**Productivity of Sheep in Different Climatic Zones**

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**Abstract.** The issue of global climate change requires the most effective utilization of bioclimate in order to develop a production technology that can optimize the natural potential. This study examines the impact of different climate zones on sheep productivity in order to identify resources for wool and lamb production. The research was conducted on fine-wooled sheep (*Ovis aries*). The study used variation statistics methods and analyze of digital data. The criterion for the reliability of the difference between the average indicators was calculated using MS Excel 2000. We used exterior physical and phenotypic indicators: meat (live weight) and wool (wool cut). Productivity measures were collected between 2012 to 2016 from 8,056 sheep from 13 flocks of Issyk-Kul type sheep, 24 flocks of Talas type sheep, and 10 flocks of South-Kyrgyz type sheep. In terms of live-weight (X±SX=58.20±0.31; CV=4.98), Issyk-Kul ewes outperformed their counterparts from other climatic zones with a significant difference (P<0.01; P<0.05). The research’s results allow farmers and livestock breeders to make the best use of existing sheep adaptation strategies and take climate change into account when developing and implementing agricultural policies.

**Keywords:** ecology, climate, adaptability, live weight, exterior, Merino wool

**Introduction**

Kyrgyzstan is a mountainous country, with over three-quarters of its territory located in the western and central parts of the Tien-Shan and Pamir-Alai Mountain ranges. The average land elevation is 2,750 m and more than half of its territory is located at altitudes between 1,000 to 3,000 m above sea level. Therefore, approximately 83% of agricultural land is comprised of natural mountainous pastures, and only 6.8% of the total land area is used for crop cultivation [1].

The main regions used for sheep farming are located within 35–55oN in Europe and Asia and between 30–45oS in South America, Australia, and New Zealand [2]. Domesticated sheep (*Ovis aries*) have a variety of genotypes that are adapted to a wide range of environments and conditions, including but not limited to: the tropics, deserts, extreme seasonal variations, high altitudes, and excessive rainfall. According to [3],this diversity of genotypes (consisting of more than 2,000 breeds) enables this species to easily adapt to extreme environmental and climatic conditions, a conclusion that is supported by researchers Petit, Boujenane [4] and Hoffmann [5].

Seo et al. [6] writes that results show that climate variables are very significant in determining the choice of one’s primary flock species, after controlling for soil type, geography, domestic characteristics, and fixed country effects. The effects of climate change will vary depending on species and specific climate conditions.

To ensure that food production is not compromised, agricultural discussion is continually in search of a suitable approach for responding to climate change that addresses the challenges currently faced by agriculture worldwide [7; 8; 9]. Within this unstable global climate, the agricultural sector will need to feed more people without impairing the ecosystem services upon which production depends [10].Therefore, our research, the first to study productive qualities of the Kyrgyz mountain Merino breed in the highlands of Kyrgyzstan, has relevance for this broader discussion. Budolfson et al. [11] argue that climate change affects animals and that, in turn, animals affect climate change. Food security in the era of global climate change relies on our ability to adapt livestock systems to these changes in climate [12].

Sheep breeding is both a traditional and leading industry in Kyrgyzstan. Sheep are bred in all regions of the country and there are various mixed methods of animal husbandry. Both natural and climatic conditions contribute to the development of sheep breeding and the production of inexpensive and environmentally friendly products.

The main goal of our research is to produce an adaptive approach to sheep breeding in high-altitudes that can effectively optimize the livestock’s natural potential in changing climatic conditions.

**Methods**

The study was conducted in three state breeding facilities located in different climatic zones.

The state breeding facility, named after M. N. Lushihina, is located in the northwestern part of Kyrgyzstan, in the Talas valley. In the northwest, the valley widens and borders with the semi-deserts and deserts of the Turan lowland. The climate of the Talas region is dry and continental. The average temperature in July is 15–25°C, and in January is -6 to -14°C. The duration of the frost-free period is 157­­–163 days a year. The average annual precipitation is 300–400 mm and increases from west to east, from the foot of the mountains up the slope. Summers are dry, and permanent snow cover is formed in the foothills in November and on the plain in December [12].

