**Adaptive Ability of Kyrgyz Mountain Merino Sheep to Atmospheric Pressure of the Environment**

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**Abstract.** Sheep farming in Kyrgyzstan is the country’s main form of livestock production. Our research brings to light the poorly studied influences of climate on sheep adaptation in different climatic zones. The study defines the tasks of sheep husbandry in different regions and climatic conditions. Data on atmospheric pressure used in the study is from the website *gismeteo.ru*. The resulting data was processed using variational statistics methods. Our results indicate that the maximum atmospheric pressure (X±Sx) was recorded in the south of the country (703.70+0.94 mm Hg), and the minimum was recorded in the east (617.08+0.13 mm Hg). The results of the correlation analysis show that: amongst ewes at high atmospheric pressure, there is a significant relationship with the live weight among the sex and age groups (r= +0.345); amongst young ewes there is an insignificant relationship (r= +0.107); amongst young rams there is no relationship (r= +0.020). The results of our research will be used to ensure the long-term sustainability of both Kyrgyz agriculture and the social well-being of the country; it will also enrich current research on mountain ecosystem services and provide support to local ecosystem management strategies.

**Introduction.** The climatic conditions of Kyrgyzstan are determined by its unique geographic location and terrain. Common features of this continental climate are low precipitation, dry air, and low cloud cover. Throughout the Republic’s terrain, there is a transition from a subtropical climate in the Ferghana valley, to a semi-desert in the Chui valley, to a polar climate in high-altitude regions.

Of the total agricultural land area of Kyrgyzstan, 85% is covered by pasture ecosystems [1], which contributes to the successful development of animal husbandry, namely the sheep industry. Mountainous pastures provide ecosystem services for farmers and sheep breeders, which are the basis of the Republic’s regional development strategy.

Having studied the dependency of ecosystem services in high-altitude areas of Asia, R. Murali et al. [2] suggest that livestock-based systems are more vulnerable to ongoing changes and developments. They argue, that this is due to livestock-based-systems’ dependence on larger resource catches from ecosystem services, that they tend to have weaker land tenure, and are prone to fragmentation. In addition, pastoral farming is often subject to the vagaries of the weather [3]. Therefore, it is vital that animal owners are able to react to climate variability. Climate change’s effect on livestock is a major global issue because it can threaten food security [4; 5; 6]. Extreme climatic events have become more frequent and more severe as a result of climate change [7], and hence, livestock production will be limited by climate variability [8]. At present, research presents many indisputable facts regarding the influences of solar, spatial, and geomagnetic activities on components of the biosphere [9; 10; 11].

Researchers from Argentina [12] have proven that the environment affects the livestock industry: seasonal fluctuations affect the diameter of wool fiber, which in turn may be associated with stressful circumstances for the animals. However, future research is needed to better understand the effects of changing climatic conditions and other stressful circumstances on animals.

Certain relationships have been established between animals and environmental factors. For example, according to the research of A. I. Abilova et al. [13], atmospheric pressure on the day of sperm collection from breeding bulls affects both the quantity and quality of their sperm. In this regard, in order to reach production potential in each climatic zone, our research studies the adaptive capabilities [14] of local fine-wool sheep and aims to improve their productive qualities.

Kyrgyz scientists have previously identified several zonal types of Kyrgyz mountain Merino sheep, that have been bred in different climatic zones of the country. These types of sheep have been categorized as follows: Talas sheep from the northwestern part of the country [15]; Issuk-kul sheep from the eastern regions [16]; and South-Kyrgyz sheep from the southern part of the country [17].

**Methods.** The study was conducted on fine-wooled Kyrgyz mountain Merino sheep in the north-western, eastern, and southern parts of the country.

In order to study the effect of atmospheric pressure on the productive qualities of sheep, we used data from *gismeteo.ru*. Variation statistics was used to calculate the maximum and minimum atmospheric pressure for each year (X±Sx) and the reliability of the difference between them (td) using the following formula (1):

The average static error (Sx) is calculated using the formula (2):

(2)

Based on the value of the reliability criterion (td), the probability level was determined according to the Student-Fischer test.

For this study, one of the main indicators of meat productivity was the live weight of sheep from different zonal types. The length and thickness of wool were taken into account when measuring wool productivity, however, these indicators are not completely dependent on the size of the animal, in comparison to wool shearing.

