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Fat reserves in Dunlins *Calidris alpina* during autumn migration through Gulf of Gdańsk

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Abstract

To describe fat reserves in adult and juvenile Dunlins during autumn migration in the Gulf of Gdańsk, multiple regression equations for estimating fat mass in Dunlins were derived. The average fat level in a particular wave of migrants depends on many factors. Low amount of accumulated fat suggests that this species migrates along the southern Baltic in small steps, similarly to the rest of Europe. The interpretation of the results is difficult because at least two distinct migration routes cross the Gulf of Gdańsk region. Dunlins starting their primary moult had lower fat index than birds in advanced stages of moult. The rate of fattening in Dunlins depends on the quality of the feeding place (higher in the sewage farm than in the river estuary). Birds which stayed longer in the feeding area had, on average, lower fat mass increments than those leaving Gulf of Gdansk after a short stay. Birds with low fat mass started putting on weight immediately, whereas "fat" birds lost weight at the beginning. Those results confirmed Mascher's (1966) hypothesis about differences in body mass change rate during the first day of stay in birds with low and high fat reserves. The level of free fatty acids in the blood appears to be a factor controlling this pattern. Differences in fat accumulation between Ottenby (southern Sweden) and Gulf of Gdańsk are discussed.

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Introduction

Rapid changes in body mass have been known in migratory birds since the 19th century (for references see Mascher 1966). They put on weight before departure and loose weight during flight. It is often impossible for long distance migratory birds to cover the whole distance between the breeding and wintering grounds in one flight. They must use some refuelling sites along their route to replenish energy reserves to complete migration (Page & Middleton 1972, Davidson 1984a). Pre-migratory body mass increase is due to both fat and protein deposition (van der Meer & Piersma 1994). Fat is the main source of energy used during flight because its energetic yield is 7–8 times higher than the energetic value of wet protein (Schmidt-Nielsen 1975, Masman & Klaassen 1987).

Knowledge about fat reserves in birds is very important for migration studies. An analysis of migration phenology, biometric data, ringing recoveries and fat reserves are important for understanding the migration strategy and identifying migratory pathways of a given species or population.

The Dunlin *Calidris alpina* is the most numerous coastal wader species migrating through the Baltic region. Most of the autumn migrants belong to the nominate subspecies (Gromadzka 1989). Birds ringed in the Gulf of Gdańsk migrate in autumn mainly in W and SW directions but some have also been found migrating to the Black Sea (SE direction) (Gromadzka 1981, 1987). This suggests that at least three different groups of migrants use stop-over sites in the Gulf of Gdańsk region.

The aim of this study is to describe relationships between fat accumulation, length of stay and stage of primary moult in adult and juvenile Dunlins migrating in autumn through the Gulf of Gdańsk region.

Methods

The study areas are situated in the western part of Gulf of Gdańsk, in the Jastarnia and Rewa regions (Figure 1). In Jastarnia, walk-in traps were placed on

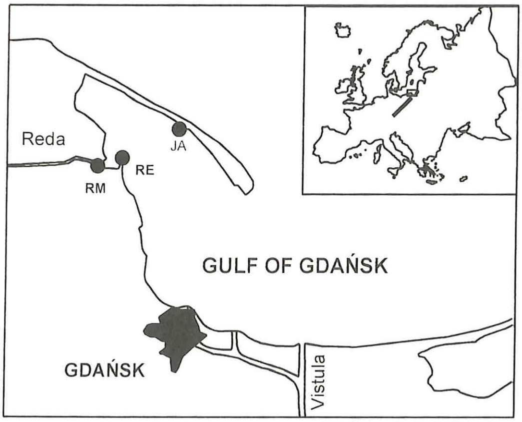


Figure 1. Western part of Gulf of Gdańsk. JA - Jastarnia, RM - Reda river mouth, RE - Rewa peninsula.

Västra delen av Gdanskbukten. JA – Jastarnia, RM – Reda flodmynning, RE – Rewahalvön.

sandy beaches, wet meadows and on the municipal sewage farm. In the Rewa region (Rewa peninsula and Reda river mouth) birds were caught in traps placed on sandy beaches, small sandy islands and on 1 km long, narrow sandy peninsula. The study areas have been described in earlier papers (WRG KULING 1985, Brewka et al. 1987, Meissner 1992, Meissner & Kozakiewicz 1992, Sikora & Meissner 1992). Each bird caught was aged in two categories: juveniles (birds in their first year of life) and adults (birds after their first year of life) (Prater et al. 1977).

Wing length (maximum chord, Evans 1986), total head length (Green 1980), bill length and nalospi length (Prater at al. 1977), and tarsus plus toe length (Piersma 1984) were measured. All measurements were taken to the nearest 1 mm using a stopped ruler. Birds were also weighed to the nearest 1 g with a Pesola spring balance and the stage of moult of the primaries was indicated (Ashmole 1962). Data from 15467 Dunlins ringed in the period 1983-1990 were used. In addition, weight data from some 4025 Dunlins caught at least twice in the same season and place (retraps) were used for calculation of fat mass changes.

In Jastarnia, birds were counted every day between 15 July and 30 September in 1994–1989. Results of the counts as well as daily numbers of trapped Dunlins were gathered in five-day periods (Berthold 1973) and used to determine particular waves of the migrants. Division of the migration period into waves was made separately for each year, because both the timing and duration of each wave were variable in different years (Figure 2). The pentad in which the number of Dunlins reached a distinct minimum between two migration peaks was considered as a border pentad between two subsequent migration waves. Separation of waves was more difficult and more subjective for juveniles than for adults, probably because the migration of juveniles is much slower than in adults (Mascher 1966, Brenning 1987, Gromadzka 1987).

