

## MORPHOMETRIC CHARACTERIZATION AND BODY MEASUREMENT CORRELATIONS IN LIPSKA PRAMENKA SHEEP

**Dragana Ružić-Muslić, Bogdan Cekić, Ivan Ćosić, Nevena Maksimović, V. Caro-Petrović, Nikola Delić, Nemanja Lečić**

Institute for Animal Husbandry, Autoput 16, 11080 Belgrade-Zemun, Republic of Serbia  
Corresponding author: Dragana Ružić-Muslić, [muslic.ruzic@gmail.com](mailto:muslic.ruzic@gmail.com)  
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**Abstract:** Lipska sheep is an autochthonous Serbian population from the group of Pramenka (Zapfel) sheep, bred in the area around Smederevo, Požarevac and Mladenovac. The average weight of male animals (BW) is 95 kg and 62 kg of female animals. Other measurements of female animals are: wither height (WH) 74 cm, body length (BL) 78 cm, chest width (CW) 23 cm, chest depth (CD) 40 cm and hearth girth (HG) 91 cm. In the last sixty years, adult female animals gained in average ten kilograms of weight. Other linear measures also increased. The increase is a consequence of better animal management, especially improved diet. Since the reduction of the size of the population, larger animals have dominated, which probably caused the change in the genetic constitution of the breed. Female animals of Lipska sheep are higher compared to the animals of other fifteen Pramenka breeds with the exception of Istrian sheep. The area from which Lipska sheep originates has better soil and richer vegetation compared to the areas of other Pramenka breeds. Partial correlations corrected for weight between individual linear measures were positive, with values between 0.196 and 0.814. Most correlations range between 0.30 and 0.55. Body measurements were studied with ANOVA on females only. The effect of flock influenced all linear measures with the exception of CW, whereas the age of animals had no effect on BL, CW and CD. The increase of individual linear measures was 0.5 to 2.1 mm per kg of BW. The increase of most body measurements from the first to the fifth year was statistically significant ( $P < 0.05$ ).

**Key words:** Pramenka, Lipska sheep, endangered breeds, linear measurements

### Introduction

Pramenka or Zapfel is a group of sheep breeds widely used in the western part of the Balkan Peninsula. One of them is a Serbian autochthonous Lipska

sheep. *Mitrović (1925)* considers that Lipska sheep developed from the long-tailed Celtic sheep and Arkali sheep. It was introduced through various migrations of people on the Balkans. It is named after the village Lipe located near Smederevo. Today, the main breeding area of Lipska sheep is the territory between the towns of Smederevo, Požarevac and Mladenovac. The reported population size is between 2000 to 3500 animals (*DAD-IS, 2022*).

The endangered status of this population was defined/determined in accordance with the Rulebook on the List of genetic resources of domestic animals, the method of preserving the genetic resources of domestic animals, as well as on the List of autochthonous breeds of domestic animals and endangered autochthonous breeds (2017). Bearing in mind the mentioned criteria, Lipska sheep belongs to the "potentially endangered" category. The strategy of preserving autochthonous populations in general, as a basic prerequisite for conservation, implies the determination of the morphometric profile (*Ružić-Muslić et al., 2021*), which was the subject of research by numerous authors: *Mioč et al. (1998)*, *Činkulov et al. (2003)*, *Georgoudis and Ligda (2006)*, *Szobolevski (2006)*, *Stojanović (2006)*, *Kompan (2006)*, *Antunović et al. (2013)*, *Važić et al. (2017a)*, *Pihler et al. (2020)*.

Morphometric characterization is of multiple importance since it represents one of the most important approaches when describing the population, it shows the morphological structure, the ability of the animal to grow and develop (*Attach et al., 2004*), it is a reflection of the breed standard (*Verma et al., 2016*), and it also represents guidelines for further breeding selection work (*Kumar et al., 2017*). The fact that the mentioned population has been less studied in our country in recent decades, and inaccurate and outdated literature data, indicates that the observation of this Pramenka is urgent.

The aim of the work is the morphometric characterization of the Lipska Pramenka as well as the determination of correlations between body measurements, in the function of its preservation and sustainable cultivation.