Calculation of the correlation coefficient is calculated using the following formula (3):

The correlation coefficient is presented as a decimal fraction and has a value of 0±1. If r=0, or has a small fractional value (up to 0.1), it indicates that there is either no connection, or a slight connection. The closer the r value is to 1, the greater (stronger) the relationship between these features [18].

**Results and Discussion.** According to *gismeteo.ru*, the average monthly maximum atmospheric pressure in Talas [19] (located in the north-west of the country) is 663.5 mm Hg (recorded in December), with a minimum of 656.8 mm Hg (recorded in June 2017). The difference between them is significant (P<0.001). The height above sea level in Talas is 1,238 m [20]. Analysis of the correlation of atmospheric pressure between live weight and wool productivity in animals of the north-western zonal type (see Table 1) shows that at maximum or high atmospheric pressure, all sex and age groups have a slight relationship with live weight, which varies from r= +0.133 to r= +0.033. At low atmospheric pressures, a negative relationship is observed.

**Table 1.** The Correlation Coefficients of Atmospheric Pressure with

 Productivity in North-Western Type Sheep

|  |
| --- |
| Atmospheric Pressure Per Year, mm Hg: Maximum: (X±Sx) 663.47+0.85Minimum: (X±Sx) 656.83+0.64(P<0.001)Height Above Sea Level: 1,238 m |
| Productivity | Atmospheric Pressure | Main Rams | Young Rams | Ewes | Young Ewes |
| n | r | n | r | n | r | n | r |
| Live weight | Maximum | 20 | +0.081 | 20 | +0.133 | 30 | +0.033 | 30 | +0.055 |
| Minimum | 20 | -0.170 | 20 | -0.148 | 30 | -0.199 | 30 | -0.141 |
| Length of Wool | Maximum | 20 | -0.138 | 20 | -0.082 | 30 | -0.130 | 30 | -0.042 |
| Minimum | 20 | +0.082 | 20 | +0.036 | 30 | +0.066 | 30 | -0.381 |
| Thickness of Wool | Maximum | 16 | -0.099 | 10 | -0.067 | 10 | -0.015 | 10 | +0.078 |
| Minimum | 16 | +0.025 | 10 | +0.036 | 10 | +0.051 | 10 | +0.058 |

When comparing indicators for the length of wool, high atmospheric pressure has a negative relationship in all age and sex groups.

Analysis at low atmospheric pressure revealed a slight relationship, which can be seen in the main rams and ewes (r= +0.082 and r= +0.066), while in the young rams and young ewes there is no relationship with atmospheric pressure.

The relationship of the thickness of wool shows that at high atmospheric pressure, all groups have no relationship, except for young rams, where there is a slight relationship of r= +0.078. At low atmospheric pressure, the main and young rams have no correlations, though there is a slight correlation amongst both ewes (r= +0.051) and young ewes (r= +0.058). Thus, sex and age groups of sheep react differently to changes in atmospheric air pressure.

In comparison to the north-western part of the country, the maximum atmospheric pressure in Karakol [21] (in the east) was 32.84 mm Hg, and the minimum pressure was 39.75 mm Hg lower (Table 2). The difference in altitude is that Karakol is 513 m higher [22].

**Table 2.** Coefficients of Correlation of Atmospheric Pressure with

Productivity in Eastern Type Sheep

|  |
| --- |
| Atmospheric Pressure Per Year, mm Hg:Maximum: (X + Sx) 630.63 + 0.63Minimum: (X + Sx) 617.08 + 0.13(P <0.001)Height Above Sea Level: 1,751 m |
| Productivity | Atmospheric Pressure | Main Rams | Young Rams | Ewes | Young Ewes |
| n | r | n | r | n | r | n | r |
| Live Weight | Maximum | 20 | -0.165 | 20 | +0.020 | 30 | +0.343 | 30 | +0.107 |
| Minimum | 20 | +0.054 | 20 | -0.025 | 30 | -0.262 | 30 | -0.219 |
| Length of Wool | Maximum | 20 | -0.132 | 20 | -0.178 | 30 | +0.022 | 30 | +0.013 |
| Minimum | 20 | +0.067 | 20 | -0.043 | 30 | +0.351 | 30 | +0.041 |
| Thickness of Wool | Maximum | 16 | +0.037 | 10 | +0.020 | 10 | -0.024 | 10 | -0.024 |
| Minimum | 16 | +0.270 | 10 | +0.043 | 10 | +0.139 | 10 | +0.277 |

In ewes at high atmospheric pressure, there is a noticeable relationship with live weight among sex and age groups, where r= +0.345. In young ewes the relationship is insignificant (r= +0.107), and in young rams there is no relationship (r= +0.020). At minimum or low atmospheric pressures, there is a slight relationship in live weight in groups of main rams, which is equal to r= +0.054, and in other cases there is a negative relationship.

