



## Biometrics of Ruffs *Philomachus pugnax* migrating in spring through southern Belarus with special emphasis on the occurrence of 'faeders'

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In spring, the Ruff *Philomachus pugnax* passes through European inland sites in large numbers. Birds from eastern and western parts of the breeding range may differ in biometrics, but data on this species in eastern Europe are scarce. The aim of this study was to describe the biometrics of Ruffs migrating through southern Belarus in spring. In 2004, 242 birds were sexed by DNA analysis. Three birds sexed as males had female plumage but wing lengths intermediate between females and breeding-plumage males, and were identified as cryptic males or 'faeders'. Between 2001 and 2005, 2,237 Ruffs were ringed at the study site (1,310 males in breeding plumage, 911 females and 14 faeders). There was a strong seasonal variation in sex ratio. For adult Ruffs wing length was the best predictor of sex. Total head length and tarsus-plus-toe length distributions overlapped slightly between the sexes. There was evidence for slight bimodality in the distributions of wing, bill and tarsus-plus-toe length in non-faeder males and in wing and bill length distributions for females. Mean wing lengths of Ruffs passing through the Belarus study site were similar to those birds from other locations in Europe and North Africa, but different from birds from South Africa, Yamal and the middle Lena River, suggesting that Ruffs have at least two different breeding populations.

In spring, the Ruff *Philomachus pugnax* passes through European inland sites in large numbers (Glutz von Blotzheim *et al* 1975, Wymenga 1999). The migration patterns of Ruffs can be subdivided into two main systems. Birds from northwestern Europe spend the winter in western Africa. In contrast, birds from Siberia tend to winter in southern Asia, but also in eastern, southern, and western Africa (van Rhijn 1991).

The dynamics of Ruff spring and autumn migration, and in some cases the species' biometrics, have been described for many sites in western Europe (Anderson 1974, OAG Münster 1990, Serra *et al* 1990, Kivit *et al* 1994, Jukema *et al* 1995, Gill *et al* 1995, Wymenga 1999, Meissner & Zięcik 2005). However, published data on biometrics of this species in eastern Europe are still scarce (Diadicheva *et al* 2001). Results of some studies suggest that birds from eastern and western parts of the breeding area differ in biometrics (Glutz von Blotzheim *et al* 1975, Schmitt & Whitehouse 1976, OAG Münster 1990). Thus, the analysis of biometrics of Ruffs caught on migration at a stopover site may help to elucidate the migration routes of different populations (Meissner & Zięcik 2005).

The main aim of this study was to describe the biometrics of Ruffs migrating during spring through southern Belarus. Furthermore, we have emphasized the occurrence of a recently discovered new male type in our migratory population. These small, non-displaying male Ruffs have a female-like breeding plumage, and are the so-called 'faeders' described for the Dutch migratory population (Jukema & Piersma 2004, 2006). Jukema & Piersma (2004) called these intermediate males 'faeders', from the Anglo-Saxon word for father. Faeders moult into prenuptial male plumage with striped feathers, but do not grow the third-generation ornamental feathers of the other males. They are thus thought to wear the original male breeding plumage, before other male types evolved. Faeders can be distinguished by wing length, which is intermediate between displaying males and females. Here we present molecular confirmation of the sex of some faeders sampled from the Belarus population, and data on the frequency of occurrence of faeders in Belarus.

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## METHODS

### Study site

Ruff spring migration was studied in the floodplain meadows of the Pripyat River in the vicinity of Turov (Gomel Region, 52°04'N 27°44'E) (Fig 1). This area is an important stopover site for waders during migration. During peak migration, 10,000–14,000 staging Ruffs have been observed in this area (authors' unpublished data). A characteristic feature of the study area is the large fluctuation of water level in the Pripyat River in different years and seasons (Pinchuk *et al* 2005). Every year during the spring floods, however, approximately the same islands remain available for migrating and breeding waders. These islands are used as pastures during late spring and summer.