## Material and Methods

The population is used for meat, milk and wool production. Milk yield is quite good, while the production of meat and wool is only moderate. Body characteristics of the breed and its productivity are not well recorded. The available records are inconsistent. In general, animals have a light and small head (*Milojić, 1952*). Head profile in ewes is slightly bulging, while in rams the bulging is more pronounced. The head is covered with black, short hair. Ewes are almost always without horns. The horns of rams are strong, spirally twisted and triangular, transversely striated and of bright yellow colour. The ears are of medium size, laying horizontally and covered, same as the head, with black, short hair. The neck

is of medium length and strong. The withers are weak and the top line rises slightly towards the rear. The pelvis is slightly lowered. The rump is long. The legs are quite long too, they have proper posture and strong bones and they are covered with dark hair. Hooves are solid, usually yellow, in some individuals they are dark brown. The abdomen is properly developed. Lower abdominal line usually does not come from the plane of the sternum. It is well covered with wool. Udder is well developed. Lipska sheep belongs to the group of long-tailed Pramenka breeds. The tail is cylindrical in shape and reaching over the ankles.

Soil and vegetation in the area is rich. Flocks are small, between 5 and 20 animals, mostly kept on pasture. Only in short periods of the production cycle (before lambing and during lactation) they are fed with cereal supplement.

The measurement of the exterior of the Lipska sheep was carried out in the villages Umčari, Vlačka and Koraćica near Belgrade. The total of 257 ewes aged 1 to 4 years and 11 rams aged 2 to 4 years were measured. The following measures were taken: body weight (BW), hearth girth (HG), withers height (WH), body length (BL), chest width (CW), and chest depth (CD). Measures were taken using the measuring stick.

Since only 11 measurements on male animals were done compared to 257 measurements on female animals, all further evaluation was done only for female animals. The following linear statistical model was used:

$$Y_{ijk} = \mu + A_i + F_j + b_1(W_{ijk} - \bar{W}) + b_2(R_{ijk} - \bar{R}) + e_{ijk}$$

where:  $Y_{ijk}$  is dependent variable (BW, HG, WH, BL, CW, CD),  $\mu$  is the mean value,  $A_i$  is the effect of age  $i$  in years,  $F_j$  is the effect of the flock  $j$ ,  $b_1(W_{ijk} - \bar{W})$  is the regression of weight (in case of  $Y_{ijk}$  = BW birth weight, in other cases actual body weight (BW)) dependent variables,  $b_2(R_{ijk} - \bar{R})$  is the regression of year of birth and  $e_{ijk}$  is the residual for measurement  $ijk$ . The Pearson correlations were calculated between BW and other body measurements. Other correlations are partial with BW as control variable. Statistical analysis was done with package R ver. 3.0.0 (5).

## Results and Discussion

### Body measurements

BW of adult ewes was  $61.95 \pm 6.05$  kg, and males  $95.00 \pm 7.03$  kg (Table 1). BW of males is high, which is probably due to the fact that only a small number of selected animals have remained in the population. According to official data (Stojanović, 2006), BW is 65 kg for adult male and 60 kg for adult female animals.

The estimation of females' weight is correct; however, the official figures for BW of male animals are probably underestimated. In genetically related Svrlijig sheep, according to the same source (*Stojanović, 2006*), BW is somewhat lower: 50 kg for rams and only 42 kg for ewes. BW of Svrlijig rams is probably also underestimated. The historical sources (*Milojić, 1952*) state that the weight of Lipska ewes is 50.7 kg, and 66.3 kg of rams. According to *Pavlovich (1937)*, the average weight of Lipska sheep is 60 kg. The average body weight of Sjenica ewes (*Nikolić, 1952*) is 52.2 kg and 69.63 kg in rams. It can be established that the modern Lipska sheep is slightly heavier than it was fifty years ago. BW has increased by 10 kg or 20 percent. Svrlijig breed, according to the available data, has not changed. The reduction of the population was significantly greater in Lipska sheep compared to Svrlijig sheep. Only the largest animals remained in the population. Furthermore, Lipska sheep is nowadays better fed than half a century ago, while the Svrlijig sheep is kept almost under the same conditions.

**Table 1. Parameters of descriptive statistics for body measurements by gender**

Variable	Male			Female		
	avg. $\pm$ SD	min.	max.	avg. $\pm$ SD	min.	max.
BW	95.00 $\pm$ 7.03	85.0	107.0	61.95 $\pm$ 6.05	42.0	73.0
WH	84.00 $\pm$ 4.73	80.0	94.0	74.46 $\pm$ 4.49	64.0	91.0
BL	91.64 $\pm$ 4.61	85.0	99.0	78.05 $\pm$ 4.79	67.0	91.0
CW	31.45 $\pm$ 3.11	28.0	38.0	23.49 $\pm$ 3.07	19.0	84.0
CD	47.82 $\pm$ 3.03	45.0	53.0	39.76 $\pm$ 2.76	34.0	49.0
HG	122.27 $\pm$ 5.88	112.0	128.0	91.05 $\pm$ 6.57	79.5	114.0

