# VARIATION OF MORPHOMETRIC PARAMETERS WITHIN THE SAVI'S WARBLER (*Locustella luscinioides*) POPULATION IN EASTERN POLAND

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## ABSTRACT

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Characteristics of the intra-populational variation of morphological parameters in the Savi's Warbler is based on measurements of 512 individuals caught in the breeding seasons of 1989-1998 in the Bagno Ławki peatbog (the southern basin of the Biebrza river valley). In the studied population, adult Savi's Warblers had longer and more rounded wing, longer tail and larger body mass than young individuals. Moreover, significant differences in the length of allula and 1st primary were found between these age classes. The range of wing length noted in this population, with the maximum value of 78 mm, distinctly exceeded the range of this parameter described for European populations of the Savi's Warbler. The average lengths of wing, tail allula and tarsus were distinctly higher in males than in females. Sexes did not differ in body mass, Kipp's distance and wing pointedness index. In the studied population, a distinct long-term variability of tail length, Kipp's distance, wing-tip pointedness index and tarsus length was found in young birds. In adults such variability was found only in tarsus length. The paper discusses possible reasons for the long-term variability of studied parameters.

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**Key words:** Savi's Warbler, biometry, long-term variability, natural selection

## INTRODUCTION

Studies on variation of morphometric parameters in birds refer mainly to the characteristics of geographical variation among populations (Power 1969, James 1970, Banks 1988), morphological variation of migratory groups (Busse 1976, 1988, Lövei 1983, Busse and Maksalon 1986, Kelsey *et al.* 1989), ecomorpholgical comparisons (Van Valen 1965, Opdam 1975, Nordberg 1979, Tiainen 1982) and descriptions of intra-populational variation (Andersson and Wester 1971, Dorsch 1981, Norman 1983a, Saeman 1987, Cuadrado 1991).

Morphometric parameters are often an important criterion for species identification and in many species they allow to determine sex or age (Corkhill 1972, Svensson 1992, Baker 1993). In the Savi's Warbler, the intra-specific variation of morphometric parameters is relatively poor known and the morphometric characteristics is based on a limited set of measurements (Steiner 1970, Thomas 1977, Bub and Dorsch 1988, Svensson 1992). Furthermore, information about inter-seasonal variability in morphometric parameters within a population is lacking for this species although it has been described for other passerines (Van Balen 1967, Busse 1976, Jones 1987a, Nowakowski 2000, Nowakowski and Wojciechowski 2002).

The aim of the paper is to describe the intra-populational and seasonal variation of selected morphometric parameters in the Savi's Warbler.

## STUDY AREA

Bird catching was conducted in the Bagno Ławki peatbog located in the southern basin of the Biebrza river valley, within the protected area of the Biebrza National Park. The Biebrza Valley is vast swampy-peatbog lowland of *ca* 2600 km$^2$ area, about 120 km long and 10-20 km wide. It is delimited by high plains: Kolneńska, Wysokomazowiecka and Białostocka, by the Ełk Lake District and by the Augustowska Plain (Kondracki 1994). The Biebrza river valley narrows several times along its course, what restrains water outflow and divide the Biebrza Valley into three basins: northern, central and southern. Ecological conditions that determine the character of the vegetation differ among these basins. In southern basin, the perpendicular zonation of the vegetation is well developed and preserved. Three zones can be distinguished from the river bank towards valley edges. The first – immersion zone is formed by the river valley area with the longest retaining floods, with developed sedge *Caricetum sp*., *Phalaretum* and manna *Glycerietum* rushes. The immersion-emmersion zone is an area of shorter floods with tussock sedge communities formed, dominated by *Carex appropinquata* and often accompanied by *Carex hudsonii.* The third – emmersion zone is the area outside the flood reach where sedge communities: *Caricetum limoso-diandrae* and *Caricetum rostrato-diandrae* with well-developed moss turf occur (Pałczyński 1984).

The study area was located in the region of village Szostaki, in *ca* 300 m from the left bank of the Biebrza, within plant communities of the immersion zone.

The Biebrza Valley is one of the coldest regions of Poland with a pronounced influence of the continental climate. The mean yearly temperature of the valley is 6-7°C. In June, the mean minimal temperature is *ca* 11.6°C and the maximal – slightly above 23°C. The yearly sum of precipitation in this area falls within the range 570-750 mm with 125-160 days with precipitation per year on an average (Kossowska-Cezak 1984, Maciejewski 1996).

## METHODS

### Methods of fieldwork

Studies were conducted in 1989-1998, from mid-June to the beginning of August. The collected material comprises measurements of 512 Savi's Warblers. Birds were caught in mist-nets. One row of mist-nets was fixed at the border between the reedbed and the high sedge rushes, the second row – at the border between the sedge rushes and willow thickets.

Methods of measurements followed the Operation Baltic standards (Busse 1974): wing length, tail length, wing formula for 10 primaries, the length of 1st primary (measured from the tip of wing coverts) and tarsus length. Birds were weighed to the nearest 0.1 g. Fat score was determined according to the six-score scale. Tarsus length was measured with calippers; this measurement was not taken in the first year of studies. Additionally, Kipp's distance (*i.e.* distance from the tip of 1st secondary to the wing-tip) and allula length were measured. The length of allula was measured with a ruler from the edge of the finger joint on the folded wing to the tip of allula, bending allula feather slightly towards the proximal edge of wing.

Ageing of the Savi's Warbler was based on plumage features, iris colour and presence of spots on tongue. Sex was determined only in adults according to the presence of incubation patch and the shape of cloacal protuberance (Svensson 1992).

### Methods of analyses of the biometric data

Sample sizes for all compared distributions of studied parameters fitted the formula:

$$n > 25\,\alpha_3$$

where:
$n$ – sample size,
$\alpha_3$ –standardised measure of distribution skewness.

This allowed for applying parametric tests in the analyses of material (Barrett 1982).

