Variability in the size of juvenile Red Knots *Calidris canutus canutus*

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Linear measurements of juvenile Red Knots caught in autumn on the Polish Baltic coast differed significantly between years. Exceptionally small birds were recorded in 1988 and 1989. Reasons of this variability are discussed. However, the most likely causes are differences in food availability on the breeding grounds or early departure from the breeding grounds of juveniles with bills and wings that are not fully grown.

INTRODUCTION

Biometric studies of waders on passage through the Puck Bay region (Gulf of Gdansk, Polish Baltic coast) in autumn have revealed differences in the measurements of juveniles caught both between years and within the same autumn season (Meissner 1997a, b, Meissner 1999, Meissner & Wlodarczak 1999).

No study has yet been made of variability in the linear measurements of juvenile Red Knots in Poland. However, Gromadzka (1992) showed that there were no significant differences in the bill- and wing-lengths of birds caught in the Vistula mouth (situated close to my study area) in succeeding periods of the same autumn. Gromadzka also reported differences in these measurements between seasons, but these were not statistically tested.

The aim of this study is to analyse biometric variability in juvenile Red Knots caught in subsequent autumn seasons on the Puck Bay coast.

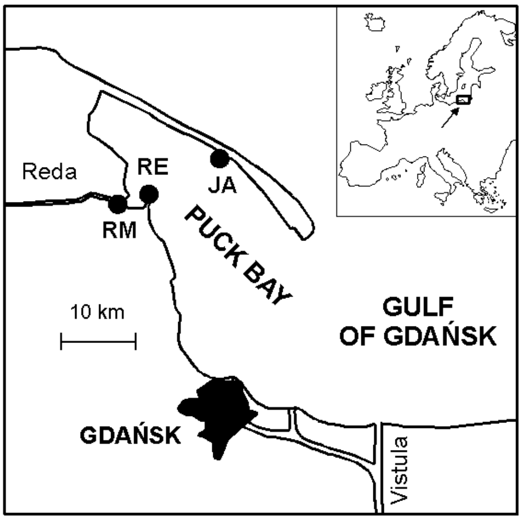

Fig. 1. Map of the study area (JA = Jastarnia, RE = Rewa, RM = mouth of the Reda river).

STUDY AREA AND METHODS

This study was conducted at three sites on the Puck Bay coast: at Jastarnia on the Hel Peninsula, at Rewa and in the surroundings of the Reda river-mouth (Fig. 1). At Jastarnia, knots mainly used a narrow sandy beach. At Rewa the site consisted of a long (1.5 km) and narrow (max. 30 m) sandy peninsula. In the Reda river-mouth, the study area comprised sandy beaches and periodically emerging sand islands on both shores of the river. Close to the river-mouth there is an ash dump of power station used by knots for roosting. At these sites, knots fed or roosted in small flocks of usually less than 200. The stopover is quite short, but the majority of retraps show increased body mass. More detailed description of fieldwork methods is given in earlier papers (Meissner & Remisiewicz 1998, Meissner 2000). At each site, waders are normally caught with walk-in traps (Meissner 1998) and mist nets are only used occasionally. During 1983–2001, 1,508 juvenile and 613 adult Red Knots were trapped. These included birds with a wide range of fat loads and of different sizes. Therefore we consider that walk-in traps are not selective in terms of the characteristics of the birds caught.

In this paper, data on wing-length, bill-length and tarsus-plus-middle-toe-length of juvenile knot are analysed. Wing-length was measured according to Evans (1986) (maximum chord). Bill-length was the exposed culmen, from the tip to the edge of the feathers on the forehead (Svensson 1992). Tarsus-plus-middle-toe-length was measured according to Piersma (1984). Between 1983 and 1990 all measurements were taken to the nearest 1 mm using a ruler with a stop. From 1991 onwards callipers were used to measure bill length to 0.1 mm. To combine more and less accurate measurements, all bill-lengths were rounded to the nearest 1 mm. Ringers were checked every year for comparability of measuring accuracy, following the procedure described by Busse (1994).

