# AUTUMN MIGRATION OF THE BAR-TAILED GODWIT (*Limosa lapponica*) IN THE GULF OF GDAŃSK REGION*

**Włodzimierz Meissner and Mateusz Ściborski**

## ABSTRACT

Meissner W., Ściborski M. 2002. *Autumn migration of the Bar-tailed Godwit (Limosa lapponica) in the Gulf of Gdańsk region.* Ring 24, 1: 3-15.

Regular counts and catching of migrating Bar-tailed Godwits were conducted at the Gulf of Gdańsk in years 1984-2000. The migration of adult birds lasted from mid-July to mid-September with a peak in the second decade of July. At the beginning, females were more numerous than males, then on the turn of July males outnumbered females. The proportion of females increased again in the second half of August and decreased in September. First young Bar-tailed Godwits arrived in small number in the third decade of July, but their regular migration started in mid-August (single young birds were seen until the end of November). The total numbers of migrants differed between seasons, reaching highest values every third year, which may have corresponded with lemming cycles on breeding grounds of the species. Low numbers of Bar-tailed Godwits stopping at the Gulf of Gdańsk coast together with short length of stay and low number of retraps of adult birds proved that southern coast of the Baltic Sea was only an emergency stopover site for this species. Values of adults measurements were generally larger than those of juveniles what is connected with growth process still lasting in young birds. Within each age group bimodality was noticed due to sexual dimorphism – females were significantly larger than males. Data on axillaries pattern and phenology of migration suggest that two different breeding populations of *L. l. lapponica* – north-European and west-Siberian – migrate through the study area. Measurements of two Bar-tailed Godwits over-ranged the nominate *L. l. lapponica* subspecies ranges, suggesting *L. l. mezenbieri*.

W. Meissner, M. Ściborski, Dept. of Vertebrate Ecology and Zoology, University of Gdańsk, Legionów 9, PL-80-441 Gdańsk, Poland, E-mail: biowm@univ.gda.pl, mateo76@tlen.pl

**Key words:** Bar-tailed Godwit, migration, biometrics, Gulf of Gdańsk

## INTRODUCTION

Bar-tailed Godwit is a typical coastal migrant (Cramp and Simmons 1983). In Poland, it is noticed regularly but in small numbers during autumn migration on the seacoast. Its percent share among all waders observed in autumn in Rewa was 1%

* Publication of the Waterbird Research Group KULING no 87.

and in other sites at the Gulf of Gdańsk even less (Ściborski 1999). The inland appearances of this species as well as spring records are very scarce (Tomiałojć 1990, Meissner and Sikora 1995).

Up to now, all published data on the autumn migration of the Bar-tailed Godwit concerned rare records from inland. For the southern Baltic coast, only general migration dynamics were described from Poland (Meissner and Sikora 1995) and Germany (Dittberner and Dittberner 1983, Kube and Struwe 1994). Thus, this paper is the first one summarising knowledge on the autumn migration of this species along the Polish Baltic coast.

## MATERIAL AND METHODS

### Phenology and dynamics of migration

Regular counts of birds were conducted at the Gulf of Gdańsk (Fig. 1), mainly in two research areas: near village Jastarnia on the Hel Peninsula (1984-1989) and at the Rewa Peninsula (1988-1995). Besides, regular observations were made at the Reda mouth in 1983-1986 and 1996-2000, but Bar-tailed Godwits appeared irregularly there. Therefore, from that place only records of large flocks and interesting phenological occurrences were taken into account. More detailed description of the study areas are given elsewhere (Meissner and Remisiewicz 1998). Fieldwork lasted from mid-July to the end of September, only in 1987 in Jastarnia it was finished in mid-September, so this season was excluded from analyses. In both study areas, all waders were counted three times a day. To illustrate the migration dynamics, only maximal daily numbers were included. Dates of beginning and finishing of the fieldwork differed slightly between the seasons. In order to compare median dates of migration and total numbers of migrants in each year, a comparable period was established (Busse and Kania 1970). For Jastarnia it was 19 July – 27 September and

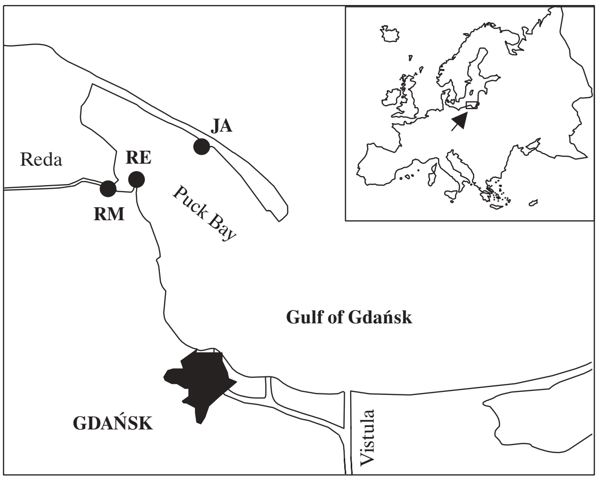


Fig. 1. Study area: RE – Rewa, RM – Reda mouth, JA – Jastarnia

for Rewa: 15 July – 29 September. In those periods the research was done continuously in all seasons.