The use of walk-in-traps makes estimation of the period of time spent in the trap by a particular bird,

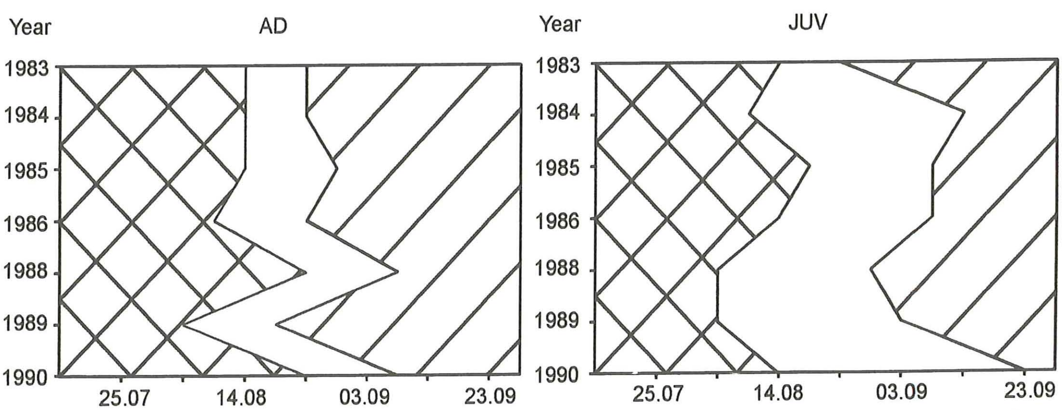


Figure 2. Variation of timing of appearance of subsequent waves of migrating Dunlins in different years. Crosshatched area – first wave, white – second wave, hatched area – third wave. No data available for 1987.

Variation av flyttningsvågor hos kärrsnäppor mellan år. Kryssmarkerat – första vågen, omarkerat – andra vågen, streckat – tredje vågen. Inga data insamlades 1987.

and hence recalculation of its original body mass difficult or impossible. Birds can sleep, feed or search for the exit when trapped, each behaviour involving a different energy expenditure. Dunlins remained in captivity for 0.5 - 3 hours. Decreases of body mass during that time were calculated by Davidson (1984b) to 0.5-2.8 g. Average time between capture and release was estimated to be 1.5 hour and mass change in that time was 1.5% of body mass, according to OAG Münster (1976), Lloyd et al. (1979), Pienkowski et al. (1979), Goede & Nieboer (1983) and Davidson (1984b). Consequently, in this study the measured body mass of each bird was corrected by 1.5%.

In order to describe amount of fat reserves in relation to moult of primaries, birds were divided into 12 groups (class width = 5, except the class with moult scores 45–49) according to primary score, score 0 (all old primaries) and 50 (all new primaries) being treated as separate classes.

For laboratory analyses, 30 adult and 32 juvenile Dunlins were collected from different migration waves (permission from Ministry of Environment Protection and Natural Resources). Some of these birds were killed accidentally during catching. Carcasses were weighed, measured and frozen. After thawing they were cut into small portions and dried in an oven at 70-80°C to constant dry mass. In 10 accidentally killed birds time between the death and weighing was impossible to ascertain, but in any case it did not exceed 12 hours. The evaporative water loss during that time was probably the main reason for large variation in water percentage among the analysed specimens. Thus, original body mass values were corrected assuming a mean water content of 70% (see Piersma & Brederode 1990 for further explanation). The fat extraction was carried out in a Soxhlet apparatus using petroleum ether as solvent. Fat mass was obtained by subtracting fat-free dry mass (dry mass without extracted fat) from dry mass.

To estimate fat mass (in grams) multiple regression equations were derived based on body mass and linear morphological measurements. Amount of fat is expressed as either a lipid index (percent of fat in relation to total body mass) or fat mass (in grams). Statistical analyses were carried out according to Sokal & Rohlf (1981). For estimating mean length of stay of Dunlins median value was used instead of average, because data revealed extremely skewed distribution. Median was calculated according to Zar (1996).

Results

Fat mass in live birds

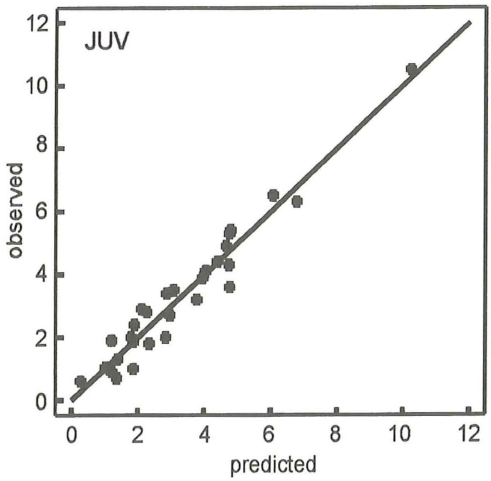
Multiple regression equations for adults and juveniles are presented in Table 1. In both cases I did not use the models with the highest R^2 value (involving wing length) because the outermost primary in adults was often worn and wing length of many adults had not been measured in the field. For juveniles, the equation with the same independent variables was

Table 1. Multiple regression functions for estimating fat mass in the Dunlin. The models used for calculating fat mass in caught Dunlins are indicated by an asterisk.

Multipla regressionsekvationer för uppskattning av fettvikt hos kärrsnäppa. Modellerna som användes för att beräkna fettmassan hos fångade kärrsnäppor har markerats med en asterisk.

