

BIOMETRICS AND MORPHOLOGY VARIATION
WITHIN SEX-AGE GROUPS OF ROBINS (*Erithacus rubecula*)
MIGRATING THROUGH THE POLISH BALTIC COAST

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ABSTRACT

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Biometrical and morphological differentiation in sex-age groups of Robins migrating through the Polish Baltic coast was studied. Altogether 446 dead birds were collected in 1963-2004 during spring or autumn migration. Dead Robins were measured (wing and tail lengths and wing formula) and additionally in 2002-2004 leg colour and amount of grey colour on head and flanks were determined. After the measurements were taken, individuals were sexed by dissection.

Birds were divided in four sex-age classes: immature females, immature males, adult females and adult males. Wing length, tail length, index of asymmetry (E') and pointedness (L) were compared among this classes using t -test. G -test was used to compare leg colour and greyness on head and flanks between the sexes for immature Robins. With a method of correlative topography charts showing combination of two parameters – wing and tail lengths – in different sex-groups of immatures were prepared.

Obtained results indicate that sexes differ in wing and tail length and greyness on head and flanks. Males have longer wings and tails and bigger amount of greyness than females. The overlap of females and males is rather large, *i.e.* in the case of wing length 69-75 mm in immature and 71-74 mm in adult birds and in the case of tail length 55-67 mm in immature and 57-64 mm in adult birds. High probability of sex determination according to wing or tail length is found only in extremes. Combination of these two features only slightly increases possibility of sex determination.

The Robin is a monomorphic species, therefore biometrical differences between males and females could be helpful in sexing. In some studies Robins were sexed according to criteria proposed by J. Pettersson referring to wing length, but only 29% of birds analysed here could be sexed when applying this criterion. These differences may result from varying composition of populations coming from different breeding areas. According to the charts presenting correlation between wing and tail length, three “biometrical” groups are distinguishable in both sexes.

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INTRODUCTION

The Robin has been the object of many investigations considering behaviour, ecology and particularly migration. It is not only one of the most widespread and abundant bird species in Europe (Cramp 1988, Hagemeijer and Blair 1997), but also the one of most numerously caught species (Busse 1994). The nominate subspecies *E. r. rubecula* is the most common (Cramp 1988, Hagemeijer and Blair 1997), and it is the object of this study.

Robins migrating through the Polish Baltic coast breed in Finland, Sweden, south-western Norway, Estonia and in the north-western Russia (Remisiewicz *et al.* 1997). In autumn birds direct to four winter quarters: the Western, Mediterranean, Apennine and Balkan (Remisiewicz 2001, 2002). Ringing recoveries' analysis of birds caught at the Baltic coast (Remisiewicz 2002) suggests following spatio-temporal pattern of Robins' migration. Birds heading to various winter quarters migrate along different routes in different time. At the earliest Robins migrate to the Western and Apennine winter quarters, next to the Mediterranean and birds directing to the Balkans migrate the latest of all (Remisiewicz 2002). Moreover, Robins caught during passage at European ringing stations in subsequent periods of spring and autumn migration differ in biometrical and morphological data (Busse 1976, Mehlum 1981, Pettersson 1983, Pettersson and Lidholm 1983, Saurola 1983, Karlsson *et al.* 1986, Lövei *et al.* 1986, Karlsson *et al.* 1988, Pettersson *et al.* 1990). These differences refer to wing length, wing shape, leg colour, amount of grey colour on head and flanks ("greyness") and a number of unmoulted greater coverts. Observed differences probably result from the passage of different populations (Högstedt and Persson 1971, Pettersson 1983, Pettersson *et al.* 1990). Saurola (1983) suggested another solution. He proposed that these differences were the result of various migration time of different sex and age groups. Busse (1976) maintained that the biometric differences cannot be explained exclusively by the differentiation of sex composition.