There is a significant or average relationship at low atmospheric pressure, amongst the length of the wool and in the group of ewes (r= +0.351), and a slight relationship in the group of main rams (r= +0.067). A negative relationship was found in groups of young rams (r= -0.043). At high atmospheric pressure, a negative relationship was observed in the length of the wool of the main rams (r= -0.132) and young rams (r= -0.178), with a positive relationship in the groups of ewes and young ewes (r= +0.022 and r= +0.013).

In terms of thickness of wool, a weak connection is observed in the group of main rams at minimum atmospheric pressure (r= +0.270), and in other groups, though the connection is not strong, it is positive (r= +0.043, r= +0.139, r= +0.277). At maximum atmospheric pressure, a positive relationship is observed in the group of main rams (r= +0.037) and young rams (r= +0.020), whereas in the groups of ewes and young ewes, a negative relationship is observed (r= -0.024; r= -0.024).

The south of Kyrgyzstan is lower in altitude [23], and its difference in height is 763 m below Karakol and 250 m below Talas. There is also a significant difference in atmospheric pressure [24]. It is on average 80.8 mm Hg higher than Karakol and 39.6 mm Hg than Talas (Table 3).

The relationship between atmospheric pressure and the productive qualities of the southern type of sheep is more pronounced. For example, for live weight at maximum and minimum atmospheric pressures, the main rams have a positive relationship (r= +0.078 and r= +0.080). The close relationship is especially pronounced at the minimum atmospheric pressure r= +0.080. Both the negative influence of the maximum atmospheric pressures (r= -0.218) and the positive influence of the minimum atmospheric pressures (r= +0.178) are well expressed in the South-Kyrgyz zonal type of young ewes.

**Table 3.** Correlation Coefficients of Atmospheric Pressure with

Productivity in Southern Type Sheep

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| --- |
| Atmospheric Pressure Per Year, mm HgMaximum: (X+Sx) 703.70+0.94Minimum: (X+Sx) 691.75+0.35(P<0.001)Height Above Sea Level: 988 m |
| Productivity | Atmospheric Pressure | Main Rams | Young Rams | Ewes | Young Ewes |
| n | r | n | r | n | r | n | r |
| Live Weight | Maximum | 20 | +0.078 | 20 | +0.021 | 30 | -0.009 | 30 | -0.218 |
| Minimum | 20 | +0.080 | 20 | -0.184 | 30 | -0.110 | 30 | +0.178 |
| Length of Wool | Maximum | 20 | +0.062 | 20 | -0.014 | 30 | +0.041 | 30 | +0.072 |
| Minimum | 20 | +0.238 | 20 | -0.111 | 30 | +0.242 | 30 | +0.339 |
| Thickness of Wool | Maximum | 16 | -0.036 | 10 | -0.119 | 10 | +0.265 | 10 | +0.095 |
| Minimum | 16 | -0.067 | 10 | -0.055 | 10 | +0.060 | 10 | +0.050 |

Regarding the length of the wool, a relatively strong relationship is observed in young ewes (r= +0.339) at minimum atmospheric pressure, as well as in the main rams and ewes (r= +0.238, r= +0.242). A weak negative relationship is observed in young rams (r= -0.111).

Regarding the thickness of wool, a positive relationship is observed in ewes and young ewes at maximum and minimum atmospheric pressures equal to r= +0.265, r= +0.060 and r= +0.095, r= +0.050, respectively. In other cases, it is either lacking relationship or has an insignificant negative relationship.

