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Competition and fat deposition in Goldcrests *(Regulus regulus)* at a migration stop-over site*

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Introduction

Birds moving between breeding areas and wintering areas normally divide their migration into several flight stages with intermittent stop-over periods of fat deposition. A bird that arrives at a stop-over site does not immediately increase in body mass. Many studies have shown that resting birds initially decrease in mass during the first days (Davis 1962, Nisbet et al. 1963, Meuller & Berger 1966, Page & Middleton 1972, Langslow 1976, Rappole & Warner 1976, Mehlum 1983a, Pettersson 1983a). Cherry (1982) and Moore & Kerlinger (1987), however, found an immediate gain in body mass. Several explanations of this initial decrease in body mass have been suggested, summarized by Clark (1979) as follows:

1 The birds that decrease in body mass are not healthy.
2 The birds need recovery time after completed particularly stressful flights.
3 The birds fail to locate enough food in an unsuitable and unfamiliar area.
4 The birds fail to obtain enough food due to social subordination.
5 The reduction in body mass is an adaptation for prolonged stop-overs.
6 The birds loose opportunities to feed because of time spent in nets or being processed by ringers.
7 The birds get a handling shock.

Number 1 and 2 can be seen as physiological explanations and 3–5 as ecological explanations, whereas 6 and 7 are connected with handling.

To evaluate the different hypotheses concerning this initial decrease in body mass we have analysed capture and recapture data of Goldcrests *(Regulus regulus)* trapped during autumn migration at Ottenby Bird Observatory and at a few other nearby sites.

The median date of the passage of Goldcrests at Ottenby Bird Observatory is 8 October with a main period of passage between mid September and late October (Enquist & Pettersson 1986). Goldcrests trapped at Ottenby Bird Observatory origin from the Scandinavian peninsula, Finland and the western part of the Soviet Union (Kania 1983, Liljefors et al. 1985). These populations winter from the north of Western Europe south to central France (Österlöf 1966, Karlsson 1980, Hanssen 1981, Kania 1983, Pettersson et al. 1986).

Methods

Ottenby Bird Observatory is situated on the southernmost point of the island of Öland, in southest Sweden (56.12 N, 16.24 E). The Bird Observatory and the small lighthouse society, with adjoining vegetation of trees and bushes, compose an isolated area. The nearest area with higher vegetation is Ottenby Lund, a 220 hectar deciduous wood, 3 km to the north. The area inbetween consists of open meadows. In other directions, the observatory is surrounded by open sea (Fig. 1).

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* Contribution no. 116 from Ottenby Bird Observatory

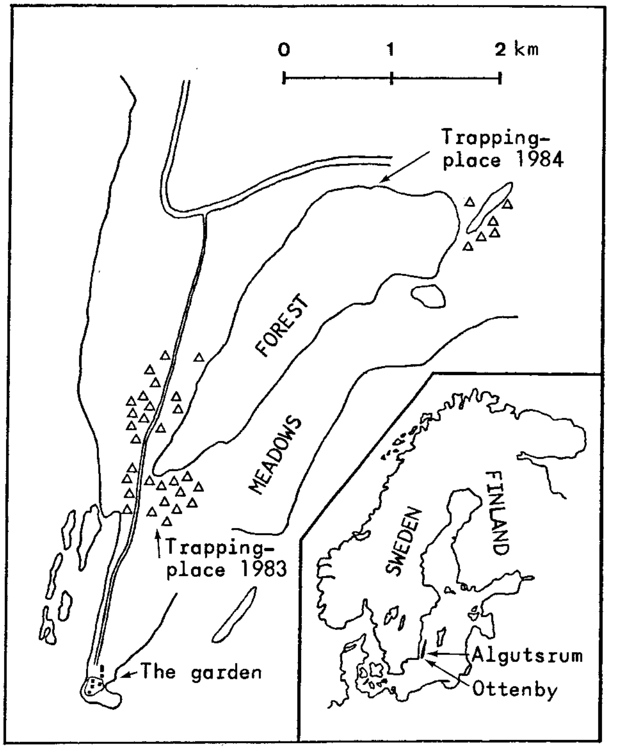

Fig 1: Ottenby and the southernmost point of Öland with places mentioned in the text. Open triangel = bush/open forest. Algutsrum was the trapping place in 1982.

Abb. 1: Ottenby und die Südspitze der Insel Öland mit den im Text erwähnten Örtlichkeiten. Dreiecke kennzeichnen Buschwerk/offenen Wald. Bei Algutsrum wurde 1982 gefangen.

