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Biometrics of Turnstone *Arenaria interpres* migrating in autumn through the Gulf of Gdańsk region

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Abstract

In this study we analyse biometrical data of 69 adult and 389 juvenile Turnstones *Arenaria interpres* caught during autumn migration when passing through the Gulf of Gdańsk in the period 1983–1999. Adults had significantly longer wings than juveniles. Mean values of other measurements did not differ significantly between the age classes. Adults migrating early were larger than those passing the study area later. These earlier and larger migrants are regarded as females, which leave nesting areas before the somewhat smaller males. Data obtained from 67 juvenile Turnstones caught at least twice in the same season showed that juvenile Turnstones may have more than one migration strategy when departing from the Gulf of Gdańsk. Some of them behave as energy minimising migrants and migrate with low fat reserves in small steps. The others stay longer, build up large energy reserves (up to 50% of their initial body mass) and are probably able to reach West Africa in one flight.

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Introduction

The Turnstone *Arenaria interpres* is a regular migrant along the southern Baltic coast. This species migrates in small flocks and the annual number of ringed birds and the ringing recovery rate are low (Brenning 1986, Gromadzka 1998, Meissner & Remisiewicz 1998, Stolt et al. 2000). Moreover, data on biometrics and body mass changes at Baltic stopover sites have not yet been published. An analysis of ringing recoveries showed that the majority of Turnstones passing through the southern Baltic originates from Fennoscandia (Meissner & Koziróg 2000). Negligible ringing activity in northern Russia makes presumptions about the eastern range of birds appearing in the Baltic area very speculative. It has recently been stated that the borders between breeding and wintering areas of different populations are not so clear as had been suggested (Underhill et al. 1999, Meissner & Koziróg 2000). Birds that stop in the Gulf of Gdańsk depart in two directions. Probably the majority of them follow the southern Baltic and North Sea coasts, but some of them head directly south to the Mediterranean (Meissner & Koziróg 2000). Low number of Turnstones at inland stopover sites (Harengerd et al. 1973, Tomiałojć 1990) suggests that these birds cover that distance in one flight.

The main aims of this study are to describe the biometrics and migration strategies of Turnstones migrating through the Gulf of Gdańsk and to asses the ability of birds to reach wintering sites in one flight.

Material and methods

Birds were caught between 1983 and 1999 in walk-in traps (Meissner 1998a) placed at three sites: at Jastarnia (54°42'N, 18°40'E), in the Reda river mouth (54°39'N, 18°30'E) and at Rewa (54°38'N, 18°31'E) (Meissner & Remisiewicz 1998). Every year the fieldwork started in mid-July and finished in the end of September. This period covered almost the whole Turnstone migration period (Meissner & Koziróg 2000).

Each caught bird was aged following Prater et al. (1977). Measurements were taken as described by different authors; wing length (Evans 1986), total head length (Green 1980), bill length (Prater et al. 1977), tarsus length (Svensson 1992) and tarsus plus toe length (Piersma 1984). Before 1991, total head length and bill length were measured to the nearest 1 mm with stopped ruler, later on with callipers to the nearest 0.1 mm. To combine less and more precise measurements, the latter were rounded to the nearest 1 mm. Birds were also weighed to the nearest 1 g. Every year the accuracy and the repeatability of measurements taken by different ringers were checked as described by Busse (1984). In total, 69 adults and 389 juveniles were measured between 1983 and 1998. Body mass data from 67 juvenile Turnstones caught at least twice in the same season (retraps) were used to calculate body mass changes during the birds' stay. The mean accumulation rate of energetic reserves was calculated for the third day after the first capture, when the increase of body mass became more prominent and the sample size was still sufficient. The same approach was applied in a previous study on Dunlin (Meissner 1998b). For assessing the theoretical flight range of birds, the equation derived by Pennycuick (1975) was used. This formula is quite robust, because it does not take into account the fact that waders often migrate in flight formations, which leads to decrease of flight costs (Hummel 1983). Moreover, improved body-drag coefficient recommended by Pennycuick et al. (1996) results in increasing the distance that a bird can fly with a given fuel mass. Thus, the obtained results should be treated as a minimum possible distance, which could be covered with given fat reserves in still air conditions. Such calculations require assumptions regarding the body mass at the beginning and at the end of the flight. For this analysis, the final body mass of 82g (the mean body mass of 25% of the lightest Turnstones at the first capture) was presumed. Statistical methods followed Zar (1996).

