

Biometrics and body mass variation of Curlew Sandpiper *Calidris ferruginea* caught on the Puck Bay coast, Poland, during southward migration

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The study was conducted on the Puck Bay coast (inner part of the Gulf of Gdańsk, Polish Baltic coast). Between 1983 and 1998, 1783 Curlew Sandpipers were trapped in walk-in traps and measured. The absolute differences in the average measurements between adults and juveniles were small. Nonetheless, all measurements of adults (except tarsus length) were significantly longer than in juveniles. In adults, only the distribution of bill length showed bimodality, whereas in juveniles, two peaks appeared only in wing-length distribution. In juveniles, the average wing length, the total head length and tarsus length varied significantly between years.

Within a season, 158 (19.3%) juveniles and 47 (4.9%) adults were trapped more than once. The median length of stay of adults was two days, while that of juveniles was four days. On average, during the first three days after initial capture, juveniles put on 3.8 g and adults 5.2 g. Birds that did not increase body mass during the first days after catching had significantly higher body mass at first capture than birds that put on weight from the beginning. The highest rate of body mass increase occurred at the beginning of the staging period and later on its value decreased gradually. The mean body mass of birds caught in Puck Bay was low in comparison to data collected during southward migration in other parts of Europe. This suggests that Curlew Sandpipers migrate through Puck Bay with small fat reserves.

INTRODUCTION

A primary aim of the research on wader migration in Puck Bay, Poland, was to gain insight into the migration strategies used by different species at this stage of southward migration. Initially, analysis included examination of migration phenology, biometrics, length of stay and body mass changes. To date, data relating to Common Sandpiper *Actitis hypoleucos*, Wood Sandpiper *Tringa glareola*, Redshank *T. totanus*, Dunlin *Calidris alpina*, Sanderling *C. alba*, and Grey Plover *Pluvialis squatarola* have been analysed (Krupa 1997, Meissner 1996, 1997a, 1977b, 1998a, unpubl. data). These studies showed that many waders stop at the study area, but only for a short time, and that their body masses remain at rather low levels.

In spite of several thousand Curlew Sandpipers *C. ferruginea* having been ringed and measured on the Polish Baltic coast, the biometric data on this species have not previously been analysed and published. The main aim of this paper is to describe the biometrics and body mass variation of Curlew Sandpipers caught in the Puck Bay region between 1983 and 1998.

METHODS

The study was conducted on the Puck Bay coast at three sites on the inner coast of the Gulf of Gdańsk, Poland: at the Hel Peninsula in Jastarnia, at Rewa and in the vicinity of the Reda River mouth; further details of the study areas are in Meissner (2006). At the three sites, Curlew Sandpipers were caught in

walk-in traps (Meissner 1998b). Between 1983 and 1998, a total of 1783 birds were trapped and measured. Additionally, 213 Curlew Sandpipers were caught more than once within a season.

Birds were aged (Prater *et al.* 1977). Wing length (maximum chord; Evans 1986), total head length (Green 1980), bill and nalospi length (Prater *et al.* 1977), tarsus-plus-toe length (Piersma 1984) and tarsus length (Svensson 1992) were measured. The last-mentioned measurement was taken only in the seasons 1991–97. 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 total head, bill, nalospi and tarsus lengths (0.1 mm). To combine these measurements of differing degrees of precision, the more precise measurements of the lengths of bill, total head and nalospi were rounded to 1 mm classes. Birds were weighed to the nearest gram. Ringers were checked every year with respect to comparability of measuring accuracy, according to the procedure described by Busse (1994).

For estimation of the dependence of body mass at first and last captures, the rate of body-mass change and stopover length, partial correlation was used. As in other similar papers (Holmgren *et al.* 1993, Meissner 1997), birds which did not increase their body mass between first and last capture, and individuals for which the time between first and last capture was less than 17 hour, were omitted from these analyses. A sample size sufficient for this procedure ($n = 120$) was collected only in the case of juveniles. Statistical methods followed Sokal & Rohlf (1995) and Zar (1996).