The Robin is monomorphic species, but some biometrical differences can be noted between the sexes: males have longer wings than females (Mehlum 1979 after Mehlum 1981, Pätzold 1982, Pettersson 1983, Pettersson and Lindholm 1983, Cramp 1988, Cuadrado 1991, Svensson 1992, Madsen 1997, Catry *et al.* 2004). According to Cramp (1988), the variation range within *E. r. rubecula* subspecies is 70-76 mm in males and 68-74 mm in females. According to Svensson (1992), J. Pettersson suggested that 60% of Robins could be sexed based on wing length, *i.e.* the wing of adult males is longer than 75 mm, in immatures – 74 mm, and the wing of adult females is shorter than 72 mm, in immatures – 71 mm. But when Madsen (1997) applied wing length criterion to Robins caught in western Denmark (caught both during breeding season and migration), he noticed that only 36% of birds were sexed correctly. He found that females and males differed also in tarsus length and proposed another method based on combination of two features: wing and tarsus

lengths. With this method up to 81% of individuals could be sexed successfully. Males and females of Robins differ also in tail length (variation range for *E. r. rubecula* subspecies: males – 53-60 mm and females – 51-59 mm; tail length was the distance from the point where the central tail feathers emerge from the skin to the tip of the longest feather) (Cramp 1988). Although the Robin is monomorphic species, some papers reported differences between sexes concerning plumage colouration (García Diego 1984, Cramp 1988, Pettersson *et al.* 1990). Sexes can differ in depth of rufous shade on the chin and chest – deeper in males and adult birds (Cramp 1988) or in the range of grey feathers on head and flanks – with more greyness in males than in females (Pettersson *et al.* 1990). In Spain differences in grey and rusty red colour between sexes at forehead were found. Males had wider stripes of these two colours than females and a curve of these stripes was gentler (García Diego 1984).

Pettersson *et al.* (1990) revealed differences between sexes not only during migration, but also in winter quarters. Birds ringed in the four wintering areas (Spain, France, Greece and Cyprus) differed in wing length, leg colour and greyness within sex-age groups. Also in these areas the number of unmoulted greater coverts differed among young birds. Males and females wintering in southern Spain differed in wing length as well. They could be sexed in 35% according to wing length (Cuadrado 1991).

The aim of this study was to determine biometrical (wing and tail length, wing shape) and morphological differentiation (leg colour and greyness) within sex-age groups of Robins migrating through the South Baltic coast.

MATERIAL AND METHODS

In the study, measurements of dead birds found at the Polish Baltic coast in 1963-2004 were used. Dead Robins were found on the beach, close to roads and tracks and came from other sources as well. Altogether 446 birds were collected during spring (from the end of March to mid-May) or autumn (from the end of September to mid-November) migration. The number of Robins found in different seasons, years and sex groups is presented in detail in Table 1.

Robins were aged according to their plumage characteristics: mainly presence of unmoulted greater coverts, shape of tail feathers, colour of the inside of the upper mandible or skull ossification stage (Busse 1990, Svensson 1992). Afterwards, wing length (maximum chord method), tail length and wing formula measurements were taken (Busse 1974, 2000). The wing formula was recorded by measuring the distances between the wing tip and tips of subsequent primaries – from the second to the eighth (Busse 1974, 2000). All measurements were taken to the nearest 1 mm, using a ruler. Material was collected during long time, but all measurements were taken by Operation Baltic ringers according to standard methods. It should be pointed that tail length measurement was taken using “to the back” method (Busse 1974), that gives higher values than the method “between rectrices” using callipers

(Svensson 1992). Additionally, in 2002-2004 morphological characteristics of found birds: leg colour and amount of grey colour on head and flanks were determined. These characteristics were examined according to the four-score scales by Pettersson *et al.* (1990) (leg colour: 1 – yellowish, pinkish, 2 – light brown, 3 – dark brown, 4 – almost black or black; greyness amount on head and flanks: 1 – almost no grey feathers, 2 – broken stripe on flanks, 3 – continues stripe on flanks, 4 – wide, grey stripe from head to flanks). Morphological characteristics were made by the author. After all the measurements were taken, Robins were sexed by dissection. All the measurements and dissections were taken just after an individual was found or during the next day. This was to avoid effects of *post-mortem* changes in corpses on biometrical measurements, what can produce a bias (Knox 1980).

Table 1
Number of individuals used in the analysis

Year	Spring		Autumn		Total in year
	□ □	□ □	□ □	□ □	
1963	-	-	2	2	4
1964	-	-	3	6	9
1965	-	-	4	3	7
1966	-	-	3	3	6
1967	-	-	5	7	12
1968	-	8	-	-	8
1969	16	35	-	-	51
1970	-	6	-	-	6
1972	7	20	-	-	27
1973	-	-	13	13	26
1979	-	1	-	1	2
1980	-	1	1	-	2
1981	-	-	11	12	23
1986	1	1	4	7	13
1988	-	4	3	3	10
1989	1	-	-	-	1
1993	1	-	-	-	1
1994	1	-	-	-	1
1996	1	-	-	-	1
2002	-	-	38	23	61
2003	-	11	27	18	56
2004	2	-	67	50	119
Total	30	87	181	148	446
	117		329		

