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Utjecaj pasmine i dijela tijela na promjer vunskoga vlakna

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THE INFLUENCE OF BREED AND BODY REGION ON THE WOOL FIBRE DIAMETER

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SUMMARY

To investigate the influence of a breed and body region on the wool fibre diameter, the wool samples were taken from the three body regions (shoulder, rib, and rump) of the three sheep breeds: the Merinolandschaf (ML – closed fleece), Pag sheep (PS – semi-open fleece), and the Travnika Pramenka sheep (TP – open fleece). A significant difference in fleece yield was determined between the breeds investigated ($P < 0.001$). The smallest fibre diameter was detected in the Merinolandschaf sheep breed (27.70 μm), a slightly larger in the Pag sheep (27.78 μm), while the largest was established in the Travnika Pramenka sheep (39.57 μm). The average fibre diameter of the Merinolandschaf sheep breed's wool and of the Pag sheep breed's wool was similar and significantly smaller than that of the Travnika Pramenka sheep breed's wool ($P < 0.001$). The finest fibres came from the shoulder (ML, 25.13 μm ; PS, 25.56 μm ; TP, 37.14 μm) and then from the rib (ML, 27.83 μm ; PS, 27.57 μm ; TP, 39.76 μm), while the coarsest wool was found in the rump samples (ML, 30.13 μm ; PS, 30.22 μm ; TP, 41.83 μm) in the fleece of the investigated sheep breeds. The research determined a significant influence ($P < 0.001$) of a body region on a fibre diameter of the investigated breeds.

Keywords: breed, body region, wool, fibre, diameter

INTRODUCTION

Wool is a natural keratin (protein) fibre and has been one of the most important ovine products for centuries, playing an important civilizational, economic, and cultural role. A need for clothing and body protection from the cold were the basic reasons for sheep breeding and the "formation of wool types" (Mazinani and Rude, 2020). The wool fibre structure enables spinning and the production of long threads (yarns) used for weaving. Wool is a poor conductor of heat and is therefore mainly used to produce clothing, shoes, and blankets. It is resistant to moisture because wool fibres are made of keratin, a waterproof substance. The quantity and quality of wool produced per head does not depend on the shearing method, but primarily on the breed, the age and physical development of the head, nutrition and condition, the climatic conditions of the breeding area, the breeding system, the proportion of impurities in the fleece, etc. (Cholewinska et al., 2020; Allafi et al., 2021).

Although wool is increasingly less interesting in the European market today and is often disposed of uncontrolled in the environment, making it an environmental problem, it is still a very important sheep product in some countries.

A raw wool's market value is determined by its quality, which is adjusted based on the consumer needs to meet the requirements of the processing industry (Holman and Malau-Aduli, 2012). Wool quality is evaluated by a routine assessment of the fleece, which includes the average fibre diameter and waviness, a variability of fibre diameter in the fleece, sliver characteristics, comfort factor, spinning fineness, and a pure wool yield. The aforementioned assessment enables an objective quantification of wool quality prior to processing. Wool is

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a versatile and commercially interesting product due to its specific physical properties that have a direct impact on a wearing comfort (Hatcher et al., 2010), processing properties, and product durability (Swan et al., 2008). The qualitative characteristics of a fibre determine its future and its use in the textile industry. Wool is not a “uniform” biological product because its physical properties vary according to a sheep breed, environmental factors, and breeding strategy (Poppi and McLennan, 2010). Europe is considered to be the cradle of modern sheep farming, and the very purpose of production and the economic importance of sheep on this continent has greatly changed throughout history. In the past, significantly more sheep were bred in Europe, averagely producing more wool per year. Unfortunately, the number of sheep in Europe and Croatia is decreasing annually, and one of the reasons for this phenomenon is a decreasing market value of wool. Mioč et al. (2023) state that an interest in wool, especially a coarse and a poor quality one, has considerably decreased in the recent decades due to a strong competition with the synthetic fibres. Sheep farmers in Croatia have recently become increasingly interested in the production of sheep milk due to a relatively high purchase price (Antunović et al., 2022). The Pag sheep is one of the most famous Croatian sheep breeds intended for the production of milk, which is processed into the famous Pag cheese. The Travnik Pramenka sheep is used for the production of meat (lamb) and milk (Antunović et al., 2021), while the Merinolandschaf sheep breed is now bred exclusively for meat production, although it was originally intended for wool and meat production.