	Models	R^2
Juveniles	FM = 0.51 BM - 0.15 WL - 0.20 TH + 17.13	0.957
Ungfåglar	FM = 0.49 BM - 0.27 TH - 4.94	0.946
N=32	FM = 0.48 BM - 0.28 BL - 10.80 *	0.936
	FM = 0.53 BM - 0.28 WL + 11.41	0.923
Adults	FM = 0.57 BM - 0.14 WL - 0.21 BI + 0.40	0.950
Gamla fåglar	FM = 0.56 BM - 0.32 BL - 12.13 *	0.931
N=30	FM = 0.56 BM - 0.22 WL + 3.98	0.930
	FM = 0.54 BM - 0.24 TH - 8.22	0.922

FM = Fat mass *Fettmassa*, BM = Total body mass *Total kroppsmassa*, WL = Wing length *Vinglängd*, BL = Bill length *Näbblängd*, TH = Total head length *Total huvudlängd*.



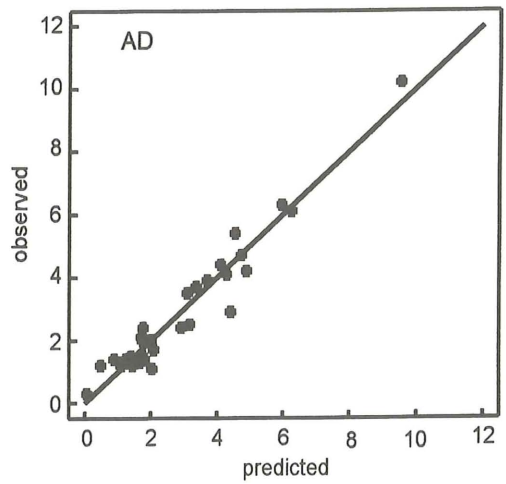


Figure 3. Correspondence between observed (measured) and estimated (based on regression equations) values of fat mass (in grams) in Dunlins. The straight line is y=x line.

Sambandet mellan observera och uppskattad (från regressionsanalys) fettvikt (g) hos kärrsnäppor. Linjen visar sambandet y=x.

chosen as in adults. Observed and predicted values were within a band about 2.5 g wide running along the y = x axis (Figure 3).

Application of the derived equations for Dunlins caught during the fieldwork, showed that in some birds the estimated fat mass was less than zero. Percentage of birds with negative fat index varied among the seasons from 0.2% to 7.7% in adults and from 3.4% to 14.4% in juveniles. The lowest value was -12.0%. The average value for birds from the Rewa region was -2.1% and from Jastarnia -1.8%.

Fat reserves in Dunlins from different migrating waves

Dunlins caught in Jastarnia had significantly more fat reserves than birds from the Rewa region (t-test, $p<0.001$). In both areas adults carried more fat than juveniles (t-test, $p<0.001$). These differences remain at the same significant level even in case of retraps at the first capture.

In both places, juveniles trapped during the second migration wave were the fattest (only few birds were caught in the first wave) (Figure 4). The only exception was noted in 1990 at Rewa, when juveniles migrating in the third wave had significantly higher fat index than in the second wave. On average adults had significantly higher mean fat indices in the third wave at Jastarnia and in the second and third waves in the Rewa region than in earlier waves. However, in some years differences in average fat index between birds migrating in each wave could be quite different. For example in 1996 adults migrating in the third wave had lower fat index than those migrating earlier on, whereas in 1990 the lowest average fat index was found in the second wave and the fattest birds were caught in the third wave.

Fat reserves in adult Dunlins in different stages of the primaries moult

About 50% of adult birds trapped in the region of Gulf of Gdańsk moult their primaries during autumn migration (Gromadzka 1986). Data from birds retrapped in the Rewa region show that many are in active moult (unpublished data), as occurs on the Swedish coast (Holmgren et al. 1993). Only 3.8% of all Dunlins moulting primaries caught in the study area showed suspended moult.

In the Rewa region, the group with moult score 26-30 had significantly higher fat index than birds from groups with moult scores from 0 to 25 and 46-49. Dunlins which had already finished primary moult carried more fat than individuals with moult scores 1-15 and 46-49. Moreover, the Dunlins whith moult scores 41-45 had higher average fat index than birds with moult scores 1 – 5. At Jastarnia significant differences occurred between birds that had not started moult and birds that had finished primary