In the first step percentage distribution of wing and tail lengths and frequencies of leg colour and greyness amount classes were drawn for immature females and males, due to insufficient number of adults. Wing asymmetry (E') and pointedness (L) indices were calculated according to formulas proposed by Busse (1986, 2000) based on wing formula measurements:

$$E = \frac{p}{p} \frac{d}{d} 100\% \quad L = \frac{p}{w} \frac{d}{d} 100\%$$

where:

Σp – a sum of distances from wing tip to the tips of proximal primaries,

Σd – a sum of distances from wing tip to the tips of distal primaries,

w – wing length.

Data on birds found during spring and autumn migration were analysed jointly, because preliminary comparison between seasons did not indicate differences. Birds were divided in four sex-age classes: immature females, immature males, adult females and adult males. Next, the morphological data were compared among these groups. All biometric variables were tested for fit to normal distribution using the Kolmogorov-Smirnov test. Afterwards, wing length, tail length, index of asymmetry (E) and pointedness (L) were compared between sexes using the t -test. Separately, G -test was used to compare frequencies of leg colour and greyness amount classes between the sexes for immatures (due to insufficient number of adults). Additionally, average values of leg colour and greyness amount were calculated similarly to paper of Pettersson *et al.* (1990) to make comparisons easy.

Then conceptual models were used to explore possibility of sex determination according to wing length, tail length or both characteristics jointly. This was expressed as follows: let p be the probability that a bird is a female and $(1 - p)$ – the probability that a bird is a male. Assume that:

- 1) $f(p) = A + B_1 w$
- 2) $f(p) = A + B_2 t$
- 3) $f(p) = A + C_1 w + C_2 t$

where:

f – link function,

w – wing length,

t – tail length

In order to force that $0 \leq p \leq 1$, this dependence must be described with conventional logistic transformation:

$$1) \text{logit}(p) = \log \frac{p}{1-p} = A + B_1 w$$

$$2) \text{logit}(p) = \log \frac{p}{1-p} = A + B_2 t$$

$$3) \text{logit}(p) = \log \frac{p}{1-p} = A + C_1 w + C_2 t$$

Given p this model can be connected with binary data in following way:

female = 1

male = 0

$$p_i = p_i(w)$$

$$p_i = p_i(t)$$

$$p_i = p_i(w, t)$$

where:

p_i – probability that i^{th} bird is a female

Probability of sex distribution for each bird is in a form: $\text{sex}_i \sim \text{binomial}(p_i, 1)$. In order to determine values of model parameters B_{ie} , C_{ie} , a common statistical tool Generalized Linear Model (GLM) was used (McCullagh and Nelder 1989). GLM makes possible to extend linear regression approach to various probability distributions and various link functions. As a result of GLM, mean value of each parameter (A_i , B_i , C_i), its standard error or confidence interval and confidence level p_i for hypothesis that A_i , B_i , $C_i = 0$ were obtained. If parameter B_i is statistically different from zero, then corresponding independent variable (w_i , t_i , $w_i t_i$) influences significantly dependent variable p .

Next, with a method of correlative topography, charts showing combination of two parameters, wing length and tail length, in different sex groups of immature Robins were prepared using SURFER 8 program for Windows. This method was proposed by Busse (1968, 1999) to study intra-group biometrical differentiation.

RESULTS

Charts presenting percentage distribution of wing and tail lengths for immature birds indicate differences between sexes (Fig. 1). The wing length range is 67-75 mm for immature females, 67-74 mm for adult females, 69-79 mm for immature males and 71-76 mm for adult males. The wing length distributions in females and males are unimodal in the case of immature Robins. The overlap of females' and males' wing length is rather large *i.e.* 69-75 mm in immature birds and 71-74 mm in adults. The tail length range is 52-67 mm for immature females, 55-64 mm for adult females, 55-69 mm for immature males and 57-67 mm for adult males. The tail length distributions in immature Robins are unimodal, but asymmetric for both sexes. The overlap of females' and males' tail length is 55-67 mm in immature and 57-64 mm in adult birds. On average, males have longer wings and tails than females, both in immature and adult birds (t -test – Table 2). In Figure 2 data were grouped according to wing length and according to tail length as well. For each group modal values of p (probability that an individual with given wing length or tail length is a female) were calculated:

$$p = \frac{k}{N}$$

where:

k – number of females with given wing length,

N – number of all birds with given wing length,

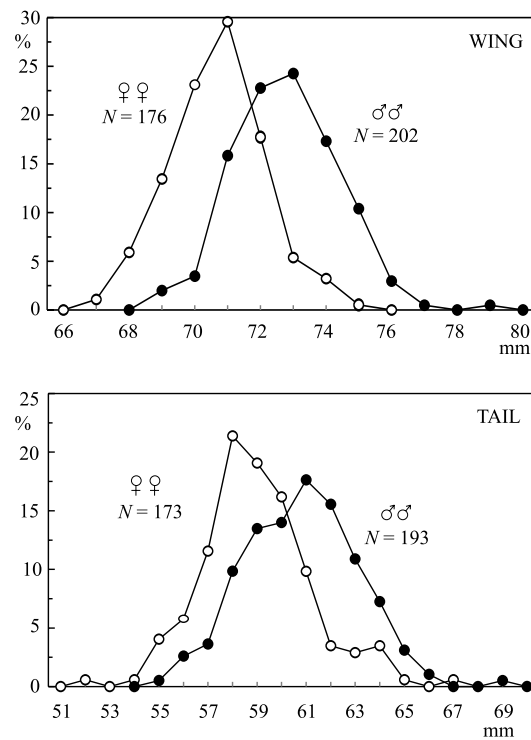


Fig. 1. Percentage distribution of wing and tail lengths in sex groups of immature Robins

Table 2

Biometrical differentiation of sex-age groups (statistically significant differences given in bold)

			Mean	SD	N	t-test
Wing length	imm.	□ □	70.68	1.47	186	$t = 13.53$
		□ □	72.79	1.60	202	$p < 0.0001$
	ad.	□ □	71.52	1.94	21	$t = 4.38$
		□ □	73.71	1.41	28	$p < 0.0001$
Tail length	imm.	□ □	58.98	2.25	173	$t = 7.62$
		□ □	60.80	2.30	193	$p < 0.0001$
	ad.	□ □	59.21	2.44	19	$t = 3.80$
		□ □	62.23	2.87	26	$p < 0.001$
E' index	imm.	□ □	10.18	9.80	132	$t = 1.61$
		□ □	12.15	10.58	147	$p = 0.11$
	ad.	□ □	7.52	9.68	14	$t = 0.43$
		□ □	6.06	9.31	17	$p = 0.67$
L index	imm.	□ □	42.66	5.01	132	$t = 1.24$
		□ □	43.44	5.58	147	$p = 0.22$
	ad.	□ □	44.84	4.08	14	$t = 0.05$
		□ □	45.93	5.06	17	$p = 0.96$

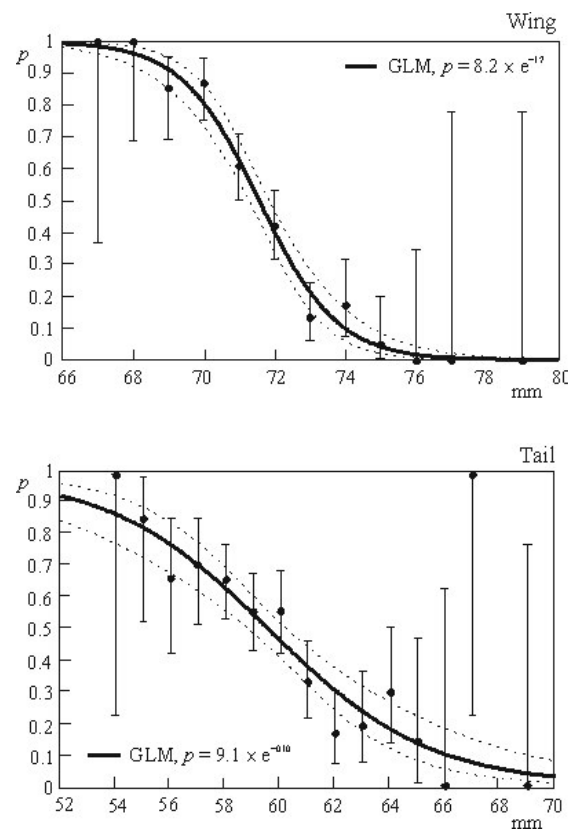


Fig. 2. Probability of sex determination of immature Robins according to wing length and tail length; p – probability that a bird is a female, black dot – modal value, vertical line – 95% reliability interval for p , thick line – means of GLM p , dotted lines – limits of 95% confidence interval for p .