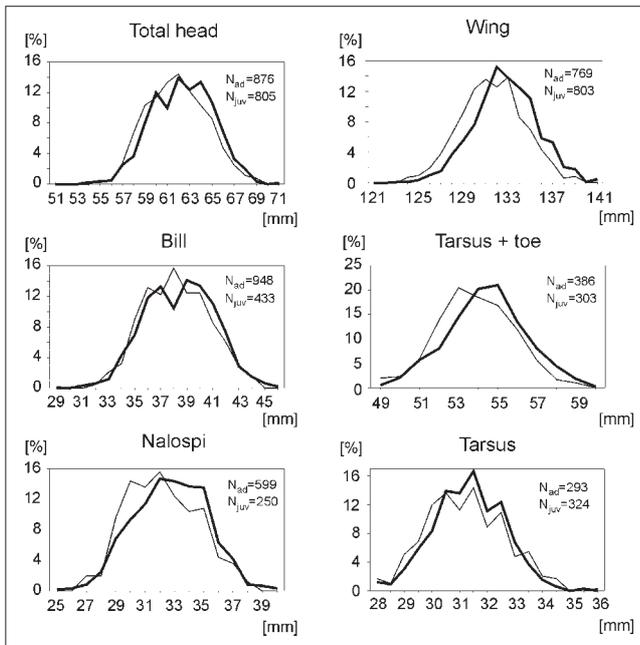


Fig. 1. Frequency distribution of different measurements in juvenile (thin line) and adult (thick line) Curlew Sandpipers caught on the Puck Bay coast during southward migration.

RESULTS

The absolute differences in average measurements between adults and juveniles were small (Table 1). The differences were the largest in the case of bill, nalospis and total head length (1.5%–1.6%). Despite the small magnitude of these differences, all measurements of adults (except tarsus length) were significantly longer than in juveniles, on average.

In adults, only the distribution of bill length showed bimodality. In juveniles, the distribution of this measurement was unimodal with a peak falling between the two peaks shown by adults (Fig. 1). Distributions of the remaining measurements were unimodal (tarsus-plus-toe length, wing length in adults and total head length in juveniles), or had three small peaks (total head and tarsus lengths in adults, tarsus and nalospis lengths in juveniles), or had no clearly defined maximum (nalospis length in adults). In juveniles, two indistinct peaks appeared only in wing-length distribution (Fig. 1).

ANOVA and Spjøtvoll & Stolone tests were used to check the variability of average measurements of juvenile birds between seasons. The wing length ($F = 10.01$, $P < 0.001$), total head length ($F = 2.76$, $P < 0.005$) and tarsus length ($F = 10.33$, $P < 0.001$) differed significantly between seasons. Birds caught in 1993 had significantly shorter tarsi than those from 1991 and 1996. Juveniles from 1996 had signifi-

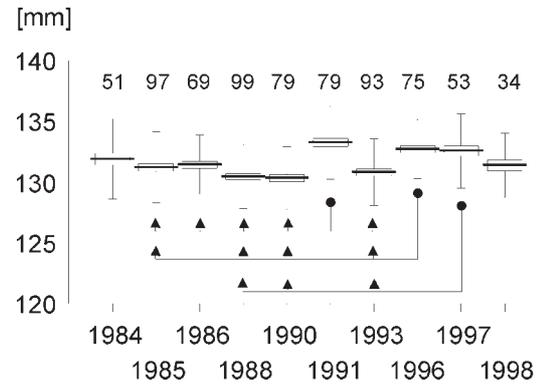


Fig. 2. Mean wing lengths (horizontal line), standard error (rectangle) and standard deviation (vertical line) in juvenile Curlew Sandpipers caught on the Puck Bay coast in subsequent years. Arrows indicate significant differences between groups of migrants (ANOVA, Spjøtvoll & Stolone test, $P < 0.05$). Numbers above indicate the sample size.

cantly longer heads than birds caught in 1986. The largest annual differences were manifested in wing length (Fig. 2). Birds with the longest average wing lengths were trapped in 1991, 1996 and 1997.

Within a season, 158 (19.3%) juveniles and 47 (4.9%) adults were trapped more than once. The median length of stay of adults was two days, while that of juveniles was four days; this difference was significant (U-test, $Z = 3.79$, $P < 0.001$).

The mean body mass of retrapped birds increased only slightly over one day (Fig. 3). Some birds even lost body mass during the first day after initial capture. Over a longer period of time, increases in body mass became more prominent. On average, during the first three days after initial capture, juveniles put on 3.8 g and adults 5.2 g. In adults, there was no significant difference between males and females classified using the discriminant function of Wymenga *et al.* (1990) (U-test, $Z = 0.35$, $P > 0.05$).