WH in females was  $74.46 \pm 4.49$  and in rams  $84.00 \pm 4.73$  cm. Lipska sheep is the largest among Pramenka breeds. According to *Stojanović (2006)*, WH is 65 and 60 cm in male and female animals, respectively, and is, according to our results, underestimated. In previous studies, the WH was 66.3 cm (*Mitrović, 1926*) and 67 cm (*Pavlovich, 1937*). BL of ewes was  $78.05 \pm 4.79$  and  $91.64 \pm 4.61$  cm in rams. Historically, BL found on Lipska sheep was 69.4 (*Mitrović, 1925*) and 81.23 cm (*Pavlovich, 1937*). The first one is significantly lower, while the second is similar to our results. There are no recent data of BL of other Pramenka breeds. The comparison is therefore impossible. CW of ewes is  $23.49 \pm 3.07$  and  $31.45 \pm 3.11$  cm of rams. According to previous studies, CW of Lipska ewes was 23.67 cm (*Milojić, 1952*), which is nearly identical to our result. According to the same source, CW of rams was 24.56 cm. This is significantly less than in our study. CW according to *Pavlovich (1937)* is 24.05 cm, which is again close to our values. It can be concluded that CW has not changed. CD in female animals was  $39.76 \pm$

2.76 and  $47.82 \pm 3.03$  cm in rams. The comparable CD of ewes was 29.86 (*Milojić, 1952*) and 33.23 (*Pavlovich, 1937*), and of rams 32.60 cm (*Milojić, 1952*). It is evident that CW of modern Lipska sheep is greater than CW of earlier Lipska sheep. HG of females is  $91.05 \pm 6.57$  cm and of males  $122.27 \pm 5.88$  cm. Comparable data were not found in literature. The body of Lipska sheep has a square shape. The height of withers is nearly equal to the length of the body. The weight has increased during the last decades. Reduction of population size probably changed its genetic structure. Improved animal nutrition has also contributed to the increase of body measures.

**Table 2. Body Weight (BW) and Wither Height (WH) for females of different Zapfel breeds**

Breed	Country	BW	WH	Author
Kefallinias	Greece	42	60	<i>Georgoudis and Ligda, 2006</i>
Sfakia	Greece	39	58	<i>Georgoudis and Ligda, 2006</i>
Mytilini (Lesvos)	Greece	48	64	<i>Georgoudis and Ligda, 2006</i>
Boutsiko (Orino)	Greece	38	54	<i>Georgoudis and Ligda, 2006</i>
Cikta	Hungary	38	44	<i>Szobolevski, 2006</i>
Hortabagyi Racka	Hungary	40	50	<i>Szobolevski, 2006</i>
Gyimesi Racka	Hungary	58	55	<i>Szobolevski, 2006</i>
Pirot	Serbia	46	60	<i>Stojanović, 2006</i>
Bardoka	Serbia	48	60	<i>Stojanović, 2006</i>
Svrljig	Serbia	40	65	<i>Stojanović, 2006</i>
Krivovir sheep	Serbia	38		<i>Stojanović, 2006</i>
Bela Krajina sheep	Slovenia	48	60	<i>Kompan, 2006</i>
Istrian sheep	Croatia-Slovenia-Italy	65	74	<i>EFABIS, 2013</i>
Lika	Croatia	47	61	<i>EFABIS, 2013</i>
Dalmatian sheep	Croatia	37	56	<i>EFABIS, 2013</i>
Kupres sheep	Bosnia	46	69	<i>EFABIS, 2013</i>

The only source of data on the physical characteristics of autochthonous sheep populations are organizations that deal with their preservation. The data, which can be obtained there, is mainly for BW and WH. Table 2 presents the data for BW and WH of adult female animals of different Pramenka breeds. Lipska sheep (61.95 kg) is, following Istrian sheep (65 kg), the largest in Pramenka group. Similar BW can be observed in animals of Gyimesi Racka breed (58 kg). Weight of other breeds from Pramenka group ranges from 37 to 48 kg. Pramenka breeds originate from the Karstic terrain with poor pasture. Only Hungarian Pramenka sheep and Lipska sheep come from the area with rich vegetation, so it is possible that the breeders selected larger breeding animals. WH of Lipska breed females is 74.46 cm (Table 1) and it is equal to the WH of Istrian sheep. WH of all other

breeds (Table 2) is below 70 cm. While the average weight of Gyimesi Racke is almost equal to the weight of Lipska sheep, its height is quite low - only 55 cm. This suggests the animals of small frame, with developed soft tissues, while the larger weight of Lipska sheep is a consequence of a larger frame of sheep. The rough frame of the animals allows appropriate adaptation to poor breeding conditions.