The state breeding facility Orgochor is located in the eastern part of the country in the Issyk-Kul valley. In the southern part, plains stretch at a high altitude of more than 3,000 m above sea level. The climate of the Issyk-Kul valley is influenced by its geographic isolation and proximity to a large ice-free lake. The lake moderates the valley’s climate; there is no sweltering heat in the summer nor severe frosts in the winter. The average temperature in July is approximately 18°C, and in January -2 to -4°C. The average annual precipitation in the east of the valley is approximately 600 mm, whereas the western valley receives only 115 mm of rainfall. The majority of rain falls in the summer. On the slopes of the mountain ridges surrounding the basin, climatic conditions are subject to vertical zoning: with increasing altitude, the temperature decreases and precipitation increases. This sloping region has a fully continental climate, where the average annual temperature is 3–7°C, and average annual precipitation is 200–300 mm [13].

The state breeding facility, Katta-Taldyk, is located in the southern part of the country. A significant part of the region is covered by the Pamir-Alai and western Tien Shan mountains. Variations in altitude range from 500 m in the north to 7,000 m in the south. Generally, the region has a continental climate: the summers are hot and dry with average July temperatures of 24­–25oC, and winters are short-lasting and moderate with average January temperatures of -3 to 4°C. At altitudes of 600–1,100 m the climate is warm and semi-arid; the vegetation in the region is subject to zonal altitude [14].

The sheep researched were fine-wooled Kyrgyz mountain Merino sheep (*Ovis aries*) from state breeding facilities during 2012–2016. In all three zonal types, the sheep were fed and kept under the normal conditions of local practice throughout the duration of the research. The indicators for meat and wool productivity are based on 8,056 sheep from 24 flocks in Talas, 13 flocks in Issyk-Kul, and 10 flocks of South-Kyrgyz sheep.

The study used zootechnical methods and techniques. Normative animals that met the requirements for the productivity indicators of the zonal types were selected for the study groups. To assess the variation statistics and determine the relationship between climate zones, body mass and measurements were conducted during the spring assessment of 20 heads of main rams and repair rams, and 30 heads of Queens and young ewes.

Assessment was carried out in accordance with local instructions for fine-wooled sheep breeds [15]. The physical, mechanical and technological properties of wool were studied and assessed according to the methods and standards outlined in GOST 17514-93 [16] and GOST 28491-90 [17].

Live body-weight was determined using a scale with an accuracy of 500 grams. The data obtained was compared with the body weight grouped by sex and age of the sheep.

The animals’ physique was determined by torso measurements. Sheep from each sex and age group were categorized as “typical,” based on six main body measurements: height (withers), body length (oblique), chest width, chest depth, chest girth behind the shoulder blades, and pastern girth. The body measurements were used to calculate various body composition indices, such as long-legged, stretched, thoracic, downed, oversized, and bony, which are presented in percentages [18].

In order to classify and determine the yield of pure wool fiber, samples were taken from the area behind the shoulder blade before shearing, during assessment, and during the shearing period. Wool samples were taken using a stencil mesh with round cells. During the shearing period, wool shearing was taken into account for each sheep individually.

The main parameters of wool quality (such as tone, length, and their biometric constants) were measured with the Australian device OFDA-2000. The yield of pure wool was determined for each animal using the hydraulic device GPOSH-2M.

The study’s results were analyzed using variational statistics methods [19], and the criteria for the reliability of the difference between the average indicators was calculated using MS Excel 2000.

**Results and Discussion**

Adaptation of farm animal breeds to their environment is influenced by their natural history of territorial settlement [20]. Based on the territorial settlement of the Kyrgyz mountain Merino breed, we have identified three types of sheep according to climatic zones: Talas, Issyk-Kul and South-Kyrgyz.

Sheep from different zonal types differ in body weight. Ewes of the Issyk-Kul type are heavier, and hence, superior to their counterparts from other climatic zones (Table 1). South-Kyrgyz ewes’ body weight is 2.15 kg lower, or 3.8% less than the Issyk-Kul ewes; a high significant difference of P<0.01, and a small coefficient of variation of CV=0.23. Concurrently, Talas ewes are inferior to the Issyk-Kul ewes by 0.85 kg, or 1.5%, with no significant difference (P>0.05). The difference between the weight of Talas and South-Kyrgyz ewes was 1.3 kg, or 2.3%, and is significant (P<0.05). In addition, there is high variation amongst the Talas ewes (CV=1.5).

