Environment and sheep wool quality indicators

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Abstract. The features of the skin histology and the determination of the quality indicators of wool of young female Tsigai breed sheep are presented in the article. A positive correlation was found between the fineness of the wool and the live weight (p ≤ 0.05); between the shearing of natural wool and the fineness of the wool (p ≤ 0.05); between the shearing of natural wool and the live weight (p ≤ 0.05); between the washed wool and the fineness of the wool (p ≤ 0.05) and the shearing of natural wool (p ≤ 0.05). There is no reliable relationship between the fineness and the percentage of the washed wool shearing. However, the percentage of the shearing of washed wool is negatively related to the live weight (p ≤ 0.05), the shearing of natural wool.

The greatest thickness of the skin was on the back and leg are 968.07 and 968.24 microns respectively. It is assumed that the skin regeneration occurs due to the cells of the basal layer. This is due to the fact that the thickness of the basal layer decreases in the following order: side-back-leg-neck, which correlates with the degree of exposure to damaging factors on these areas.

1. Introduction

The development of sheep breeding for Crimea in scientific work should be solved on the basis of modern effective research methods that have been successfully tested by scientists in the southern regions of the Russian Federation [1,2, 3, 4, 5]. Sheepskin is an important object of study [6, 7]. Histological studies make it possible to judge the constitutional and breed affiliation, to carry out a biological assessment of various technologies for keeping animals, to assess the level of productivity, to assess the physical and technological qualities of sheepskins, the age of animals, etc. [8, 9, 10].

A significant influence on the formation of histological features of the skin is also due to genetic factors. Minor skin morphogenesis in the postnatal period is associated with the influence of various paratypical factors [11, 12]. Sheepskins are an important technological raw material as well [13]. Different breeds of sheep have different coats and are characterized by different morphogenesis at the histological level of the structural organization of the skin, according to many scientists. The study of breed differences in the structure of the skin and wool cover of sheep in different productivity directions is of theoretical and practical importance [14].
Since wool in sheep farming is considered the most energy-intensive component [15], it is important to widely implement a system of complex selection and technological techniques to improve the quality of fine wool produced [16].

Sheep of the Tsigai Breed is given an important place in the conditions of the Crimean steppe historically. Tsigai is also widely spread in areas of South Ukraine, in some regions of Russia, Kazakhstan, and Eastern Europe [17].

Intensive breeding of various breeds of farm animals often leads to the loss of unique, historically formed, genotypes. Not well-thought-out selection to increase the productive characteristics often leads to the loss of the hereditary characteristics of local breeds [18]. Thus, selection and breeding work should be carried out taking into account the preservation of existing animal breeds of the domestic gene pool and their valuable traits [19]. One of these features in the breed is the wool productivity of Tsigai Breed sheep, local to the Crimean Peninsula [20].

Based on the analysis of literary sources, the Tsigai Breed still occurs on the Eurasian continent. The animals are characterized by satisfactory indicators of live weight and average shearing of wool, achieved in the course of breeding work with herds in the last few decades. Breeders in the Tsigai Breed fixed the indicator of the fineness of wool fiber in the range from 23 to 40 microns. Due to the decrease in the relative economic value of wool in the total cost structure to 0.3%, breeders and practitioners in the area of distribution of the Tsigai Breed, are actively working to improve the wool quality [21].

The study of the histological characteristics of the skin and the determination of the characteristics of wool productivity is important in the selection work with the Tsigai Breed at the present stage; also it was the main goal of our research.

2. Materials and methods

The conditions for keeping sheep are pasture in the period from March to the first half of December. The rest of the period is stable maintenance. Therefore, the environment has an impact on the formation of the wool productivity of young female’s sheep in the conditions of the Steppe Crimea, certainly.

The work was carried out on samples of wool of the Tsigai Breed young female (n = 30), taken for analysis in period 2019-2020, obtained in LLC "Southern Crimean Sheep Breeding". Skin samples were taken (n = 5) by biopsy. Accounting indicators: qualities of wool; histological indicators of the skin of the young female.

Samples of wool fibers were taken in the following places: 20-30 g of the sample from the sides of the trunk, 10-15 g of the sample from the back of the trunk, and 5-10 g of the sample from the leg and neck of the sheep. The studied parameters were also: shearing of natural and washed wool, the percentage of washed wool yield, the length of wool fibers, the thickness of wool fibers [22].