There are numerous factors that influence the quality of wool, and the most important ones are an animal's genotype and the environmental factors that directly contribute to the quantity and quality of the wool produced (Galaye et al., 2021). The physical properties of a wool fibre are as follows: waviness, diameter, length and height, strength, elasticity, suppleness, luster, hygroscopicity, and warmth, being the best indicators of the qualitative characteristics of the wool. The average fibre diameter is the most important parameter of wool quality and is directly related to a spinning performance. The wool fineness refers to the average value of fibre diameter expressed in micrometers (μm) or in the thousandths of a millimeter (Rowe, 2010), and is considered to be the most important physical property in the evaluation of wool's quality, price, and utility value (Gleba, 2012). A fibre diameter (fineness) is the most variable wool characteristic, which is influenced by numerous genetic and non-genetic factors and can range from 7 to 40 μm , often more (Mioč et al., 2007). The genotype is the most important factor for the efficiency of an animal in a high-quality wool production. In most cases, the sheep breeds selected for meat or milk production produce a coarser wool than those selected only for wool production. A wool fibre diameter is primarily influenced by a genotype, but there is marked variability in the wool fibre fineness (Mioč et al., 2020) even within the same genotype and the same individual (in terms of a body

part). Throughout the history of creation of the wool-production breeds, the breeders and selectors have strived for animals to have the most uniform fibre diameter in the fleece (Scobie et al., 2015). Therefore, this paper's objective was to determine the average wool fibre diameter from three body regions of the three sheep breeds raised in Croatia.

MATERIALS AND METHODS

Sampling and wool diameter measurement

The study was conducted on the three sheep breeds with different fleece types and wool qualities: the Merinolandschaf (ML; closed fleece, fine fibres), Pag sheep (PS; semi-open fleece, medium-fine fibres), and the Travnik Pramenka (TP; open fleece, coarse fibres). All the animals studied were kept in a pasture-stall system, in which the animals remain indoors during the night and during a bad weather, while they are let out on pasture during the growing season. A total of 360 healthy sheep (120 per breed) with healthy fleece, uniform age and body condition and uniform physical development within the breed were selected for shearing and wool sampling (wool staples). The Pag sheep were bred and sheared on the island of Pag (the town of Pag, Zadar County), the Travnik Pramenka in the area of Bjelovar-Bilogora County (Velika Peratovica), and the Merinolandschaf sheep in the area of Vukovar-Syrmia County (Štitar). Shearing took place after one year of wool growth, in March for the Merinolandschaf sheep and at the beginning of June for the Pag sheep and the Travnik Pramenka. To determine a wool fibre diameter (fineness), three wool samples (staples) were taken from the right side of the body of each animal before shearing: from the shoulder (A), the rib (B), and the rump (C). The wool samples were cut with the hand scissors just above the skin surface and placed in a plastic zip-lock bag, labelled, and stored at a room temperature until analysis. A total of 1,080 wool samples were collected—that is, 360 samples per breed, or 120 samples from each body region of a breed. The measurements of wool fibre diameters were performed at the University of Zagreb, Faculty of Agriculture, Department of Animal Science and Technology, using the FibreLux Micron Meter. Prior to the measurement, a microstaple (as thick as a pencil) was peeled off the wool sample. All external impurities were removed from the microsample by combing, and the fibres within the microsample were aligned to be more or less in parallel to each other, so that they had a width of about 30 mm. The prepared microsamples were then placed between the two parts of a sample holder and fixed in place. The sample holder with the prepared microsamples was then placed in the FibreLux Micron Meter to measure a fibre diameter of the unwashed wool.

Statistical analysis

Data preparation, preliminary analyses, and statistical data analysis were performed with the statistical program R (R Core Team, 2023). Data preparation prior to the analysis was performed using a tidyverse package

(Wickham et al., 2019), while a descriptive and inferential statistical analysis was performed using the rstatix package (Kassambara, 2023a). Prior to the analysis, model assumptions were checked, such as the following ones: no significant outliers (rstatix package), normality with QQ plot (ggpubr package; Kassambara, 2023b), and sphericity with Mauchly's test (rstatix package). When all assumptions were met, a repeated-measure ANOVA was performed with the rstatix package, while the post

hoc tests were performed with the emmeans package (Lenth, 2024). To reduce the type I error, the Bonferroni test was performed to correct the p-value.

RESULTS AND DISCUSSION

The descriptive statistical-analysis results (Table 1) show the values for an average fleece yield and an average wool fibre diameter of the sheep breeds studied.