Eight adults and 19 juveniles showed a decrease in body mass, and in five adults and 14 juveniles there were no differences in body mass between first and last capture. Birds that did not increase in body mass had significantly greater body mass at first capture than birds that put on weight from the beginning (Table 2). The median length of these birds' stay was one day in adults and two days in juveniles (range 1–3 days and 1–8 days, respectively). The body mass of the rest of the birds increased by 1.7 g/day (SD = 1.2) in adults and 2.1 g/day (SD = 1.2) in juveniles, on average.

There was remarkable variation in the body mass of juveniles caught over successive 5-day periods (ANOVA $F = 9.58$, $P < 0.001$) (Fig. 4). Birds migrating at the beginning of September (29 August–7 September) were signifi-

Table 1. Comparison of measurements (mm) of adult and juveniles Curlew Sandpipers caught on Puck Bay coast during southward migration.

	Adults			Juveniles			Difference in %	t-Student or Cox-Cochran test (t')		
	Mean	SD	n	Mean	SD	n		df	P	
Total head	62.6	2.57	452	61.6	2.81	434	1.5	t' = 5.27	869.5	P < 0.001
Bill	38.8	2.56	524	38.2	2.54	433	1.6	t = 3.78	955.0	P < 0.001
Nalospis	32.7	2.40	280	32.2	2.44	250	1.6	t = 2.40	528.0	P < 0.002
Tarsus	30.9	1.57	293	31.0	1.30	325	-0.3	t' = -0.83	568.6	ns
Tarsus + toe	54.4	2.18	385	53.8	1.95	303	1.0	t' = 3.49	674.9	P < 0.001
Wing	132.7	2.89	769	131.6	2.90	803	0.9	t = 8.00	1570.0	P < 0.001



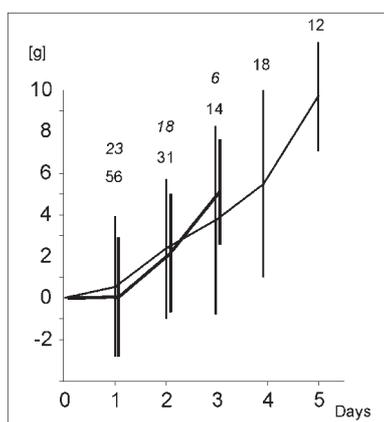


Fig. 3. Comparison of mean body mass changes in juvenile (thin line) and adult (thick line) Curlew Sandpipers staying on the Puck Bay coast. Vertical line – standard deviation, numbers indicate the sample size (for adults in italics).

cantly heavier than those caught earlier (14–28 August) (Spjøtvoll & Stoline test, $P < 0,05$)

The results of partial correlation showed positive relationships between body mass of juveniles at first and last capture, between stopover length and body mass at last capture, and a negative relationship between rate of body mass change and stopover length (Table 3). All this means that birds which stayed longer reached higher body mass at last trapping, and birds which were heavier when caught for the first time, attained higher body mass at last trapping. The marginally significant negative correlation between initial body mass and length of stay ($P = 0.077$) supported the results of analyses of the relationship between body-mass increase and stopover time. It is noteworthy that juveniles with higher rates of body-mass change tended to stay for shorter periods of time.

DISCUSSION

It is well known that during southward migration, mean wing length of adult waders is often shorter than that of juveniles, because the longest primary in adults is worn, whereas juveniles migrate with new feathers (Pienkowski & Minton 1973). This effect is strengthened by higher content of cartilage in the carpal and finger joints in juveniles. Such differences between age groups were described in the Gulf of Gdańsk for Dunlin and Common Sandpiper (Meissner 1997a, 1998a). An opposite result was found during this study. Longer mean wing length in adults could not be the result of a lower percentage of smaller males in the sample, because the proportion of both sexes was similar (Meissner 2006).