The trapping at the observatory is carried out according to standardized methods with 13 mist nets and 2 Helgoland traps. Nets and traps are emptied every half hour from dawn to 11 a.m., daily from 15 March to 15 November. Birds are transported in flatbottomed dark bags and then kept in dark boxes in the laboratory until ringing and data recording takes place. All birds in this study were aged and sexed according to Svensson (1975) and Pettersson (1983 b) and their wing lengths were measured according to Method 3 (Svensson 1975). Body mass was estimated using a 50 g Pesola spring balance with an accuracy of 0.1 g. Fat deposits were estimated visually, following a classification from 0 to 6 (Pettersson & Hasselquist 1985). A bird without visible fat is classified as 0 whereas 6 refers to a very fat individual. The average increase in body mass per fat class in the Goldcrest is 0.24 g (Pettersson & Hasselquist 1985).

No Goldcrests breed within 4 km distance from the Bird Observatory. Accordingly, all Goldcrests trapped at the observatory are supposed to be on migration.

In order to get comparable data from other stop-over sites, trapping was carried out in three different places (Fig. 1): 1) 23 September – 22 October 1982 in a pine forest at Algutsrum, about 70 km north of Ottenby, 2) 1–23 October 1983 at the southern point of Ottenby Lund, about 2 km NNE of the Bird Observatory and 3) 27 September – 18 October 1984 at the northern part of Ottenby Lund, 5 km NNE of the Bird Observatory. Only mist nets were used for trapping. The handling of these birds was kept as identical as possible to the handling at the Bird Observatory. The day when the bird is trapped for the first time is called day 0. Day 1 is the first day after ringing, etc.

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Results

The number of adult Goldcrests trapped at the Bird Observatory in the autumns of 1982–1985 were 280, 43, 30 and 4 respectively. Of these, 11, 3, 3 and 0 were retrapped on at least one occasion after ringing. Because of the small number of retrapped adults, only juveniles are treated in the following calculations. The number of trapped and retrapped juvenile Goldcrests and the number of days they were staying are shown in Table 1. The length of the resting period increased with increasing number of trapped individuals. In 1985 (with a total catch of only 394 birds) 95% of the resting birds had left after 5 days. The corresponding figures for 1983 (1014) and 1984 (1349) are 7 and 8 days respectively. In 1982 (4280) it took as much as 10 days before 95% of the resting Goldcrests had left the area. However, more than 50% were gone after 2 days all the years. The proportion of retraps differed significantly between years ($x2 = 160.2$, $p<0.001$, d.f.3) with the highest proportion of retraps in 1985 when only 394 juvenile Goldcrest were caught.

Table 1: Number of trapped and retrapped juvenile Goldcrests and the length of their stay in the four different autumns at Ottenby Bird Observatory.

Tab. 1: Anzahl beringter und wiedergefangener juveniler Wintergoldhähnchen und Rastdauer bei der Ottenby-Station in vier Herbstzugperioden.

Year	Trapped	Retrapped	% Retrapped	Days since ringing 1	2	3	4	5
1982	4280	297	6.9	122	47	33	23	10
1983	1014	105	10.4	52	18	15	5	5
1984	1349	87	6.4	35	22	8	8	6
1985	394	109	27.7	48	24	17	10	4

Year	Days since ringing 6	7	8	9	10	11	12	13	14	15	16	20	21
1982	11	8	18	7	4	2	3	—	3	3	2	—	1
1983	4	2	1	—	1	1	—	—	—	—	1	—	—
1984	2	—	2	2	—	1	—	—	—	—	—	1	—
1985	4	—	—	—	—	—	1	—	1	—	—	—	—

Figures 2a–d show the change in body mass of retrapped Goldcrests in four different autumns. The initial decrease in body mass of the resting birds includes on average only the first day. The decrease in body mass of the first day tends to be greater in years with a lot of trapped Goldcrests (Table 2). The initial body mass was on an average not reached until after 9.9 days in the autumn of 1982 (Fig. 2a), 3.6 days 1983 (Fig. 2b), 3.4 days 1984 (Fig. 2c) and 2.1 days 1985 (Fig. 2d). In the same way the initial fat level was on average reached after 9.2 days 1982, 2.8 days 1983, 2.9 days 1984 and 2.5 days 1985.