### Correlations between body measurements

Table 3 shows the correlation coefficients between the individual body measurements of female animals. Correlation coefficients between BW and other body measurements were calculated by Pearson method. The others are partial correlation coefficients with BW as a correction variable.

**Table 3. Correlations between body measurements in females**

	WH	BL	CW	CD	HG
BW	0.323	0.342	0.233	0.484	0.540
WH		0.814	0.301	0.503	0.454
BL			0.361	0.562	0.479
CW				0.318	0.196
CD					0.691

As seen, all correlations are positive. The highest is the correlation coefficient between WH and BL (0.814). Proportion between the height and the length of the animal is constant and independent of the size of adult animals. Correlation is higher than in Texel (0.31), Suffolk (0.37) and Bleu du Maine (0.44) breeds (*Janssens and Vandepitte, 2004*), as well as in Menz breed (0.69) (*Gizaw et al., 2008*) and in Yankasa breed (0.76) (*Afolayan et al., 2006*). The correlation between CD and HG is high (0.691). Correlation between CW and HG is low (0.196). The chest volume depends on the depth and not the width. Chest width is poorly correlated with other body measures; the highest correlation is 0.361. Correlation of BW with CD is 0.483, with HG 0.540, and with CW 0.233. Correlations between BW and CD and BW and HG (*Janssens and Vandepitte, 2004*), in the following breeds are: Bleu du Maine (0.57, 0.69), Suffolk (0.63, 0.74) and Texel (0.56, 0.67). They are slightly higher than in our study. Correlations found in Menz breed (*Gizaw et al., 2008*) are 0.77 between BW and HG, 0.292 between GT and CW, and 0.255 between GT and HG. All other correlations are in the range from 0.3 to 0.5. These values are of medium size and similar to correlations between the same body measures in breeds Bleu du Maine, Suffolk and Texel (*Janssens and Vandepitte, 2004*). It can be concluded that the mature females of Lipska breed are of similar shape, regardless of size, and that the

correlations between the same linear measurements are similar to the linear correlations in the literature. Parts of the body, regardless of the size of the individual animals, are of the same proportion. Only CW is relatively poorly correlated with other body measurements.

### The effect of age, flock, animal weight (birth or body) and year of birth on body size

Table 4 presents the results of analysis of variance (ANOVA). Model explains the increase of all linear measures between ages one and four years as statistically significant. The coefficients of determination are: 0.6302 for HG, 0.6165 for BW and 0.4003 for CD. Other coefficients of determination, 0.2008 for WH, 0.1795 for BL, and especially 0.0823 for CW, are low. The model poorly explains the last three linear measurements

**Table 4. Analysis of variance according to the linear model**

	Model			Effect (P-value)			
	F-value	P-value	R <sup>2</sup>	age (A <sub>i</sub> )	flock (F <sub>j</sub> )	$b_1(W_{ijk} - \bar{W})$	$b_2(R_{ijk} - \bar{R})$
BW	46.060	<0.00001	0.6165	<0.00001	<0.00001	0.20540	0.27060
WH	9.634	<0.00001	0.2008	0.00063	0.00095	0.01819	0.80130
BL	8.393	<0.00001	0.1795	0.11657	0.01132	0.00003	0.33929
CW	3.439	<0.00001	0.0823	0.75985	0.11194	0.00067	0.79901
CD	25.600	<0.00001	0.4003	0.98675	0.00063	<0.00001	<0.00001
HG	65.360	<0.00001	0.6302	0.00295	0.00105	<0.00001	<0.00001

The influence of all four effects on HG is statistically significant ( $P < 0.05$ ). The age of animal (A<sub>i</sub>), the effect of flock (F<sub>j</sub>) and the weight of the animal are significantly influenced by WH. CD is influenced by flock (F<sub>j</sub>), weight and year of birth of the animal. BW is affected by age (A<sub>i</sub>) and flock (F<sub>j</sub>), while BL is influenced by flock (F<sub>j</sub>) and weight of animals. CW is influenced only by weight.

Regression coefficients between the measured values and body weight (BW) were positive and statistically significant (Table 5,  $P < 0.05$ ). The increases of body size were small, from around one (WH, CW, CD) to around two millimetres (BL, HG) per kg of BW or birth weight, but statistically significant ( $P < 0.05$ ). Regression coefficients between the year of birth and body measures were negative. Animals born in later years, were probably not of mature size, so the influence can be considered as a correction of linear measure of the body for its age, although the age of the animals was included as an independent effect in the model (A<sub>i</sub>).