Because of low number of birds, migration dynamics was shown only for Rewa (where birds were slightly more numerous than in Jastarnia) as the mean sum and the maximal daily number per pentade (five-day period), similar to the paper of Meissner and Sikora (1995). Pentades and decades were signed with their first dates.

### Biometrical analysis

Birds were caught in years 1983-1999 in walk-in traps (Meissner 1998) placed on the seashore in Jastarnia, Rewa and at the Reda mouth. Each caught bird was aged and the majority of adults were also sexed according to plumage characteristics (Prater *et al.* 1977). Wing length (Evans 1986), total head length (Green 1980), bill length (Prater *et al.* 1977) and tarsus length (Svensson 1992) were measured. Before 1991, total head length and bill length were measured to the nearest 1 mm with a 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 with accuracy of 2 g. Every year the accuracy and the repeatability of the measurements taken by different ringers were checked as described by Busse (1984).

Bar-tailed Godwits show a clinal variation in the amount of brown colour on the axillary feathers (Nieboer *et al.* 1985). In years 1998-1999 the longest axillaries were collected from 26 juveniles and 2 adults (including one male). Brown-barring on the feathers was checked and classified according to 6-class scale developed by Nieboer *et al.* (1985).

In total, 136 adults and 218 juveniles were ringed and measured in years 1983-2000. Weight data from 43 juvenile Bar-tailed Godwits caught at least twice and weighed in the same season (retraps) at Rewa and at the Reda mouth were used to calculating of the body mass changes during the birds' stay. For assessing the theoretical flight range of birds, the equation after Pennycuick (1975) was used, assuming the still air conditions. Such calculations require assumptions regarding the body mass at the beginning and at the end of the flight. For the analysis, the final body mass of 176 g and 163 g (the mean body mass of 25% and 10% of the lightest Bar-tailed Godwits at the first capture, respectively) were presumed. The body mass on the departure was 245 g and 275 g (the mean body mass of 25% and of 10% of the heaviest Bar-tailed Godwits in the sample, respectively). Statistical methods followed Zar (1996).

## RESULTS

### Dynamics of migration

The migration started with adult birds in mid-July (Fig. 2). The earliest observations were made at the Reda mouth on 10 July 2000 – 1 *ad.*, 12 July 1994 – 6 indiv.

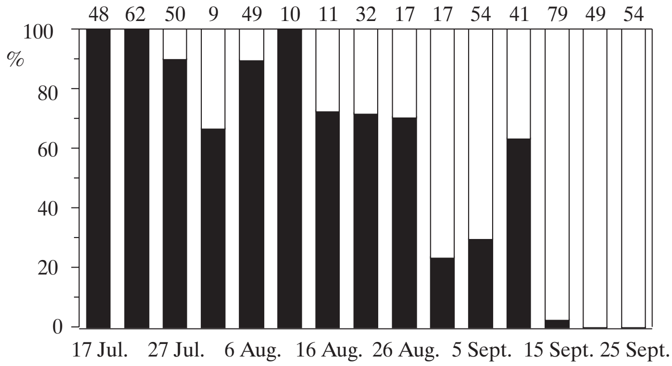


Fig. 2. Proportion of adult (black) and juvenile (white) Bar-tailed Godwits observed in subsequent five-day periods in Rewa. Data from all seasons were combined. Numbers above the bars indicate sample size.

and at Rewa on 16 July 1990 – 17 *ad.* and 3 indiv., 16 July 1992 – 2 *ad.*, 16 July 1994 – 13 *ad.* It is also worth to mention a low flying flock observed on 26 June 1994 – 55 *ad.* (Rewa). From mid-August to mid-September, the number and percent share of adults declined. The latest observations of adult Bar-tailed Godwits were made on 13 September 1994 – 2 *ad.* (Reda mouth), 14 September 1991 – 2 *ad.* (Rewa).

