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Morphometric Analysis and Sex Dimorphism of the Autochthonous Lipe Sheep

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Abstract

Lipe sheep is an autochthonous and endangered sheep endemic to a limited area in Serbia, representing an important element of national livestock biodiversity. As a locally adapted genetic resource, belonging to the Pramenka group of sheep, it holds ecological, cultural, and production-related value. However, population decline and exclusion from intensive breeding programs have made the population vulnerable to genetic erosion. This study evaluated sex dimorphism of the Lipe sheep through body measurements, craniometric, and pelvimetric morphometry. A total of 19 adults (10 ewes and 9 rams, aged 2.5 to 3.5 years) were analyzed. Results showed highly significant differences between sexes for body traits ($p < 0.001$), with rams consistently exhibiting greater values. Significant dimorphism was observed in cranial traits, with rams displaying more pronounced characteristics. Rams also had yellowish to dark, large, triangularly shaped, and spirally twisted horns, a key feature

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of sexual dimorphism. In contrast, no significant differences were found for pelvic traits, suggesting well-developed pelvis in ewes, ensuring easy lambing and uniform pelvic conformation. These findings indicate that the Lipe sheep exhibits stronger sex dimorphism in body and cranial morphology while maintaining functional uniformity in pelvic structure. The study contributes to a broader characterization of the Lipe sheep and provides a foundation for targeted conservation and breeding strategies. Preserving this sheep helps maintain agrobiodiversity and strengthens its role as a valuable genetic resource.

Keywords: autochthonous breed, genetic resource, Lipe sheep, morphometric analysis, sexual dimorphism

Introduction

Autochthonous breeds of sheep, such as the Pramenka, represent long-established populations whose genetic diversity has been shaped by specific agroecological conditions and traditional breeding practices in Serbia (ĐEDOVIĆ et al., 2024). One of the most significant types of Pramenka is the Lipe sheep, which originated and is traditionally bred in the village of Lipe near Smederevo. Known locally as Gara or Garulja, the Lipe sheep is a late-maturing, triple-purpose breed, highly valued not only for meat, milk, and wool, but also for its strong adaptability and resilience to the diverse environmental conditions of its native region (BECSKEI et al., 2018; CEKIĆ et al., 2019). Owing to its valuable genetic traits and reduced population size, the Lipe sheep has been designated a potentially endangered variety of the Pramenka breed in accordance with the Rulebook on the Preservation and Classification of Genetic Resources of Domestic Animals (RUŽIĆ-MUSLIĆ et al., 2022). In many animal species, males and females exhibit consistent differences in body size and shape (ANDERSSON, 1994), which can be of practical importance in breeding programs. Identifying and quantifying these phenotypic differences between males and females allows for informed selection strategies aimed at improving growth rates, reproductive efficiency, and maternal traits, thereby enhancing both productivity and genetic management of the breed (GUDEX et al., 2009). These patterns of sexual differentiation emerge as a consequence of distinct selective pressures acting on males and females, and understanding them provides a framework for designing breeding strategies that maintain the breed's structural stability and phenotypic variability (BLANCKENHORN, 2005). The present study evaluates the Lipe sheep as a valuable genetic resource by analyzing its morphometric traits with particular attention to differences between rams and ewes. By examining these sex-specific characteristics, the study offers a comprehensive characterization of the breed, enhancing the understanding of its historical and adaptive traits and supporting the preservation of agrobiodiversity and sustainable

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management of this locally important sheep population. This approach contributes to the development of targeted breeding programs that safeguard genetic integrity while optimizing performance traits, ultimately promoting the long-term viability and conservation of the Lipe sheep as a genetically valuable autochthonous breed.

Material and methods

To collect phenotype-related parameters, identify the existing production systems, and assess the population status of the Lipe sheep, onsite visits were conducted, including detailed measurements of phenotypic traits, consultation of the breed registry, and interviews with local breeders, providing comprehensive information about the management and characteristics of the breed. The study specifically evaluated sexual dimorphism in the Lipe sheep through body, cranial, and pelvic morphometry, analyzing a total of 19 adult individuals, consisting of 10 ewes and 9 rams aged between 2.5 and 3.5 years. Body measurements focused on traits relevant for assessing growth and structural differences, including height at the withers, measured as the distance from the ground to the top of the withers; body length, determined from the cranial point of the shoulder to the caudal margin of the pin bone; chest circumference, recorded immediately behind the withers and shoulders; cannon circumference, measured at the midshaft of the cannon bone; and body weight, obtained using a calibrated scale. Cranial measurements comprised head length, measured from the tip of the nose to the top of the occipital crest; front length, from the occipital crest to the medial corner of the eye; face length, from the tip of the nose to the medial corner of the eye; head width, as the distance between the zygomatic arches; height of the ear base, from the incisura vasorum mandibulae to the ventral base of the ear; ear length, from the base to the tip along the lateral aspect; and horn length, measured from the base to the tip of the horn along its lateral aspect. Pelvic morphometry included rump length, defined as the distance between the cranial part of the hip and the most posterior point of the pin bone; hip width, measured between the coxal tubercles; coxo-femoral diameter, as the distance between the coxo-femoral joints; and rump width, measured between the two most posterior points of the pin bones. All statistical analyses were performed using GraphPad Prism version 6 (GraphPad, San Diego, CA, USA), with descriptive statistics including arithmetic mean, standard deviation (SD), coefficient of variation (CV), and variation index (VI), and differences between groups assessed using appropriate statistical tests, with significance set at $P < 0.05$.