Body mass and fat deposits at the time of ringing were on average smaller of Goldcrests retrapped one or more days later than of birds trapped only on day 0 (females resting: body mass

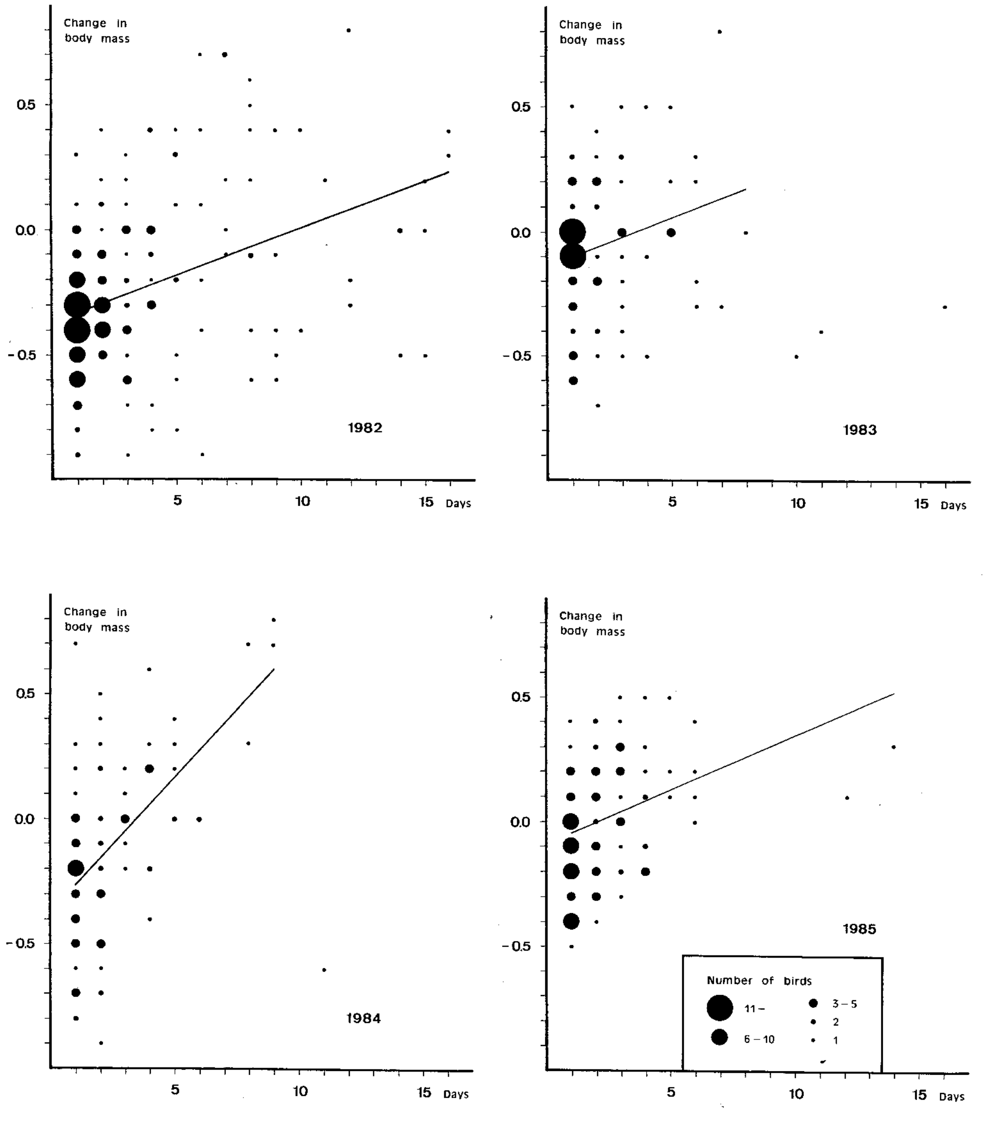

Fig. 2a–d: Changes in body mass (in grams) in the autumns 1982–1985. The Y-axis shows the change in body mass, i.e. the mass by the time of the last control minus the mass at the time of ringing. The X-axis shows the day for the last control. a) $y = 0.038x-0.37$, $r = 0.382$, $p<0.001$. b) $y = 0.039x-0.14$, $r = 0.231$, $p<0.05$. c) $y = 0.109x-0.38$, $r = 0.563$, $p<0.001$. d) $y = 0.044x-0.092$, $r = 0.349$, $p<0.001$. In the data from 1983 (b) and 1984 (c), three and one weighings, respectively, were omitted from the calculations as they clearly deviated from the general pattern (birds retrapped on days 10, 11 and 16 in 1983 and on day 11 in 1984).

Abb. 2a–d: Gewichtsänderungen bei rastenden Wintergoldhähnchen in den Herbstzugperioden 1982–1985. An der y-Achse ist die Änderung (Gewicht in g bei der letzten Kontrolle abzüglich Gewicht bei der Beringung) abzulesen. Die x-Achse zeigt den jeweils letzten Kontrolltag nach der Beringung.