and located in the picture. According to wing length, high probability of sex determination for immature birds was found only in extremes, what is indicated by means of GLM p values located in Figure 2. Values of wing length to 68 mm attain the probability that an individual is a female close to one and values higher than 74 mm attain the probability that an individual is a female close to zero. In the case of tail length the results are somewhat worse, because the probability that an individual is a female does not reach values close to one or zero (Fig. 2). Confidence level for the hypothesis that an individual is a female is lower for the wing length (model 1: $p = 8.2 \times 10^{-17}$) than for the tail length (model 2: $p = 9.1 \times 10^{-10}$). It should be stressed that in the mixed model (3) the tail length factor is out of statistically significant influence ($p = 0.4$) comparing to wing length ($p = 2.7 \times 10^{-13}$), what suggests that the addition of tail length to wing length does not enhance sex determination. In particular it is visible in Figure 3, where along the X -axis, one can see extreme wing lengths that are characteristic only for males or females, whereas along the Y -axis tail lengths of males overlap entirely with measurements of females, what indicates

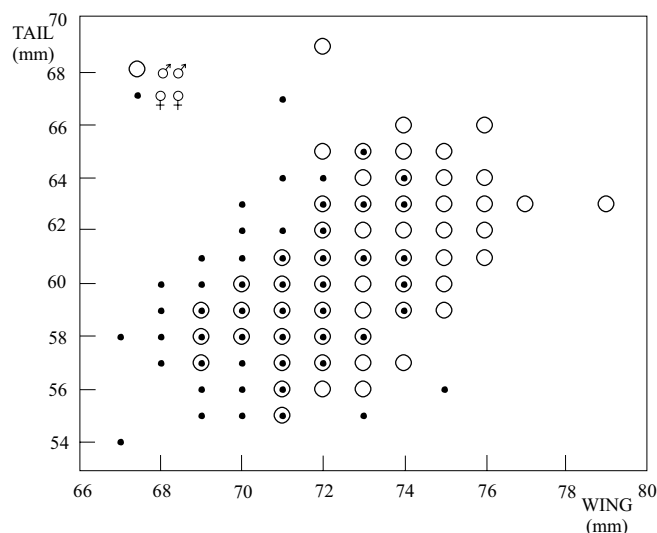


Fig. 3. Sex determination of immature Robins according to combination of wing and tail lengths

that tail length does not influence markedly sex determination. According to results of *t*-test, the wing shape indices (*E'* and *L*) do not differ between sexes (Table 2). In all cases differences were not statistically significant.

Leg colour categories are represented with similar frequencies for both sexes (Fig. 4), the results of *G*-test did not indicate differences (Table 3). Among males there is a bigger proportion of birds with greater greyness range on head and flanks than among females (Fig. 4), what is confirmed by the results of *G*-test (Table 3). Averages of leg colour both for males and females are similar and average greyness range is larger in males than in females (Table 3).

Table 3
Differentiation in leg colour and amount of greyness on head and flanks
among immatures (statistically significant differences given in bold)

		Mean	<i>N</i>	<i>G</i> -test
Leg colour	□□	2.29	113	<i>G</i> = 1.35
	□□	2.39	75	<i>p</i> = 0.25
Greyness	□□	2.21	95	<i>G</i> = 6.28
	□□	2.44	61	<i>p</i> < 0.02

Charts presenting correlation between wing and tail length indicate differentiation between immature males and females and within each sex group as well (Fig. 5). Males are bigger, but in both sexes three “biometrical” groups are distinguishable, and two of them are exactly in the same place for males and females (wing – 71 mm, tail – 59 mm and wing – 72 mm, tail – 61 mm). Besides, all these