Results

Biometrics

Almost all measurements of juveniles are unimodal. Only in the case of wing length two distinct peaks appeared (Figure 1). Adults had significantly longer wings than juveniles (Table 1, t-test, df=437, t=2.4, p=0.02). Mean values of other measurements did not differ significantly between the age classes (t-test, p>0.05). Adults migrating before 24 July had significantly longer wings (158.2 mm, SD=2.6) than those passing the Gulf of Gdańsk after 9 August (154.5 mm, SD=3.3) (t-test, df=24, t= 3.01, p=0.006). Other measurements did not differ between these two groups of adults (t-test, p>0.05). The number of measured adults was insufficient for more detailed analysis. Juveniles migrating in subsequent decades did not differ significantly in average wing length (ANOVA $F_{5,373}$=1.44, p=0.20), nor in total head length (ANOVA $F_{5,372}$=2.00, p=0.08), bill length (ANOVA $F_{5,367}$=1.60, p=0.16), tarsus plus toe length (ANOVA $F_{4,139}$=2.19, p=0.07) and tarsus length (ANOVA $F_{5,193}$=1.08, p=0.37). Mean body mass of juveniles and adults was similar (Table 1). Juveniles caught later in the season were heavier than earlier migrants (Kruskal-Wallis test, $H_{5,536}$=86.2, p<0,001) (Figure 2). Significant differences occurred between birds caught in September decades and those caught in August decades (Dunn post-hoc nonparametric test, p<0.05). There were no significant differences in body mass among birds caught in different August decades and among birds caught in different September decades.

Body mass changes and theoretical flight ranges

Among adults, only two birds (2.8%) were caught more than once, while in juveniles 67 birds (16.6%) were retrapped. The median length of stay as estimated by recapture intervals of juveniles was 3.9 days. Their body mass showed a significant increase during the stay (r=0.81, t=13.2, p<0.001), although during the first two days after the first capture some birds lost mass (Figure 3). Thus, the mean body mass change rate was significantly lower during the first day of stay (0.4 %/day) (ANOVA $F_{6,76}$=6.33, p<0.0001 – Tukey test). Later, between the second and the seventh day it varied insignificantly between 3.5% and 4.6% per day (Tukey test, p>0.05). In this period juveniles gained on average 3.9 g/day (SD ±2.1g). Some juveniles staying more than one week, build up more than 50% of their initial body mass (Figure 3). The rate of accumulation of reserves calculated for the third day of stay was 3.9%.

Theoretical flight ranges of Turnstones with a body mass between 130g and 162g (10% of the heaviest birds) ranged between 2500 and 3800 km. However, the theoretical flight range of birds which weighed 99g (the average body mass of juveniles) and 88g (the upper limit of 25% of the lightest birds) would be no more than 1200 and 480 km, respectively.