### Capture methods

Between 2001 and 2005, Ruffs were caught on the small islands (in total about 2 km<sup>2</sup>) in the flooded area. Birds were caught mainly using walk-in traps (Meissner 1998) that were placed on these islands and moved according to the water level. The number of traps used each season varied from seven in 2001 to twelve in 2002. Mist-nets were also used occasionally. Every year the fieldwork started at the end of March or beginning of April and finished at the end of May, covering almost the entire period of Ruff migration through the study area (Mongin & Pinchuk 1999).

### Ageing and biometrics

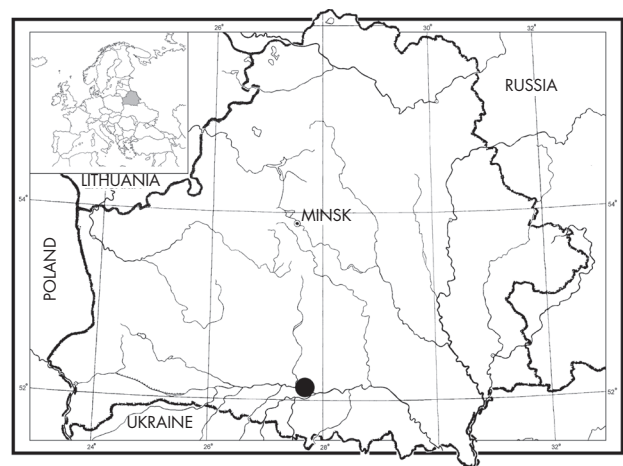
The age of the captured birds was defined by the presence (or absence) of juvenile inner median coverts (Prater *et al* 1977) and other criteria such as leg colour and the amount of wear on the primaries (Schmitt & Whitehouse 1976, Meissner & Scobbba 2005). Two age classes were distinguished: second-year birds (hatched in the previous year) and adults (three or more years old). The following measurements were taken: total head length (Green 1980), bill length and *nalospi* (bill tip to anterior edge of nostril opening: Prater *et al* 1977), tarsus length (Svensson 1992), tarsus-plus-toe length (Piersma 1984) and wing length (maximum chord method: Evans 1986). Wing length and tarsus plus toe were measured with a stopped ruler (to an accuracy of 1 mm and 0.5 mm, respectively); the remaining measurements were taken with callipers to an accuracy of 0.1 mm. Three ringers measured the birds during all study years and each year the accuracy and repeatability of measurements taken by the different ringers were checked as described by Busse (2000). Ruffs are highly sexually dimorphic (Prater *et al* 1977) and were sexed using breeding-plumage characteristics. In 2004, blood samples were taken from 127 adult males, 110 adult females and five birds with female-type plumage and wing lengths in the range

170–180 mm. For each bird, c 100 µl of blood was taken from an under-wing vein and preserved in 96% ethanol until laboratory analysis. These samples were used to sex the birds using DNA analysis (molecular sexing) at the University of Groningen by amplification of the chromohelicase-DNA-binding (CHD) gene with DNA primers P2 and P8 as described by Griffiths *et al* (1998).

To compare the wing lengths of Ruff caught at different European localities, a correction factor was needed to account for differences in primary-feather length between spring birds with relatively fresh primaries and autumn birds with worn primaries. The reduction in wing length between the completion of one moult and the start of the next is about 3 mm in females and 5 mm in males (Pearson 1981). Therefore, we added 3 mm to the reported mean wing length of females and 5 mm to the reported mean wing length of males caught during autumn migration to make published data comparable with results obtained during spring migration.

### Statistical methods

For biometric analyses of female and male Ruff, field measurements were combined with the sexing results for each individual. For some birds, not all measurements were taken, and so the sample sizes differ slightly between analyses. Parametric statistical tests were used and a probability ( $P$ ) < 0.05 was accepted as significant. All statistical methods used in this study followed Zar (1996) and analyses were done using STATISTICA 6.0 software (StatSoft 2001).



**Figure 1.** The study area is situated in the flood plains of the Pripyat river system in southern Belarus (indicated with the black dot). The study was conducted near the "Turov" Ringing Station, located near Turov town (Gomel Region, 52°04'N 27°44'E).