At the beginning of migration females were less numerous than males. The number of adult females increased from the beginning to the end of August and decreased again in September (Fig. 3). Changes in the mean bill length in subsequent

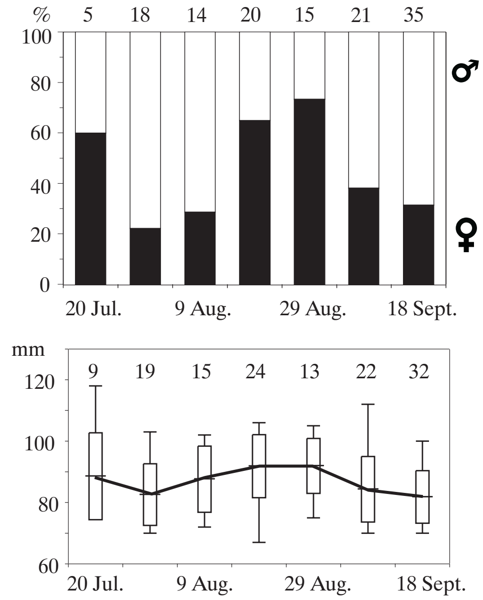


Fig. 3. Proportion of adult males to adult females (identified according to plumage) among birds ringed in subsequent decades (upper panel). The average bill length (horizontal line), standard deviation (rectangle) and range (vertical line) of adult Bar-tailed Godwits caught in subsequent decades (lower panel). Numbers above bars indicate sample size.

decades confirmed this scheme (Fig. 3). Birds caught in the second part of August (decades starting on 19 and 29 August) had significantly longer bills than those from decades starting on 30 July and 18 September (ANOVA: $F_{5,119} = 4.46$, $p < 0.001$ and Neuman-Keulis *post hoc* test, $p < 0.05$; decade starting on 20 July was omitted due to small sample size).

First young Bar-tailed Godwits arrived in small numbers in the third decade of July: 19-20 July 1994 – 4 *juv.* (Reda mouth), 25 July 1984 – 1 *juv.* (Jastarnia), 27 July 1995 – 1 *juv.* (Rewa), and 29 July 1992 – 1 *juv.* (Rewa). A regular migration of young Godwits took place not earlier than in mid-August. The last birds were recorded on 3 November 1985 – 3 indiv. at Jastarnia and 23 November 1996 – 3 indiv. at Rewa (Sikora pers. comm.).

Bar-tailed Godwits appeared most numerously in the end of July and in September. The first wave was constituted by adults, whereas the second one – mostly by juveniles. In August, the number of birds was very low, but they were seen more regularly since then (Fig. 4). The biggest recorded flocks of Bar-tailed Godwits were seen on passage in western direction, without stopping in the study area: 5 September 1991 – 65 indiv. and 7 August 1994 – 63 indiv. (Rewa), 29 July 1996 – 40 indiv. (Reda mouth). The biggest foraging groups of Bar-tailed Godwits were noticed at Rewa on 22 July 1994 – 42 *ad.* and 14 September 1991 – 2 *ad.* and 30 *juv.* (Fig. 4). At Jastarnia maximal numbers (30 *juv.*) were noted on 26 and 27 September 1988. At the Reda mouth abundance of these birds was strongly correlated to the sea water level. Most commonly they were foraging there on small sandy islets occasionally emerged from the sea, congregating sometimes in large groups: 22-23 July 1994 – 67 indiv., 13-14 July 1983 – 35 indiv., 27 August 1990 and 5 October 1996 – 25 indiv.

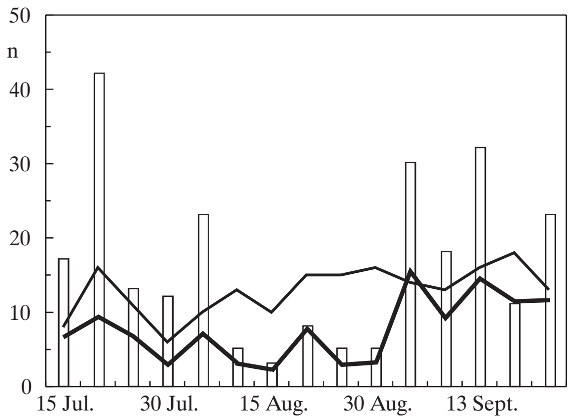


Fig. 4. Dynamics of autumn migration of Bar-tailed Godwit in Rewa in 1988-1995. Thick line – the average sum of birds in a given pentade, thin line – the number of days in a given pentade with a presence of the species, bars – the highest number of birds recorded in a given pentade.