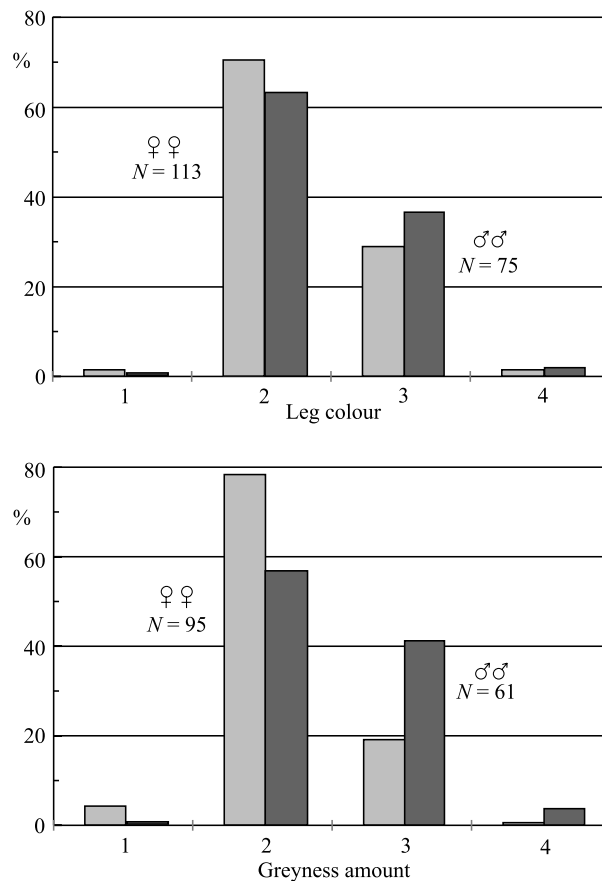


Fig. 4. Frequencies of leg colour and greyness amount classes for females and males in immature Robins

groups are located along one, the same line for both sexes. It should be underlined, that these groups are more distinct in the case of males. Besides, two parameters' range is larger in males than in females.

DISCUSSION

The Robin is a monomorphic species as to colouration, therefore biometrical differences between males and females could be helpful in sexing. Amongst populations of Robins migrating through the Polish Baltic coast sexes differ in wing length, tail length and greyness range on head and flanks, what is indicated by the results of this study. This corresponds with earlier papers (Mehlum 1979 after Mehlum 1981, Pätzold 1982, Cramp 1988, Pettersson *et al.* 1990, Cuadrado 1991, Svensson 1992, Madsen 1997, Catry *et al.* 2004). In some studies (Pettersson *et al.* 1990, Cuadrado 1991, Svensson 1992, Madsen 1997) Robins were sexed due to criteria proposed by J. Pettersson referring to wing length (*op. cit.*). According to Svensson (1992),

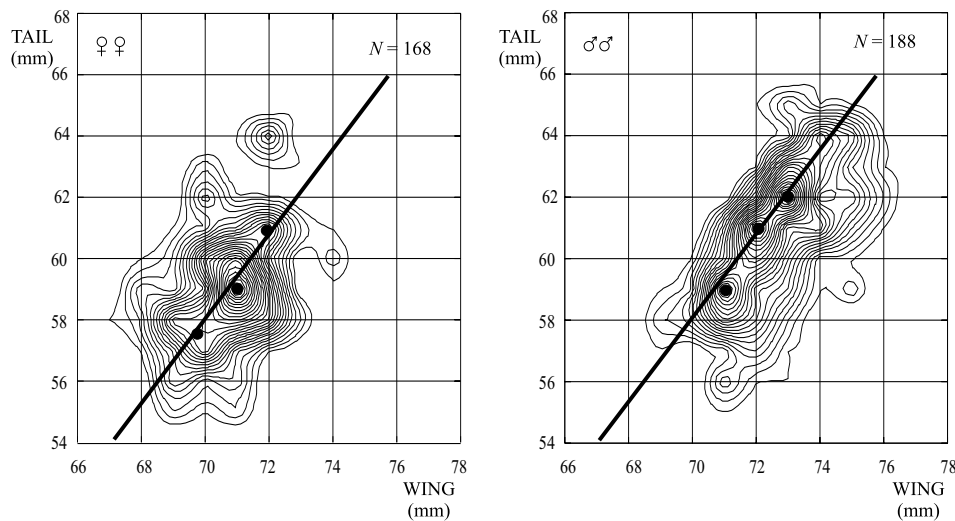


Fig. 5. Correlation charts (wing length / tail length) for immature females and males