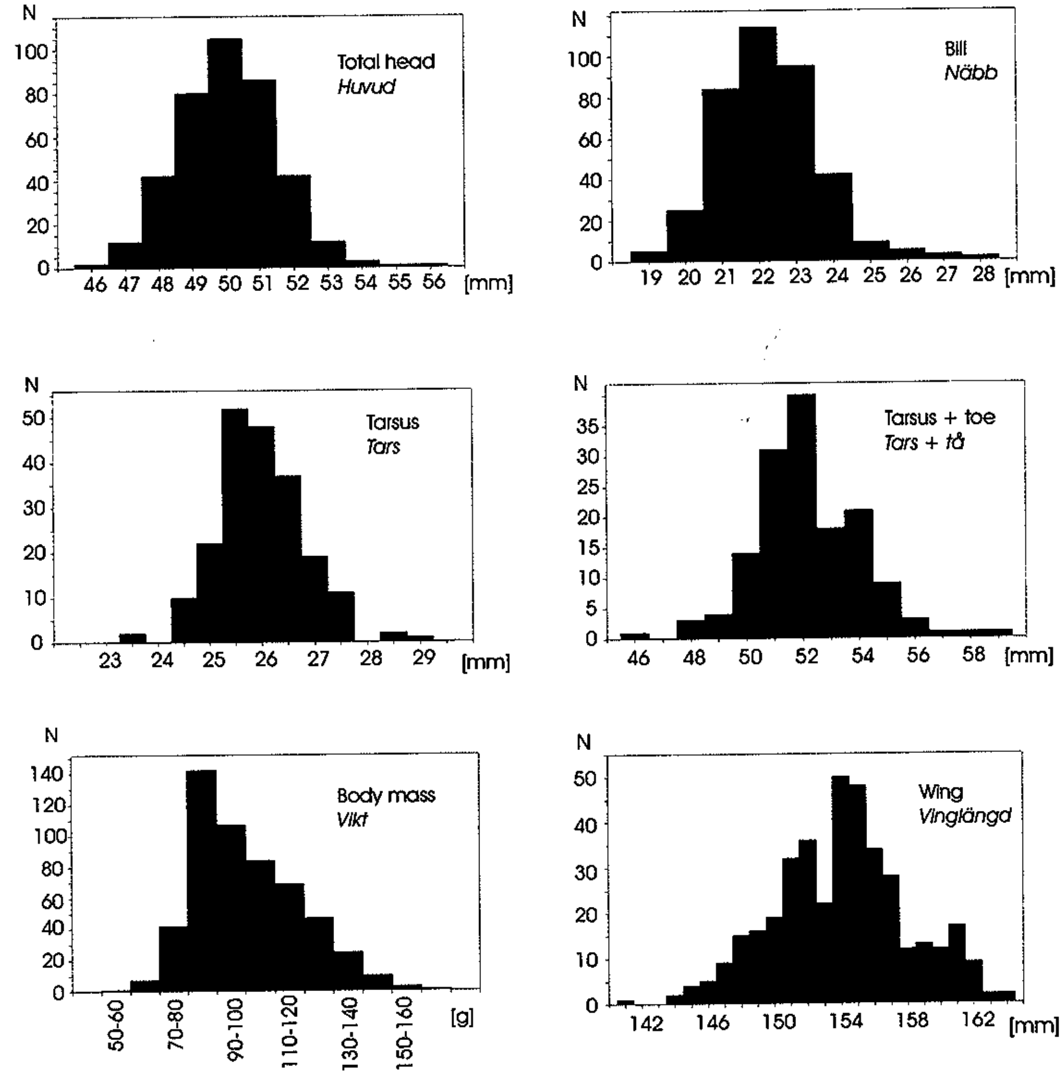

Figure 1. Frequency distribution of different measurements in juvenile Turnstones caught on the coast of the Gulf of Gdańsk in the autumns of 1983–1999

Fördelningen hos olika mått insamlade från juvenila roskarlar fångade i Gdanskbukten under höstarna 1983–1999.

Discussion

Biometrics

The wing length is the best measurement reflecting the sexual dimorphism in Turnstones. Adults migrating early were larger than those passing the study area in the later part. This indicates that females, which have longer wings, leave breeding grounds some days before males. In southern Finland the departure of females starts in mid-July (Glutz von Blotzheim et al. 1975, Liedel & Bianki 1985), which corresponds to the time of arrival of first adults in the Gulf of Gdańsk region (Meissner and Kozirόg 2000). The 3.7 mm-difference in the mean wing length between the earlier and the later migrants is only a little smaller than that reported for males and females after completing moult of primaries in South Africa (Summers et al. 1989).

Turnstones migrating along the southern Baltic

Table 1. Comparison of mean values of measurements between adult and juvenile Turnstones caught at the coast of the Gulf of Gda_sk in the autumns of 1983–1999. Results of statistical tests are given in the text.
Fördelningen hos olika mått insamlade från adulta och juvenila roskarlar fångade i Gdanskbukten under höstarna 1983–1999.