Table 2: The decrease in body mass during the first day of resting.
Tab. 2: Gewichtsabnahme während des ersten Tages nach der Beringung.

Year	Mean decrease in body mass	SD	n	t-test
				$p<0.001$
1982	—0.38	0.24	73	
				$p<0.05$
1983	—0.11	0.24	46	$p<0.001$
				n. s.
1984	—0.25	0.32	35	
				$p<0.05$
1985	—0.09	0.21	46	
				$p<0.02$

5.21±0,34 g, fat 2.7±1.3, n = 242, females not resting: 5.30±0.36, 3.0±1.4, n = 2209, $p<0.001$ (t-test), males resting: 5.33±0.35, 2.6±1.2, n = 224, males not resting: 5.46±0.38, 3.0±1.4, n = 2413, $p<0.001$ (t-test).

Body mass at the time of ringing was also significantly smaller in birds trapped on "small days" (<50 trapped Goldcrests) as compared to birds trapped on "big days" (>200) (Table 3). Among resting birds only females arriving on "big days" agree with this pattern (Table 3).

Table 3: Average body mass of all juvenile Goldcrests and resting juvenile Goldcrests on the day of ringing grouped according to the number of trapped Goldcrests on day 0.
Tab. 3: Durchschnittliches Gewicht aller juvenilen bzw. der rastenden juvenilen Wintergoldhähnchen jeweils am Beringungstag, aufgegliedert nach der Anzahl der Fänglinge am „Tag 0".

Number of trapped Goldcrests	Sex	All ringed Goldcrests Mean body mass, SD, n, t-test				Resting Goldcrests Mean body mass, SD, n, t-test			
					$p<0.001$				$p<0.001$
>200	♀	5.36	0.407	546		5.44	0.401	36	
	♂	5.53	0.405	657		5.47	0.386	22	
					$p<0.001$				n. s.
					$p<0.001$				$p<0.001$
50–200	♀	5.28	0.349	1097		5.18	0.293	94	
	♂	5.45	0.363	1129		5.31	0.349	81	
					$p<0.001$				n. s
					$p<0.05$				n. s.
<50	♀	5.25	0.347	805		5.13	0.336	109	
	♂	5.39	0.378	821		5.34	0.330	120	
					$p<0.001$				n. s

Birds controlled two or three times were not found to decrease more in mass than birds controlled only once (Table 4).

The decrease in body mass during the first day of resting seems to increase with number of trapped Goldcrests (Fig. 3). The same trend was found when the birds were separated in different fat classes according to their fat level at the time of ringing, except for birds with the smallest fat reserves (Table 5).

Table 4: Mean change (standard deviation) in body mass (in grams) of juvenile Goldcrests in relation to the number of recaptures. No significant differences were found between birds with different number of recaptures (t-test).

Tab. 4: Durchschnittliche Gewichtsänderung juveniler Wintergoldhähnchen in g (Wert in Klammern = Standardabweichung), die 1×, 2× bzw. 3× wiedergefangen wurden. Es ergab sich zwischen den drei Gruppen kein signifikanter Unterschied.

Days since ringing	Number of times recaptured 1	2	3
1	—0.22 (0.28) n = 208		
2	—0.15 (0.32) n = 66	—0.09 (0.24) n = 27	
3	—0.10 (0.31) n = 30	—0.03 (0.33) n = 21	—0.04 (0.29) n = 9
4	—0.16 (0.39) n = 13	0.04 (0.35) n = 12	—0.07 (0.39) n = 10

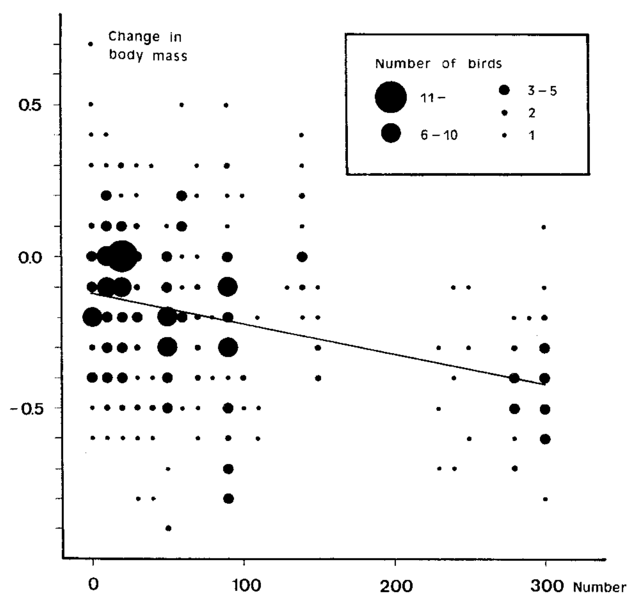

Fig. 3: The changes in body mass of Goldcrests controlled at day 1 in relation to the number of trapped Goldcrests at day 0. $y = -0.00098x - 0.12$, $r = 0.334$, $p < 0.001$.

