituudesta on esitetty kuvassa 2 ja taulukossa 4. Pohjois-Norjassa urpiaisen siipi on noin 5 mm pitempi kuin Englannissa. Urpiaisia ei voida erottaa sukupuolelleen siiven pituuden perusteella.

Tutkittujen urpiaisten painoa on analysoitu kuvassa 3 ja taulukossa 5, joissa on otettu huomioon myös punnituksen vuorokaudenaika. Koiraat olivat syyskuussa keskimäärin painavampia kuin elokuussa, mutta naarailla ero oli päinvastainen. Molemmilla sukupuolilla väheni sekä hyvin kevyiden että hyvin painavien lintujen määrä syyskuussa. Painavien lintujen vähyys syyskuussa viittaa siihen, että urpiaiset eivät kokoa ihonalaista rasvavarastoa ennen poismuuttoa. Myöskään nuorilla urpiaisilla ei esiinny merkittävää painonkasvua ennen muuttoa. Toisaalta on kuitenkin huomattava, että eräiden lintulajien painon on todettu kasvavan vain vähän rasvan varastoimisesta huolimatta, koska ne samanaikaisesti pystyvät vähentämään rasvattoman lihaskudoksensa painoa.

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