The numbers of migrants in different seasons varied considerably (Fig. 5). Analysis of the total number of Bar-tailed Godwits observed on both study sites re-

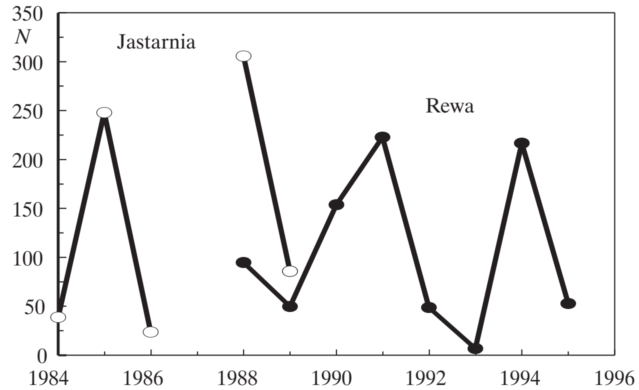


Fig. 5. Total number of Bar-tailed Godwits recorded within the comparability period in subsequent seasons at Jastarnia and Rewa. No data available for season 1987.

vealed that the biggest numbers were recorded every third year – 1985, 1988, 1991 and 1994. Only in 1988 at Rewa there were less birds than in 1990 and much less than at Jastarnia in the same year.

There was a strong relationship between the median date of migration and the total number of birds in the comparable period in a given season (Fig. 6, Spearman rank correlation coefficient $r_S = 0.99$, $t = 16.6$, $p < 0.001$). However, the median date is not a good parameter of the migration dynamics of this species (see *Discussion*).

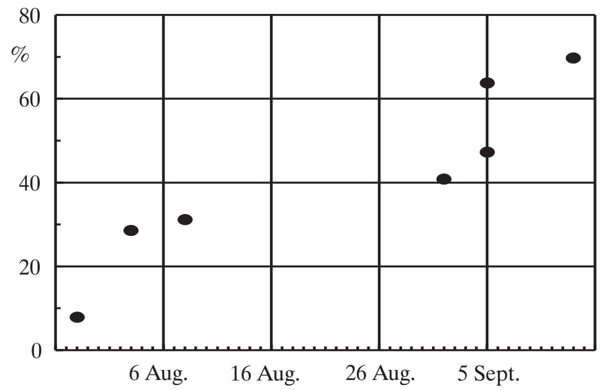


Fig 6. Correlation between the median date of migration and the percent share of juveniles in a given season

### Biometrics

Except for the tarsus length, adults had all dimensions significantly higher than juveniles (Table 1). Bimodality of distribution was more evident in adults (Fig. 7), especially in the case of bill length and wing length. However, in the latter case the sample size was rather small. In juveniles bimodality was the most apparent in total head length.