In order to judge the degree of environmental sustainability and adaptation in conditions of vertical zoning exploitation, M.S. Gabaev and V.M. Gukezhev [25] studied the level of realization of the productivity potential in mountainous conditions. The results of the study indicate that the choice of breed is of great practical importance in the case of mountain pasture sheep-keeping. Furthermore, the level of adaptation depends on economic and natural conditions (especially above sea level), the adaptability of individual breeds, and individual characteristics of the animals. It has been proven that making adjustments to the placement of different sheep breeds in high-altitude zones, in conjunction with a driving-mountain system of maintenance, will contribute to a more logical use of their genetic resources and effective use of the productive potential of the animals and the mountain foraging areas.

In order to identify the relationship between the influence of atmospheric pressure on meat and wool productivity of different zonal types, Table 4 shows the distribution of the correlation relationship.

For values between 0.1 to 0.39, a positive relationship between atmospheric pressure and live weight is observed in three cases, and a negative relationship is observed in eight cases. Therefore, we can conclude that in general, atmospheric pressure does not affect the live weight.

The values of the positive relationship of atmospheric pressure with the length of wool between 0.1 to 0.39, compared with live weight, are slightly higher and the positive relationship was observed in four cases (one more in comparison to live weight). A negative relationship was observed in six cases. This suggests that there is a weak correlation between atmospheric pressure and wool length.

For the thickness of the wool, most of the distribution of positive and negative correlation values between 0.05 to 0.1, or below 0.05, which indicates either an insignificant or absent relationship.

**Table 4.** Correlative Relationship (r)

|  |  |  |
| --- | --- | --- |
| Below 0.05 | From 0.05 to 0.1 | From 0.1 to 0.39 |
| Live Weight | Length of Wool | Thickness of Wool | Live Weight | Length of Wool | Thickness of Wool | LiveWeight | Length ofWool | Thickness of Wool |
| **r +** |
| 0.02 | 0.013 | 0.02 | 0.054 | 0.062 | 0.05 | 0.133 | 0.238 | 0.139 |
| 0.021 | 0.022 | 0.025 | 0.055 | 0.066 | 0.051 | 0.178 | 0.242 | 0.265 |
| 0.033 | 0.036 | 0.036 | 0.078 | 0.067 | 0.058 | 0.345 | 0.339 | 0.27 |
| - | 0.041 | 0.037 | 0.08 | 0.072 | 0.06 | - | 0.351 | 0.277 |
| - | 0.041 | 0.043 | 0.081 | 0.082 | 0.078 | - | - | - |
| - | **-** |  | 0.107 | - | 0.095 | - | - | - |
| **r -** |
| -0.009 | -0.014 | -0.015 | -0.025 | -0.082 | -0.055 | -0.17 | -0.111 | -0.119 |
| - | -0.042 | -0.024 | - | - | -0.067 | -0.148 | -0.13 | - |
| - | -0.043 | -0.024 | - | - | -0.067 | -0.199 | -0.132 | - |
| - | - | -0.036 | - | - | -0.099 | -0.141 | -0.138 | - |
| - | - | - | - | - | - | -0.219 | -0.178 | - |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
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The distribution of the correlation between atmospheric pressure and sheep productivity, both positive (r+) and negative (r-), is shown in Figure 1.



Figure 1. The Distribution of the Correlation Coefficient

The correlation analysis that we studied showed a low degree of influence of atmospheric pressure on the meat and wool productivity of sheep of zonal types bred in different climatic conditions.

This phenomenon can be explained by the prolonged influence of atmospheric pressure within the zones where animals are bred, and by the adaptive ability of sheep. This is supported by the work of V. A. Afanasyev et al. [26 ; 27] of the Friendship University of Russia, who studies the life support of animals with different cosmophysical activity. They found that in years of low solar activity, atmospheric pressure negatively correlates with milk yields; in years of high solar activity, the correlation was positive.

**Conclusion.** Our research results show little correlation between meat and wool productivity of different zonal sheep and atmospheric pressure, with differing and low relationships. This is probably due to the cosmophysical activity of the planet in specific natural and climatic zones of animal habitats, and therefore requires interpretation in relation to other factors.

The results of our research are essential for ensuring long-term sustainability of agriculture and will enrich research on mountain ecosystem services, as well as providing ecosystem management support to different regions.

**Keywords.** ecology, climate, atmospheric pressure, correlation, live weight, length of wool, thickness of wool.

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