Measurement *Mått*	Adults *Adulta*				Juveniles *Juvenila*			
	Mean	SD	Range *Vidd*	N	Mean	SD	Range *Vidd*	N
Total head (mm) *Huvud och näbb*	50.2	1.8	47–54	64	50.0	1.5	46–56	381
Bill (mm) *Näbblängd*	22.4	1.5	20–25	69	22.4	1.7	19–32	385
Wing (mm) *Vinglängd*	155.4	3.7	146–161	57	154.0	4.1	145–164	382
Tarsus + toe (mm) *Tars + tå*	51.7	1.7	48–55	28	52.2	1.9	46–58	145
Tarsus (mm) *Tars*	25.64	0.8	24.4–27.3	29	25.77	0.8	23.2–30.6	200
Body mass (g) *Vikt*	98.9	13.1	62–136	58	99.0	17.7	55–160	389

coast belong mainly to the Fennoscandian – West Russian population, which winters in the vast area extending from western Europe to western Africa (Summers et al. 1989, Meissner & Koziróg 2000). Adults start moulting primaries after completion of autumn migration (Pienkowski et al. 1976, Summers et al. 1989). In fresh plumage in western Africa, the mean wing length of adults ranged between 156.9 mm and 157.3 mm (Ens et al. 1990, Wymenga et al. 1990). Birds caught in the Gulf of Gdańsk in autumn had worn primaries and this resulted probably in the lower mean wing length found. Even though adults had worn primaries, the mean wing length of juveniles, which migrate in fresh plumage, was significantly shorter. The same results were obtained in autumn in Scotland, southern Africa (Summers et al. 1989) and also in Australia (Houston & Barter 1990). It seems that the relatively short wing in juveniles may be a general rule in this species, similarly as in Knot *Calidris c. canutus* (Fournier & Spitz 1970, Gromadzka 1992, Meissner 1992) and Grey Plover *Pluvialis squatarola* (Gromadzka & Serra 1998). During autumn migration, adult birds of many other wader species have shorter wings than juveniles, due to the wear of the outermost primary (OAG Münster 1990, Meissner 1997a, b, 1998b).

The published data on biometrics of Turnstones caught within the flyway and wintering range of Fennoscandian – West Russian population are inconsistent. The mean wing length of adults obtained during this study (155.4 mm) is shorter than that reported by Branson et al. (1979) for non-moulting birds staging in the Wash in August (156.7 mm). It is noteworthy that the method used to measure wing was declared as the "maximum chord method" in both studies. Probably the sample from the Wash consisted not only of Fennoscandian – West Russian birds, which usually do not moult there, but also of Nearctic birds which had not started their primary moult after arrival. Turnstones from Greenland and Northeast Canada have longer wings than Fennoscandian – West Russian birds (data from Branson et al. 1979, Summers et al. 1989, Wymenga et al. 1990) and their presence in the Wash sample might have increased the average of the wing length. Average bill lengths in the study and in southern Africa (Summers et al. 1989) are very similar, but they are lower than those measured in Mauritania and Guinea-Bissau (Ens et al. 1990, Wymenga et al. 1990). The majority of Turnstones wintering in West Africa and migrating along the Baltic coasts belong to the same population. Hence it is difficult to explain why birds from Mauritania measured in spring had longer bills than birds migrating in autumn with worn feathers on the forehead. The same difference was found in the case of total head length and tarsus plus toe length (Ens et al. 1990). It is also possible that the manner of taking measurements differed slightly among sites, although it was claimed to be the same.

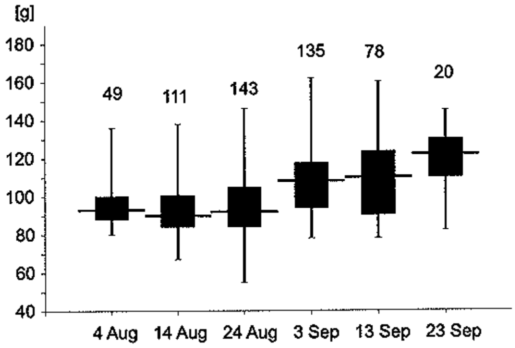

Figure 2. Comparison of body mass of juvenile Turnstones caught in subsequent decades. Horizontal line – median, rectangle – 5% and 95% of the distribution, vertical line – range. Numbers above the bars indicate sample size.
Kroppsvikt hos juvenila roskarlar fångade under olika tiodagarsperioder. De vågräta linjerna anger medianvärde, rektanglarna visar mellan 5% och 95% av fördelningen och de lodräta linjerna variationsvidden. Siffrorna ovanför anger antalet fåglar som vägts i de olika perioderna.