The mean studied parameters were compared in relation to age and sex using the *t*-test for independent variables (Zar 1996). Variation of means among years was tested in stable models of the one-way analysis of variance (Lindman 1992). In cases when significant differences among means were found they were compared by Tukey multiple comparison, verifying the assumed null hypothesis of the lack of differences among means (Lindman 1992).

Differences of birds' fat score among subsequent two-hour periods of a day were tested by the non-parametric analysis of variance (Sokal and Rohlf 1997). The relation between body mass and time of a day was analysed in the multiple regression model controlled for the number of a day (Sokal and Rohlf 1997).

To describe the size of birds, similarly to *e.g.* Jones (1987b) and Moreno (1989), the index of standardised body mass ("size index") was used, being the quotient of body mass and tarsus length. The wing shape was described by the wing pointedness index (*L*-index), which is the sum of distances of 7 subsequent primaries (2-8 ascendently) from the tip of the wing, expressed in percent of the wing length (Busse 1986).

Relations between the studied parameters were described by Pearson's linear correlation coefficient, and the significance of the coefficient was tested assuming the two-tailed null hypothesis (Zar 1996).

All calculations were done by the statistical software package SPSS Pc+.

## RESULTS

### Variation of morphometric parameters in relation to age and sex

The differences of morphometric parameters between juveniles and adult birds are presented in Table 1 and at Figure 1. Adult Savi's Warblers had longer wing, longer tail, greater body mass and size in comparison with juvenile individuals. Juveniles had more pointed wing, longer allula and 1st primary than adults. The significant difference between these age groups was stated in the population also in relation of tail length to wing length.

Table 1
Values of biometric parameters for age groups

| | Juveniles | | | Adults | | |
|---|---|---|---|---|---|---|
| | *n* | Mean (*SD*) | Range | *n* | Mean (*SD*) | Range |
| Wing length | 374 | 69.48 (1.78) | 64-78 | 104 | 70.31 (2.19) | 66-76 |
| Tail length | 363 | 54.27 (2.59) | 44-65 | 101 | 58.24 (2.64) | 48-64 |
| Allula length | 365 | 23.53 (1.06) | 20-27 | 101 | 23.03 (1.15) | 20-26 |
| Kipp's distance | 362 | 19.82 (1.33) | 16-23 | 75 | 20.07 (1.62) | 17-24 |
| 1st primary | 353 | -1.66 (1.26) | -5-2 | 94 | -2.52 (1.45) | -7-0 |
| Tarsus length | 327 | 21.32 (1.09) | 18.0-24.2 | 93 | 21.29 (1.22) | 17.9-24.0 |
| Body mass | 363 | 14.47 (1.15) | 11.5-19.9 | 107 | 15.51 (1.67) | 13.0-23.5 |
| Size index | 310 | 0.68 (0.05) | 0.56-0.87 | 90 | 0.72 (0.07) | 0.59-0.93 |
| *L*-index | 362 | 85.9 (8.50) | 59-113 | 72 | 81.4 (9.42) | 61-108 |
| Tail/wing ratio | 363 | 0.78 (0.03) | 0.68-0.97 | 98 | 0.83 (0.03) | 0.72-0.89 |

Differences of morphometric parameters between sexes in adult birds are presented in Table 2 and at Figure 2. In the studied population, the mean lengths of wing, allula and tarsus differed significantly between adult males and females. Significant differences between sex classes were noted also in the length of 1st primary.

Kipp's distance, wing pointedness index, body mass and size index in both sex classes fell within similar ranges and testing differences in means of these parameters did not reveal any statistically significant differences.