The percentage of the yield of clean (washed) wool was determined by the following formula (1):

$$B = \frac{M_2 \times 117}{M_1}$$

where $B$ is the percentage of pure wool yield, %; $M_2$ is residual mass of the sample after washing, g; $M_1$ is the initial mass of the unwashed sample, g [22].

The material for histological examination in the Logos microwave Milestone histological processor was studied. The finished preparations were photographed on a Leica Microsystems DM 2000 microscope with N Plan 10×/0.25 and N Plan 40×/0.65 lenses. Skin layers were measured in the ImageJ program using the Stage Micrometer scale (TS-M1 P/N 106011) [23].

Statistical data processing was carried out with the calculation of the average value of the attribute, the statistical error, and the reliability of the difference according to the Student's criterion.

3. Results and discussion

The features of the distribution of the fineness of the wool fibers on different surfaces of the body of
The coarsest wool fibers are marked on the back, which significantly exceed all other topographical areas of the body of the Tsigai Breed young female: in comparison with the data of the wool fineness on the back, this difference was 10.27 (p < 0.05) μm, on the neck was 12.4 (p < 0.01) μm and on the side was 14.1 (p < 0.001) μm (Table 1, Figure 1).

**Table 1.** The features of the distribution of the fineness of the wool fibers on different surfaces of the body of the Tsigai Breed young female

| Statistical indicator | leg | back | neck | side |
|------------------------|-----|------|------|------|
| $X \pm m_x$            | 35.3 ± 1.4 | 25.0 ± 1.3* | 22.9 ± 1.1** | 21.2 ± 0.8*** |
| $\sigma$               | 4.5 | 4.4 | 3.6 | 2.6 |
| $C_v, \%$              | 12.8 | 17.5 | 15.5 | 2.3 |

Note: confidence levels calculated by the Student’s criterion: * - p ≤ 0.05; ** - p ≤ 0.01; *** - p ≤ 0.001.

**Figure 1.** Micrographs of Tsigai Breed young female wool fibers from different topographic areas: (a) – from the leg (35–36 μm); (b) – from the back (24–25 μm); (c) – from the neck (21–22 μm); (d) – from the side (21 μm).

Indicators of wool productivity are shown in Table 2. The highest coefficient of variation is observed in the fineness of wool, therefore, the existence of the average level of variability causes to a certain extent, the efficiency of breeding work with Tsigai Breed herd the sheep towards the improvement of this important indicator.

**Table 2.** Indicators of wool productivity of the Tsigai Breed young female.

| Statistical indicator | The average fineness of the wool, μm | Live weight, kg | Wool cut, kg | Percentage of cut of washed wool, % |
|-----------------------|-------------------------------------|----------------|--------------|-----------------------------------|
| $X \pm m_x$           | 26.1 ± 0.7                          | 40.0 ± 0.5     | 4.0 ± 0.1    | 1.9 ± 0.03                        |
| $\sigma$              | 2.4                                 | 1.7            | 0.3          | 0.1                                |
| $C_v, \%$             | 9.1                                 | 4.2            | 6.9          | 4.2                                |

The calculated indicators of the interactions of the studied characters of wool productivity and quality of the wool are shown in Table 3.

Positive and significant correlation between wool fineness and live weight (p ≤ 0.05) was stated; positive and reliable production of natural wool correlated with wool fineness (p ≤ 0.05) and live weight (p ≤ 0.05), and washed wool cut with only with wool fineness (p ≤ 0.05) and natural wool cut (p ≤ 0.05). There is no reliable connection between the fineness and the percentage of cut of washed wool. However, the percentage of cut of washed wool is negatively related to such indicators as live weight (p ≤ 0.05), natural wool cut (p ≤ 0.001) and washed (p ≤ 0.05) wool cut.
Table 3. Correlation of indicators of wool productivity indicators of quality of wool of Tsigai Breed young female.

|     | X2  | X3  | X4  | X5  |
|-----|-----|-----|-----|-----|
| X1  | 0.68 ± 0.24* | 0.60 ± 0.27* | 0.68 ± 0.25* | -0.34 ± 0.31 |
| X2  | 0.59 ± 0.27* | 0.49 ± 0.29 | -0.58 ± 0.27* |
| X3  | 0.92 ± 0.13*** | -0.87 ± 0.17*** |
| X4  | -0.61 ± 0.26* |

Note: confidence levels calculated by the Student's criterion: * - p ≤ 0.05; ** - p ≤ 0.01; *** - p ≤ 0.001. Symbols of the indicators studied in the correlation: X1 - wool fineness; X2 - live weight; X3 - cut of unwashed (natural) wool; X4 - cut of washed wool; X5 - percentage of cut of washed wool.