**Table 1.** Live Weight of Sheep from Different Climatic Zones (kg)

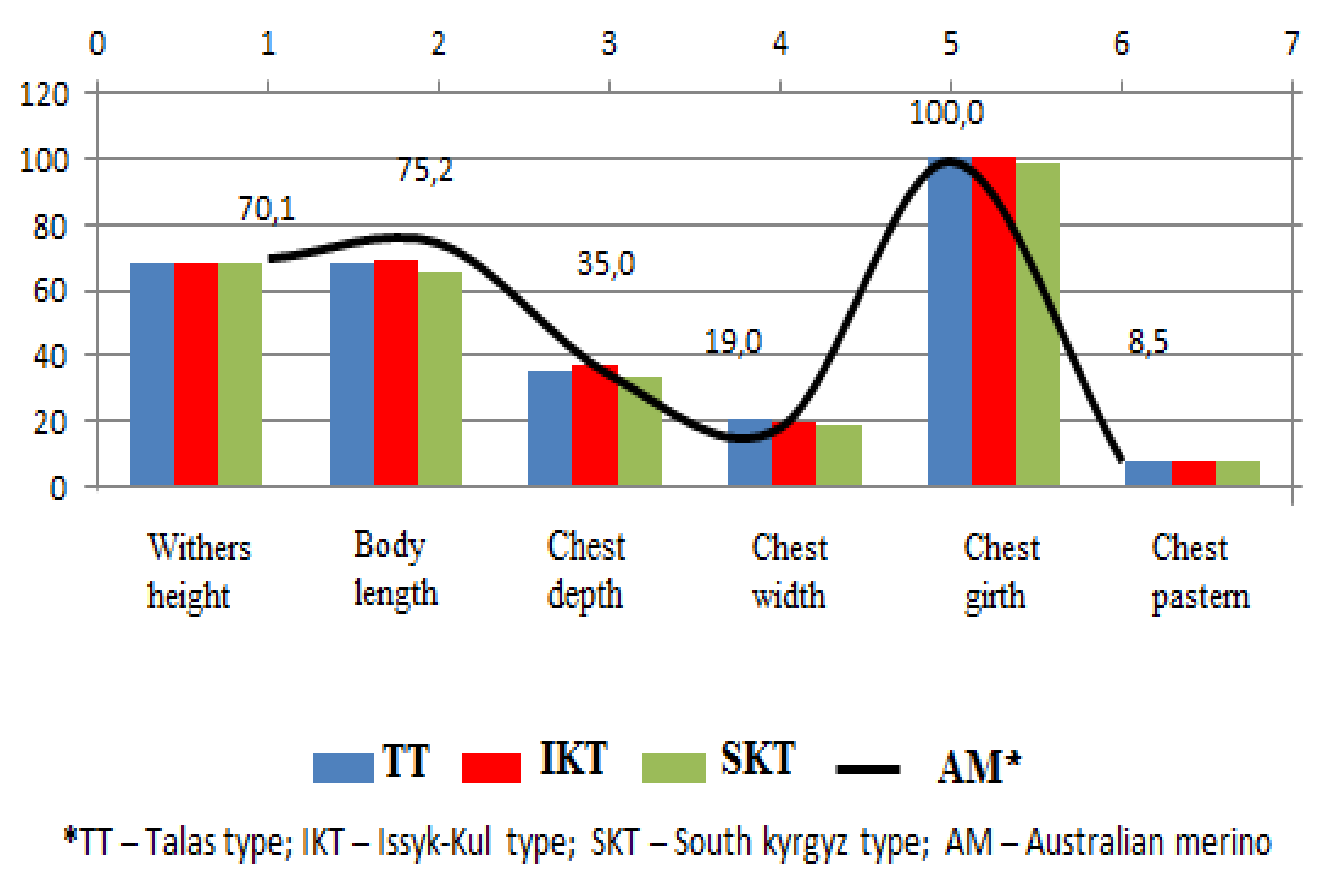
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| --- | --- | --- | --- |
| Zonal Type of Ewe | n | Х±SX | Coefficient,  CV |
| Talas | 30 | 57.35±0,34 | 3.25 |
| Issyk-Kul | 30 | 58.20±0,31 | 4.98 |
| South-Kyrgyz | 30 | 56.05±0,49 | 4.75 |

To evaluate characteristics of the ewes’ physical and constitutional qualities in different zonal types, we compared them with Australian Merino ewes, as shown in Figure 1. For example, Issyk-Kul ewes are 0.20 cm, or 0.3%, taller (P>0.05) than Talas ewes and 0.42 cm, or 0.6%, taller (P>0.05) than South-Kyrgyz ewes. The height difference between the Talas and South-Kyrgyz ewes is 0.22 cm, or 0.3%, (P>0.05). The largest height difference between Australian Merinos and the Kyrgyz mountain Merino is 1.69 cm, or 2.5%, (compared to the South-Kyrgyz type), and the smallest difference is 1.27 cm, or 1.8%, in comparison to the Talas type.