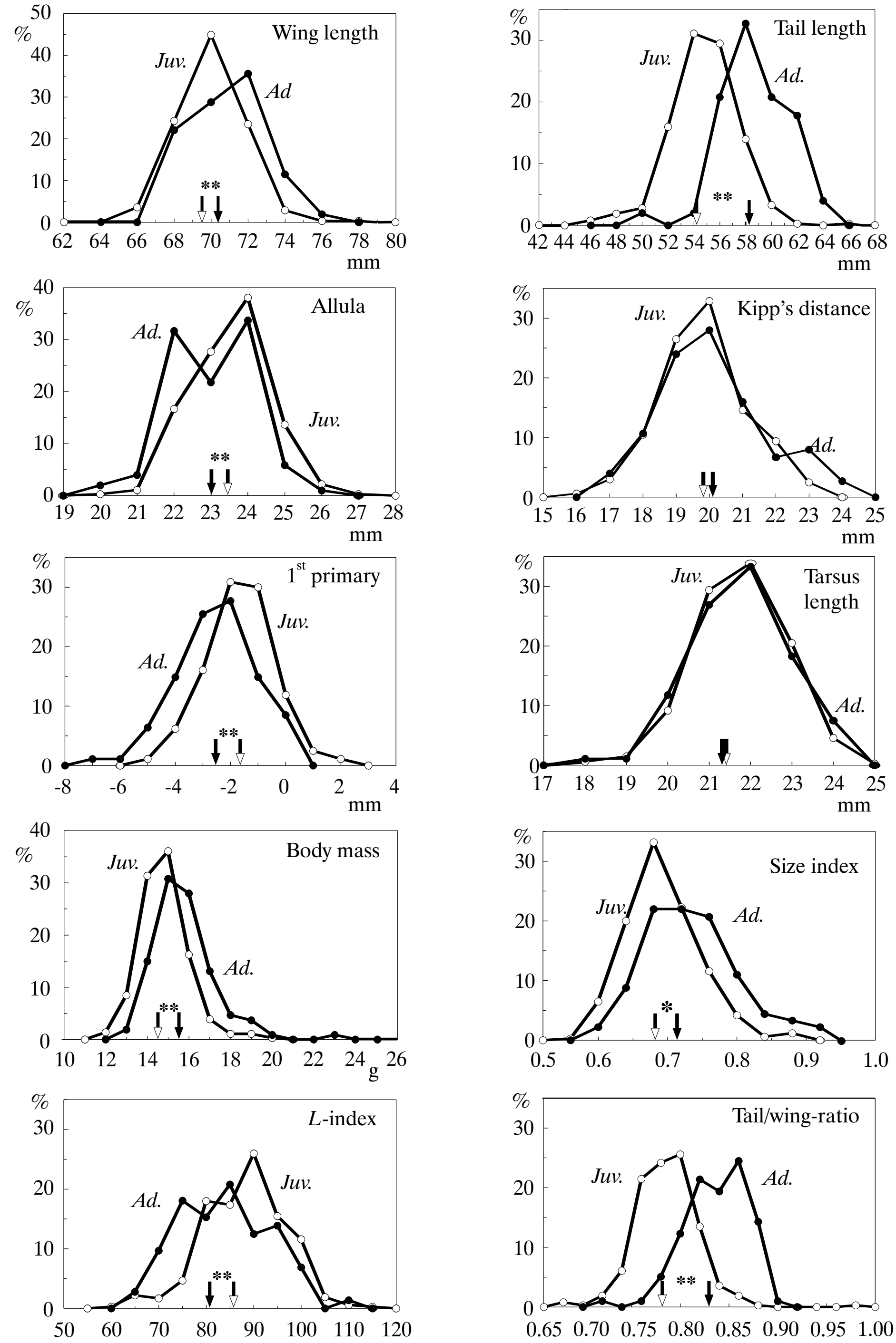


Fig. 1. Distributions of values of biometric parameters for juveniles (*Juv.*) and adults (*Ad.*). Arrows point location of averages for age groups; significant differences between averages are pointed with asterisks: * – $p < 0.05$, ** – $p < 0.01$.

Table 2
Values of biometric parameters for sex groups of adults

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | *n* | Mean (*SD*) | Range | *n* | Mean (*SD*) | Range |
| Wing length | 62 | 70.92 (2.15) | 66-76 | 42 | 69.41 (1.94) | 66-74 |
| Tail length | 58 | 58.74 (2.83) | 48-64 | 43 | 57.56 (2.21) | 53-63 |
| Allula length | 60 | 23.48 (1.00) | 21-26 | 41 | 22.37 (1.04) | 20-24 |
| Kipp's distance | 47 | 20.23 (1.48) | 18-24 | 28 | 19.79 (1.83) | 17-24 |
| 1st primary | 53 | -2.92 (1.54) | -7-0 | 41 | -2.00 (1.14) | -4-0 |
| Tarsus length | 52 | 21.59 (1.23) | 17.9-24.0 | 41 | 20.90 (1.11) | 19.2-22.9 |
| Body mass | 59 | 15.55 (1.57) | 13.2-23.5 | 48 | 15.45 (1.81) | 13.0-22.5 |
| Size index | 50 | 0.71 (0.06) | 0.59-0.92 | 40 | 0.73 (0.08) | 0.60-0.93 |
| *L*-index | 44 | 82.0 (9.11) | 61-108 | 28 | 80.5 (10.0) | 65-97 |
| Tail/wing ratio | 56 | 0.83 (0.03) | 0.72-0.89 | 42 | 0.83 (0.03) | 0.77-0.87 |

In females three fractions of birds that differed distinctly with the wing pointedness index were distinguised (Fig. 2). In males no variation of this type was found.

### Correlation relations

Some of the studied morphometric parameters showed significant correlation relations. Wing length in this species was significantly positively correlated with tail length, allula length, Kipp's distance and body mass in adult males and females, as well as in juveniles (Table 3). The correlation coefficient between wing length and body mass was in juveniles lower than in the case of the remaining significant relations. Wing length was also significantly correlated with tarsus length, but only in juveniles and adult males.

Significant relations among the remaining parameters occurred in juvenile birds, except for the relations with body mass, which (with one exception) were non-significant and non-significant relation between tarsus length and Kipp's distance (Table 3). In adult birds the majority of correlation coefficients were non-significant, what could be a result of the low sample size.

Mean body mass was significantly related with bird's fat score in both age and sex groups of birds (Fig. 3, Table 4). The relationships are similar in males and females. The differences between the relation in juveniles and in adult birds may result from different lipid metabolism. The metabolism of lipids may differ in juveniles and adults, due to differences in food intake, energy expenditure to thermoregulation and metabolic adaptation to migratory behaviour.

Body mass was changing significantly within the day – birds were the lightest in the morning hours and the heaviest in the evening (Fig. 4). Because this relation was shown on the basis of variation of all caught birds, to make it independent from the influence of the part of the season and the different stage of their aptitude to migration, the relation between body mass and time of a day was analysed in the multiple regression model with the control for the number of a day. This relation was highly significant in juvenile birds and adult males (Table 5). These differences