Table 1. Descriptive statistics of the quantity (kg) and quality of wool (μm) of the investigated sheep breeds

Tablica 1. Opisna statistika količine (kg) i kvalitete proizvedene vune (μm) istraživanih pasmina ovaca

Sheep breed / Pasma	Indicator/ Pokazatelj	$\bar{X}$	Min.	Max.	SD	CV (%)
Merinolandschaf	Fleece yield / Nastrig	2.14	0.94	3.6	0.68	31.86
	Fibre diameter / Promjer vlakna	27.70	17.45	37.67	4.28	15.46
Pag sheep / Paška ovca	Fleece yield / Nastrig	1.34	0.52	2.53	0.42	31.08
	Fibre diameter / Promjer vlakna	27.78	21.91	35.27	2.79	10.03
Travnik Pramenka sheep / Travnička pramenka	Fleece yield / Nastrig	3.08	1.76	4.92	0.68	21.98
	Fibre diameter / Promjer vlakna	39.57	31.29	49.73	3.91	9.87

The highest average fleece weight was measured in the Travnik Pramenka sheep (3.08 kg), which is due to an open fleece consisting of the long whip-like staples covering the body and a relatively large breed frame. A significantly lower average fleece weight was recorded for the Merinolandschaf (2.14 kg), which is characterised by a closed fleece with the significantly shorter staples than that of the Travnik Pramenka sheep. The lowest average fleece weight was recorded for the Pag sheep (1.34 kg), which can be attributed to a small size of the breed and a weak wool covering, especially on the belly and legs. The differences in fleece weight between all three investigated sheep breeds were statistically significant (Table 2). Mahajan et al. (2018) reported on an average wool production of 1.60 kg in the Rambouillet sheep, with the year having a significant influence on the qualitative characteristics of the wool. Mathis and Faris (1992) also emphasise a significant influence of breed on the amount of wool produced and specified the different values for the specific breeds, from 1.8-3.6 kg for the Suffolk to 5.0-6.8 kg for the Merino. As expected, the smallest average wool-fibre diameter was found in the Merinolandschaf

sheep (27.70 μm), slightly higher in the Pag sheep (27.78 μm), while the largest diameter, or the coarsest wool, was found in the Travnik Pramenka sheep (39.57 μm). A slight wool-diameter difference between the Merinolandschaf sheep and the Pag sheep is due to a crossbreeding of the Pag sheep with the different Merino types, which was systematically carried out in the 19th and in the early 20th centuries, when a demand for a higher quality wool increased. Therefore, the differences in the wool-fibre diameter between the Merinolandschaf and the Pag sheep wool were not statistically significant, while the Travnik Pramenka's wool had a significantly larger diameter when compared to the Merinolandschaf and the Pag sheep's wool (Table 2). The wool-fibre diameter primarily depends on a breed, from which the differences between the other authors' results can be derived. For example, Mahajan et al. (2018) reported an average fibre diameter of 21.20 μm for the Rambouillet sheep, El-Din et al. (2018) reported the fibre diameter values for the Hampshire (26-30 μm) and the Corriedale (28-33 μm) breeds, and Mathis and Faris (2002) for the Border Leicester (28-30 μm) and the Dorset (26-32 μm) breeds.

Table 2. The influence of a breed on the annual fleece yield and the average fibre diameter

Tablica 2. Utjecaj pasmine na godišnju količinu proizvedene vune i prosječan promjer vlakna

Indicator / Pokazatelj	Sheep breed / Pasma		
	Merinolandschaf	Pag sheep / Paška ovca	Travnik Pramenka sheep / Travnička pramenka
Fleece yield / Nastrig, kg	2.14 $\pm$ 0.04 ^b	1.34 $\pm$ 0.04 ^a	3.08 $\pm$ 0.04 ^c
Fibre diameter / Promjer vlakna, μm	27.7 $\pm$ 0.24 ^a	27.8 $\pm$ 0.24 ^a	39.6 $\pm$ 0.24 ^b

The symbols a, b, and c next to the values indicate the statistically significant differences between the breeds.

oznake a, b i c uz vrijednosti označuju statistički značajne razlike između pasmina.

As already mentioned and confirmed by the present study, a genotype has a significant influence on the wool-fibre diameter. However, in addition to the genotype, a body region also has an influence on the wool-fibre diameter, as the fibres with different diameters grow in differ-

ent parts of the sheep body. Observing a body region, it can be seen that a wool-fibre diameter increases from the front to the rear of the body in all three sheep breeds studied (Table 3).

Table 3. Descriptive statistical indicators of a wool fibre diameter in relation to breed and body region (μm)Tablica 3. Opisni statistički pokazatelji promjera vunskoga vlakna s obzirom na pasminu i dio tijela (μm)

Sheep breed / Pasmina	Body region / Dio tijela	$\bar{X}$	Min.	Maks.	SD	CV %
Merinolandschaf	Shoulder / Plećka	25.13	16.45	33.4	4.01	15.96
	Ribs / Rebra	27.83	17.24	37.00	4.55	16.36
	Rump / But	30.13	18.15	42.6	4.71	15.64
Pag sheep / Paška ovca	Shoulder / Plećka	25.56	19.45	33.5	3.02	11.82
	Ribs / Rebra	27.57	21.46	35.75	2.95	10.68
	Rump / But	30.22	22.45	38.75	3.29	10.90
Travnik Pramenka sheep / Travnička pramenka	Shoulder / Plećka	37.14	28.44	45.61	3.85	10.36
	Ribs / Rebra	39.76	31.70	50.16	3.99	10.06
	Rump / But	41.83	32.68	53.42	4.12	9.84