The skin of the studied Tsigai Breed young female at the histological level has a typical edifice. Figure 2 shows the characteristics of the main layers of the skin.

Figure 2. Thickness of the main skin layers.

The greatest thickness of the skin on the back and leg was 968.07 and 968.24 microns respectively. The skin was thinner on the side (751.62 ± 12.6 microns), and the thinnest is on the neck (617.18 ± 10.5 microns). The dermis was proportionally reduced at the same time.

The epidermis consists of keratinized, granular, spinous, and basal layers. Below the epidermis is the dermis, extending papillae into the epidermis. Among the connective tissue fibers of the dermis, there are hair follicles with sebaceous glands adjacent to them. There are also sweat glands. The thickness of the skin layers varies depending on the topography (Table 4).

Table 4. Characteristics of the skin layers of the Tsigai Breed young female (n = 5).

| Layer | keratinized (stratum corneum) | granular (stratum granulosum) | spinous (stratum spinosum) | basal (stratum basale) |
|-------|-------------------------------|-------------------------------|---------------------------|-------------------------|
| Side  | 2.93±0.36**                  | 4.15±0.44*                   | 11.52±0.55*               | 1.79±0.17*              |
| Leg   | 1.55±0.17*                   | 1.64±0.14**                  | 6.78±0.14**               | 0.59±0.05**             |
| Back  | 1.71±0.17*                   | 2.61±0.14*                   | 14.62±0.39*               | 1.03±0.08*              |
| Neck  | 2.04±0.16                    | 3.77±0.52*                   | 14.47±0.67*               | 0.58±0.04**             |

Note: confidence levels calculated by the Student's criterion: p ≤ 0.05. There is a significant difference in comparison with the: ● – side; ▲ – leg; ■ – back; * - neck.
The thickness of the epidermis was not directly related to the thickness of the skin as a whole. The thickness of the epidermis on the leg was the smallest, amounting to $10.10 \pm 0.29$ microns; however, in the other areas, the thickness of the epidermis was close to 20 microns. These differences are statistically significant with an error probability of less than 5%. The reticular layer of the skin of the leg and neck was characterized by a more friable arrangement of fibers.

The epidermis in the studied areas consisted of four layers. The greatest contribution to the thickness of the epidermis in all cases was the spinous layer. It was the smallest on the leg ($6.78 \pm 0.14$) and significantly different from other areas. The granular layer has a second thickness; it is on the leg proved to be the most subtle. Thus, the regeneration of the skin occurs due to the cells of the basal layer. Its thickness decreased in various areas in the following order: side-back-leg-neck. This is adequate to the extent of the impact of damaging factors on these areas.

The thickness of the basal layer did not correlate with the thickness. However, the greatest thickness was also reached in the side area, amounting to almost 3 microns, which was significantly different from the back and leg area, where its thickness was the smallest.

In general, the most distinctive structure was the skin in the limb area. Most of all, it was different from the skin in the side area (Figure 3, Figure 4).

Figure 3. Young female sheep skin in different areas of the body: (a) is side, (b) is leg, (c) is back, (d) is neck. Hematoxylin-Eosin staining. Magnification is 100×. 1 - epidermis; 2 - dermis; 3 - hair follicle; 4 - sebaceous gland; 5 - sweat gland.

Figure 4. Young female sheep skin epidermis in various areas: (a) is side, (b) is leg, (c) is back, (d) is neck. Hematoxylin-Eosin staining. Magnification is 400×. The epidermis has 4 layers: horny (long arrow), granular (*), spiny (º) and basal, or sprout (short arrow).

4. Conclusion
A positive correlation was established between the fineness of the wool and the live weight of young female sheep of Tsigai Breed ($p \leq 0.05$). A similar correlation pattern is proved between the haircut of natural wool and the fineness of the wool; between the haircut of natural wool and the living weight; between the washed wool and the fineness of the wool and the haircut of natural wool ($p \leq 0.05$). There is no reliable relationship between fineness and the percentage of washed wool per haircut. However, the percentage of washed wool shearing is negatively related to live weight and natural wool shearing ($p \leq 0.05$-$p \leq 0.001$). The greatest thickness of the skin was on the back and leg: 968.07 and 968.24 microns, respectively. It is assumed that the regeneration of the skin occurs due to the cells of
the basal layer. This is due to the fact that the thickness of the basal layer decreases in the following order: side-back-leg-neck, which correlates with the degree of influence of damaging factors on these areas.

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