

## Brief report

# Sex identification of adult Dunlins *Calidris alpina alpina* migrating in autumn through Baltic region

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Eighty Dunlins *Calidris alpina* were trapped and measured in autumn in northern Poland and sexed by dissection or DNA analysis. A discriminant function, based on bill and wing length, was also constructed to predict the sex of adult Dunlins. This function classified correctly 100% of males and 97.3% of females. The resulted classification rate is one of the highest among studied wader species. The presented discriminant equation may be successfully used for sexing Dunlins when blood sampling is impossible and could be applied to samples collected in the past providing the opportunity to re-examine the results of previous analysis.

## 1. Introduction

The Dunlin *Calidris alpina* is a numerous migrant wader species at the coasts of the Baltic and North Seas (Glutz von Blotzheim *et al.* 1975). Plumage sex dimorphism is faint in the Dunlin; males tend to have grey and females brown neck (Glutz von Blotzheim *et al.* 1975), but this feature is difficult to apply directly in the field due to the commonness of intermediate coloration (authors' unpublished data). Although females are larger than males, the distributions of a given measurement overlap between the sexes, which makes sexing based on one trait difficult (Brennan *et al.* 1984, Engelmoer & Roselaar 1998). Several studies

have previously been conducted on Dunlin migration in Europe (e.g., Fuchs 1973, Gromadzka 1986, Holmgren *et al.* 1993, Meissner 1998, Serra *et al.* 1998, Meissner *et al.* 2005), but their results remain restricted due to these authors' inability to sex birds. Discriminant equations for sexing juvenile Dunlins have recently been provided by Meissner (2005), but because of possible differences in biometrics between juveniles and adults, they cannot be used for both age classes.

The aim of this paper is to provide a novel method for sexing adult Dunlins migrating through Europe. The method may be applied not only in future research, but also to sex individuals already measured during previous studies.

Table 1. Measurements for males and females of adult Dunlin. Mean, standard deviation (SD) and sample size (N), along with *t*-test results and a dimorphism index (DI), are provided.

Measurement	Males			Females			Test		DI
	Mean	SD	N	Mean	SD	N	t	P	
Total head length	54.80	1.60	37	59.59	1.63	37	12.75	<0.0001	8.36
Bill length	31.16	1.53	37	35.53	1.39	39	13.53	<0.0001	13.12
Tarsus length	24.71	0.85	36	26.05	0.73	41	7.43	<0.0001	5.28
Wing length	117.1	1.50	36	121.3	1.85	40	10.71	<0.0001	3.50

## 2. Material and methods

In autumns, between 1998 and 2001, there were 32 accidental deaths of Dunlins at the ringing sites of Waterbird Research Group KULING project, carried out in Puck Bay on the Polish Baltic coast. These individuals were sexed by dissection. In 2007, blood samples were taken from 48 additional birds caught during autumn migration in Lisewo, northern Poland. The sex of these Dunlins was identified molecularly, based on size differences in chromo-helicase-DNA-binding gene (Griffiths *et al.* 1998). The applied laboratory procedure followed Remisiewicz and Wennerberg (2006). From all these birds, the following measurements were taken: total head length, bill length, and tarsus length to the nearest 0.1 mm, using callipers. Wing length (maximum chord) was measured to the nearest 1 mm using a ruler (Meissner 2000). During the field study the accuracy and repeatability of these measurements, taken by different ringers, were checked. However, the first author measured about 90% of the birds. Some carcasses were partly damaged and for these specimens it was not possible to take the whole set of measurements. Thus, the sample sizes for different measurements are not equal. All data met the assumptions of the variance homogeneity (*F*-test;  $P > 0.05$ ) and normality (Shapiro-Wilk test;  $P > 0.05$ ), with two exceptions: male wing length ( $P = 0.02$ ) and the total head length in females ( $P = 0.03$ ). Data were not transformed, however, because discriminant analysis is robust with respect to this assumption, especially when deviations are minor (StatSoft Inc. 2007). All birds were sampled between 17<sup>th</sup> July and 28<sup>th</sup> September, when the subspecies *Calidris alpina alpina* migrates through the Baltic coasts numerously. The adults

of the subspecies breeding at the Baltic region, *C. a. schinzii*, migrate considerably earlier, mainly in June and early July (Glutz von Blotzheim *et al.* 1975).

To provide a measure of the sexual dimorphism, the Storer's index (Storer 1966) was calculated following the formula  $DI = 100(f - m) / 0.5(f + m)$ , where *f* and *m* are the mean values of a measurement in females and males, respectively. In the discriminant analysis, the equal prior probabilities were chosen. The presented equations are based on non-standardized canonical discriminant function coefficients, but standardized coefficients were also given to assess the contribution of one predictor in the context of the other predictors in the model. The success rate of the classification was assessed applying the jackknife procedure, in which each case is classified using a discriminant function based on all cases except the given one (Sokal & Rohlf 1995). Statistical analyses were done using STATISTICA 8.0 (StatSoft Inc., Tulsa), except the jackknife procedure that was done in SPSS for Windows 14.0 (SPSS Inc. Chicago).

## 3. Results

The sample consisted of 38 males and 42 females. All measurements of females were significantly larger (Table 1). The bill was the most sexually dimorphic trait, followed by total head length (Table 1). However, total head length was not used in the discriminant analysis, because it was highly correlated with bill length. Hence an inclusion of both traits would have violated the assumption of low multicollinearity of the independent variables.