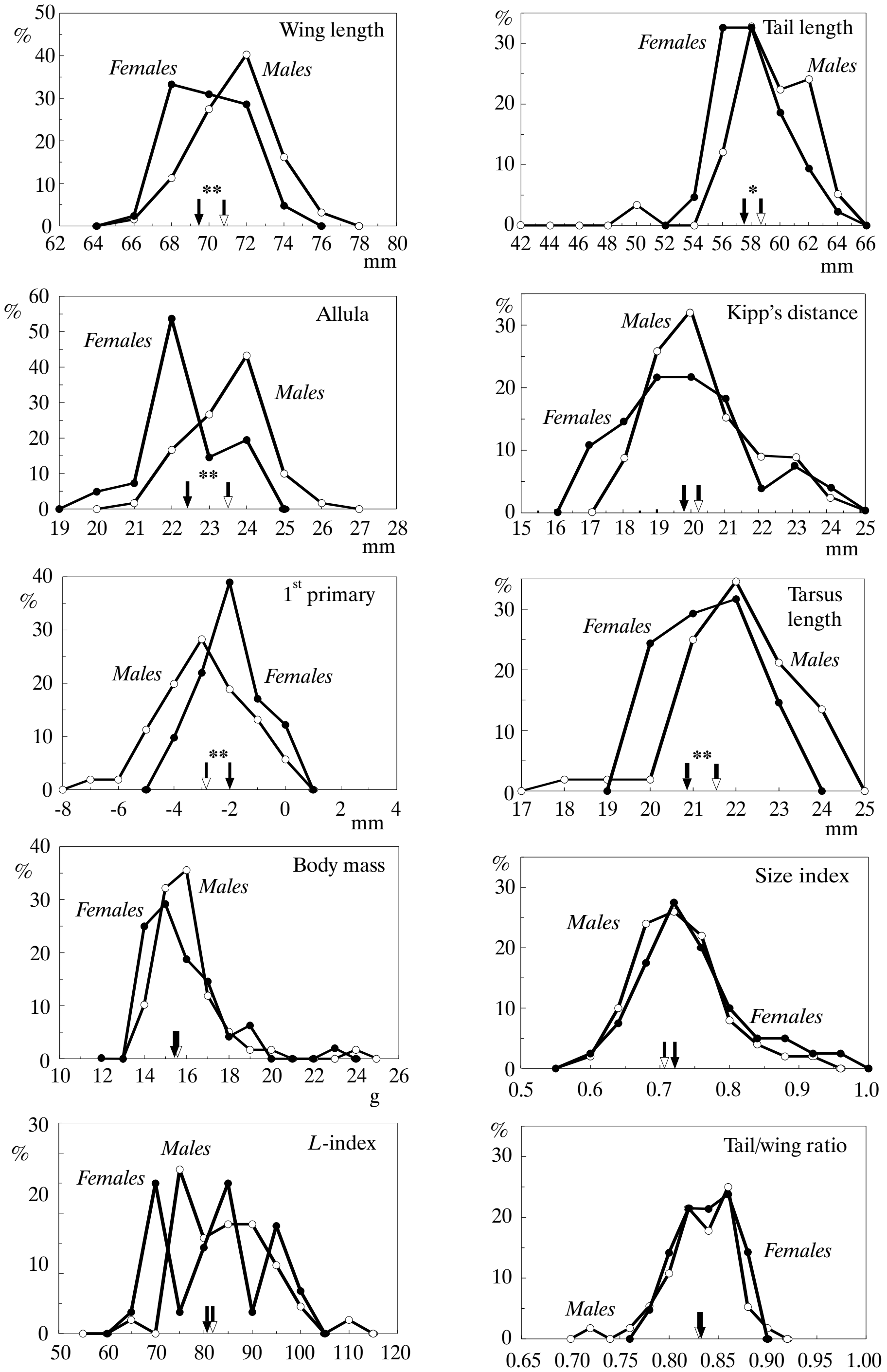


Fig. 2. Distributions of values of biometric parameters for males and females. Arrows point location of averages for sex groups; significant differences between averages are pointed with asterisks: * – $p < 0.05$, ** – $p < 0.01$.

Table 3
Correlations between selected biometric parameters. Pearson's correlation coefficient ($r$), sample size ($n$) – upper part of the table and significance ($p$ – lower part) are given (significant correlations are shown in bold, ns – $p > 0.05$).

| | Wing length | Tail length | Allula length | Kipp's distance | Body mass | Tarsus length |
|---|---|---|---|---|---|---|
| Juveniles | | | | | | |
| Wing length | X | **0.59** $n = 363$ | **0.49** $n = 365$ | **0.60** $n = 362$ | **0.18** $n = 347$ | **0.24** $n = 327$ |
| Tail length | ***0.0001*** | X | **0.35** $n = 357$ | **0.35** $n = 357$ | 0.05 $n = 343$ | **0.19** $n = 322$ |
| Allula length | ***0.0001*** | ***0.0001*** | X | **0.24** $n = 361$ | 0.10 $n = 345$ | **0.20** $n = 322$ |
| Kipp's distance | ***0.0001*** | ***0.0001*** | ***0.0001*** | X | 0.06 $n = 343$ | 0.06 $n = 326$ |
| Body mass | ***0.001*** | *ns* | *ns* | *ns* | X | **0.25** $n = 310$ |
| Tarsus length | ***0.0001*** | ***0.0001*** | ***0.0001*** | *ns* | ***0.0001*** | X |
| Adult males | | | | | | |
| Wing length | X | **0.57** $n = 56$ | **0.26** $n = 59$ | **0.61** $n = 47$ | **0.35** $n = 54$ | **0.29** $n = 50$ |
| Tail length | ***0.001*** | X | 0.01 $n = 55$ | 0.14 $n = 43$ | 0.19 $n = 51$ | 0.18 $n = 48$ |
| Allula length | ***0.045*** | *ns* | X | 0.20 $n = 45$ | -0.10 $n = 53$ | -0.03 $n = 50$ |
| Kipp's distance | ***0.001*** | *ns* | *ns* | X | **0.34** n = 41 | 0.02 n = 38 |
| Body mass | ***0.01*** | *ns* | *ns* | ***0.03*** | X | 0.13 $n = 50$ |
| Tarsus length | ***0.045*** | *ns* | *ns* | *ns* | *ns* | X |
| Adult females | | | | | | |
| Wing length | X | **0.52** $n = 42$ | **0.45** $n = 40$ | **0.72** $n = 28$ | **0.34** $n = 41$ | 0.13 $n = 39$ |
| Tail length | ***0.001*** | X | 0.17 $n = 41$ | 0.11 $n = 28$ | 0.28 $n = 42$ | 0.04 $n = 40$ |
| Allula length | ***0.004*** | *ns* | X | 0.35 $n = 26$ | 0.29 $n = 40$ | **0.44** $n = 38$ |
| Kipp's distance | ***0.001*** | *ns* | *ns* | X | 0.10 $n = 27$ | -0.08 $n = 26$ |
| Body mass | ***0.03*** | *ns* | *ns* | *ns* | X | 0.13 $n = 40$ |
| Tarsus length | *ns* | *ns* | ***0.005*** | *ns* | *ns* | X |