To study size variation between birds passing Puck Bay at different times, the autumn season was divided into half-month periods. Variation in measurements between years and between half-month periods was analysed using two-way ANOVA (ANOVA II). The number of birds caught and measured from year to year and in half-month periods within each season differed considerably so that for several year/periods there was insufficient data for proper analysis. There-

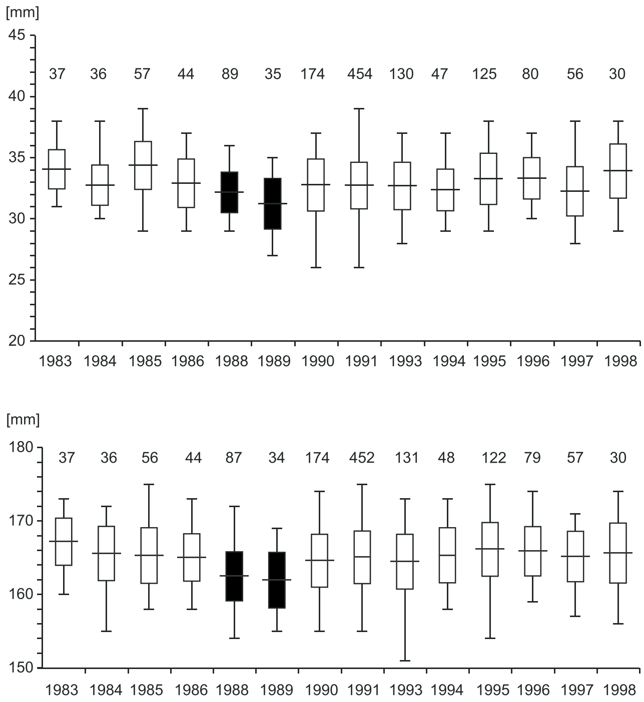

Fig. 2. Annual variation in bill-length (upper panel) and wing-length (lower panel) of juvenile Red Knots caught in autumn in the Puck Bay region of Poland (Horizontal line = mean, rectangle = SD, vertical line = range, black rectangles = seasons when measurements were significantly lower than in at least three other seasons. Sample sizes are given above the bars).

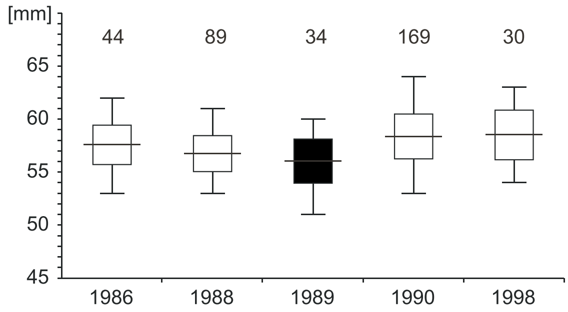

Fig. 3. Annual variation in tarsus-plus-middle-toe-length in juvenile Red Knots caught in autumn in the Puck Bay region of Poland (Horizontal line = mean, rectangle = SD, vertical line = range, black rectangles = seasons when measurements were significantly lower than in at least three other seasons. Sample sizes are given above the bars).

fore, the within-season analysis only covers data from the second half of August and the first half of September on the basis of a minimum sample size of 30 birds for each half-month period. Statistical methods followed Zar (1996) and StatSoft (1997).

RESULTS

Samples sufficient for analysing variability in bill- and wing-lengths both within and between season were collected in 10 seasons: 1984–1986, 1988, 1990, 1991, 1993, 1995, 1996 and 1998 and for tarsus-plus-toe length, only in 1988 and in 1990.

Results of two-way ANOVA revealed that, for juvenile knots, year, but not half-month period, was responsible for significant variation in the case of all measurements studied (Table 1). Thus, in further analysis it was assumed that there were no differences in the size of juvenile knots migrating earlier and later in the season. One-way ANOVA was therefore used to investigate differences among 14 seasons: 1983–1986, 1988–1991, and 1993–1998. In case of tarsus plus toe length, sample sizes were sufficient only for 5 seasons: 1986, 1988–1990 and 1998.