The finest wool fibres in all three breeds studied grew in the shoulder area (ML, 25.13 μm ; PS, 25.56 μm ; TP, 37.14 μm), less fine in the rib area (ML, 27.83 μm ; PS, 27.57 μm ; TP, 39.76 μm), and the coarsest (ML, 30.13 μm ; PS, 30.22 μm ; TP, 41.83) in the rump area (Table 3). These results agree with those of Behrem and Gül (2022), according to which the finest wool was found on the shoulder (23.6 μm), slightly less fine on the ribs (23.8 μm), and the least fine on the rump (25.3 μm).

The differences in wool diameter between the breeds in the investigated body regions were statisti-

cally significant in all three body regions analysed (Table 4). A statistically significant larger wool diameter was detected in the Travnik Pramenka sheep in all three body regions. Although a difference between the individual body regions of the same breed was not tested, it is obvious that the wool in the rump area had the largest diameter in all three breeds. This agrees with the results of Behrem and Gül (2022), who found a very similar fibre diameter in the shoulder and rib body region ($p > 0.05$) and a higher value of fibre diameter in the rump region ($p < 0.01$).

Table 4. The influence of a breed on the wool-fibre diameter (μm) in relation to the body regionTablica 4. Utjecaj pasmine na promjer (μm) vunskoga vlakna s obzirom na dio tijela

Body region / Dio tijela	Breed / Pasmina		
	Merinolandschaf	Pag sheep / Paška ovca	Travnik pramenka sheep / Travnička pramenka
Shoulder / Plećka	25.1 $\pm$ 0.24 ^a	25.6 $\pm$ 0.24 ^a	37.1 $\pm$ 0.24 ^b
Ribs / Rebra	27.8 $\pm$ 0.25 ^a	27.6 $\pm$ 0.25 ^a	39.8 $\pm$ 0.25 ^b
Rump / But	30.1 $\pm$ 0.26 ^a	30.2 $\pm$ 0.26 ^a	41.8 $\pm$ 0.26 ^b

The values in the same row marked with the different letters are statistically significantly different.

Vrijednosti u istome redu označene različitim slovima statistički se značajno razlikuju.

CONCLUSION

The present study determined a significant influence of breed on the fleece yield and wool-fibre diameter. Most wool (3.08 kg) was produced by the Travnik Pramenka sheep, but the wool had the largest average diameter (39.57 μm), it was the coarsest one. The Merinolandschaf sheep produced significantly less wool per animal (2.14 kg), and the Pag sheep the least (1.34 kg). The wool of the Merinolandschaf sheep breed and the Pag sheep had an almost identical diameter (27.70 μm : 27.78 μm). In all three breeds, a significant influence of the body region on the average wool-fibre diameter was observed, whereby the finest fibres came from the shoulder area, whereas and the coarsest one came from the rump area.

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UTJECAJ PASMINE I DIJELA TIJELA NA PROMJER VUNSKOGA VLAKNA

SAŽETAK

Za istraživanje utjecaja pasmine i dijela tijela na promjer vunskih vlakana uzeti su uzorci vune s triju dijelova tijela (plećka, rebra i but) triju pasmina ovaca: Merinolandschaf (ML – zatvoreno runo), paška ovca (PO – poluotvoreno runo) i travnička pramenka (TP – otvoreno runo). Utvrđena je značajna razlika u količini vune između istraživanih pasmina ovaca ($P < 0,001$). Najmanji promjer vlakna utvrđen je u pasmine Merinolandschaf ($27,70 \mu\text{m}$), neznatno veći u paške ovce ($27,78 \mu\text{m}$), dok je najveći utvrđen u travničke pramenke ($39,57 \mu\text{m}$). Prosječan promjer vlakana vune pasmine Merinolandschaf i paške ovce bio je sličan i signifikantno manji od onoga utvrđenog u vuni travničke pramenke ($P < 0,001$). U runu istraživanih pasmina najfinija vlakna bila su s plećke (ML, $25,13 \mu\text{m}$; PO, $25,56 \mu\text{m}$; TP, $37,14 \mu\text{m}$), zatim s rebra (ML, $27,83 \mu\text{m}$; PO, $27,57 \mu\text{m}$; TP, $39,76 \mu\text{m}$), dok je najgrublja vuna utvrđena u uzorcima s buta (ML, $30,13 \mu\text{m}$; PO, $30,22 \mu\text{m}$; TP, $41,83 \mu\text{m}$). Utvrđen je signifikantan ($P < 0,00$) utjecaj dijela tijela na promjer vlakna istraživanih pasmina.

Ključne riječi: pasmina, dio tijela, vuna, vlakno, promjer

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