MORPHOMETRIC CHARACTERISTICS OF HAIR FOLLICLES IN ORENBURG GOATS OF DIFFERENT SEXES

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https://doi.org/10.5281/zenodo.19381068

Abstract. This study reports, for the first time, the morphometric characteristics of different types of hair follicles in white-coated Orenburg down goats imported into the country, with emphasis on sex-related differences. The research was conducted on physiologically healthy one-year-old goats. Morphometric analysis was performed using biopsy samples collected from various anatomical regions of the body. The findings provide valuable scientific and practical insights into the influence of sex on hair follicle density in down goats bred under local conditions.

Keywords: orenburg down goats; down fiber; guard hair; sex; biopsy; hair follicles.

Introduction. The skin is a vital organ that performs essential biological functions within the organism. In animals, the integumentary system executes numerous critical roles, most notably providing protection against environmental factors, thermoregulation, excretion, and sensory reception, while also actively participating in metabolism. The chemical composition of animal skin comprises water, proteins, lipids, minerals, pigments, and other essential substances. Furthermore, the structural morphology of the skin in livestock varies significantly not only across species but also across different breeds and sexes.

Understanding the skin structure of Orenburg goats is of paramount importance, as they are a specialized breed for down (cashmere) production; the down fiber is a direct derivative of the dermal layer. Moreover, investigating the patterns of skin and wool-fiber development provides deeper insights into the individual ontogenetic regularities of animals. The formation of down fibers in Orenburg goats is a complex morphological process that depends on hereditary traits and environmental conditions throughout ontogenesis.

One of the key biological characteristics of Orenburg goats is the possession of fine down fibers that are relatively uniformly distributed across the body and do not coarsen significantly as the animal ages. Preserving these vital biological and economic traits during phylogenesis, and subsequently enhancing the length and elasticity of the down fiber through selective breeding, remains the primary objective in breed improvement. Achieving this goal requires selection based not

only on exterior physical traits but also on interior structural characteristics, as fundamental biological processes and metabolism are intrinsically linked to the internal constitution of the organism.

To develop down-oriented goat breeding and establish downy wool production in our country, Orenburg and Angora goat breeds are being imported. However, there is a significant lack of comprehensive research concerning the growth, development, and down productivity indicators of these imported breeds under new ecological conditions, particularly regarding changes in skin and fiber density.

In the breeding of Orenburg goats, the primary economically valuable trait is down productivity. The down of Orenburg goats is distinguished by its extreme fineness, thinness, and elasticity. Physical properties such as fineness, length, strength, softness, and flexibility are crucial for industrial processing. Furthermore, the quantity and quality of down are the fundamental criteria considered in selective breeding [1].

The coat of Orenburg goats consists of long, lustrous guard hairs (outer coat), relatively shorter and finer down fibers (undercoat), and intermediate fibers. Many scholars characterize intermediate fibers as either coarse down or fine guard hair. The primary determinant of the wool's economic value is the ratio of down fibers to guard hairs within the coat. This ratio is influenced by numerous factors, primarily the breed, sex, nutritional conditions, and other environmental variables [2,3].

Goat down is classified as a specialized wool raw material, differing from other wool fibers in its structure, chemical composition, and unique physical properties. Nonetheless, like other wool fibers, down consists of sulfur-containing protein compounds. More than 10% of this sulfur content is attributed to the amino acid cystine. Down fibers are finer and lighter than Merino sheep wool, resulting in products that are both lightweight and aesthetically superior. Additionally, down possesses significantly lower thermal conductivity. Accounting for these physical characteristics is vital for future technological processing and yarn spinning [5].

Skin function plays a critical role in an animal's survival, adaptation to the natural environment, and metabolism. The formation of the Orenburg goat breed has been profoundly influenced by its indigenous environmental conditions, specifically the strong winds, severe frosts, and the unique climate of the Orenburg region. As previously noted, this breed is distinguished from others by its down productivity and specific physical indicators. Since down is a derivative

of the skin, its quantity is directly correlated with the skin surface area. In mammals, wool fiber develops within specialized glandular bulbs known as hair follicles (folliculus pili) located in the epidermal layer [4].

Based on their structure and formation, wool follicles in the skin are classified into primary and secondary follicles. Primary and secondary follicles differ in their anatomical-morphological characteristics and the type of wool fiber they produce. Primary follicles develop first, followed by the formation of secondary follicles. Kids are born with their bodies already covered in wool, indicating that follicle formation begins during the embryonic period. The higher the density of wool follicles on the skin surface, the greater the wool productivity. Consequently, it is natural for breeds specialized in down-wool production to possess a higher number of wool follicles compared to meat or dairy breeds. In down-oriented breeds, it is essential to determine not only the total number of follicles per unit of skin surface but also their quantitative distribution by type. This is because guard hairs originate from primary follicles, whereas down fibers are produced by secondary follicles [6].

Materials and methods. The research was conducted on down-oriented Orenburg goats bred at the 'Nurota Qorakol Naslchilik' Limited Liability Company (LLC), situated in Temirqovuq village, Nurota district, Navoiy region, Republic of Uzbekistan. Healthy one-year-old goats were selected for the study. To determine the quantity and ratio of wool follicles on the skin surface, biopsy samples were collected from various anatomical regions of the body, strictly adhering to aseptic and antiseptic protocols.