The other possibility is that, as in the Turnstone *Arenaria interpres*, juvenile Curlew Sandpipers had shorter primaries than adults. In Turnstone, the occurrence of shorter wings in juveniles has been confirmed at different places in Europe (Branson *et al.* 1979, Summers *et al.* 1989, Meissner &

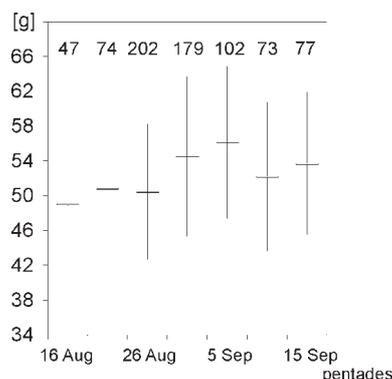


Fig. 4. Changes in mean body mass (horizontal line) in juvenile Curlew Sandpipers caught on the Puck Bay coast in subsequent pentades. Vertical line – standard deviation. Numbers above indicate the sample size.

Koziróg 2001) and in Africa (Summers *et al.* 1989, Ens *et al.* 1990, Wymenga *et al.* 1990). It is unlikely that juvenile Turnstones migrate without fully-grown flight feathers, because the difference in mean wing length was apparent throughout the whole migration period and on the non-breeding grounds. A similar situation may occur in the Curlew Sandpiper.

The bill and especially its horny part is still growing during the first months of a bird’s life (Szulc-Olechowa 1964, Holland & Yalden 1991). That is why there were small but significant differences in the bill, the total head and naospi lengths between adults and juveniles. The absence of differences in tarsus length between adults and juveniles is probably related to ossification of the leg bones, which is completed early (Strawiński 1964). Greater tarsus-plus-toe length in adults is difficult to explain. In other species, adults have shorter legs than juveniles, due to a decrease in cartilage content of the tarso-metatarsus-finger and finger joints, which causes shortening of the tarsus-plus-toe length (Cymborski & Szulc-Olechowa 1967, Meissner 1997a). This “overgrowth” in juveniles is transitional and it is possible that juvenile Curlew Sandpipers had passed this stage already, before arrival at the southern Baltic coast.

The mean wing length and bill length of juveniles obtained in this study was the same as in birds caught in Germany (OAG Münster 1983), but a little bit lower than in West Africa due to higher degree of feather abrasion (Wymenga *et al.* 1990).

The pronounced bimodality of adult bill lengths confirmed that bill length is the best measurement to separate adult males and females. The average values of all measurements taken at Puck Bay were similar to those given by Glutz *et al.* (1975) for different parts of Europe, except for southern France (Camargue). It is hypothesised that birds from different areas do not show a geographical variation in size (Cramp & Simmons 1983).

Juvenile males and females migrate together (Meissner

Table 2. Mean body mass (g) at the first capture in Curlew Sandpipers increasing and not increasing their weight during first days after the first capture.

	Increasing body mass			Not increasing body mass			U-test	
	Mean	SD	n	Mean	SD	n		
Juveniles	49.7	6.5	127	52.9	7.3	33	Z = 2.33	P = 0.002
Adults	49.3	4.3	31	53.1	5.5	16	Z = 2.49	P = 0.013



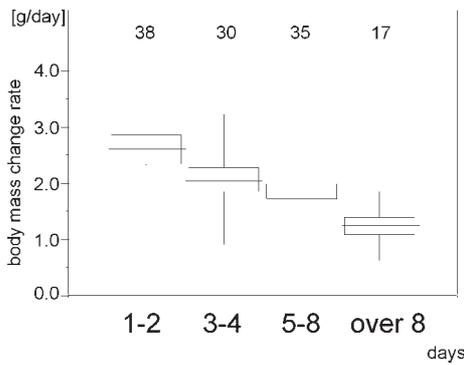


Fig. 5. Mean body mass change rates in juvenile birds (horizontal lines) in subsequent periods of their stay on the study area. Rectangle: standard error; vertical line: standard deviation. Numbers indicate sample size.

2006), thus it is assumed that their representation in the caught sample is approximately equal. The variability of average dimensions of juvenile birds between years has been described in some waders (Meissner 1997b) and passerines (Busse 1976). In Wood Sandpiper, in years with high breeding success, young birds are also significantly larger (Meissner 1997b). In Curlew Sandpiper, this relationship between the percentage of juveniles in a given season and mean wing and bill length did not exist (Spearman's rank correlation coefficients: -0.13 and 0.12 respectively).