Wing length showed the smallest overlap be-

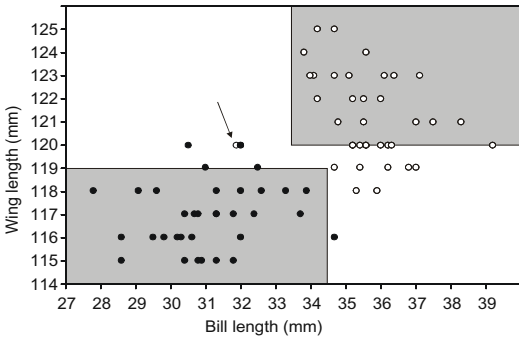


Fig. 1. Correlogram of the bill and the wing length of males (black dots) and females (white dots) of adult Dunlins. Shaded areas show the ranges of the measurements with no overlap between the sexes. The only female misclassified by the use of the discriminant function is indicated by an arrow.

tween sexes (20% of the total range), followed by bill length (25%), total head length (27%) and tarsus length (67%). In the analysed sample 92% of males and 81% of females could be correctly sexed using the criteria of the bill or the wing lengths alone (Fig. 1). The best discriminant function included the bill length and the wing length (Wilks' Lambda = 0.191,  $\chi^2 = 114.2$ ,  $P < 0.001$ ) with the resulted equation:

$$D = 63.24 - 0.56 * \text{Bill length} - 0.37 * \text{Wing length} \quad (1)$$

Values of  $D > 0$  identified males and values of  $D < 0$  identified females. This function correctly classified 100% of males and 97.3% of females (Fig. 1). The only misclassified female had an uncharacteristically short bill of 31.9 mm and a wing length of 120 mm, resulting in the discriminant score of  $D = 0.544$ . The cross-validation with the jackknife procedure produced the same rate of successful classification to the sex category.

The relationship between the discriminate score ( $D$ ) and the posterior probability ( $P$ ) followed the logistic curve (Fig. 2):

$$P = \frac{e^{-2.211 + 4.609 * D}}{1 + e^{-2.211 + 4.609 * D}} \quad (2)$$

If sexing of birds was limited only to individuals with a probability of a group membership  $P > 0.95$ , all males with discriminant scores greater than 1.119 and all females with discriminant scores lower than  $-0.159$  would be classified correctly,

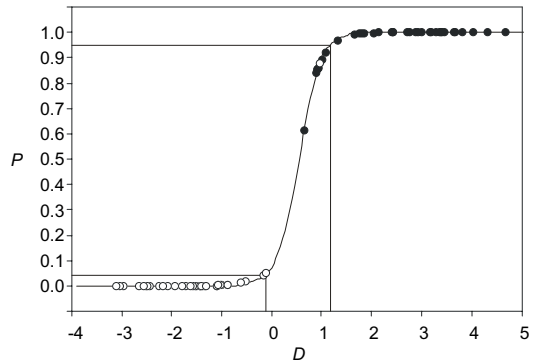


Fig. 2. Probability of being a male ( $P$ ) in relation to the discrimination score ( $D$ ). Black dots represent males and white dots females. Lines indicate 5% and 95% probability of being a male and the corresponding discriminant scores.

leaving 9 (11.25%) birds unclassified in the analyzed sample (Fig. 2). Standardized canonical discriminant function coefficients for bill length and wing length were  $-0.804$  and  $-0.637$ , respectively, which indicates that bill length had higher discriminatory power than wing length.

#### 4. Discussion

The bill length has appeared the best predictor of the sex in the Dunlin regardless of subspecies or age class (Brennan *et al.* 1984, Engelmoer & Roselaar 1998, Meissner 2005). The presence of the female with a very short bill in the present sample, and results presented by Mullié & Meininger (1981), Meissner (2005) and Lopez *et al.* (2006), indicate that short-billed females are more frequent in this species than are long-billed males. As a consequence, the discriminant functions derived for adult (this study) and juvenile Dunlins (Meissner 2005) were only able to sex males correctly. These short-billed females may have belonged to the subspecies *schinzii* that migrates through the Baltic region earlier than *C. alpina alpina* does (Glutz von Blotzheim *et al.* 1975). However, the rate of successful classification obtained for adult Dunlins is one of the highest among the studied wader species (e.g., Maron & Myers 1984, McCloskey & Thompson 2000, Ura *et al.* 2005, Dubiec & Sikora 2007). Thus, the presented discriminant equation may be successfully used for sexing Dunlins if DNA analysis is

not a viable option, or to evaluate sex-related measurements from past studies. However, because of differences in the measurements between Dunlin subspecies (Engelmoer & Roselaar 1998), the proposed equation can be used only for sexing birds of the subspecies *C. alpina alpina*.

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### Aikuisten suosirrien *Calidris alpina alpina* iänmääritys syysmuuton aikana Baltiassa

Pyydystimme ja mittasimme 80 suosirriä *Calidris alpina* syksyllä Pohjois-Puolassa, ja määritimme yksilöiden sukupuolet näytepala- tai DNA-analyyseillä. Parhaisiin aikuisten suosirrien sukupuolia erottaviin tekijöihin kuuluivat nokan ja siiven pituus, millä muuttujilla sukupuoli saatiin oikein 100 % koiraista ja 97,3 % naaraista. Tällainen luokittelun onnistuminen on tutkittujen kahlaajalajien parhaimmistoa. Työssä esiteltyä erotteluyltälöä voi menestyksellisesti käyttää suosirrien sukupuolen määrittämisessä silloin, kun verinäytteen otto ei ole mahdollista, ja sitä voidaan käyttää myös vanhoihin näytteisiin, jos halutaan tarkistaa vanhojen analyysien tuloksia.

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