The obtained samples were fixed in 10% buffered neutral formalin for 24 hours. Subsequently, the biological specimens were rinsed under running water for 24 hours to remove the formalin. Dehydration was performed using a graded series of ethyl alcohol (60%, 70%, 80%, 90%, 96%, and 100%). In the intermediate stage, the biological samples were prepared for paraffin embedding using ethyl alcohol (100%) + chloroform, pure chloroform, and chloroform + paraffin series. The paraffin infiltration process was carried out at a temperature of 56°C using Paraffin I, Paraffin II, and paraffin + wax series.

Sections with a thickness of 5 µm were prepared using a rotary microtome and subsequently stained with hematoxylin and eosin (H&E). The stained preparations were again dehydrated through a graded series of ethyl alcohol (60% to 100%). Clearing was performed using xylene, followed by mounting in balsam (ficsation). The morphometric parameters of primary and secondary wool

follicles in the prepared histological sections were determined using a micrometric grid.

Based on the gathered data, the type and quantitative proportion of wool follicles per 1 cm2 of skin surface area were calculated. The numerical data obtained were subjected to mathematical-statistical biometric processing. Key indicators, including the arithmetic mean (– $\bar{X}$), the coefficient of variation (Cv%), and the standard error of the mean (Sx,), were calculated using the respective formulas [7].

Results and discussion. The data obtained during the research regarding the morphometric indicators of wool follicles in skin samples collected from the goats are presented in Table 1.

Table 1.

Quantity of wool follicles per 1 cm^2 in different body regions

Body Region	Male		Female		Wether	
	$\bar{X}\pm S_x$	Cv%	$\bar{X}\pm S_x$	Cv%	$\bar{X}\pm S_x$	Cv%
Primary Follicles						
Withers	552.9±49.1	39.74	490.7±38.2	34.77	518.4±37.4	32.23
Chest	435.4±28.9	29.63	407.8±21.2	23.27	421.6±23.5	24.89
Rump	497.6±38.1	34.20	483.8±34.0	31.44	490.7±34.0	30.96
Thigh	400.9±28.2	31.45	387.1±23.7	27.42	394.0±23.0	26.15
Secondary Follicles						
Withers	4921.0±323.0	29.35	5086.9±313.2	27.54	4817.4±276.2	25.64
Chest	5294.3±306.8	25.92	5273.5±243.6	20.66	5232.0±229.6	19.63
Rump	5840.3±309.6	23.70	5985.4±287.0	21.44	5950.8±271.8	20.42
Thigh	5460.1±295.4	24.19	5570.7±268.4	21.54	5474.0±254.2	20.77
Total Follicles						
Withers	5473.9±379.7	31.02	5577.6±307.8	24.68	5335.8±269.2	22.56
Chest	5729.7±307.4	23.99	5681.3±239.2	18.83	5653.6±228.2	18.05
Rump	6337.9±304.6	21.49	6469.2±287.5	19.87	6441.5±272.3	18.91
Thigh	5861.0±294.2	22.45	5957.8±271.5	20.38	5867.9±256.4	19.54

According to the data presented in the table. primary follicles on the skin surface were most abundant in the withers region. Across the sex groups. the

number of primary follicles in males was higher than in females and wether males by 62.2 units (12.68%) and 34.5 units (6.66%) respectively. However, these differences were not statistically significant (P > 0.05). The thigh region exhibited a relatively lower density of primary follicles across all sex groups. with average counts of 400.9 in males. 387.1 in females. and 394.0 in wether males. Nevertheless. the male group consistently showed a higher relative density of primary wool follicles in the thigh area as well. Overall. the male group demonstrated absolute dominance in the number of primary follicles across all anatomical regions of the body. though no significant differences were recorded between the sex groups.

The quantity of secondary wool follicles on the skin surface was several times higher than that of primary follicles. showing some degree of variation based on sex groups and anatomical regions. In contrast to the pattern observed with primary follicles. the density of secondary follicles in the withers region was relatively lower across all sex groups. Specifically, the average count was 4921.0 in males. 5086.9 in females. and 4817.4 in wether males. Although the secondary follicle density in females was higher than in males by 165.9 units and higher than in wether males by 269.5 units. these variations did not reach statistical significance.

Figure. Different types of wool follicles: A-primary; B-secondary. (Mag. 10x20).

The rump region exhibited the highest density of secondary follicles. with average counts of 5840.3 in the male group. 5985.4 in the female group. and 5950.8 in the wether group. Although the female group showed a relative numerical superiority across sex groups. the observed differences were not statistically significant.

The total number of primary and secondary wool follicles per 1 cm2 across various body regions was found to be relatively higher in the rump area across all sex groups. Specifically, the total follicle count averaged 6337.9 in males. 6469.2 in females. and 6441.5 in wether males. While the follicle density in the thigh and chest regions occupied an intermediate position. the withers region was found to have the lowest total follicle count. Furthermore. regarding the total density of primary and secondary follicles per 1 cm2. the female group maintained a relative advantage over other sex groups; however, no statistically significant differences were recorded between the groups.

Table 2.

The ratio of primary to secondary wool follicles in different body regions

Body Region	Male	Female	Wether
Withers	1:8.9	1:10.4	1:9.3
Chest	1:12.2	1:12.9	1:12.4
Rump	1:11.7	1:12.4	1:12.2
Thigh	1:13.6	1:14.4	1:13.9

Conclusion. The results obtained and their subsequent analysis indicate that while primary wool follicles are more prevalent in the male and wether goat groups. secondary wool follicles are more abundant in female goats. The ratio of secondary to primary (S/P) wool follicles was also relatively higher in females. whereas this ratio was lower in males; wether males occupied an intermediate position in this regard. The uneven distribution of wool follicle density across the skin surface results in significant variation in this trait.

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