Abb. 1: Gewichtsänderungen bei den nach einem Tag wiedergefangenen Wintergoldhähnchen in Beziehung zur Anzahl gefangener Individuen am jeweiligen „Tag 0".

Table 5: Correlations between changes in body mass of Goldcrests controlled day 1 and the number of trapped Goldcrests day 0. The birds are separated in different fat classes according to their fat level day 0.

Tab. 5: Korrelation zwischen Gewichtsänderung von „Tag 0" auf „Tag 1" und der Anzahl am „Tag 0" gefangener Wintergoldhähnchen. Die Vögel wurden nach ihrem Depotfett aufgegliedert (jeweils Befund am „Tag 0").

Fat level day 0	r	p	n
0—1	0.140	n. s.	57
2	—0.305	<0.01	94
3	—0.252	<0.05	77
4—5	—0.292	<0.01	82

The number of trapped juvenile Goldcrest at the three different "inland" localities 1982, 1983 and 1984 were 46 (14 individuals retrapped), 222 (26) and 164 (5) respectively. At the time of ringing these birds were on average 0.3 gram heavier, and one fat score unit fatter, than the birds trapped in the Bird Observatory garden during the same period (Table 6). The initial decrease in body mass found in the Bird Observatory garden (Table 2), was not so pronounced at these inland localities. Due to small samples we have pooled data from the three inland localities. Average change in body mass one day after ringing was –0.01 gram (SD = 0.18, n = 15), which differ significantly from the Bird Observatory data in 1982 and 1984 (t-test, $p<0.001$ and $p<0.01$ respectively) but not in 1983 and 1985 (t-test). Individual changes in mass of birds retrapped 1–15 October 1983 at the inland localities and in the garden, indicate that the inland localities are more favourable to rest in than is the Bird Observatory garden (Fig. 4). During this period more than twice as many Goldcrests were ringed at the inland localities as in the garden.

Table 6: Differences in mean body mass and fat score of juvenile Goldcrests at time of ringing in the garden compared with Goldcrests trapped in three different inland localities.

Tab. 6: Gewicht und Depotfett juveniler in Garten der Ottenby-Station gefangener Wintergoldhähnchen zum Zeitpunkt der Beringung im Vergleich zu Individuen, die an drei Inlandplätzen gefangen wurden.

Autumn	Sex	The inland Mean body mass, SD, n			The garden Mean body mass, SD, n			t-test
1982	♀	5.35	0.67	20	4.92	0.40	331	p<0.01
	♂	5.58	0.50	26	5.05	0.44	373	p<0.001
1983	♀	5.39	0.38	108	5.29	0.38	44	n. s.
	♂	5.54	0.38	114	5.29	0.38	57	p<0.001
1984	♀	5.18	0.38	79	4.81	0.23	310	p<0.001
	♂	5.33	0.47	85	4.99	0.44	272	p<0.001
		Mean fat, SD, n			Mean fat, SD, n			
1982	♀	4.8	1.7	20	3.6	1.2	331	p<0.01
	♂	4.8	1.0	26	3.5	1.2	373	p<0.001
1983	♀	3.8	1.6	108	2.7	1.3	44	p<0.001
	♂	3.7	1.7	114	2.5	1.2	57	p<0.001
1984	♀	4.2	1.3	79	2.4	1.5	310	p<0.001
	♂	4.3	1.2	85	2.7	1.6	272	p<0.001