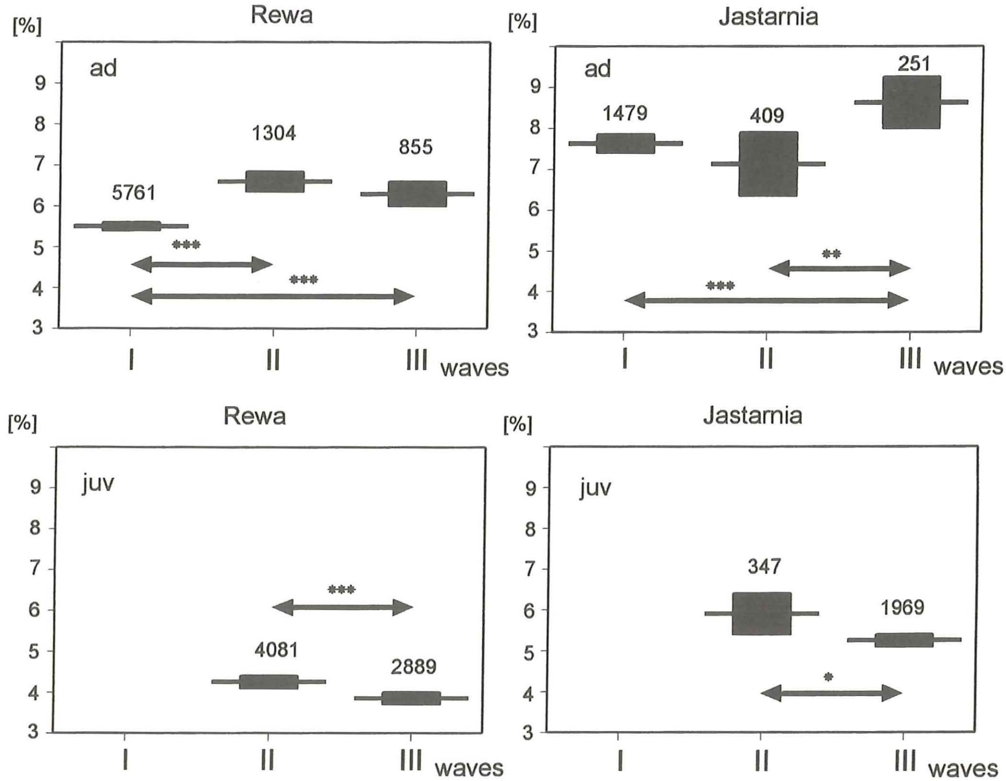


Figure 4. Mean fat index in adult and juvenile Dunlins migrating in subsequent waves in two study sites. Horizontal line - mean value, rectangle height - 95% confidence intervals for mean. Numbers indicate sample size. Horizontal arrows mark significant differences between migrating waves (ANOVA, Tukey test). *** $p<0.001$, ** $p<0.005$, * $p<0.05$.

*Genomsnittliga fettindex hos adulta och juvenila kärrsnäppor från olika flyttningsvågor vid två lokaler. Horisontell linje – medelvärden, rektangelns höjd – 95% konfidensintervall. Siffror markerar stickprovsstorlek. Pilar markerar signifikanta skillnader mellan flyttningsvågor. *** p<0.001, ** p<0.005, * p<0.05.*

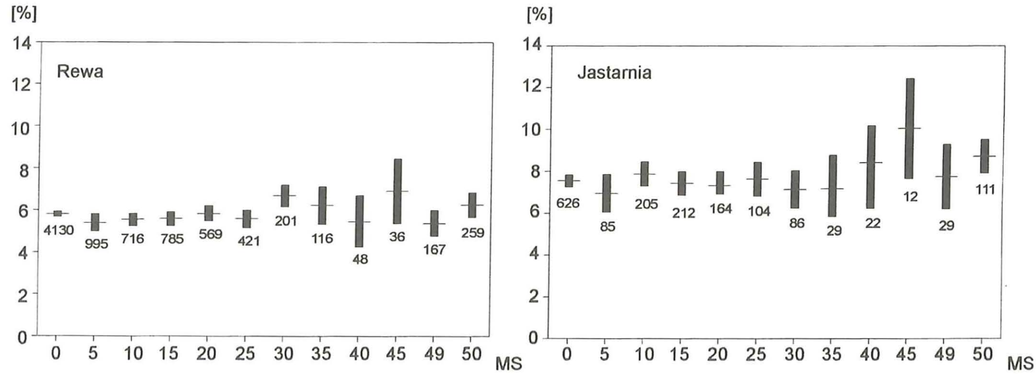


Figure 5. Mean fat index in adult Dunlins in different moult stages caught in the Rewa region and in Jastarnia. Horizontal line - mean value, rectangle height - 95% confidence intervals for mean. Numbers indicate sample size.

Genomsnittliga fettindex hos adulta kärrsnäppor I relation till ruggningsstadium vid Rewa och Jastarnia. Horisontell linje – medelvärde, rektangelhöjd – 95% konfidensintervall. Antal indikerar stickprovsstorlek.