## RESULTS

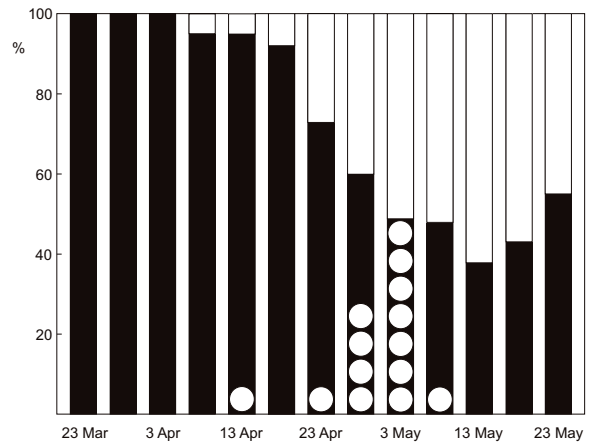
In the five years of this study, 2,237 Ruffs were ringed: 1,310 males in breeding plumage, 911 females and 14 faeders (see below). There was strong seasonal variation in sex ratio. In March, the catches were all males and only at the beginning of May did the sex ratio change to 1:1 (Fig 2).

### Identification of faeders

Among the birds sexed by DNA analysis in 2004 ( $n = 242$ ), the longest female wing length was 170 mm whereas the shortest wing length for a breeding-plumage male was 183 mm. Two of the birds with female-type plumage and with wing lengths within the range possible for faeders (170–180 mm) were female by DNA analysis and had wing lengths of 170 mm. For the other three female-plumaged Ruffs within this wing-length range, DNA analysis revealed they were males (Table 1). In addition, another bird with female-type plumage and a wing length of 178 mm was collected under licence and shown to be male by dissection: it possessed a pair of large, oval testes (12 x 7.5 mm left and 10 x 5.0 mm right) comparable in size to those of faeders described in the Netherlands (Jukema & Piersma 2006). On the basis of these results, all birds with a wing length between 172 and 179 mm and with female-type plumage were regarded as faeders. These criteria are in agreement with data from the Netherlands, where the shortest wing length of faeders sexed by DNA analysis was 171 mm and the longest wing length of females was 165 mm (Jukema & Piersma 2006). Using these criteria, an additional 10 faeders were identified, giving a total of 14 during the study period overall. All faeders were caught after 10 April when the first females arrived; no faeders were caught after 10 May (Fig 2). The frequency of faeders showed some annual variation, with values between 0.2 and 0.9%, and an overall average of 0.65% (Table 2). The biometrics of faeders with respect to wing, total head, bill, tarsus-plus-toe, tarsus and nalospi lengths are compared with females and breeding-plumaged Ruffs in Fig 3.

**Table 1.** Wing lengths and sex assigned by DNA analysis of five Ruffs with female plumage and wing lengths between 170 and 180 mm.

Ring number	Wing length	Catching date	Sex by DNA analysis
GS 01369	179	2-05-04	M
HS 00374	172	13-04-04	M
HS 00380	170	21-04-04	F
HS 00437	173	30-04-04	M
HS 00577	170	12-05-04	F