Regarding the oblique body length among queens, the minimum and maximum differences of Australian Merino queens in comparison to Kyrgyz zonal types was 5.70 cm and 6.43 cm, or 8.2% and 9.4%.

The same trend was present for chest depth data: the largest difference was 3.16 cm, or 9.4%, (P<0.001) and the smallest difference was 1.96 cm, or 5.8%, (P<0.001). There was also a difference between the Issyk-Kul and Talas in comparison to the South-Kyrgyz type. The difference in chest depth between the Issyk-Kul and Talas types was 1.20 cm, or 3.4%, with a significant difference (P<0.05). It should be noted that with the exception of the South-Kygyz sheep, the other two Kyrgyz types are superior to the Australian breed in chest depth. The differences are 0.63 cm and 1.83 cm, respectively, or 1.8% and 5.2%. A possible explanation for this may be that because Kyrgyz mountain Merino sheep are adapted to high-altitude conditions where more oxygen is required, their chest depth is greater.

Thus, our research shows that the Kyrgyz mountain Merino breed (of varying zonal types) have well-developed latitudinal measurements, with sufficiently developed limbs and average body heights.



**Figure 1.** Exterior Physical Traits of Different Zone-Type Ewes

The noted phenotypic differences between the various zonal-type ewes creates heterogeneity among the Kyrgyz mountain Merino breed and helps maintain animal vitality. Considering that phenotypic traits are determined by heredity (the genotype), they are therefore either directly or indirectly related to biochemical processes and metabolism, and hence, also related to productivity.

The wool productivity of zonal types is high, and meets the standard requirements of the Kyrgyz mountain Merino breed.

Pure wool is an important indicator that characterizes the true value of the wool productivity of sheep. We found that the yield of pure fiber (60.0%) of the Talas type sheep is inferior to other zonal types. Thus, the difference between Talas sheep and the Issyk-Kul type is 4.1% and the South-Kyrgyz type is 3.8%. These fluctuations seem to result from the clogging of wool, and not to the individual characteristics the Talas sheep. This is evident from the indicator of the mass of washed fiber, where there is no significant difference between the Talas and Issyk-Kul types, though they are superior to the South-Kyrgyz type, respectively, by 0.27 kg (10.6%) and by 0.4 kg (15.7%) with an insignificant difference (P>0.05).

The Issyk-Kul type has a high yield of pure fiber of 64.1%. This can be explained by the fact that selective breeding to produce the Kyrgyz fine-wool breed, mainly crosses “strong” Australian sheep with Orgochor (Issyk-Kul) ewes. Moroz [21] writes that in Australia, there are four distinct main types of Merino sheep. Nonetheless, there is a clear superiority of the “strong” sheep in their yield of washed fiber, which results from the fact that these sheep are larger in size and produce longer wool fibers than other types. This is strengthened by Biltuev et al. [22], who write that the blood-lines of the “strong” Australian Merino type are characterized by high shearing ability, high output of washed wool, and both longer and thicker wool fibers.

On the other hand, South-Kyrgyz sheep have a slightly lower shearing rate of pure fiber [23]. This results from both the density of their wool and their hereditary, as confirmed by our research. Only 74.1% of the wool mass of South-Kyrgyz sheep is of satisfactory quality, in comparison to 84.8% and 85.1% of the Talas and Issyk-Kul types’ wool, respectively.

**Conclusion**

The results of this study have revealed the resources needed for obtaining high-quality wool and lamb from sheep in high-altitudes in various climatic conditions of Kyrgyzstan. We identified three purebred zonal types of the Kyrgyz mountain Merino breed: Talas (northwestern), Issyk-Kul (eastern) and South-Kyrgyz (southern).

This study shows that under the conditions of the Issyk-Kul zone, there is the breeding advantage of larger sheep (58.2 kg). Sheep from of the southern zone rank in-between those from the breeding facilities Lushihina (north-west) and Orgochor (east).

We found that purebred Kyrgyz mountain Merino sheep exceed the minimum productivity requirements of wool standards and meat-wool productivity by 17.4–20%.

The results of this research will help farmers and livestock breeders learn how to make optimal use of existing sheep adaptation strategies and take climate change into account when developing the best management strategies for the sheep industry.

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