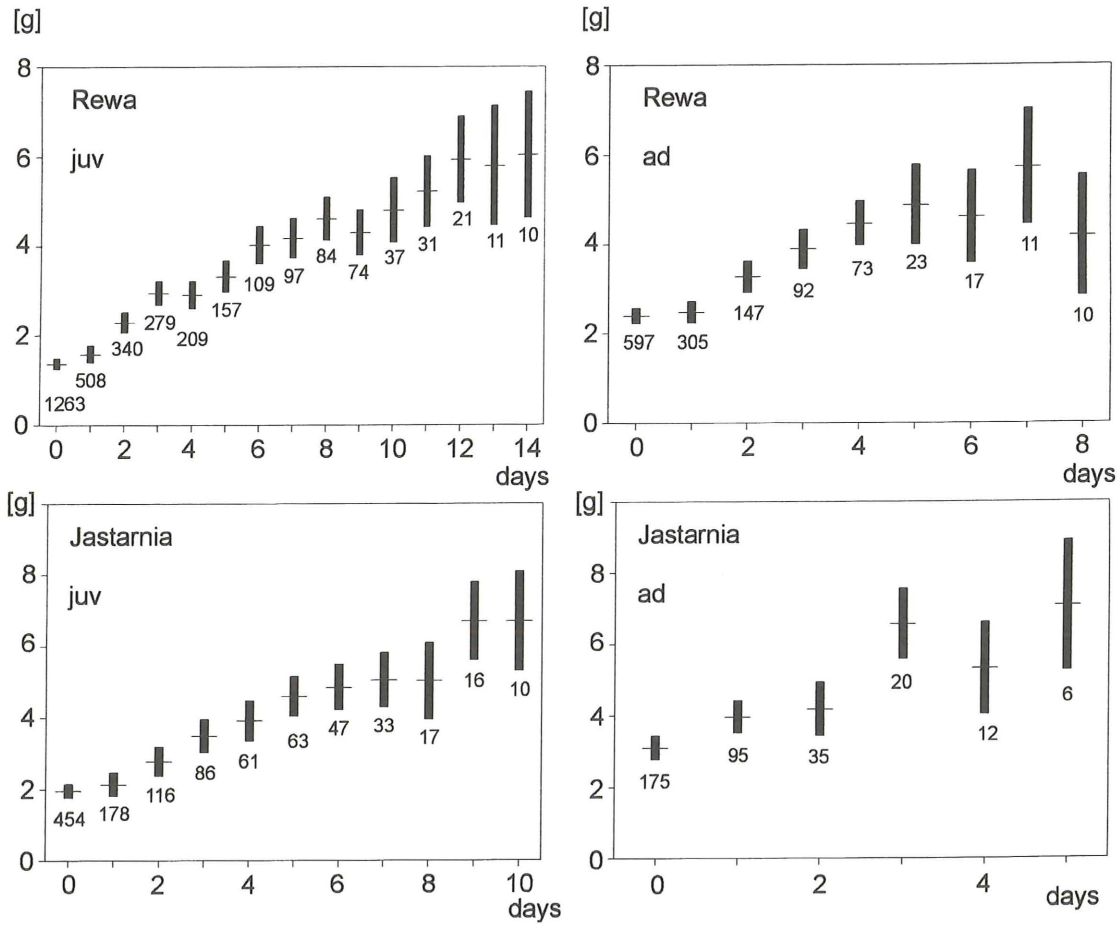


Figure 6. Mean fat mass in birds caught more than once. 0 - day of first capture. Horizontal line - mean value, rectangle height - 95% confidence intervals for mean. Numbers indicate sample size.

Genomsnittliga fetvikter hos fåglar som fångats mer än en gång. 0 – dag för förstafångst. Horisontell linje – medelvärde, rektangelhöjd – 95% konfidensintervall. Antal indikerar stickprovsstorlek

moult (Figure 5). Dunlins with moult score 50 carried more fat than those with moult score 0.

Fat mass changes in Dunlins

Mean fat mass increased only slightly in birds retrapped after one day (Figure 6). Some birds even lost their weight during the first day, which affected the mean value of mass change. In the second and third day of staying increase of fat mass became more prominent.

Dunlins caught in the Rewa region at least twice were divided into subgroups according to their length of stay. In adults, two groups were distinguished: birds staying up to four days and those staying more than four days. In juveniles there were three groups distinguished: birds staying up to four days, staying five to eight days and more than eight days. Figure 7 shows the estimated fat mass changes in those groups during their stay in Rewa. Birds stopping on the study area for a shorter time had more fat at arrival than those staying longer. In adults the difference was not significant, but in juveniles the differences between all groups were statistically significant (t-test, $p<0.05$). In all groups of adults and juveniles the average fat mass increment during the first day after catching was small.

Dunlins caught in the Rewa region were divided into lean birds (less than 2 g of fat) and fat ones (more than 2 g of fat) for comparison of length of stay

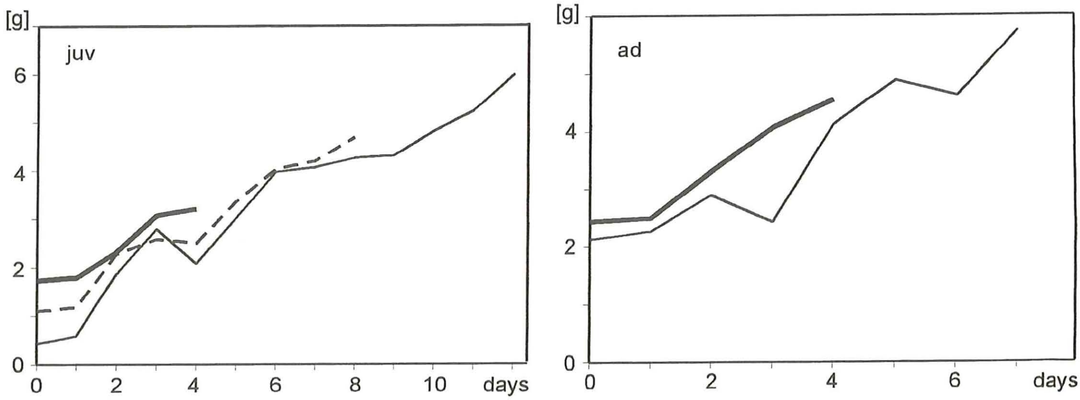


Figure 7. Comparison of fat mass changes in adult and juvenile Dunlins staying in Rewa region for different number of days. In adults: thick line - birds stayed up to 4 days, thin line birds stayed over 4 days. In juveniles: thick line - birds stayed up to 4 days, dashed line – birds stayed at least 5, but no more than 8 days, thin line - birds stayed over 8 days. All sample sizes more than 10 birds.

Jämförelse av fettviktsvariationer hos adulta och juvenila kärrsnäppor I relation till rasttid vid Rewa. Adulta fåglar: tjock linje – rasttid upp till 4 dagar, strckad linje – rasttid minst 5–8 dagar, tunn linje – rasttid längre än 8 dagar. Alla medelvärden baseras på minst 10 individer.