Significant between season differences were found in bill-length ($F_{13,1380} = 9.0$, $p < 0.001$), wing-length ($F_{13,1373} = 8.3$, $p < 0.001$) and tarsus-plus-middle-toe-length ($F_{4,361} = 16.8$, $p < 0.001$). Results of the Spjotvoll & Stoline post-hoc test showed that in 1988 and 1989 juvenile knots had the smallest linear dimensions ($p < 0.05$) (Figs 2 & 3). The bill-lengths of juveniles caught in 1988 and 1989 were significantly shorter than in the other five and eight seasons, respectively. In the case of wing-length, these differences were even more pronounced. Birds from 1988 and 1989 had significantly shorter wings compared with the other ten and eleven seasons respectively. The absolute difference between the highest and the lowest annual values were the greatest in wing-length, but bill-length was the most variable measurement between years (Table 2).

DISCUSSION

There were no significant differences in the measurements of juvenile knots between earlier and later migrants. Gromadzka (1992) drew the same conclusion for birds caught in the Vistula mouth. However, variation in measurements between seasons was quite pronounced. There may be several reasons for this. The ringers' team of WRG KULING gradually changed over the years. All were well trained, but it is possible that slight differences between people in measuring technique could have been responsible for some of the

Table 1. Results of two-way ANOVA on bill-length, wing-length and tarsus-plus-middle-toe-length against year and half-month period in juvenile Red Knots caught in the Gulf of Gdansk, Poland.

Source of variation	df	Mean square	F	p
Wing-length				
Year	3	55.84	4.32	0.005
Half-month period	1	1.54	0.12	0.730
Interaction	3	6.76	0.52	0.667
Bill-length				
Source of variation	**df**	**Mean square**	**F**	**p**
Year	3	14.59	3.67	0.012
Half-month period	1	0.51	0.13	0.720
Interaction	3	5.28	1.34	0.261
Tarsus-plus-middle-toe-length				
Source of variation	**df**	**Mean square**	**F**	**p**
Year	1	74.50	19.16	<0.001
Half-month period	1	0.21	0.05	0.818
Interaction	1	1.04	0.27	0.605

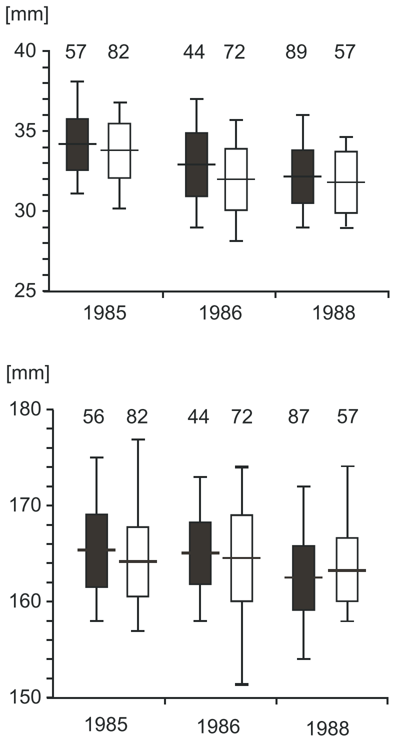

Fig. 4. Annual variation in bill-length (upper panel) and wing-length (lower panel) at WRG KULING ringing sites (black rectangles) and at the Vistula mouth ringing site (white rectangles). Data from Vistula mouth after Gromadzka (1992). (Horizontal line = mean, rectangle = SD, vertical line = range, sample sizes are given above the bars.)

variation. However, it seems unlikely that only in 1988 and 1989 both bill-length and wing-length, would have been systematically measured short. It is noteworthy that measuring tarsus-plus-toe accurately is quite easy (Meissner 2000) and this measurement was also significantly shorter in 1989. Moreover, changes in wing-lengths and bill-lengths noted in 1985–1986 and 1988 at ringing sites of WRG KULING were similar to those found at the Vistula mouth by a different ringing team (Fig. 4). In both cases, the lowest values were obtained in 1988.