J. Pettersson believes that 60% of Robins could be sexed with this classification. The results presented in this study are different. Only 29% of Robins analysed here migrating along the Polish Baltic coast could be sexed when applying Pettersson's criterion. Additionally, this study shows that within birds classified with this criterion as females nearly 14% were males. Also other researchers in different parts of Europe faced similar problem. Only 49% of Robins caught in western Denmark during breeding season and autumn migration could be sexed this way. Additionally molecular sex determination by analysis of DNA revealed that only 36% were sexed correctly (Madsen 1997). In winter quarters in southern Spain 35% of Robins were sexed correctly with Pettersson's criterion (Cuadrado 1991). Also for other passerines various range of sexual dimorphism was noted. Mean wing length of females and males of the Dipper (*Cinclus cinclus*) of the British race was significantly lower than values found for Scandinavian population (Galbraith and Broadley 1980). Similarly amongst Blue Tits (*Parus caeruleus*) the proportion of birds that can be sexed according to wing length was from 58% to 82% in different bird groups containing five British populations (Harper 2000). Also in the case of Willow Tits (*Parus montanus*) probabilities calculated for correct sexing of various wing length birds from southern and central Norway could not be used for birds caught at the Polish Baltic coast (Cofta 1986). The criterion of Pettersson refers to Robins caught at Swedish ringing stations, where probably local birds arrive in the first part of autumn migration. These are followed by populations breeding to the east of Sweden (Pettersson and Lidholm 1983). Robins migrating at the Polish Baltic coast also come from breeding populations of Scandinavia (Finland, Sweden, south-western Norway) and more eastern populations (Estonia and north-western Russia) (Remisiewicz *et al.* 1997). Concerning all the data above I suppose that differences in

the percentage of birds classified by the wing length criterion, found by several authors may result from varied composition of populations coming from different breeding areas, what was also suggested by these researchers. This could be confirmed by different wing length averages for sexes in different places in Europe – see Table 4. Birds from Germany and Denmark had the shortest wings, but we should bear in mind that the number of females measured in Germany was very small ($N = 7$) and that the Danish data included both breeding and migrating Robins. Males from Sweden and migrating females in the Netherlands had the longest wings. It has to be emphasized, that the ranges of wing length variation obtained here are broader than those cited by Cramp (1988). It is especially interesting in the case of Swedish birds because ringing recoveries indicate that winter quarters of Robins ringed in Sweden are similar to those ringed in Poland (Pettersson and Lindholm 1983, Pettersson *et al.* 1990, Remisiewicz 2002). Moreover, birds ringed at Swedish stations were recaptured at the Polish Baltic coast (Von Hialmar 1965, Pettersson *et al.* 1990, Remisiewicz *et al.* 1997). Hence, different wing length variation range found in these two places, although surprising, can result from varied ratio of populations migrating across these regions. One must remember that it is not clear whether measurements of birds from Sweden cited by Cramp (1988) refer to breeding or migrating birds. According to correlative topography charts, three “biometrical” groups are distinguishable in females and in males as well (Fig. 5).

Table 4
Average wing lengths of Robins (females and males) in different parts of Europe

	□□	□□	Period of measurements	Source
Poland	70.8	72.9	migration	this study
Balkans, Turkey	70.5	72.6		Cramp 1988
Denmark	69.8	72.2	breeding, autumn migration	Madsen 1997
Germany	69.3	72.5		Pätzold 1982
Netherlands	70.5	72.8	breeding	Cramp 1988
Netherlands	71.4	72.8	late September to March	Cramp 1988
Norway	70.1	73.1		Mehlum 1979
Spain	71.3	72.4	wintering	Cuadrado 1991
Sweden	70.6	73.2		Cramp 1988

A group of individuals with shorter wings and tails is distinguishable from the rest in both sexes. Birds migrating for the longest distances have longer wings, what is a morphological adaptation for flying faster (Alatalo 1983, Winkler and Leisler 1992, Berthold 1993, Calmaestra and Moreno 1998). Thus the individuals with shorter wings and tails could belong to population migrating for shorter distances. It is interesting that difference between females with the shortest and longest wing length according to data from several places in Europe (Table 4) is twice as big as differences between males with the shortest and longest wing. Hence, it seems that females of Robins are more differentiated. This study shows three “biometrical” groups in both sexes, at least for birds migrating through the Polish Baltic coast.

Additionally all these groups are located along one, the same line. For Robins migrating along Hel Peninsula similar phenomenon was found, but “biometrical” groups distinguished in Mierzeja Wiślana ringing station were not located along one line (Busse 1976). Probably among Robins analysed in this study the share of groups characterised for Mierzeja Wiślana was small.