(Table 2). Generally, the leaner the bird, the longer it stayed in the study area, both in juveniles (t-test, $p<0.001$) and in adults (t-test, $p<0.05$).

In general, Dunlins with higher fat reserves stayed in the study area for shorter period (Table 2). It is possible that those birds reach adequate fat level faster because they start to store fat reserves from higher initial levels than lean birds. To examine this a rate of fat mass increment during the first three days after catching in groups of birds staying for different lengths of time on the staging grounds was calculated (Table 3). It occurred that birds which had lost fat mass during the first day after catching showed higher fat mass at the first capture than the birds putting on the fat mass from the beginning (Table 4). The same conclusion was drawn by Mascher (1966). Birds with low fat reserves stay longer in the feeding area and they do not lose their weight during the first day after capture. Fatty Dunlins, on the other hand, lose weight at the beginning and stay shorter.

Certainly not all Dunlins were trapped just after their arrival and some of them could have been caught after initial weight loss had already occurred. Such specimens could be included in the group of birds that do not lose their weight. Nevertheless, the difference between both groups was significant (Table 4).

Table 2. Median time of stay of Dunlins with different fat mass at first capture. Sample sizes are given in brackets (see text for explanation).

Median av rasttid hos kärrsnäppor med olika vikt vid första fångsttillfället. Stickprovsstorlek anges inom parentes (se text för förklaring)

Fat mass *Fettmassa*	Juveniles *Ungfåglar*	Adults *Gamla fåglar*
less than 2 g *mindre än 2 g*	4.2 (833)	1.7 (279)
over 2 g *över 2 g*	3.0 (413)	1.5 (297)

Discussion

Bill length in Dunlins is often found to be the best linear measurement correlated with lean body mass (Davidson 1983, Goede & Nieboer 1983, Piersma & Brederode 1990), and the same result was found in this study for adult birds. For juveniles, however, the total head length seems to be a better estimator of fat free weight. The bill, especially its horny part, is still growing in birds during their first autumn (Szulc-Olechowa 1964, Nitecki & Zamajska 1979, Holland & Yalden 1991), which may confound the relationship.

Table 3. Comparison of fat mass increase on the third day after first capture in Dunlins remaining different number of days in Rewa region. Sample sizes are given in brackets. Significance levels refer to t-test.

Jämförelser av fettviktsökningar på dag tre efter förstafångst hos kärrsnäppor med olika långa rasttider vid Rewa. Stickprovsstorlek inom parentes. Signifikansnåvåer avser t-test.

	Juveniles			Adults	
Number of days *Antal dagar*	up to 4 *upp till 4*	5 - 8	over 8 *över 8*	up to 4 *upp till 4*	over 4 *över 4*
Rate *Takt*	1.74	1.09	0.42	1.76	0.71
(g/day) *(g/dag)*	(747)	(332)	(185)	(82)	(10)
Significance	—— $p<0.001$ ——			—— $p<0.05$ ——	
Signifikans		—— $p<0.001$ ——			

The multiple regression equation for estimating fat mass from total body mass and wing length derived for juvenile Dunlins in this study (Table 1) had a similar slope, but higher intercept, as that given by Mascher & Marcström (1976). Mascher & Marcström however used a mixture of ethanol and ether as the solvent during carcass analysis. Presence of ethanol results in lipo-protein complexes being included in the extracts. Such components can not be used as fuel and normally remain in the organism even after starvation (Davidson & Evans 1982). This procedure results in higher fat values in Mascher & Marcström's study compared to this study.

A negative value of estimated fat mass means that the bird has a deficit of body mass in relation to its body dimensions, or the body size (bill length in this case) is larger than expected for its mass. Similar results were found for Semipalmated Sandpipers *Calidris pusilla* (Page & Middleton 1972), for Knot *Calidris canutus* in autumn in the Gulf of Gdansk region (Meissner 1992) and during spring migration in central France (Piersma et al. 1992). Such a situation may occur when fat reserves have been exhausted and catabolism of other nutritional reserves such as proteins has started. This may happen after a long flight from breeding grounds or previous stop-over sites. Such a situation has been described by Davidson & Evans (1989) for the Knot and by Piersma & Jukema (1990) for the Bar-tailed Godwit *Limosa lapponica*. Some areas along a flyway could be important as "emergency feeding places", which are used by birds with insufficient fat reserves. Departing flocks may stimulate birds with insufficient fat levels to undertake migration (Dolnik &

Table 4. Mean fat mass at first capture in Dunlins losing and increasing their weight during the first day after first capture (t-test). Sample sizes (N) and standard deviations (SD) are given.

Fettvikter vid första fångsttillfället hos kärrsnäppor som förlorar respektive ökar i vikt den första dagen efter fångst. Stickprovsstorlek (N) och standardavvikelse (SD) anges.

	Juveniles *Ungfåglar*		Adults *Gamla fåglar*	
	Fat mass *Fettmassa*	Significance	Fat mass *Fettmassa*	Significance
Loosing weight *Förlorar i vikt*	2.36		3.05	
SD	1.80		2.12	
N	147		111	
		$p<0.001$		$p<0.001$
Increasing weight *Ökar i vikt*	0.92		1.94	
SD	0.11		1.02	
N	324		194	

Blyumenthal 1967, Dolnik 1975). Such birds may then be forced to interrupt their migration because they initiated migratory flight with inadequate reserves, or because poor weather conditions lead to exhaustion of reserves. The Gulf of Gdańsk appears to be such a place for the Knot (Gromadzka 1992, Meissner 1992, Piersma et al. 1992), and it is possible that a similar situation occurs (at least partly) also in the Dunlin. In this case the percentage of birds with negative fat indices would be expected to vary from year to year because it depends on several external factors such as weather conditions during flight and feeding conditions at previous stopovers, as observed in the present study.