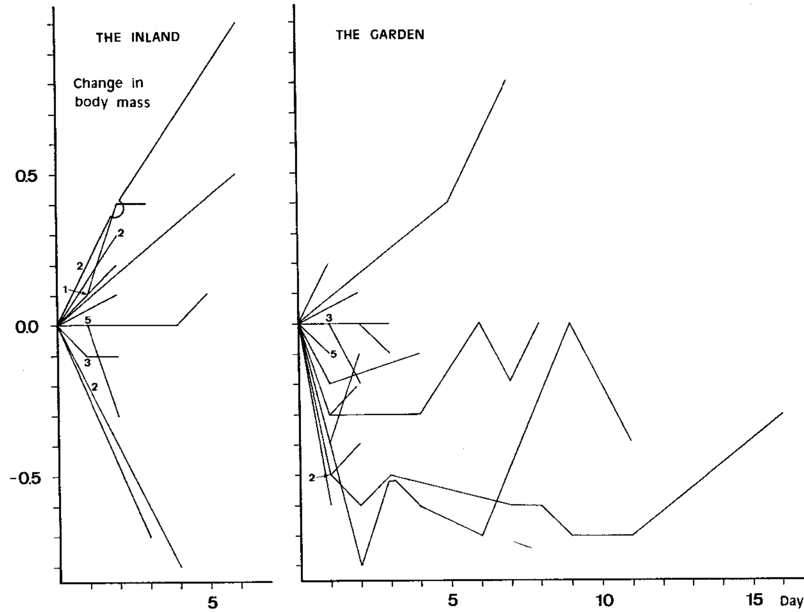

Fig. 4: Changes in body mass of retrapped Goldcrests trapped at two different localities in the period of 1–15 October 1983. To the left birds resting in the "inland" localities 1983 (Fig. 1) (n = 25). To the right birds resting in the Bird Observatory garden (n = 26). A numeral at the end of a line mark the number of birds with the same change in body mass.

Abb. 4: Gewichtsänderungen bei den vom 1.–15. Oktober 1983 im „Inland" (linke Grafik) bzw. im Garten der Ottenby-Station (rechte Grafik) wiedergefangenen Wintergoldhähnchen. Die Zahl am Ende eines Striches steht für die Anzahl der Individuen mit gleicher Gewichtsänderung.

Discussion

We will now discuss our data in relation to the hypotheses concerning initial decrease in body mass in resting birds, summarized by Clark (1979) and listed in the introduction.

Handling explanations

We argue against the handling explanations (item 6 and 7 of Clark 1979), as the initial decrease in body mass found in the Bird Observatory garden was less pronounced at the inland localities, in spite of the fact that the ringing methods used were the same (Table 2 and Fig. 4). Even if most studies show an initial decrease in mass it is strange that Cherry (1982) and Moore & Kerlinger (1987) did not, if the handling explanations would be valid.

Further, the difference in time of handling between days with big and small catches is about half an hour (absolute time one hour and half an hour, respectively). The difference in mass decrease between big and small catches is about 0.2–0.3 gram (Fig. 3), presumably all fat. We do not think the loss in time of searching food could reflect this big difference in mass. Further, we did not find a slower gain in mass in birds retrapped several times (Table 4). Meuller & Berger (1966), however, supposed the handling to be the course of the initial decrease in body mass of the Swainson's Thrushes *(Hylacichla ustulata)*. They found a faster gain in mass of birds retrapped just one time compared with birds controlled several times, but significance existed only between birds controlled one time compared with birds controlled four times.

Ecological explanations

The Bird Observatory garden constitutes an isolated area, thought to be a bad resting place. Conditions for fattening seem to be much better at the inland localities (Table 6 and Fig. 4). The initial decrease in body mass increases with larger catches of Goldcrests (Fig. 3). The number of trapped Goldcrests is assumed to reflect their density in the area. The sometimes very high density of birds causes extreme conditions in which a bird may have problems to gain in body mass. We believe that the decrease in mass of the first day to the greatest part depends on failure to locate enough food in an unsuitable und unfamiliar area in which the density of birds is uncommonly high (item 3 of CLARK 1979). The unsuitability of the area is pronounced with an increased number of Goldcrests resting at the same site.

RAPPOLE & WARNER (1976) and MEHLUM (1983b) have shown that Northern water thrushes *(Seiurus noveboracensis)* and Robins, respectively did not gain mass until they had established a territory at the stop-over site (item 4 of Clark 1979). We have no indications that Goldcrests have territories at their stop-over sites.

PETTERSSON & HASSELQUIST (1985) argued that Goldcrests normally fly for only one night at a time with intermittent stops of fast replenishing of the fuel store. With such a strategy of repeated flights and fat depositions we cannot see why Goldcrests deliberately should decrease their body masses as an adaption to prolonged stop-over periods (item 5 of CLARK 1979).

Physiological explanations

Possibly, a few individuals are unhealthy (irrespectively of their fat loads) (item 1 of CLARK 1979) but we believe the majority of resting Goldcrests to be healthy, as most of them increase their body mass after a few days of resting. Further, 44 recoveries from places outside Ottenby indicate that they leave the study area and continue their migration (LILJEFORS et al. 1985).