The mean body mass of birds caught in Puck Bay was low as compared to other parts of Europe during southward migration (Glutz *et al.* 1975, Cramp & Simmons 1983). Our results are similar to the average body mass of birds immediately after their arrival in Morocco and Mauritania. It suggests that Curlew Sandpipers migrate through Puck Bay with small fat reserves. Despite this, only a small proportion of adults and juveniles stopped here for longer than one day. Also, the median length of stay was short, similar to other waders that stop at the study area (Meissner 1997b, 1998a, unpubl. data). The rate of body-mass change for birds staying at the study area, on the third day after first capture, reached 1.3 g/day in juveniles and 1.7 g/day in adults. These rates are similar to values estimated for Dunlins caught in the same area during southward migration (Meissner 1998a). However, they are a little lower than in juvenile Curlew Sandpipers caught at a sewage farm in Münster, Germany (OAG Münster 1983) and far less than in Great Britain (Stanley &

Minton 1972).

The slight decrease in body mass during the first days of a birds' stay on a staging site is a natural phenomenon (Masher 1966, Meissner 1998a). Masher (1966) and Meissner (1998a) claimed that only individuals with very low body mass put weight on immediately after arriving. Certainly not all Curlew Sandpipers were trapped just after their arrival, and some of them could have been caught after initial weight loss had already occurred. Such individuals would be included in the group of birds that do not lose their body mass (group with lower body mass). Nevertheless, the difference between both groups was significant (Table 2). Individuals staying longer in the study area deposit larger fat reserves (Table 3). Moreover, birds' body masses at last capture were correlated with their initial capture weight. This suggests that birds do not stop accumulating fat reserves at any pre-determined level; they continue fat deposition, and thereby also increase their potential flight distance.

Interestingly, of the juveniles that increased in mass, birds staying for a short time achieved higher rates of body-mass change than individuals that stopped for longer (Table 3). This was the result of declines in the rate of body-mass increase over time (Fig. 5). The highest rate occurred at the beginning of the staging period; later the rate of fattening decreased gradually. A similar situation was found in Dunlin in the same area (Meissner 1998a). The decline in the daily rate of mass gain over time might be a result of changes in foraging behaviour before departure, or depletion of the food supply. The latter seems unlikely because changes in density of ragworms *Hediste diversicolor* and chironomid larvae (Chironomidae), the main prey of Curlew Sandpipers in the study area, did not show any regular pattern between July and late September (Górecki 2002, unpubl. data). Birds which attained body mass sufficient for take off probably depressed their feeding intensity, because carrying extra fat reserves is costly (Alerstam & Lindström 1990).

Juvenile Curlew Sandpipers showed significant differences in initial body mass between birds losing and increasing in weight during the first days after capture. Birds which lost body mass immediately after first capture were heavier than those that put on weight from the beginning. Identical results were obtained in the case of Dunlin in the same study area (Meissner 1998a).

The low proportion of retraps among adult Curlew Sandpipers, and low average body mass, indicated that the majority of the birds stopped only for a short time at the study area and continued migration with low fat reserves. The Common Sandpiper and the Wood Sandpiper exhibit a similar migration strategy in this region (Meissner 1996, 1997b). Curlew Sandpipers that stopped for refuelling increased their body mass quite quickly. Juvenile retraps which stayed longer than two days weighed 60.7 g ($n = 82$, $SD = 7.7$ g), while adult retraps after the same time reached 57.7 g ($n = 13$, $SD = 4.6$). According to Pennycuik (1975), Curlew Sandpipers of this mass could fly *c.* $1,000$ – $1,200$ km in still air. Although the flight range estimates are rough and the real flight distance depends heavily on environmental factors (Weber & Houston 1997, Liechti & Bruderer 1998), the results indicate that Curlew Sandpipers are unable to reach the African coast directly from Puck Bay. Several resightings of colour-ringed individuals suggest that the mouth of the River Elba (*c.* 700 km away) is the next important stopover area for this species (O. Zeiske *in litt.*).

Table 3. Results of partial correlations (pairwise, the third parameter held constant) between body mass at the first capture (BM1), body mass at last capture (BM2), rate of body mass change (MC) and observed stopover length (SL). Only juvenile birds which gained body mass were included in the analysis ($n = 120$).

	BM2	SL	MC
BM1	0.65 $t = 9.37$ $P < 0.001$	-0.16 $t = -1.79$ $P = 0.077$	-0.09 $t = -0.98$ $P = 0.330$
BM2		0.39 $t = 4.57$ $P < 0.001$	0.14 $t = 1.49$ $P = 0.138$
SL			-0.31 $t = -3.59$ $P < 0.001$



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