On the other hand, the regression equations are based on samples of about 30 specimens only, and these have been used to calculate fat mass for samples of thousands of caught birds. The range of bill length in Dunlins caught in the Gulf of Gdańsk region reaches 24 mm (own unpublished data) and large variations in lean mass are known to occur at different times of the year, some being associated with physiological changes and temperature (Dolnik 1975, Davidson et al. 1986, Driedzic et al. 1993). Hence negative values of estimated fat mass could be to some extent a statistical artefact, because a much wider range of lean body mass is likely to be found in the larger samples of caught birds.

In the Gulf of Gdańsk region, adult Dunlins migrate in three waves. Females dominate in the first wave and males in the second one (Zajac 1980). In September only small numbers of adults occur and those birds were grouped in the third wave. Juveniles also migrate in three waves. In July only a few of them are caught. Those juveniles belong to local breeding population of *Calidris alpina schinzi*, and the majority of them leaves Gulf of Gdańsk in June or July (Król 1985). This group of juveniles was included in the first wave. The remaining juveniles migrate in two distinct waves with peak numbers in mid-September.

Similar to conditions in Sweden (Mascher 1966, Mascher & Marcström 1976), southern France (Fuchs 1973) and north-west Africa (Pienkowski & Dick 1975), Dunlins migrating in the Gulf of Gdańsk region in autumn put on only a moderate amount of fat. Low amount of accumulated fat and distribution of recoveries (Gromadzka 1983, 1989) suggest that this species migrates along the southern Baltic coast, as well as through the rest of Europe in small steps. In spring Dunlins appear to be preparing for longer flights (Pienkowski et al. 1979, Goede at al. 1990).

Both adults and juveniles from Jastarnia had significantly larger fat depots than birds from the Rewa region even at the first capture. In addition, the average fat level in successive waves of migrants varied between the years. These facts are difficult to explain, but could result from a difference in the proportions of birds using different migration routes at the two sites. At least three distinct migration routes cross each other in the Gulf of Gdańsk region. One leads along the southern Baltic coast to western Europe. The second and the third lead over inland routes to the Black Sea and to the Mediterranean (Gromadzka 1981, 1987). Birds migrating along all those routes are present in the study area in each wave (own unpublished data). The average fat level in a particular wave may depend on the intensity of immigration from neighbouring feeding areas, length of stay and turnover rate (arrival of lean birds and departure of fat ones). The weather conditions along the migration route before the Dunlins' arrival in the Gulf of Gdańsk have also important influence on energy expenditure during the flight and could affect body condition of the birds.

Birds in active primary moult have a higher energy expenditure than non-moulters owing to the additional energy needed to build new feathers (Lindström et al. 1993). Moreover, the gap in the wing make flight less efficient. Dunlins starting their primary moult had lower fat index than birds in advanced stages of moult. This is in agreement with other findings (Owen & Krohn 1973, Goede & Nieboer 1983, Barter 1984). Birds have the largest gap in the wing when primary moult scores are 1-25, because a number of primaries are growing simultaneously. Rather small variation in lipid indices throughout moult indicates that moult has in overall only a small influence on fat content in migrating Dunlins. Similar results were obtained by Holmgren et al. (1993) in southern Sweden. It suggests that gaps in the wing are of low aerodynamic cost (cf. Hedenström & Sunada 1999).

Small increment, or even a slight decrease in body mass during the first day after capture has been described by Mascher (1966), Page & Middleton (1972), OAG Münster (1976, 1983), but different explanations have been given. Mascher (1966) suggests that this is a natural phenomenon which always takes place soon after arrival of the birds on new staging grounds. Birds which do not lose their weight during the first day after first capture could have been present in the study area for some days and had already passed the initial stage of weight loss. However, birds with very low weight could put on weight during the first day. Other authors suggest that a body mass decrease soon after capture is caused by stress resulting from being caught and handled (Mueller & Berger 1966, Ens et al. 1990, Piersma & Jukema 1990). However, why does this stress take place only after the first capture and not after the second and third ones? Studies in the Gulf of Gdańsk confirmed Mascher's (1966) hypothesis about different mass change rate during the first day after arrival in birds with low and high fat reserves. Mascher (1966) wrote: birds which arrived with well preserved fat stores were still in a "migratory mood" which causes them to waste much more time and energy on "migratory unrest activities". Free fatty acid levels in blood could be a controlling mechanism of this phenomenon. According to Dolnik (1975), low levels of free fatty acids in the blood cause increasing food demand, whereas high levels stimulate migratory activities. Low levels of fatty acids occur in birds which have depleted their fat reserves and such birds start to feed intensively just after arrival. Birds with high free fatty acid levels feed less intensively and spend a lot of time on "migratory" restless activities and have a negative energetic budget, which causes body mass decrease during the first days after arrival on the feeding grounds (Mascher 1966).