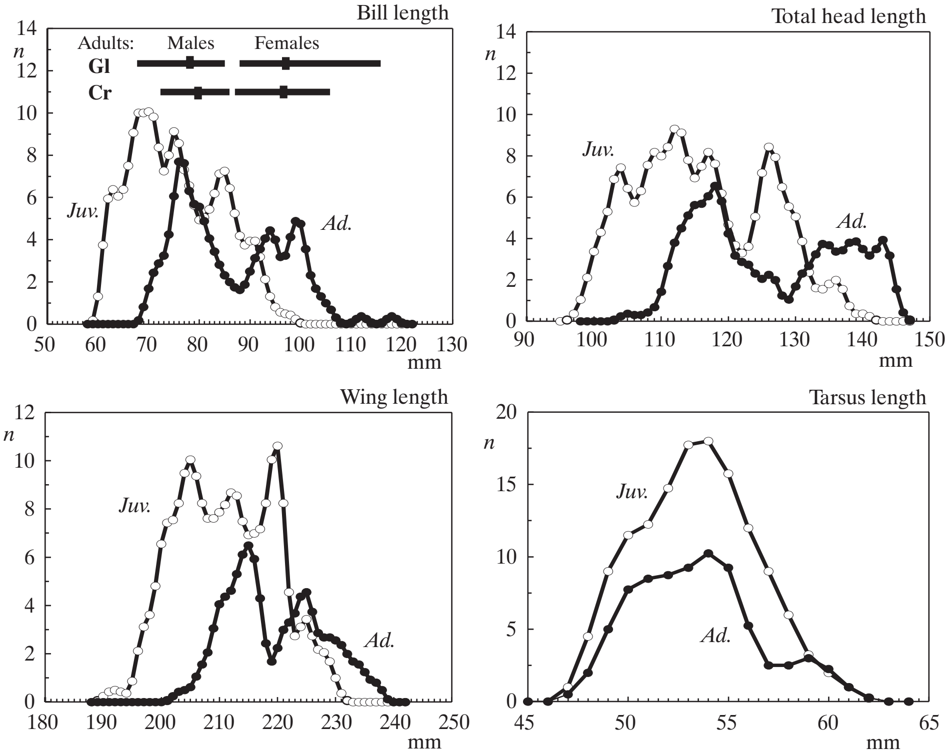


Fig. 7. Distribution of bill length ($N_{Juv}$ = 220, $N_{Ad}$ = 134), total head length ($N_{Juv}$ = 222, $N_{Ad}$ = 125), wing length ($N_{Juv}$ = 222, $N_{Ad}$ = 102) and tarsus length ($N_{Juv}$ = 222, $N_{Ad}$ = 102) of juvenile and adult Bar-tailed Godwits. Horizontal lines indicate ranges, while strokes – mean values of bill length of adult males and females, according to Gluz von Blotzheim *et al.* (1977) – **Gl**, and Cramp and Simmons (1983) – **Cr**.

Table 1
Comparison of all measurements between juveniles and adults

| | *Juveniles* | | *Adults* | | *U*-test | |
|---|---|---|---|---|---|---|
| | Mean ± *SD* | *N* | Mean ± *SD* | *N* | *Z* | *p* |
| Bill length | 75.5 ± 8.9 | 220 | 86.1 ± 10.7 | 135 | 8.53 | **< 0.001** |
| Total head length | 113.0 ± 9.8 | 222 | 123.0 ± 10.9 | 125 | 7.50 | **< 0.001** |
| Wing length | 211.2 ± 8.4 | 222 | 219.4 ± 8.1 | 102 | 7.12 | **< 0.001** |
| Tarsus length | 53.4 ± 2.8 | 138 | 53.4 ± 3.0 | 78 | 0.31 | 0.75 |

To compare mean measurements of young birds caught in subsequent seasons, only years: 1985, 1991, 1994, 1996 and 1998 were taken into account, when more than 10 individuals were measured. Statistically significant differences were noticed in total head length (ANOVA: $F_{168,4}$ = 4.64, $p < 0.005$), bill length (ANOVA: $F_{164,4}$ = 3.66, $p < 0.01$) and wing length (ANOVA: $F_{170,4}$ = 2.83, $p < 0.05$). Birds in 1998 were on average larger than those in 1985 (in all measurements) and in 1994 (in total head and bill length) – Duncan *post hoc* test, $p < 0.05$.

Axillaries of two adult birds were classified to 1 (a male caught on 29 July 1998) and 3 classes. Among feathers of young birds there were: two axillaries of 0 class, eight of 1 class, five of 2 class, ten of 3 class and one feather of 5 class.

### Length of stay, body mass changes and theoretical flight range

Only 5 (3.7%) adult Bar-tailed Godwits were caught twice within the same season. Four of them were weighed. Two (males) showed almost no changes in body mass after one day, but two others, a male and a female, put on 10 g after 1 day (4.4% of initial body mass) and 22 g after 2 days (8.9%), respectively.

The median length of juveniles' stay according to retrapping intervals was 4.6 days ($N$ = 58). Their body mass showed an increase during the stay, although during the first days after the first capture some birds lost their mass (Fig. 8). Thus, the mean body mass change rate was low after the first day of retraps' stay (+0.2% per day). The highest recorded body mass increase exceeded 80 g and 30% of initial body mass and in some individuals the body mass increase rate was higher than 10 g (and 4% of initial body mass) per day (Table 2).

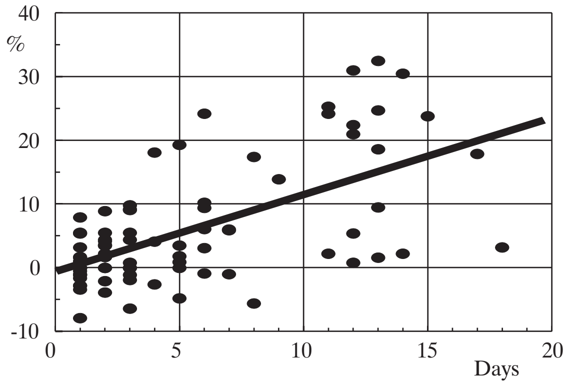


Fig. 8. Body mass changes in juvenile retraps in subsequent days after the first capture. Body mass at the first capture was regarded as 0%. Regression line is given: y = 1.233x – 0.606 ($p < 0.001$, $R^2 = 0.381$).

Theoretical flight range of Bar-tailed Godwits with body mass of 275g (the average value for 10% of the heaviest birds) ranged between 3100 and 3700 km, whereas in the case of birds with body mass of 245 g – between 2300 and 2800 km. However, the theoretical flight range of birds, which weighed 210 g (the average body mass of juveniles), would be no more than 1500-2100 km.