From our data it is hard to eliminate the need of a recovery time after completed particularly stressful flights (item 2 of CLARK 1979) as the cause of the decrease in body mass during the first day of resting. Nevertheless, we do not believe in this physiological explanation as our results show the Goldcrests trapped at the inland localities to decrease less in mass (–0.01 gram) compared with those at the Bird Observatory garden (Table 2 and Fig. 4). The birds in the different localities are believed to migrate the same distance. Thus, if this explanations would be valid, all birds would be in need of the same recovery time and show the same initial decrease in body mass. The birds studied by MOORE & KERLINGER (1987) had just crossed the Gulf of Mexico but did not show an initial decrease in mass. They had flown more than twice the distance of the Baltic Sea, which we believe to be the greatest distance Goldcrests fly before they reach Ottenby Bird Observatory. In addition, if the birds need a recovery time it remains to show the physiological reasons.

Could the relationship between the decrease in body mass during the first day of resting and the number of trapped Goldcrests on day 0 (Fig. 3) be an artifact? Birds, which are ringed on "big days" and thus do decrease much in mass, tend to be heavier at the time of ringing compared with those trapped on "small days" (Table 3). The heavy birds would accordingly have a greater potential to decrease in body mass. However, a comparison between birds with the same value of fat when ringed show that Goldcrests ringed on days with large catches decrease more in mass than those trapped on days with only small catches (Table 5).

Conclusion

Our data indicate that the initial decrease in body mass of birds arriving to a stop-over site depends on unfamiliar and unsuitable conditions at the new site, and that the situation gets worse with increased competition from conspecifics. The negative effect of a high density of birds indicates that a bird derives advantages from migrating before or after the majority of his conspecifics. However, this advantage must be put in relation to the advantages of migrating during good conditions of wheather, wind and food supply, which is generally considered to be of great importance (ALERSTAM 1982). The importance of the competition factor for the total migration is hard to estimate. Goldcrests can avoid this negative factor by avoiding exposed stop-over sites like small islands and landpoints. Possibly, the initial decrease in body mass upon resting, found in so many studies, is sometimes due to the fact that many Bird Observatories and trapping sites are situated at such exposed sites, simply because of their proneness to attract large numbers of migrating birds.

Summary

Changes in body mass and fat of resting juvenile Goldcrests *(Regulus regulus)* were studied during four autumns at Ottenby Bird Observatory in Southeast Sweden. Most of the Goldcrests that stayed for more than one day decreased in mass during the first days of resting. This initial mass decrease was more pronounced in days with large catches of Goldcrests. These data were compared with data from stop-over areas with a supposed higher food supply. We argue that the decrease in body mass during the first day is caused by competition for limited resources rather than by physiological factors or handling by ringers.

Zusammenfassung

Konkurrenz und Fettdepotbildung beim Wintergoldhähnchen *(Regulus regulus)* an einem Rastplatz

Bei Ottenby auf Öland im Südosten Schwedens wurden während vier Herbstzugperioden an rastenden juvenilen Wintergoldhähnchen die Änderungen von Körpergewicht und Depotfett untersucht. Die meisten der länger als einen Tag rastenden Individuen zeigten während der ersten Tage eine Gewichtsabnahme. Diese war an Tagen, an denen viele Wintergoldhähnchen gefangen werden konnten, besonders ausgeprägt. Die Daten werden mit den entsprechenden Werten verglichen, die an anderen – vermutlich nahrungsreicheren – Rastplätzen gewonnen wurden. Die Verf. nehmen an, daß die Gewichtsabnahme während des 1. Tages in erster Linie eine Folge von Konkurrenz um nur begrenzt vorhandene Nahrung ist und nicht auf physiologische Ursachen oder die Prozedur von Fang und Beringung zurückgeht.