It is worth noticing that Dunlins caught at Ottenby (220 km to the north of Gulf of Gdańsk) did not show a correlation between body mass at ringing and stopover length (Holmgren et al. 1993). Probably Dunlins which are ready to cross the Baltic (Ottenby), show a different departure strategy than those preparing to fly along the southern Baltic coast or over inland (Gulf of Gdańsk). Holmgren et al. (1993) suggest that unpredictable weather conditions may force migrants to wait at staging areas and that this is why the stopover length would appear to be random. Consequently, body mass at ringing would be a poor predictor of stopover length at places such as Ottenby. However, between 15 June and 30 September (main migration period of Dunlins) strong winds, which would make the flight along any of the three main migration routes impossible, rarely occur at the southern Baltic (Remisiewicz 1996). It is worth to notice that in central Sweden length of stay in Dunlins showed the same dependence on fat level as in the Gulf of Gdańsk (Mascher 1966). A similar situation was described by Dunn et al. (1988) for Semipalmated sandpipers during autumn migration in the North America. Fat level had an influence on length of stay in this species only at coastal staging areas, where birds stopped before long transoceanic flights. There was no such relationship at inland resting places.

The fact that birds accumulate heavy fat loads before flight over ecological barriers is well known. It is considered as a risk insurance in case of unpredictable weather conditions during the flight or at the destination. The Baltic is not a vast barrier, but during the flight over it birds cannot land and rest. It could be a reason of higher average body mass in Dunlins at Ottenby (Holmgren et al. 1993) in comparison to birds at the Gulf of Gdańsk (this study) or to central Sweden (Masher 1966).

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Sammanfattning

Fettreserver hos höstflyttande kärrsnäppor Calidris alpina *vid Gdanskbukten, Polen*

Under flyttningen förekommer stora viktvariationer hos fåglar genom att stora fettreserver lagras som flygbränsle inför långa flygetapper. Under flygningen förbrukas fettet (samt även en del protein) och fågeln är normalt lättare då den landar än då den startade. Genom att studera fåglars viktvariationer på rastplatser kan man nå en ökad förståelse om deras flyttningsstrategier. Kärrsnäppan *Calidris alpina* är den talrikaste småvadaren under flyttningen genom Östersjöområdet. I föreliggande uppsats analyseras data om fettupplagring, ruggning och rasttid hos kärrsnäppor i området kring Gdansk.

Kärrsnäppor fångades vid två lokaler, Jastarnia och Rewa (Figur 1). Fåglarna åldersbestämdes till juveniler (första kalenderår) eller adulter (andra kalenderår eller äldre). Följande biometriska uppgifter togs: vinglängd med 1 mm noggrannhet, avståndet från näbbspets till nacke togs med skjutmått ("total huvudlängd"), näbblängd, tars plus tålängd samt vikt (g). Dessutom togs uppgifter om ruggning av vingpennorna enligt gängse metod där gammal fjäder ges 0 poäng, just tappad eller "pigg" ges 1 poäng och ny fjäder ges 5 poäng. Totalt ringmärktes 15467 kärrsnäppor under perioden 1983–1990 och 4025 individer fångades minst två gånger samma säsong. Vid Jastarnia räknades kärrsnäppor dagligen 15 juli–30 september åren 1994–1989. Fångstmaterialet delades upp i distinkta "flyttningsvågor" (Figur 2). I genomsnitt dröjde det ca 1 timma och 30 minuter från det att en fågel fångades tills det att den ringmärktes och mättes, varför vikterna korrigerades uppåt med 1.5%. För att analysera ruggningsstadiets eventuella inverkan på fettreserverna delades fåglarna in i 12 ruggningsklasser m a p ruggningspoäng. För laboratorieanalyser av kroppssammansättning samlades 30 adulta och 32 juvenila kärrsnäppor in. Kropparna torkades till konstant vikt i ugn vid 70–80°C. Fett extraherades i en Soxhlet-apparat med petroleumeter som lösningsmedel. Dessa data användes för att beräkna samband mellan fettvikt, levande vikt och morfologi (Tabell 1), och dessa samband användes sedan för att uppskatta fettvikt hos de ringmärkta fåglarna.

Resultatet från regressionsanalyserna av fettvikt i relation till morfologi visas i Tabell 1 och Figur 3. Dessa ekvationer användes för att uppsakatta fettvikter hos de fångade fåglarna. Kärrsnäppor vid Jastarnia hade signifikant mer fett än de vid Reva. På båda lokalerna var juvenilerna fetast under den andra flyttningsvågen (Figur 4), med undantag av 1990 då fåglarna från den tredje flyttningsvågen var fetast. I genomsnitt hade adulta kärrsnäppor högre fettindex under andra och tredje flyttningsvågorna jämfört med den första, men avsteg från dettat generella mönster förekom enstaka år.

Många fåglar var i aktiv ruggning då de fångades och endast 3,8% hade uppskjuten ruggning. Fettindex ökade något i relation till ruggningsstadium (Figur 5), men variationen var ganska liten vilket tyder på att kostnaden av att ha en lucka i vingen till följd av av ruggning är ganska blygsam. Återfångade fåglar ökade i fettindex i relation till rastningens längd (Figur 6), med låg ökning eller t o m en minskning det första dygnet. Detta stämmer med vad många andra rastningsstudier visat. Ju lägre fetthalt vid första fångsttillfället desto längre tid rastade fåglarna (Figur 7, Tabell 2). Tabell 3 visar variationer i fettupplagringshastighet hos fåglar med olika långa rasttider. Kärrsnäppor som minskade i fettindex första dagen hade initialt högre fettindex än de som ökade i fettindex direkt efter första fångsttillfället (Tabell 4), vilket överensstämde med tidigare studier i Sverige. Generellt hade kärrsnäpporna förhållandevis låga fetthalter, vilket antyder att de flyttar med korta etapper under höstflyttningen genom södra Östersjöområdet.