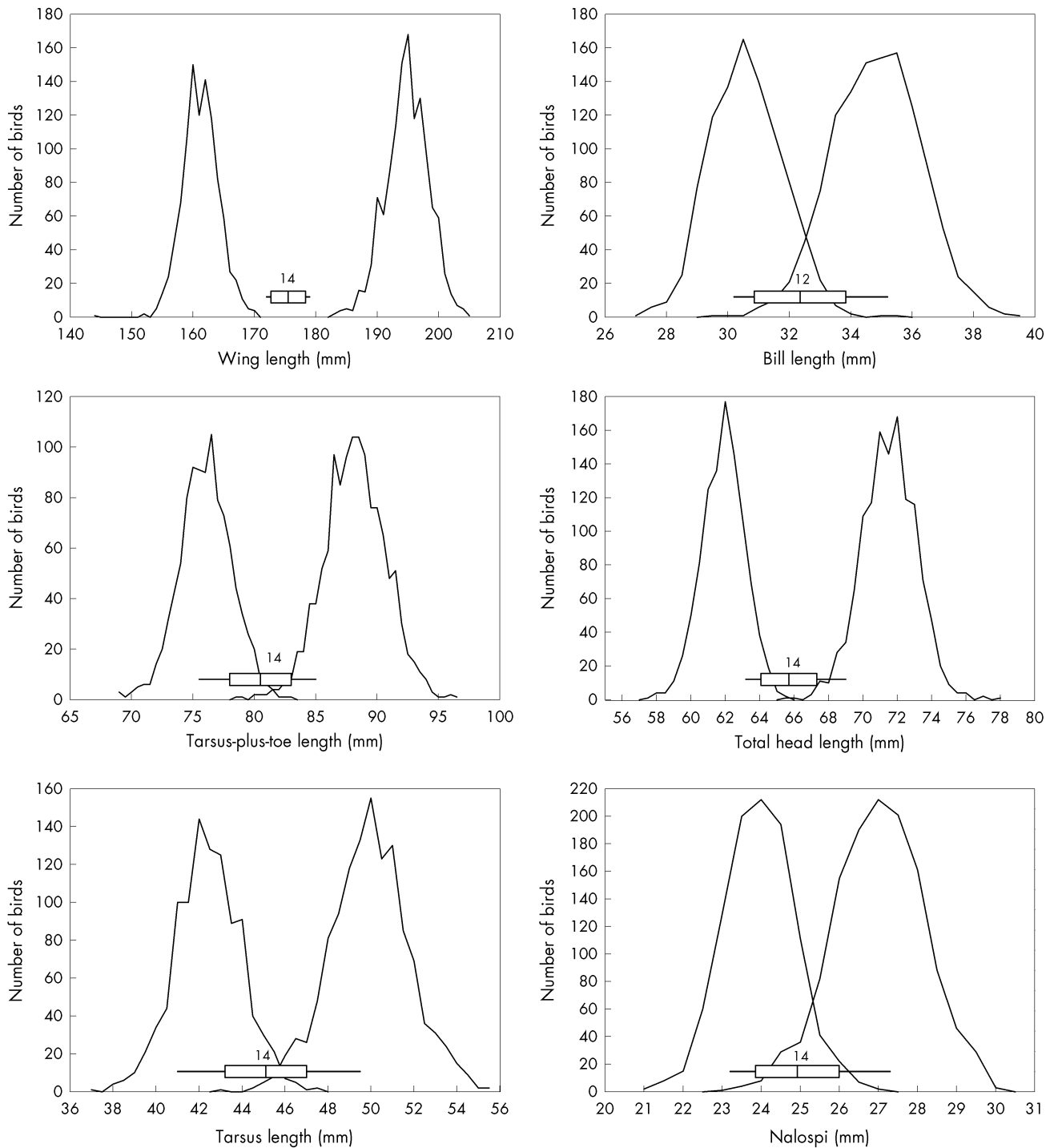
**Figure 2.** Seasonal changes in the proportion of captured male (black bars) and female (white bars) Ruffs in Belarus. Data from 2001–05 were combined and grouped into a standard pentad scheme (Berthold 1973). Dates are the middle dates of pentads. White dots indicate catches including faeders; each dot represents one individual.

### Biometrics of adult males (non-faeders) and females

Comparison of mean measurements of adults and second-year birds, excluding the faeders, showed that the two age classes did not differ significantly for any biometric measurements except wing length (Table 3). However, the sample sizes for second-year birds were smaller than for adults and data for adult birds only were used in the following analyses of biometric data. The distributions of adult total head lengths and tarsus-plus-toe lengths overlapped slightly between the sexes; the highest degree of overlap between the sexes was with bill length and nalospi (Fig 3). Conversely, there was no overlap in wing length between females and breeding-plumage males (Fig 3). Wing lengths of faeders did not overlap with males and females. Other linear measurements of faeders overlapped slightly more with females (tarsus and tarsus-plus-toe lengths) or were located in the middle of the overlap zone between normal (displaying) males and females (nalospi,