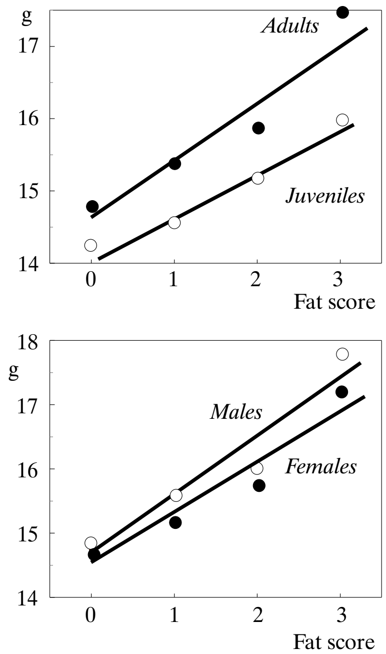


Fig. 3. Relations between fat scores and body mass for age and sex (only for adults) groups. Mean values of body mass for fat scores and regression lines are given.

Table 4
Mean body mass, *SD* value (in brackets) and sample size (*n*) for subsequent fat scores

| | Fat score | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Juveniles | 14.21 (1.06)<br>$n$ = 190 | 14.56 (0.98)<br>$n$ = 137 | 15.15 (1.34)<br>$n$ = 20 | 15.96 (1.16)<br>$n$ = 10 |
| Adults | 14.80 (1.05)<br>$n$ = 35 | 15.40 (1.43)<br>$n$ = 39 | 15.89 (1.28)<br>$n$ = 21 | 17.49 (1.75)<br>$n$ = 11 |
| Ad. males | 14.84 (0.81)<br>$n$ = 22 | 15.60 (1.37)<br>$n$ = 21 | 16.02 (1.02)<br>$n$ = 10 | 17.80 (3.27)<br>$n$ = 5 |
| Ad. females | 14.74 (1.40)<br>$n$ = 13 | 15.17 (1.50)<br>$n$ = 18 | 15.76 (1.52)<br>$n$ = 11 | 17.23 (2.83)<br>$n$ = 6 |

were significantly related with the increase of birds' fat score during the day (Kruskal-Wallis test: adults – $\chi^2 = 55.92$, $df = 8$, $p < 0.001$; juveniles – $\chi^2 = 39.13$, $df = 8$, $p < 0.001$). In adult birds, statistically significant differences in fat score between parts of a day were stated only in males (Kruskal-Wallis test: males – $\chi^2 = 30.986$, $df = 8$, $p < 0.001$; females – $\chi^2 = 15.096$, $df = 8$, $p = 0.057$).

### Inter-seasonal variability of morphometric parameters

Significant variability of the studied morphometric parameters among years was revealed in juvenile birds with respect to tail length, value of wing pointedness in-

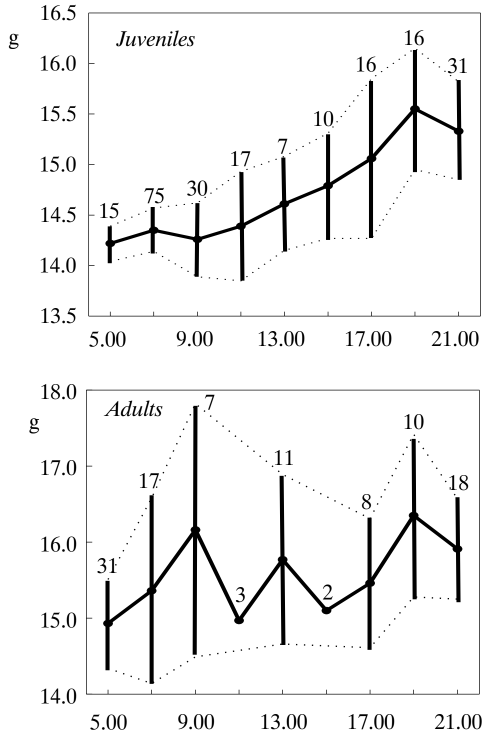


Fig. 4. Changes of body mass in the course of a day for juveniles and adults: averages and 95% confidence ranges are given. Numbers point sample sizes.

Table 5
Relations between body mass and time of a day (hour) and a season course (day number). $R^2$ = sum of squares, *b* – partial regression coefficient, $SE_b$ – standard error of *b* coefficient, *t* – value of *t*-test, significant values of *p* given in bold.

| | Variability source | *b* | $SE_b$ | *t* | *p* |
|---|---|---|---|---|---|
| Juveniles | Hour | 1.452 | 0.210 | 6.912 | ***0.0001*** |
| $R^2$ = 0.137 | Day number | - 0.157 | 0.054 | 2.825 | ***0.005*** |
| Adults | Hour | 1.115 | 0.506 | 2.204 | ***0.030*** |
| $R^2$ = 0.073 | Day number | - 0.207 | 0.130 | 1.592 | *0.114* |
| Ad. males | Hour | 1.393 | 0.635 | 2.192 | ***0.033*** |
| $R^2$ = 0.079 | Day number | 0.099 | 0.212 | 0.469 | *0.641* |
| Ad. females | Hour | 0.921 | 0.829 | 1.110 | *0.273* |
| $R^2$ = 0.115 | Day | - 0.367 | 0.177 | 2.081 | ***0.043*** |

dex, Kipp's distance and tarsus length, while in adults – only in the case of tarsus length and allula length (Table 6, Fig. 5 and 6). The trends of variability of allula length and tarsus length in adults birds were correlated ($r = 0.805$, $n = 9$, $p = 0.009$).