References

Alerstam, T. (1982): Fågelflyttning, Signum, Lund. * Busse, P., & W. Kania (1970): Operation Baltic 1961–1967 working methods. Acta Orn. 12: 231–267. * Cherry, J.D. (1982): Fat deposition and length of stopover of migrant White-crowned sparrows. Auk 99: 725–732. * Clark, G.A., Jr. (1979): Body weight of birds: A review. Condor 81: 193–202. * Davidson, N.C. (1984): How valid are flight range estimates for waders? Ring. & Migr. 5: 49–64. * Davis, P. (1962): Robin recaptures on Fair Island. Br. Birds 55: 225–229. * Enquist, M., & J. Pettersson (1986): The timing of migration in 104 bird species at Ottenby – an analysis based on 39 years trapping data. Special report from Ottenby Bird Observatory No. 8: 1–248. (In Swedish with English summary). * Gezelius, L., & A. Hedenström (1988): The influence of wind on trapping figures of Robins *Erithacus rubecula* and Goldcrests *Regulus regulus*, at Ottenby, Sweden. Vår Fågelvärld 47: 9–14. (In Swedish with English summary). * Gladwin, T.W. (1963): Increases in the weight of *Acrocephali.* Bird Migration 2: 319–324. * Hanssen, O.J. (1981): Migratory movements of Scandinanvian Goldcrests *Regulus regulus*. Cinclus 4: 1–8. * Hjort, C., C.-G. Lindholm & J. Pettersson (1981): Bird ringing statistics at Ottenby Bird Observatory 1946–1980. Special report from Ottenby Bird Observatory No. 2: 1–191. Degerhamn. (In Swedish with English summary). * Kania, W. (1983): Preliminary remarks on the migration of North European Goldcrests *Regulus regulus.* Ornis Fennica, Suppl. 3: 29–30. * Karlsson, L. (1980): The autumn migration of the Goldcrests *Regulus regulus* at Falsterbo, South Sweden. Anser 19: 139–146. (In Swedish with English summary). * King, J.R. (1972): Adaptive periodic fat storage by birds. Proc. XV Intern. Ornith. Congr.: 200–217. * Langslow, D.R. (1976): Weights of Blackcaps on migration. Ring. & Migr. 1: 78–91. * Liljefors, M., J. Pettersson & T. Bengtsson (1985): Recruitment areas for migrants trapped at Ottenby Bird Observatory. Special report from Ottenby Bird Observatory

No. 5: 1–128. Degerhamn. (In Swedish with English summary). * Lindström, Å (1986): Fördelen med att vara fet – om fettupplagring hos flyttande fåglar. Anser 25: 173–190. * Mehlum, F. (1983a): Weight changes in migrating Robins *Erithacus rubecula* during stop-over at island of Store Faeder, Outer Oslofjord, Norway. Fauna norv. Ser. C, Cinclus 6: 57–61. * Ditto (1983b): Resting time in migrating Robin *Erithacus rubecula* at Store Faeder, Outer Oslofjord, Norway. Fauna norv. Ser. C, Cinclus 6: 62–72. * Meuller, H.C., & D.D. Berger (1966): Analyses of weight and fat variations in transient Swainsons's trushes. Bird-Banding 37: 83–112. * Moore, F., & P. Kerlinger (1987): Stopover and fat deposition by North American wood-warblers *(Parulinae)* following spring migration over the Gulf of Mexico. Oecologica 74: 47–54. * Nisbet, I.C.T., W.H. Drury & J. Baird (1963): Weight loss during migration. Bird-Banding 34: 107–159. * Odum, E.P. (1960): Premigratory hyperphagia in birds. Am. J. Clin. Nutr. 8: 621–629. * Odum, E.P., & J.D.Jr. Perkinson (1951): Relation of lipid metabolism to migration in birds seasonal variation in body lipids of the migratory White-throated Sparrow. Physiol. Zool. 24: 216–230. * Österlöf, S. (1966): Kungsfågelns *Regulus regulus* flyttning. Vår Fågelvärld 25: 49–56. (In Swedish with English summary). * Page, G., & A.C.A. Middleton (1972): Fat deposition during autumn migration in Semi-Palmated Sandpipers. Bird-Banding 43: 85–96. * Pettersson, J. (1983a): The autumn migration of the Robin *Erithacus rubecula* at Ottenby. Vår Fågelvärld 42: 333–342. (In Swedish with English summary). * Ditto (1983b): Åldersbestämning av tättingar och vadare (2 ed.). Special report from Ottenby Bird Observatory No. 1: 1–9. Degerhamn. * Ditto (1985): Ottenby fågelstation 1984. Calidris 14: 13–32. * Pettersson, J., & D. Hasselquist (1985): Fat deposition and migration capacity of Robin *Erithacus rubecula* and Goldcrest *Regulus regulus* at Ottenby, Sweden. Ring. & Migr. 6: 66–76. * Pettersson, J., A. Sandström & K. Johansson (1986): Wintering areas of migrants trapped at Ottenby Bird Observatory. Special report from Ottenby Bird Observatory No. 6: 1–276. Degerhamn. (In Swedish with English summary). * Rabøl, J., & F.D. Petersen (1973): Lengths of Resting Time in Various Night-Migrating Passerines at Hasselø, Southern Kattegat, Denmark. Ornis Scand. 4: 33–46. * Rappole, J.H., & D.C. Warner (1976): Relationships between behavior, physiology and weather in avian transients at a migration stopover site. Oecologia 26: 193–212. * Svensson, L. (1975): Identification guide to European Passerines (2 ed.). Naturhistorika riksmuseet. Stockholm. * Torre-Bueno, J.R. (1978): Evaporation cooling and water balance during flight in Birds. J. exp. Biol. 75: 231–236.

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