## DISCUSSION

### The Gulf of Gdańsk as an emergency stopover site

A distribution of Bar-tailed Godwit outside the breeding period is restricted to tidal areas (del Hoyo *et al.* 1996). The majority of bigger flocks was seen passing

Table 2
Juvenile Bar-tailed Godwits showed the highest body mass increase during the stay in the Reda mouth region

| Body mass at the first capture (g) | Days between the first and the last capture | Difference in body mass (g) | Relative difference in body mass (%) | Mean body mass increase (g/day) | Relative mean body mass increase (%/day) |
|---|---|---|---|---|---|
| 292 | 13 | 99 | 32.5 | 7.6 | 0.3 |
| 246 | 12 | 80 | 31.0 | 6.7 | 2.6 |
| 242 | 14 | 78 | 30.5 | 5.6 | 2.2 |
| 279 | 13 | 72 | 24.7 | 5.5 | 1.9 |
| 292 | 6 | 72 | 24.2 | 12.0 | 4.0 |
| 287 | 11 | 72 | 24.2 | 6.5 | 2.2 |
| 271 | 15 | 68 | 23.8 | 4.5 | 1.6 |
| 307 | 17 | 58 | 17.9 | 3.4 | 1.1 |
| 264 | 12 | 58 | 21.0 | 4.8 | 1.8 |
| 275 | 5 | 54 | 19.3 | 10.8 | 3.9 |
| 220 | 12 | 52 | 22.4 | 4.3 | 1.9 |
| 272 | 4 | 50 | 18.1 | 12.5 | 4.5 |
| 179 | 11 | 48 | 25.3 | 4.4 | 2.3 |

over the study area. Besides, in central and western part of the Polish coast the number of records of this species is low (Tomiałojć 1990). Among adults the number of retraps is low and there is only one short-distance recovery between two ringing sites localised on the Gulf of Gdańsk coast. It means that adults stop here for a very short time. Their average body mass (217.2 g, $SD$ = 25.7, $N$ = 109) is very low, lower than in the breeding grounds (Kozlova 1962). These facts suggest that the stopover places situated along the southern Baltic coast are not optimal feeding areas for adults, but only a kind of emergency feeding places. Similar situation was met in some other coastal waders, like Knots – *Calidris canutus*, Sanderlings – *Calidris alba* and at least some Turnstones – *Arenaria interpres* (Davidson and Piersma 1992, Meissner 1992, Meissner and Włodarczak 1999, Meissner and Koziróg 2000).

Bearing in mind all caveats concerning flight range estimates (Gudmunsson *et al.* 1991, Weber and Houston 1997, Liechti and Bruderer 1998) and low average body mass of Bar-tailed Godwits caught in the Gulf of Gdańsk region it appears that only a few heaviest birds are able to reach northern Africa in one flight. The majority of them probably follow the southern Baltic coast towards the Wadden Sea. Despite of very low energetic reserves at least some of them may survive and succeed in migration to this rich tidal area (an adult female ringed at Rewa on 15 August 1991 was controlled on 15 may 1998 at Oosterend, Netherlands).

## Populational differentiation

In the Bar-tailed Godwit both parents incubate eggs and tend the young, but it is also possible that only a male takes care of chicks (del Hoyo *et al.* 1996). Surprisingly, males outnumber females in the first phase of adult birds' migration and in September the proportion of males becomes high again. This pattern probably reflects migration of two different breeding populations of this species (Drent and Piersma 1990). The north-European population (from the area around the White Sea), begins to breed in the third decade of May (Glutz von Blotzheim *et al.* 1977). Incubation lasts 20-21 days and hatched birds need another 28 days for fledging (del Hoyo *et al.* 1996). Adult birds from this population may appear somehow more numerously on the Baltic coast in July. It seems also that very early records of young Bar-tailed Godwits in the third decade of July may concern the European breeders, as it is in the case of the Turnstone (Meissner and Koziróg 2000). The west-Siberian birds start breeding in June and they migrate later than the former population (Glutz von Blotzheim *et al.* 1977, Drent and Piersma 1990). These adults seem to stop on the Gulf of Gdańsk coast only exceptionally.

According to Nieboer *et al.* (1985), birds with axillary feathers classified to 0 and 1 classes come from Scandinavian and north-Russian populations, whereas those of class 3 and higher breed on the east of the Ural Mountains. Although in juvenile birds this character could be more diffuse, obtained results suggest that some Bar-tailed Godwits migrating in autumn through the Gulf of Gdańsk region may originate from western Siberia.