Table 6
Long-term variability of biometric parameters 1989-1998 (ANOVA)

| | Source of variance | Sum of squares | *df* | *F* | *p* |
|---|---|---|---|---|---|
| **Juveniles** | | | | | |
| Wing length | Between groups<br>Within groups | 29.678<br>1151.651 | 9<br>364 | 1.042 | *0.4056* |
| Tail length | Between groups<br>Within groups | 133.260<br>2290.740 | 9<br>353 | 2.282 | ***0.0170*** |
| Kipp's distance | Between groups<br>Within groups | 50.388<br>586.941 | 9<br>352 | 3.358 | ***0.0006*** |
| Allula length | Between groups<br>Within groups | 14.881<br>393.941 | 9<br>355 | 1.490 | *0.1498* |
| 1st primary | Between groups<br>Within groups | 15.985<br>543.222 | 9<br>343 | 1.121 | *0.3466* |
| Tarsus length | Between groups<br>Within groups | 21512.53<br>17041.79 | 8<br>317 | 50.178 | ***0.0000*** |
| Body mass | Not analysed | | | | |
| Size index | Not analysed | | | | |
| Tail/wing ratio | Between groups<br>Within groups | 0.013<br>0.321 | 9<br>353 | 1.605 | *0.1123* |
| *L*-index | Between groups<br>Within groups | 2132.798<br>23980.478 | 9<br>352 | 3.478 | ***0.0004*** |
| **Adults** | | | | | |
| Wing length | Between groups<br>Within groups | 63.261<br>430.893 | 9<br>94 | 1.533 | *0.1476* |
| Tail length | Between groups<br>Within groups | 44.652<br>651.645 | 9<br>91 | 0.693 | *0.7137* |
| Kipp's distance | Between groups<br>Within groups | 27.642<br>167.025 | 9<br>65 | 1.195 | *0.3133* |
| Allula length | Between groups<br>Within groups | 22.779<br>110.132 | 9<br>91 | 2.091 | ***0.0382*** |
| 1st primary | Between groups<br>Within groups | 23.910<br>171.547 | 9<br>84 | 1.301 | *0.2488* |
| Tarsus length | Between groups<br>Within groups | 9405.268<br>4361.931 | 8<br>84 | 22.640 | ***0.0000*** |
| Body mass | Not analysed | | | | |
| Size index | Not analysed | | | | |
| Tail/wing ratio | Between groups<br>Within groups | 0.013<br>0.081 | 9<br>88 | 1.547 | *0.1443* |
| *L*-index | Not analysed | | | | |

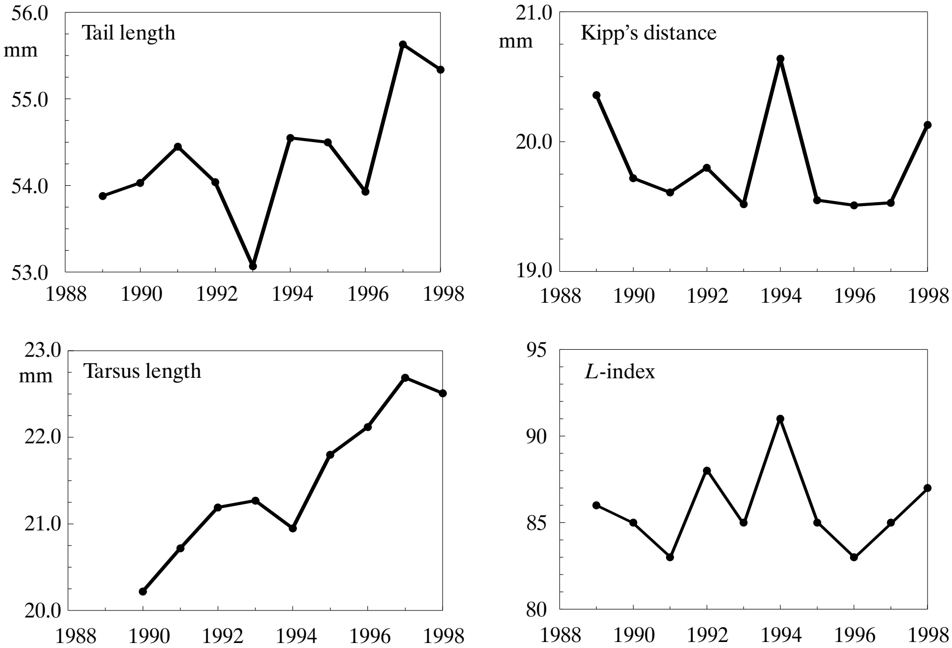


Fig. 5. Long-term changes in average values of biometric parameters for juveniles

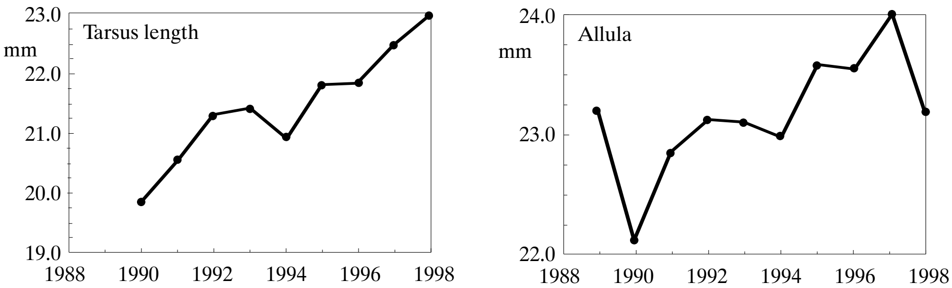


Fig. 6. Long-term changes in average values of biometric parameters for adults

Mean seasonal values of studied parameters separated in Tukey test procedure allowed to distinguish for juvenile birds two groups of years. In years 1989, 1992, 1994 and 1998, juveniles presented high values of wing-tip pointedness index and of Kipp's distance; whereas tail length was at the average level for the population. These birds differed significantly with two first parameters from values in years 1990, 1991, 1993, 1995-97 (Tukey test, $p < 0.05$).