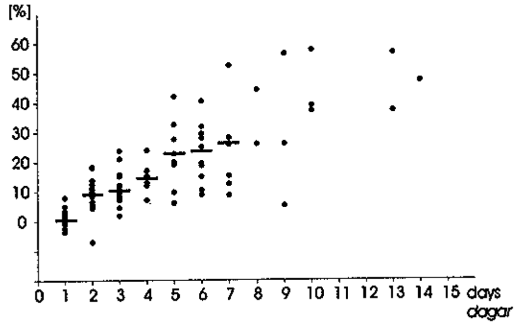

Figure 3. Relative body mass changes in juvenile Turnstones caught more than once. Horizontal lines indicate the mean value for a given day after the first capture.
Relativ förändring av kroppsvikten hos juvenila roskarlar återfångade olika antal dagar efter första fångsttillfället. De vågräta linjerna anger den genomsnittliga förändringen olika dagar efter märkningen.

Migration strategy

The low proportion of retrapped individuals in this study means that the majority of Turnstones did not stay in the Gulf of Gdańsk longer than one day. Much lower proportion of retrapped adults might be the result of combination of greater experience (avoidance of traps) and shorter length of stay (lower probability of being recaptured).

The small increment or even the decrease in body mass during the first day of stay is a commonly seen phenomenon, which takes place soon after arrival of the migrating bird at a new stopover site (Mascher 1966, Meissner 1998b). This is probably the main reason for the small increase of body mass in retraps the day after the first capture found in this study and also in other wader species (e.g. Page & Middleton 1972, Meissner 1992, 1998b, Meissner & Górecki in press). Such transitional body mass decrease does not occur later after next recaptures of the same bird at the same stopover site (Meissner 1998b). Thus, it seems to be unlikely that only the stress is responsible for this phenomenon. Moreover, individuals with very low body mass at the first capture do not show body mass decrease (Masher 1966, Meissner 1998b). It is possible that the fattest birds need some time after landing to convert the metabolism of lipids from lipolysis, which takes place during flight, to lipogenesis at the stopover place. In mammals, for instance, it takes from several to over ten hours until the organism is able to start an effective accumulation of fat deposit (Iritani et al. 2000). The increase of body mass in lean individuals, which takes place just after arrival at the foraging site, can result from the increase of water amount in organism in the effect of synthesis and storage of glycogen (Jenni & Jenni-Eiermann 1998, Meissner 2001), which is used as the source of energy for all kinds of activity in the stopover site (Rothe et al. 1987). Ens et al. 1990 reported that in Mauritania Turstones suffered badly from being caught and it took them about 25 days to recover from traumatic effect of catching. All birds trapped in the Gulf of Gdańsk were released after 0.5–3 hours, whereas in Mauritania within 12 hours. The body mass decrease within first few hours in captivity was mainly due to dehydration, whereas fat and lean dry mass loss become prominent after about 4 hours (Davidson 1984). A prolonged time of being in captivity in high ambient temperatures might be the reason for that it took birds in Mauritania a longer period to recovery.

The mean body mass of birds in the study area was low, like in African wintering grounds (Ens et. al. 1990), and only somewhat higher than recorded during breeding season (Glutz von Blotzheim et al. 1975). Turnstones, which are ready for long-distance flight, have body mass ranging between 120 and 200g (Gudmunsson et al. 1991). Bearing in mind all caveats concerning flight range estimates (Gudmunsson et al. 1991) and low average body mass of Turnstones caught in the Gulf of Gdańsk it appears that only the heaviest birds can reach northern Africa in one flight. The average body mass (99g) allows them to fly in one step at the most only to the North Sea coast or, when flying southwards over the mainland, to northern Italy. For more than 25% of Turnstones departing from the Gulf of Gdańsk the next stopover site is probably localised somewhere in the eastern Baltic, for example in the Mecklemburg Bay (450 km in straight line to the west), where three birds were caught 3, 3 and 9 days after ringing (Meissner & Kozirόg 2000).