In females and males migrating through the Polish Baltic coast wing and tail length ranges were similar. These could be caused by differences among populations, but it should be remembered, that the tail length measurement is very variable. Therefore, this variable is not reliable when used alone for sexing. In Denmark combination of 2 parameters: tarsus and wing length was applied for sexing Robins. Sexing with this new criterion was in 80-81% successful, and the results were confirmed by DNA sex determination (Madsen 1997). In this study I investigated sex determination according to another combination of parameters *i.e.* tail and wing length, but in this method was not as successful as the combination of tarsus and wing length. High probability of sex determination according to wing or tail length separately was found only in extremes. Combination of these two features only slightly increased possibility of sex determination. Probability of sex determination according to wing length was small, however the addition of tail length to wing length increased this probability a little. Possibly it is caused by high correlation between wing and tail length (birds with longer wings have longer tails).

The results of the present study indicate that sexes of Robins differ also in the range of greyness on head and flanks. In Spain differences between females and males were found in grey and rusty red colour at forehead (García Diego 1984). Males had wider stripes of these two colours than females and a curve of these stripes was gentler. Generally greater amount of greyness in males found hereby could play an important role during breeding season. So far, it has been well known that the orange colour on the breast of males plays an important role in the social behaviour of species. Maybe the same applies to the amount of greyness in males. In other species plumage colouration can indicate social rank and condition of an individual.

Robins caught during migration and also in winter quarters differ in morphological data: leg colour and greyness on head and flanks (Pettersson *et al.* 1990). The same paper revealed differences between males and females in greyness on head and flanks. So, changes in greyness amount relate to differentiation between sexes but also between populations. In the case of wing shape and leg colour sexes did not differ. Similar results were obtained during migration at Ottenby – males and females did not differ in leg colour (Pettersson 1990).

The changes in leg colour and wing shape could be related to differences among populations. This is the case in a study by Lövei *et al.* (1986) on an island in the Gulf of Naples concerning wing shape differentiation. Robins with more pointed wing (probably more northern birds) migrated intensively in October before groups of birds with more rounded wings, which dominated in numbers in November and December. As it was said earlier, in this study three “biometrical” groups are dis-

tinguishable in both sexes. In addition, two of these groups are exactly in the same place for males and females. These distinguishable groups probably represent different populations migrating through the Polish Baltic coast. Also populations of other passerines differ in morphological characteristics like flight apparatus (wing length, wing shape), feeding apparatus (bill length), tarsus length or foot (Nitecki 1969, Busse and Maksalon 1986, Lo Valvo *et al.* 1988, Chandler and Mulvihill 1990, Hanski and Tiainen 1991, García Peiró 2003, Schönfeld and Eck 2003, Chernestov 2004). These differences were revealed during migration: in the Song Thrush (*Turdus philomelos*) and Dunnock (*Prunella modularis*) at the Polish Baltic coast (Nitecki 1969, Busse and Maksalon 1986), Reed Warbler (*Acrocephalus scirpaceus*) in the western Mediterranean (García Peiró 2003), Dark-Eyed Junco (*Junco hyemalis*) in south-western Pennsylvania (Chandler and Mulvihill 1990), Blackcap (*Sylvia atricapilla*) in Sicily (Lo Valvo *et al.* 1988); or among birds breeding in different places, as in the case of different colonies of the House Martin (*Delichon urbica*) in Germany and in other parts of Europe (Schönfeld and Eck 2003) or Willow Warblers (*Phylloscopus trochilus*) and Chiffchaffs (*Phylloscopus collybita*) from northern and central Europe (Hanski and Tiainen 1991).

On the other hand, we should bear in mind that biometrical differentiation can be related to dietary and habitat differences (Herrera 1978, Michalak 1995). Robins having shorter tarsus and longer bill were feeding on a greater variety of prey size (Herrera 1978). Kind and quality of food can influence condition and size of birds as well as their plumage quality. Also, birds living in different habitats can differ in biometrics characteristics, like Willow Warbler's males (Michalak 1995). Individuals from three habitats differed in wing, tail and tarsus length.

Recapitulating above interpretation of biometrical and morphological characteristics variability is difficult because it is caused by differences between sexes, age groups and various populations. In the case of monomorphic Robins, sexing could be helpful to interpretation of biometrical changes during migration. Results of this study show that only a small number of Robins could be sexed according to the combination of wing and tail lengths. The cited classification based on tarsus and wing lengths seems to be much better (Madsen 1997). The most successful is molecular sex determination by analysis of DNA, but the use of such method is still difficult in bird migration investigations. Thus, further, more detailed studies on biometrical differences between sexes are needed.

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