Tarsus length both in juvenile and adult birds increased distinctly during the period of studies (Fig. 5 and 6). Inter-seasonal variability of allula length in adult birds may occur as a result of the correlation between allula length and tarsus length in adults females (Table 3).

Inter-seasonal variability in mean body mass and size index were not analysed, as the values of these parameters depended to a great extent on daily and seasonal

dynamics of catching. Also in the case of wing pointedness index in adults, the variability was not analysed due to small sample size.

## DISCUSSION

### Intra-populational variation of morphometric parameters

In passerine populations, differences in mean values of some morphometric parameters between juvenile and adult individuals are relatively well documented only for the wing length (Laaksonen and Lehikoinen 1976, Flegg and Cox 1977, Marquiss 1980, Dorsch 1981, Norman 1983a, Rostad 1986, Saeman 1987, Herremans 1988, Mulvihill and Chandler 1990). These differences are usually very prominent, and according to Alatalo *et al*. (1984) they seem to be determined by shorter hand bones of young birds, despite their longer primaries. Such differences in wing construction between juveniles and adults have adaptive value, providing young birds with better manoeuvrability in flight, at the cost of speed. In the studied population of the Savi's Warbler, the differences in wing length between age classes reflected this general rule – adult birds had longer wings than juveniles.

Adult Savi's Warblers had also longer tail, more rounded wing, shorter allula and larger body mass than juveniles. Similar differences in tail length between juvenile and adult individuals were found in other species: *e.g.* in Reed Warbler – *Acrocephalus scirpaceus* (Turyn 1970, Kurzac 1986), Chaffinch – *Fringilla coelebs* (Busse 1976), Great Tit – *Parus major* (Busse 1976), Barn Swallow – *Hirundo rustica* (De Lope 1985), Firecrest – *Regulus ignicapillus* (Seaman 1987), Goldcrest – *Regulus regulus* (Saeman 1987) and Magpie – *Pica pica* (Kavanagh 1988).

The observed differences in lengths of remiges and rectrices of young birds may result from different growth rate of both groups of contour feathers. Juveniles seem to invest first of all in the wing feathers. Based on the studies on the growth of nestlings of the Blackcap (*Sylvia atricapilla*), Berthold (1976) pointed at differentiated growth rate of wing and tail. Moreover, the differentiation of growth was more pronounced in the periods of limited feeding. Similar faster growth of wing feathers in comparison with tail was described for the Willow Warbler (*Phylloscopus trochilus*) by Norman (1983b). During staying in nest, the wing of this species reached 72.9% of the complete length, whereas the tail – only 55.1%. Differences in the wing shape between juvenile and adult birds were recorded in Reed Warbler (Turyn 1970, Kurzac 1986, Nowakowski unpubl.). Willow Warbler and Chiffchaff – *Phylloscopus collybita* (Tiainen and Hanski 1985) and Junco – *Junco hyemalis* (Mulvihill and Chandler 1990).

Differences of other morphometric parameters between males and females in passerines are poorly documented in the literature. In several species of passerines (Chaffinch, Brambling – *Fringilla montifringilla,* Firecrest, Goldcrest, Redstart – *Phoenicurus phoenicurus,* Great Tit, Siskin – *Carduelis spinus*) migrating through the Polish Baltic coast, Busse (1976) stated that males had longer tails than females.

Moreover, in these species (except for the Siskin) males had more pointed wing, what was described by the higher value of "*e*" index (Busse 1976).

In the studied population of the Savi's Warbler, males had on an average longer wing, allula, tail and tarsus than females. Sex groups did not differ in Kipp's distance, wing pointedness and size index. Longer wing in males in comparison with females was stated also in populations from Neubrandenburg in Germany and from Russia (Bub and Dorsch 1988). No difference between males and females in mean wing length was found in the population from the former Czechoslovakia (Hudec 1983). The mean wing length of males from this population was 69.1 mm ($n = 30$) and of females 69.0 mm ($n = 15$).

Statistics of the wing length distributions of the Biebrza population of the Savi's Warbler correspond to characteristics of distribution of this parameter both for juvenile and adult birds caught in northeastern Poland by Cz. Nitecki (Bub and Dorsch 1988). The mean wing length and body mass of juvenile birds, adult males and females was also similar to that found in other regions of Europe (Bub and Dorsch 1988). Only the range of key parameters (wing length, 1st primary length) in the studied population slightly differed from the range of their variation presented in the monograph of Bub and Dorsch (1988) and in "*Identification Guide to European Passerines*" by Svensson (1992). In the Biebrza valley, an juvenile Savi's Warbler with the wing 78 mm long was caught. This value distinctly exceeds the range described for European populations of this species. Hudec (1983) gave 73 mm as the maximal value of the Czechoslovakian population of the Savi's Warbler, and Ferianc (1979) defined ranges of this measurement as 67-71 mm for males and 65-67 mm for females. Similarly, Ivanov and Sztegman (1978) in the key to identification of birds of the former Soviet Union presented the range 64-73 mm for the wing length variation. A slightly higher value of the wing length (75 mm) was given by Svensson (1992). Also Bub and Dorsch (1988) who assembled wing length measurements from different regions of Europe gave 76 mm as the maximal known wing length (for males caught in Neubrandenburg and for juveniles caught in northeastern Poland). However, parameters of the distribution of wing length described in the present paper (Table 1 – mean value and *SD*) show that in this population the probability of obtaining the value of the measurement equal to 78 mm is lower than 0.0005. Thus, this value could be treated rather as the effect of a growth aberration.