**Table 5. Regression coefficients and their standard errors according to the linear model**

	W <sup>1</sup>	R <sup>2</sup>
BW	-0.423±0.333	-0.250±0.227
WH	0.099±0.042*	-0.054±0.215
BL	0.193±0.046***	-0.223±0.234
CW	0.102±0.030***	-0.039±0.153
CD	0.137±0.023***	-0.834±0.116***
HG	0.231±0.042***	-2.732±0.217***

<sup>1</sup>Body weight; <sup>2</sup>Birth year (Significance levels: \* 0.05>P ≥0.01; \*\* 0.01>P ≥0.001;\*\*\* 0.001>P)

## Conclusions

Lipska sheep is one of the Serbian native breeds from the group of Pramenka breeds (Zapfel), which is native in the area near Smederevo, Požarevac and Mladenovac, where the residuals of the breed can be found. Mature ewes of the breed, compared to 16 breeds of Pramenka group from Greece, Croatia, Hungary and Slovenia, were of the largest size following Istrian Pramenka.

Recently measured animals are much larger than the animals measured 60 years ago or more.

Correlations between linear body measurements of female animals were positive and quite high. It can be determined that the mature female animals of Lipska breed were of similar shape irrespective of their size. Their body was square like. The individual parts of the body were of the same proportion, regardless of the size of each animal. An exception was found in CW, where the correlation with other body measures was relatively low.

The effect of the flock showed an impact on all linear body measures with the exception of CW. That means that the animals in the same flock were uniform. Animal's age in years affected BW, WH and HG, but not BL, CW and CD. The frame of animals in the period of one to five years of age remained unchanged. The change in BW and HG is related to the increase in soft tissues (muscle and fat). For each kg of body weight, the linear body measures increased by half to two millimetres. The increase was small, but statistically significant ( $P<0.05$ ).

Based on the existing results it can be concluded that the Lipska sheep is among the largest breeds in the Pramenka group. The size of animals has increased during the last half of the century. Recently measured animals are not phenotypically identical to the animals of the same breed fifty years ago, or more. Determined differences between modern and historical animals indicate the need of new researches on the remains of endangered breeds. Phenotypic changes can be

expected in those animals as well. New phenotypic studies on the remains of such breeds will help to define the standards for their future breeding.

## Morfometrijska karakterizacija i korelacija telesnih mera Lipske pramenke

*Dragana Ružić-Muslić, Bogdan Cekić, Ivan Ćosić, Nevena Maksimović, Violeta Caro-Petrović, Nikola Delić, Nemanja Lečić*

### Rezime

Lipska ovca je autohtona populacija iz grupe pramenki (Zapfel) koja se gaji u okolini Smedereva, Požarevca i Mladenovca. Prosečna telesna masa odraslih muških životinja iznosi 95 kg, a ženskih 62 kg. Eksterijerne mere ženskih životinja iznose: visina grebena (WH) 74 cm, dužina tela (BL) 78 cm, širina grudi (CW) 23 cm, dubina grudi (CD) 40 cm i obim grudi (HG) 91 cm. U poslednjih šezdeset godina, telesna masa odraslih ženskih životinja su u proseku povećala za oko deset kg, što je posledica izmenjenog menadžmenta, pre svega poboljšane ishrane. Nakon redukcije veličine populacije, dominantne su veće životinje, što je verovatno uslovalo promenu genetske konstitucije populacije. Područje na kome je nastala lipska ovca karakteriše plodnije zemljište i bogatija vegetacija u poređenju sa područjima iz kojih dolaze druge populacije pramenki. Korelacijski koeficijenti i uticaji stada, starosti životinje u godinama, godine rođenja i težine kod rođenja odnosno težine izmerene životinje, WH, BL, CW, CD i HG su ocenjeni samo na ženskim životinjama, obzirom da je bilo obavljeno jedanaest merenja na pet ovnova. Parcijalne korelacije sa korekcijom na telesnu težinu između pojedinačnih linearnih mera su pozitivne sa vrednostima između 0,196 i 0,814. Najviše korelacija nalaze se u intervalu od 0,30 do 0,55. Efekat stado uticao je na sve linearne mere sa izuzetkom CW dok starost životinja nije uticala na BL, CW i CD. Porast pojedinačnih linearnih mera iznosio je za 0,5 do 2,1 mm na kg BW. Porast većine telesnih mera od prve do četvrte godine bio je statistički značajan ( $P < 0,05$ ).  
**Ključne reči:** Zapfel, Lipska ovca, ugrožena rasa, linearne mere

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