**Table 2.** The frequency of faeders in the migratory Ruff population passing through the Belarus study site each year.

Year	Males	Females	Faeders	Total	% faeders
2001	363	130	1	493	0.20
2002	169	139	2	308	0.65
2003	167	231	3	398	0.75
2004	406	263	5	669	0.75
2005	184	154	3	338	0.89



**Figure 3.** Frequency distributions of different measurements of adult female (left) and displaying male (right) Ruffs. Non-displaying, female-mimic males (faeders) are indicated with a horizontal line. Numbers above indicate the sample size of faeders. The box and whisker plot shows mean (vertical line), standard deviation (rectangle) and range (horizontal line) of faeder measurements.

**Table 3.** Comparison of biometric measurements (mm) of adult and second-year male and female Ruffs caught in the Pripyat floodplain, 2001–05.

Measurement		Adults			Second-year birds			Results of t-test	
		Mean	sd	n	Mean	sd	n	t	P
Total head length	M	71.69	1.57	1,115	71.73	1.68	163	-0.26	0.79
	F	62.06	1.22	834	62.12	1.29	56	-0.33	0.74
Bill length	M	35.01	1.47	1,067	35.19	1.44	161	-1.43	0.15
	F	30.78	1.17	793	30.77	1.14	57	0.04	0.96
Nalospis	M	27.19	1.16	1,115	27.32	1.17	162	-1.32	0.19
	F	24.14	0.89	835	24.26	0.98	57	-0.97	0.33
Tarsus length	M	50.11	1.83	1,115	50.06	1.98	162	0.33	0.74
	F	42.59	1.54	835	42.40	1.69	57	0.86	0.39
Tarsus + toe length	M	88.17	2.52	1,115	88.09	2.54	162	0.39	0.69
	F	76.0	2.16	835	75.7	2.24	57	1.1	0.27
Wing length	M	194.9	3.48	1,120	189.9	3.90	160	16.43	0.001
	F	161.3	2.98	836	160.3	2.98	57	2.5	0.01

bill and head length). Wing, bill and tarsus-plus-toe length distributions in breeding-plumage males, and wing and bill bimodality. The mean wing lengths of the Ruffs passing through Belarus are compared with those from other Palearctic and African localities in Table 4.

## DISCUSSION

Ruffs are a strikingly sexually dimorphic species, with males being considerably larger than females (Prater *et al* 1977). The wing length is the best biometric measurement to

differentiate between the sexes. However, in some papers, a small overlap in wing length has been reported (Anderson 1974, Schmitt & Whitehouse 1976, OAG Münster 1990). Recently, Jukema & Piersma (2004, 2006) described the phenomenon of small-sized, non-displaying males, referred to as faeders. Being female-like in plumage, these intermediate males are of a cryptic nature, which may help them to obtain matings at lek sites. The authors propose that these cryptic, feminine males represent a third male reproductive strategy (in addition to the 'resident' and 'satellite' strategies) that may even include parental care. These birds are scarce in Ruff populations, comprising

**Table 4.** Comparison of mean wing length (mm) of Ruffs caught in different Palearctic and African localities (data from autumn were corrected for wear according to Pearson 1981; uncorrected data on wing length in parentheses).

Site	Males			Females			Source
	Mean	Range	n	Mean	Range	n	
Belarus	194.9	183–205	1,310	161.3	144–170	911	This study
The Netherlands	193.5	183–205	517	160.5	156–165	47	Jukema & Piersma 2004
South Turkey	187.7	183–195	27	157.1	146–165	35	Kivit <i>et al</i> 1994
Kenya	189.3		23	158.5		129	Pearson 1981
Middle Lena River (Russia)	185.4	175–203	28	150.4	142–164	27	Labutin <i>et al</i> 1988
Yamal (Russia)	182.8	177–188	12	149.5	141–159	11	Danilov <i>et al</i> 1984
Lincolnshire (UK)	193.7 (188.7)	174–198	518	159.5 (156.5)	139–175	855	Glutz von Blotzheim <i>et al</i> 1975
Sivash (Ukraine)	193.3 (188.3)	187–191	40	161.9 (158.9)	157–161	54	Diadicheva <i>et al</i> 2001
Norfolk (UK)	194.0 (189.0)	177–210	52	160.0 (157.0)	144–169	24	Gill <i>et al</i> 1995
Münster (Germany)	189.5	170–202	474	159.4	139–173	1,176	OAG Münster 1990
South Africa	184.5	170–203	115	154.4	132–170	900	Schmitt & Whitehouse 1976

no more than 1% (Jukema & Piersma 2004). In previous analyses, they have probably been misclassified as females, which might explain the overlap in wing length range of females and males reported in some studies.