Wing length is an important parameter considered in identification of two morphologically similar species – the Savi's Warbler and the Gray's Grasshopper Warbler (*Locustella fasciolata*). Until now, in the guides to bird identification, beside the differences in wing formula, structure of 3rd primary, tarsus length and coloration, the range of wing length could have been one of the features taken into account in the identification of these species. Wing length of the Gray's Grasshopper Warbler, falling in the range 73-86 mm (Ivanov and Sztegman 1978, Svensson 1992), was given as the feature that allowed to distinguish it from the Savi's Warbler. Taking into consideration the new described range of this parameter in the Savi's Warbler, the wing length measurement can not be the decisive identification feature in

the described pair of species in the case of difficulties with ambiguous interpretation of the remaining species characteristics.

The 1$^{st}$ primary length in relation to the tip of wing coverts in juvenile birds fell in the range from -5 mm to 2 mm and in adults – from -7 mm to 0 mm, which also extend the known range of this parameter (Svensson 1992).

**Inter-seasonal variability of morphometric parameters**

Darwin's theory of the natural selection, despite years passed, is still the only evolutionary theory consistent with mechanisms of heritability and explaining formation of adaptations. Studies on natural selection both in natural and laboratory conditions proved that strong selection pressure can lead to remarkable and rapid changes in morphological and physiological variation in animals (Vaughan 1970, Barnett and Dickson 1984, Iliopoulou-Georgudaki 1986, Grant 1991, Nowakowski 2000, Nowakowski and Wojciechowski 2002).

The occurrence of inter-seasonal variability of morphometric parameters in breeding bird populations has been explained mainly in the aspect of selection mechanisms or differentiated growth of birds. The mechanism of selection as the crucial factor of the described variability was best described in Darwin's finches *Geospiza sp.* in which the variation of bill width and height is determined by the directional natural selection (Grant 1986, 1991). Analogously, Smith (1990) proved occurrence of similar mechanisms of selection of bill morphometrics and action of disruptive selection in the Africal finch *Phyrenestes ostrimus.* The natural selection was given as an explanation of the occurrence of inter-seasonal variability of wing length in Great Tit population by Dhont *et al*. (1979), in Reed Warbler by Nowakowski (2000) and in Barn Swallow by Wojciechowski (1992).

An attempt to explain the variation of wing length between seasons in relation to feeding conditions was undertaken by Van Balen (1967). Similarly, Cowley (1979) drew attention to feeding factors as the cause of this variability, explaining differences in wing length of Sand Martins (*Riparia riparia*) returning from African winter quarters by feeding conditions negatively affecting this parameter.

For the studied population of the Savi's Warbler, it seems that the mechanism of the natural selection can explain the inter-seasonal variability of wing pointedness index and of Kipp's distance. Weather conditions (sum of precipitation, number of days with precipitation and mean temperature) varied between breeding seasons, which could affect the amount of food in the habitat. In ecological studies, weather is considered among the most important factors that shape food availability for insectivorous birds (Finlay 1971, Turner 1984, Stocek 1986). Savi's Warblers usually catch insects by moving in the vegetation and picking them up. The most frequent prey of Savi's Warblers are small species of dragonflies, butterflies and dipterans (Hudec 1983).

High values of wing shape index accompanied by long Kipp's distance were noted in years 1989, 1992, 1994 and 1998, that were characterised by high mean temperatures and low sums of precipitation. The most rounded wing with short

Kipp's distance was stated in years 1991, 1993 and 1996, in which frequent precipitation and lower mean 24-hour temperatures were recorded. It seems that food availability can change according to weather conditions and birds of different wing structure can use food resources with varied efficiency.

Pointed wing (high value of standardised wing pointedness index and long Kipp's distance) can have a favourable influence on the energy budget in the period of high activity of insects. At this time, the energetic expenses on movements and flight can be more varied for birds of different wing structure and can affect their survival. The fact that wing shape is distinctly associated with adaptation to flight was proved in many species, in which differences of wing pointedness were found between sedentary and migratory populations (Lo Valvo *et al*. 1988, Mulvihill and Chandler 1990). In the first ones, individuals are characterised by much more pointed and longer wings. In the Savi's Warbler only the wing shape seems to undergo the selection pressure, as its characteristics vary among seasons. The wing length does not have so high adaptive value. On the contrary, in the Reed Warbler population, the wing length is clearly the subject of selection pressure (Nowakowski 2000), while the wing shape – to a much lesser extent (Nowakowski 1994).

It is worth to note that different values of standardised wing pointedness index and differences in allula length in juvenile and adult birds point at more complex differences in wing structure than only these described by Alatalo *et al*. (1984), clearly related to birds adaptation to flight. It seems that different wing structure in juvenile birds, and in particular – its pointedness, can play an important role in optimisation of energetic costs of flight, and first of all can have an important adaptive value that influences the efficiency of catching insects. The lack of clear differences among seasons in wing shape index in adults suggests that only birds inexperienced in food searching undergo such selection. It is indirectly indicated by the response of Savi's Warblers to environmental stress (low night temperatures in the Biebrza valley), that resulted in significant 24-hour changes in body mass and fat score. The direct explanation of the revealed differences should be based on further analysis of relations among environmental factors, food availability and variation of morphometric parameters in the population.

In the case of tarsus length in the studied Savi's Warbler population, an increase of the mean value of this parameter in subsequent years was stated both in juveniles and adults. The revealed variability could be associated with habitat selection. During the period of studies in the Biebrza valley, gradual changes connected with the enlargement of area of reedbed and its ageing took place on the study plot. It is possible that the width of reeds changed, determining variability of this parameter in adult birds that inhabited this area in subsequent years. Variation of leg structure in birds, in particular – of length of toes and tarsus, can affect the ability to inhabit the reedbed of a certain type of vegetation by birds different morphometrically. As tarsus length is characterised by high heritability (Alatalo and Lundberg 1986, Cooke and Buckley 1987), variation of this parameter in adult birds could be reflected in the cohort of young birds.

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