The mean body mass of juveniles increased during the season. Such phenomenon occurs also in other waders (Glutz von Blotzheim et al. 1975, Pienkowski et al. 1979, Meissner 1997a, 2000). Greater energy stores can be accumulated as an insurance when weather makes effective feeding impossible (Pienkowski et al. 1979). Indeed, in September the risk of facing severe weather is greater than in the summer months. However, another explanation to this phenomenon is possible; birds that encountered bad weather conditions stay longer at the study area. If they behave as time minimising migrants they could also accumulate larger fat reserves and thus gaining potential flight range. Unfortunately, the number of recoveries is too small to check this hypothesis.

The median length of stay of juvenile birds which stopped for more than one day in the study area (3.9 days) was similar to other wader species studied in the Gulf of Gdańsk (Krupa 1997, Meissner 1997b, Meissner & Włodarczak 1999, Meissner & Górecki in press). From the second day of stay the mean body mass increase was more or less stable and juvenile Turnstones that stayed longer also gained more energetic reserves. However, the majority of birds arrived with small fat reserves and departed after a very short stay. Only some of them stayed for several days, gaining about 50% of their initial body mass. Thus, the body mass at departure differed considerably among the migrants. The accumulation rate (calculated for the 3rd day of stay) was about two times and about 1.5 times higher than in juvenile Dunlin and juvenile Knots respectively (Meissner 1992, 1998b). Such high rate of the body mass increase (3.7%/day) was also found in Turnstone in September in Alaska (Thompson 1974 in: Zwarts et al. 1990).

Not all birds stayed in the study area for more than one day. Moreover, the number of adults, which stopped at the study area varied considerably between different seasons (Meissner & Kozirόg 2000). It seems that the Gulf of Gdańsk is not a traditional stopover site for Turnstones, but it is probably a kind of emergency feeding place, like for Knots (Piersma et al. 1992) and for Sanderlings (Meissner & Włodarczak 1999). The body mass at departure varied considerably among juveniles. The number of recoveries is too small to investigate whether birds flying southwards over inland accumulate more energy reserves than those following seacoasts, where they can stop in many places en route. The decision to depart or to stay and gain body mass may be taken individually according to information gathered from the surrounding environment (the quality of a feeding ground, inter- and intraspecific competition for habitat resources, weather, predation pressure) and from its physiological stage (the amount of accumulated fat reserves and the rate of their accumulation) (Meissner 2001). Thus, the majority of birds behave as energy minimising migrants and migrate in small steps having low fat reserves. Others stay longer, gaining large energy reserves and probably they are able to reach North Africa in one step.

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Sammanfattning

En analys av biometriska data insamlade från roskarl Arenaria interpres *under höstflyttning i Gdanskbukten*

I denna studie har biometriska data från roskarl fångade i samband med ringmärkning under höstflyttningen i Gdanskbukten under åren 1983–1999 analyserats. Arten uppträder regelbundet, men i små flockar och antalet ringmärkta är lågt. Roskarlar som på hösten rastar i Gdanskbukten flyttar vidare i två riktningar, dels västerut till Atlantkusten och dels söderut över kontinenten till Medelhavet. Eftersom arten bara observeras i mindre antal i inlandet antas passagen av Europa ske genom en långflygning.