Apart from molecular sexing (DNA analysis), the best way to distinguish faeders from females is to measure wing length. The borderline values between females and faeders obtained in this study are similar to data from the Netherlands. However, in the Dutch study, the range of wing lengths between the largest females and smallest faeders was 6 mm, whereas in this Belarussian sample it was only 2 mm. The sample size of faeders caught in the Netherlands is small (22 individuals so far) and more data are needed to evaluate this criterion. The frequency of faeders passing through the Belarus study site was low and varied annually. A similar low frequency and annual variation in the frequency of faeders has been found in Ruffs that migrate through the Netherlands (Y. Verkuil, pers comm). The faeders in Belarus did not seem to migrate exclusively with either males or females as most were caught in the middle of the season when the sex ratio was about 1:1 (Fig 2).

The faeder strategy seems to be maintained for life. In catches, female-mimics were aged as second-year birds and older. Two birds were held for two years in captivity in the Netherlands and showed no change. As suggested by van Rhijn (1985), faeders may represent the ancestral male type, but their relatively large testes suggest that currently they behave as 'sneakers' (Taborsky 1994). The frequency of the other two male types in populations (satellite and resident males) is consistent with a single-locus, two-allele autosomal genetic polymorphism (Lank *et al* 1995). Faeders may represent the expected 1% of Ruffs homozygous for the satellite allele (Lank *et al* 1995), a genotype undisclosed in the single captive-breeding study so far.

The two peaks in male wing, bill and tarsus-plus-toe length distribution may be a result of differences in biometrics between resident and satellite males. Jukema *et al* (1998) found statistically significant differences in mean wing lengths of resident and satellite males and Höglund & Lundberg (1989) reported statistically-significant differences in mean wing, bill and tarsus lengths between males with different colour of ruffs and ear-tufts. In a study of differences between geographical populations of Ruff breeding in Yamal, Taimyr and Khanty-Mansiysk (Russia), Dobrinskiy (1981) found statistically-significant differences in average characteristic bill and tarsus lengths between males with different types of colour (piebalds and melanistics, corresponding to satellite and resident males). The two peaks in the wing and bill length distribution of females may indicate the passage of different geographical populations, which differed slightly in biometrics.



**Figure 4.** Comparison of mean wing length of adult Ruffs obtained in different sites with mean wing length obtained in this study in the context of three recognized flyways (cited by Zöckler 2002). Black dots – difference not greater than 3%, grey dots – difference greater than 5%. Asterisk – Turov (Belarus). See Table 4 for details.

The wing lengths of Ruffs passing through Belarus were most similar to those from the Netherlands and were only slightly different from other places in Europe and Africa. The most conspicuous differences were found between European birds and birds from South Africa, Yamal and the middle Lena River (Fig 4). Males and females from these localities had mean wing lengths 5–7% smaller than in birds migrating through Belarus after adding a 3–4 mm correction for primary wear. Ringing results show that northward migration from southern Africa takes place along the African Rift Valley through the Black Sea and Caspian Sea, through Kazakhstan and the Ob' and Yenisey Basins to staging points on the southern Lena River (Underhill *et al* 1999). Some eastern birds are known to reach Europe (Germany) during southward migration. The Ruff provides an example of a 'leap-frog' migrant, where the most easterly birds migrate to the most southerly part of the range. This might explain the similarity of biometric data from South Africa and the two Siberian sites. Hence, it appears that Ruffs from western populations are larger than their conspecifics breeding farther to the east, as suggested previously by Meissner & Zięcik (2005).

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