In Red Knots, females are larger than males. This difference is also well pronounced in juveniles (Prater *et al*. 1977). Therefore the variation in measurements from year to year might be the result of changes in sex ratio. However, to my knowledge, there is no evidence that autumn juvenile sex ratios vary between years or that birds of one sex are more likely to be caught than the other or that there are any between-sex differences in migration phenology. Moreover, the frequency distributions of all measurements plotted separately for each year are quite symmetrical suggesting that there is no skewing of sex ratios.

Changes in the size of juveniles from year to year might be caused by differences in food availability on the breeding grounds. Chicks fed less food than others grow slower and reach a smaller size (Kersten & Brenninkmeijer 1995). Bad weather can reduce insect availability in the Arctic (Hodkinson *et al.* 1996) and could be the cause of a reduction in the size of juveniles. In 1989, when juvenile knots had the shortest wing and bill lengths, spring was late and summer cold on the Taimyr peninsula where many *canutus* breed (Kondratyev 1992). In 1988, when the birds were also smaller than usual, spring on the breeding grounds was earlier than usual, but the weather became worse during the summer (Tomkovich 1992). Moreover, the numbers of juveniles observed as well as the numbers caught at the Baltic stop-over sites was low in 1989 and only moderate in 1988 (Blomqvist *et al.* 2002, WRG KULING – unpublished data). These observations therefore support the hypothesis that smaller size may be related to poor breeding conditions. However, there was no significant relationship between breeding success, as measured by the number of juveniles trapped from year to year, and their body size, either in relation to their mean bill-length ($r = 0.06$, $p > 0.05$) or their mean wing length ($r = 0.07$, $p > 0.05$).

It should be noted I have no data to show whether juveniles that are particularly small in their first autumn stay smaller for the rest of their life.

In 1989, the median date of the juvenile knot migration in Puck Bay was the earliest in 17 seasons of daily counts. In 1988, juveniles also passed through the study area very early (WRG KULING – unpublished data). Therefore, if these birds started migration earlier than usual, they might have left from the breeding grounds with bills and wings not yet fully grown.

Knots occurring on the Polish Baltic coast in autumn belong to the nominate subspecies *canutus* (Gromadzka 1992, Meissner 1992). Many of these make their next stop on the coasts of the North Sea where another subspecies, *islandica*, arrives at about the same time (Davidson & Wilson 1992). These two subspecies are very similar with only slight differences in biometrics of which bill-length is the best distinguishing criterion (Engelmoer & Roselaar 1998). Therefore between-year variability in the measurements of juvenile knots may confound attempts to estimate proportions of the subspecies among samples of trapped birds.

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Table 2. Absolute and relative (in relation to many-year average) differences between the maximum and the minimum average measurements of juvenile Knots.

Measurement	Maximum (mm)	Minimum (mm)	Many-years average (mm)	Absolute maximum difference (mm)	Relative maximum difference (%)
Bill length	34.4	31.2	32.8	3.2	9.8
Wing length	167.2	161.9	165.0	5.2	3.2
Tarsus + toe length	58.5	56.0	57.7	2.5	4.3

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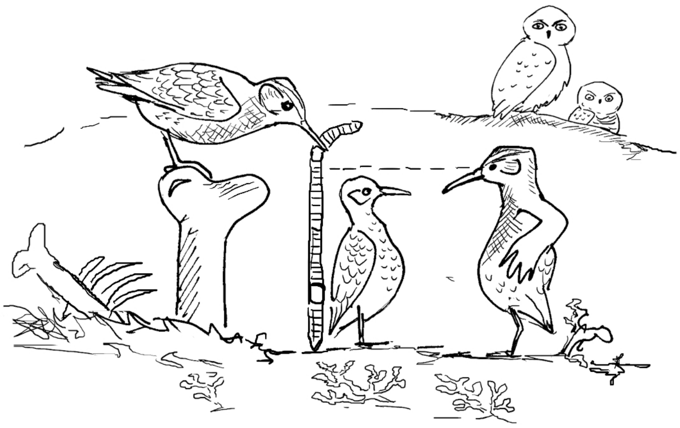
"Another millimetre and you would pass for a Siberian Knot anywhere!"



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