Roskarlarna har fångats vid tre olika platser: Jastarnia, floden Redas mynning och vid Rewa. Fältarbetet startade i mitten av juli och avslutades i slutet av september, en period som täcker så gott som hela artens flyttning. De mått som insamlats från de fångade individerna är vinglängd, huvud + näbblängd, näbblängd, tarslängd och tars + tålängd. Fåglarna vägdes också till närmaste gram. Totalt ingår 69 adulta och 389 juvenila fåglar i bearbetningen. Data från 67 juvenila fåglar som återfångats vid minst ett tillfälle under samma säsong har använts för att belysa fåglarnas viktökning under rastningen i området. Teoretiska beräkningar av flygsträcka har gjorts enligt Pennycuicks (1975) formel, även om senare rön har visat att denna formel troligen underskattar den sträcka en fågel kan flyga på en given energireserv.

Bland de insamlade måtten från de juvenila fåglarna är det bara vinglängd som uppvisar två distinkta toppar (Figur 1). Adulta fåglar hade en signifikant längre vinglängd än juvenila fåglar medan övriga mått inte skilde de båda åldersgrupperna åt. Bland de adulta fåglarna hade de som passerade före 24 juli en signifikant längre vinglängd och antas spegla honornas tidigare flyttningspassage. Någon liknande effekt kunde inte påvisas bland de unga fåglarna. Vikterna hos de juvenila fåglarna var signifikant högre i september jämfört med augusti (Figur 2).

Av de adulta fåglarna återfångades bara 2,8% (2 stycken) vid ett senare tillfälle samma höst medan samma siffra för ungfåglarna var 16,6% (67 stycken). Den genomsnittliga rastningsperiodens längd för de ungfåglar som återfångades var 3,9 dagar. Bland de återfångade fåglarna ökade vikten signifikant med tiden, även om en del fåglar minskade i vikt under de första dagarna (Figur 3). De som återfångades mellan två och sju dagar efter märkningen uppvisade en genomsnittlig ökning på 3,9g/dag och den genomsnittliga ökningen beräknad på de som kontrollerades efter tre dagar uppgick till 3,9% av ursprungsvikten/dag. Några juvenila fåglar stannade längre tid än en vecka och ökade i vikt med mer än 50% av ursprungsvikten. Den beräknade teoretiska flygsträckan för de tyngsta 10% (130–162g) uppgick till mellan 2500 och 3800 km. Den beräknade flygsträckan för fåglar som vägde 99g (den genomsnittliga vikten) var 1200 km och för de som vägde 88g (den övre gränsen för de 25% lättaste) var bara 480 km.

Den låga andelen återfångade individer i Gdanskbukten tyder på att majoriteten roskarlar inte stannar längre än en dag. Den lägre andelen återfångade gamla fåglar kan bero på att de är svårare att återfånga eller stannar kortare tid. Den lägre ökningen i vikt under den första dagen efter märkningen antas inte bara bero på hanteringen utan också på att fåglarna behöver genomgå en omställning innan de kan börja fettupplagra. Den genomsnittliga vikten var låg, snarlik den hos fåglar under vintern i Afrika och bara något högre än under häckningstid. Roskarlar som står i begrepp att genomföra långdistansflygningar har normalt vikter mellan 120 och 200g, vilket antyder att bara ett fåtal av fåglarna i Gdanskbukten kan nå Nordafrika i en flygetapp. Fåglar med genomsnittlig vikt kan nå Nordsjökusten i väster och om de flyger söderut norra Italien. För närmare 25% av fåglarna ligger förmodligen nästa rastplats i sydvästra Östersjön, till exempel i Mecklenburgbukten (450 km västerut), där också tre fåglar kontrollerats 3, 3 och 9 dagar efter märkningen. Att vikten ökar med säsong, vilket också påvisats hos flera andra vadararter, kan vara en försäkring mot dåligt väder då möjligheten till födosök kan vara försämrad. En annan möjlighet kan vara att fåglar som senare under hösten möter sämre väder stannar längre tid och lägger upp en större energireserv. Resultaten antyder att Gdanskbukten inte är en traditionell rastplats för roskarl utan snarare fungerar som en plats att nyttja i nödfall, vilket också visats för kustsnäppa och sandlöpare. Variationen är dock stor och även om huvudparten beter sig som energiminimerare som bara lägger upp små energireserver och flyger kortare sträckor, så finns det en del som lägger upp mycket stora reserver som gör det möjligt för dem att nå Nordafrika i en flygetapp.