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Results and discussion

The results of this study provide a detailed insight into sexual dimorphism in the Lipe sheep, revealing that rams consistently exhibit larger values for most body and craniometric traits compared with ewes, while pelvic measurements remain relatively uniform between sexes. These patterns are consistent with previous observations in domestic sheep, where males generally show greater body dimensions even under relaxed sexual selection pressures (PARÉS-CASANOVA, 2015). Such findings highlight both the breed's phenotypic variability and structural stability, reflecting its adaptation to traditional management and local environmental conditions. Understanding these sex-specific differences is crucial for informing targeted breeding and conservation strategies, as they provide guidance for maintaining genetic diversity, functional integrity, and the long-term viability of this autochthonous breed. The main body measurements of the Lipe sheep, presented in Table 1, provide a detailed overview of the morphometric characteristics of the population and enable an objective evaluation of sex-related differences across key growth and structural traits, which is consistent with previous approaches using quantitative measurements for breed characterization (PEÑA BLANCO et al., 1990; MARTIN et al., 1993).

Table 1: Main body measurements of the Lipe sheep

Trait	Sex F(n=10) M(n=9)	$\bar{X}$ ± SD (cm)	VI	CV (%)	P
Height at withers	F	68.65 ± 0.58	0.005	0.84	***
	M	76.25 ± 2.44	0.078	3.20	
Body length	F	78.25 ± 3.99	0.204	5.11	***
	M	92.50 ± 4.24	0.194	4.58	
Chest circumference	F	89.95 ± 2.59	0.074	2.88	***
	M	97.87 ± 4.55	0.212	4.65	
Cannon circumference	F	7.85 ± 0.75	0.071	9.52	***
	M	9.31 ± 0.66	0.047	7.07	
Body weight	F	54.65 ± 5.11	0.478	9.35	***
	M	74.88 ± 6.55	0.572	8.74	

F – female; M – male; $\bar{X}$ – mean; SD – standard deviation; VI – variation index; CV – coefficient of variation; P – significance level (ANOVA)

p-values: * – $p < 0.05$ (significant); ** – $p < 0.01$ (very significant); * – $p < 0.001$ (extremely significant); ns – $p > 0.05$ (not significant)*

The results presented in Table 1., indicate statistically highly significant differences between sexes for all analyzed morphometric traits, confirming the presence of pronounced sexual dimorphism within the population. Males consistently exhibited

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higher values than females in withers height, body length, chest circumference, cannon circumference, and body weight. This pattern is consistent with previous observations, where adult males also showed larger body measurements compared with females (RIVA, 2004). The most evident differences were observed in body length and live weight, indicating a clear sex-based differentiation in body conformation. The presence of such dimorphism is an indicator of retained genetic diversity and adaptive capacity, which are essential components for the resilience and long-term viability of local livestock breeds. Therefore, the morphometric distinctions identified in Table 1. serve not only as evidence of population structure, but also as a useful tool for conservation planning. Incorporating sex-specific traits into breeding and conservation strategies can enhance the effectiveness of programs aimed at preserving the biological identity and functional integrity of the Lipe sheep. As a part of traditional agroecosystems, this breed plays a valuable role in maintaining agrobiodiversity, and its conservation contributes to broader efforts in safeguarding genetic resources adapted to specific environmental and cultural contexts.The cranial dimensions of the Lipe sheep, detailed in Table 2, reveal notable sex-related variation and offer key information for understanding the structural differentiation and morphological characteristics within the breed.