## Interseasonal changes in number of migrants

Changes in bird number in subsequent seasons revealed a three-year scheme, similar to some other tundra breeders (Meissner and Sikora 1995, Meissner in press). Such three-year cycle is caused by changes in the number of lemmings, which are the main prey of raptors in those areas (Underhill 1987, Rybkin 1998). Despite the growing number of evidence that weather conditions may have a great influence on this cycle and the number of lemmings can be variable within a given area (Rybkin 1998, Tomkovich 1998), in Bar-tailed Godwits the highest number of migrants was observed every third year. It means that, opposite to Turnstones (Meissner and Koziróg 2000), the majority of juveniles arriving at the Gulf of Gdańsk region comes from the area with well pronounced lemming cycles.

A correlation between the median date of migration and the total number of birds in a given season is typical for the waders from northern latitudes, where adults and juveniles start to migrate separately (Meissner and Koziróg 2000). In such cases the mean date of migration depends on the proportion of adult to juvenile birds in particular season. Thus, the mean migration date is not useful as a simple parameter for the comparing of a given species migration phenology in different years.

### Biometrics

In the Bar-tailed Godwit there is a clear sexual dimorphism in the measurements (Prater *et al.* 1977). The best measure differentiating sexes in adults is the bill length. The ranges recorded for both sexes were similar to those from literature (Fig. 7). In young birds such separation is not clear. They have significantly shorter bills, wings and heads than adult birds. In the case of the bill and total head lengths such differences result from not finished growth of the bill, especially its ceratoid part. Similar differences were recorded during autumn migration for other wader species (Meissner 1997a, 1999). The process of long bill growing lasts longer and the absolute differences in measurements are greater than in smaller species. This is the main cause of a poorly marked sexual dimorphism in young birds.

Two adult birds had bill lengths beyond the range of nominate subspecies *L. l. lapponica* (Kozlova 1962, Prater *et al.* 1977). Such big single individuals were also found in the Wash, England (Atkinson 1996). This fact suggests the possibility of occurrence of the central-Siberian breeders (*L.l. mezenbieri*) in Europe, especially after a specimen showing features of that subspecies had been collected in 1913 in Poland (Tomiałojć 1990).

Interseasonal variability of measurements in young birds is a known fact in waders (Meissner 1997b, Meissner and Włodarczak 1999). However, in the case of a species with such a big dimorphism, this variability may be caused by unequal proportion of caught males (smaller – more frequently encountering walk-in traps) and females (bigger – less frequently encountering walk-in traps). To check it, we assumed after Prater *et al.* (1977), that young birds with bill length below 75 mm are males and those with bill length over 83 mm are females. In years 1983-2000, significantly more young males (108 indiv.) than young females (53 indiv.) were caught ($\chi^2$-test with Yates' correction: $\chi^2 = 8.96$, $p < 0.005$). Exceptionally, in 1998 seven young males and eleven young females were caught, and this was the reason for the significantly bigger measurements of young birds in this season.

## ACKNOWLEDGEMENTS

This study was conducted by the Waterbird Research Group KULING. We would like to thank all the people who took part in activities of the research stations, especially to the ringers, who collected data on biometrics and numbers of Bar-tailed Godwits in Jastarnia and Rewa: J. Antczak, P. Bartyzel, B. Brewka, Z. Cenian, M. Duda, D. Górecki, Z. Klawikowski, Z. Kochan, M. Kozakiewicz, R. Krupa, M. Kurowski, G. Lorek, M. Remisiewicz, M. Rodziewicz, Z. Rohde, A. Sikora, M. Skakuj, D. Staszewska, A. Włodarczak, D. Wrona.

## REFERENCES

Atkinson P.W. 1996. *The origins, moult, movements and changes in numbers of Bar-tailed Godwits Limosa lapponica on the Wash, England.* Bird Study 43: 60-72.

Busse P. 1984. *Key to sexing and ageing of European Passerines.* Beitr. Naturkdl. Niedersachsens, Sonderheft 37: 1-224.

Busse P., Kania W. 1970. *Operation Baltic 1961-1967. Working methods.* Acta orn. 12: 231-267.

Cramp S., Simmons K.E.L. (Eds). 1983. *Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic.* vol. 3. Oxford Univ. Press, Oxford.

Dittberner H., Dittberner W. 1983. *Zum Vorkommen der Pfuhlschnepfe (Limosa lapponica L.) in der DDR.* Beitr. Vogelkd. 29: 19-28.

Drent R., Piersma T. 1990. *An exploration of the energetics of leap-frog migration in arctic breeding waders.* In: Gwinner E. (Ed.). *Bird Migration: the Physiology and Ecophysiology.* Springer Verlag, Berlin: pp. 399-412.

del Hoyo J., Elliot A., Sargatal J. (Eds). 1996. *Handbook of the Birds of the World. Vol. 3. Hoatzin to Auks.* Lynx Edicions, Barcelona.