Table 2: Main cranial measurements of the Lipe sheep

Trait	Sex F(n=10) M(n=9)	$\bar{X} \pm SD$ (cm)	VI	CV (%)	P
Head length	F	24.56 ± 1.45	0.085	5.89	***
	M	28.44 ± 1.16	0.047	4.07	
Front length	F	8.80 ± 0.82	0.077	9.36	**
	M	10.06 ± 0.98	0.096	9.76	
Face length	F	15.75 ± 1.40	0.124	8.89	***
	M	18.50 ± 1.06	0.061	5.73	
Head width	F	12.40 ± 1.81	0.263	14.58	**
	M	14.75 ± 1.22	0.102	8.30	
Height of ear base	F	9.25 ± 0.82	0.074	8.92	***
	M	12.13 ± 1.05	0.091	8.69	
Ear length	F	12.90 ± 1.23	0.117	9.56	**
	M	14.13 ± 0.95	0.064	6.72	
Horn lenght	F	-	-	-	-
	M	62.31 ± 4.29	0.068	6.88	***

F – female; M – male;$\bar{X}$ – mean; SD – standard deviation; VI – variation index; CV – coefficient of variation; p – significance level (ANOVA)
*P-values: * – $P < 0.05$ (significant); ** – $P < 0.01$ (very significant); *** – $P < 0.001$ (extremely significant); ns – $P > 0.05$ (not significant)

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Table 2. demonstrates that all analyzed cranial traits show statistically significant differences between sexes, confirming the presence of sex dimorphism in the Lipe sheep population. Males exhibited greater values in all traits compared to females. Differences were extremely significant ($p < 0.001$) for head length, face length, and height of the ear base, and very significant ($p < 0.01$) for front length, head width, and ear length. Additionally, sexual dimorphism was evident in horn development, as males possessed well-developed horns while females were polled, further highlighting the pronounced differences between the sexes. This pattern aligns with previous studies showing that horn size and form, in addition to body size, may be under differential selective pressures, with horn traits often developing independently from overall body growth (CÔTÉ, FESTA-BIANCHET&SMITH, 1998; CARO et al., 2003). The most pronounced dimorphism was observed in head and face length, suggesting a more developed cranial structure in males, likely influenced by natural selection and reproductive roles. These results indicate that the Lipe sheep retains genetically and functionally meaningful variation, supporting its value as an autochthonous genetic resource. Recognizing sex-related cranial and horn differences contributes to more effective conservation and breeding strategies, aimed at preserving the breed's biological identity and long-term viability. The results of the comparison of pelvimetric traits between male and female Lipe sheep will be presented in Table 3, showing relative uniformity across sexes and indicating that pelvic morphology remains largely consistent within the population.

Table 3: Comparison of pelvimetric traits between sexes in Lipe sheep

Trait	Sex	$\bar{X} \pm SD$ (cm)	VI	CV (%)	P
Rump length	F	24.40 ± 1.68	0.116	6.89	ns
	M	25.56 ± 1.04	0.043	4.08	
Hip width	F	21.50 ± 2.13	0.212	9.93	ns
	M	22.69 ± 1.34	0.080	5.93	
Coxo-femoral diameter	F	24.15 ± 2.46	0.251	10.19	ns
	M	25.21 ± 1.72	0.118	6.83	
Rump width	F	13.55 ± 1.78	0.233	13.13	ns
	M	14.55 ± 1.20	0.099	8.26	

F – female; M – male;$\bar{X}$ – mean; SD – standard deviation; VI – variation index; CV – coefficient of variation; p – significance level (ANOVA)
*P-values: * – $P < 0.05$ (significant); ** – $P < 0.01$ (very significant); *** – $P < 0.001$ (extremely significant); ns – $p > 0.05$ (not significant)

As presented in Table 3., no statistically significant differences (ns) were observed between females and males for any of the measured pelvic traits. Although male values were slightly higher on average, the variation was not sufficient to indicate a clear pattern of sexual dimorphism in pelvic morphology. The relative uniformity of

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pelvic traits between sexes may reflect the stability of body structure in the Lipe sheep population and suggest that these measurements are conserved and functionally balanced. Accurate measurement of pelvic dimensions is crucial for reducing dystocia, as evaluating the pelvic area allows identification of ewes with smaller pelvises, which are at higher risk during lambing (VAN ROOYEN, 2012). Such anatomical consistency is characteristic of autochthonous breeds that have developed under traditional management and environmental conditions, where natural selection favored adaptability and structural efficiency. These results reinforce the importance of preserving not only genetic, but also morphological integrity of the Lipe sheep. Documenting pelvic characteristics supports the phenotypic characterization of the strain and contributes to the development of conservation strategies aimed at maintaining its identity, functionality, and role in sustainable livestock production systems.

Conclusion and recommendation

In conclusion, the Lipe sheep exhibits pronounced sexual dimorphism in body and cranial traits, while maintaining a relatively uniform pelvic structure. These results indicate that the breed retains valuable genetic diversity and functional adaptation, making it an important local and well-adapted genetic resource. The findings provide essential data to support conservation and breeding strategies aimed at preserving the biological identity, adaptive potential, and long-term viability of the Lipe sheep. Moreover, studying sex-related differences in this breed contributes to a broader understanding of domestication, adaptation, and the conservation of animal genetic resources, highlighting the crucial role of local breeds in maintaining biodiversity.

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