Evans P.R. 1986. *Correct measurements of the wing length of waders.* Wader Study Group Bull. 48: 11.

Glutz von Blotzheim U.N., Bauer K.M., Bezzel E. 1977. *Handbuch der Vögel Mitteleuropas. 7.* Akademiche Verlag. Wiesbaden.

Green G.H. 1980. *Total head length.* Wader Study Group Bull. 29: 18.

Gudmundsson G.A., Lindström Å., Alerstam T. 1991. *Optimal fat loads and long-distance flights by migrating Knots Calidris canutus, Sanderlings C. alba and Turnstones Arenaria interpres.* Ibis 133: 140-152.

Kozlova E.V. 1962. [*Fauna of the USSR. Birds.*] vol. 2, 3. Nauka, Leningrad. (In Russian).

Kube J., Struwe B. 1994. *Die Ergebnisse der Limikolenzählungen an der Südwestlichen Ostseeküste 1991.* Corax 15, 2: 4-56.

Liechti F., Bruderer B. 1998. *The relevance of wind for optimal migration theory.* J. Avian Biol. 29: 561-568.

Meissner W. 1992. *Knots' autumn migration in the western part of the Gulf of Gdańsk, Poland: preliminary results.* Wader Study Group Bull. 50: 7-16.

Meissner W. 1997a. *Autumn migration and biometrics of the Common Sandpiper Actitis hypoleucos caught in the Gulf of Gdańsk.* Ornis Fenn. 74: 131-139.

Meissner W. 1997b. *Timing and phenology of autumn migration of Wood Sandpiper (Tringa glareola) at the Gulf of Gdańsk.* Ring 19: 75-91.

Meissner W. 1998. *Some notes on using walk-in traps.* Wader Study Group Bull. 86: 33-35.

Meissner W. 1999. *Biometrics of Redshank (Tringa totanus) caught in the region of the Gulf of Gdańsk during autumn migration.* Vogelwarte 40: 110-116.

Meissner W. in press. *Timing and phenology of Curlew Sandpiper (Calidris ferruginea) autumn migration through the Puck Bay, Poland.* Int. Wader Stud.

Meissner W., Koziróg L. 2000. *Autumn migration of the Turnstone Arenaria interpres at the Bay of Gdańsk.* Not. Orn. 41: 213-223.

Meissner W., Remisiewicz R. 1998. *Wader Studies of the Waterbird Research Group "KULING" in 1983-1998.* Ring 20: 21-33.

Meissner W., Sikora A. 1995. *Spring and autumn migration of waders (Charadrii) on the Hel Peninsula.* Not. Orn. 36: 205 -239.

Meissner W., Włodarczak A. 1999. *Autumn migration of Sanderling (Calidris alba) in the Puck Bay region (southern Baltic coast).* Ring 21: 57-67.

Nieboer E., Cronau J., de Goede R., Letschert J., van der Have T. 1985. *Axillary feathers colour patterns as indicators of the breeding origin of Bar-tailed Godwits.* Wader Study Group Bull. 45: 34.

Pennycuick C.J. 1975. *Mechanics of flight.* In: Farner D.S., King J.R. (Eds) *Avian Biology.* vol. 5. Academic Press, London: pp. 1-75.

Prater A.J., Marchant J.H., Vuorinen J. 1977. *Guide to the identification and ageing of Holarctic waders.* BTO, Tring.

Rybkin A.V. 1998. *Lemming density in Taimyr tundra and its influence on reproduction of birds.* Int. Wader Stud. 10: 207-213.

Svensson L. 1992. *Identification Guide to European Passerines.* Stockholm.

Ściborski M. 1999. *The western part of the Gulf of Gdansk, Poland – an important place for migratory waders and waterfowl.* OMPO News. 20: 53-58.

Tomiałojć L. 1990. *Birds of Poland. Their number and distribution.* PWN, Warszawa.

Tomkovich P.S. 1998. *Breeding conditions for waders in Russian tundras in 1994.* Int. Wader Stud. 10: 132-144.

Underhill L. 1987. *Changes in the age structure of Curlew Sandpiper populations at Langebaen Lagoon, South Africa, in relation to lemming cycles in Siberia.* Trans. Roy. Soc. S. Afr. 46: 209-214.

Weber T., Houston A.I. 1997. *Flight costs, flight range and the stopover ecology of migrating birds.* J. Anim. Ecol. 66: 297-306.

Zar J.H. 1996. *Biostatistical Analysis.* Prentice-Hall, London.