**Adaptive ability of Kyrgyz mountain Merino sheep to atmospheric pressure of the environment**

*Amantur* Bekturov1*,* *Tyrgoot Chortonbaev*1*,* Uran *ShergazieSamir*1*,* Osmonaliev2*and Chinara* Kadyrova1

1Kyrgyz National Agrarian University named after K.I. Scriabin, 720005, Bishkek, 68 Mederova Street, Kyrgyzstan

2Kyrgyz Research Institute of Livestock, Bishkek, Kyrgyzstan

**Abstract.** Sheep farming in Kyrgyzstan is the main part of the country's livestock production. However, the issues of studying the influence of climate and adaptation of sheep in different climatic zones are poorly studied, and this is the relevance of our research. The study determined the tasks of sheep keeping systems depending on the climatic conditions of the region. Data on atmospheric pressure of the environment in different climatic zones were used from the website "Gismeteo.ru". The obtained data were processed by the method of variational statistics. The data obtained indicate that the maximum atmospheric pressure was observed in the South (X±Sx) 703.70+0.94 mm Hg and the minimum-in the East of the country 617.08+0.13 mm Hg. The results of the correlation analysis showed that in ewes, at high atmospheric pressure, there is a significant relationship with the live weight among the sex and age groups, where r= +0.345, in young ewe – an insignificant relationship (+0.107), in young rams – no (+0.020). The findings and conclusions of our research will be used to ensure the long-term sustainability of agriculture and the social well-being of the country, as well as enrich research on mountain ecosystem services and provide important support to local ecosystem management.

**Introduction.** The climatic conditions of Kyrgyzstan are determined by the peculiarities of its geographical location and terrain. Common features of the climate are: continentality, low precipitation, dry air, low cloud cover. On the territory of the Republic, you can see the transition from the subtropical climate — in the Ferghana valley, semi-desert-in the Chui valley, to the climate of the polar regions-in high-altitude areas.

Of the total agricultural land area of the Republic, 85.0% is covered by pasture ecosystems [1], which contributes to the successful development of animal husbandry, including the sheep industry. Mountain pastures provide eco-system services for farmers and sheep breeders, which are the basis of the strategy and regional development of the Republic.

Having studied the dependence of eco-system services in high-altitude areas of Asia, the researchers R.Murali and others [2] suggest that livestock-based systems are more vulnerable to ongoing developments due to their dependence on larger resource catches for ES that tend to have weaker land tenure and are prone to fragmentation. Pastoral farming is often subject to the vagaries of the weather [3]. Therefore, it is very important that animal owners can counteract climate variability. Climate change is a serious global problem for livestock because food security can be threatened [4; 5; 6]. Extreme climatic events have become more frequent and more severe as a result of climate change [7]. Livestock production will be limited by climate variability [8]. At present, world science has many indisputable facts of the presence of various kinds of influence of solar, space, geomagnetic activities on the life of biosphere objects [9; 10; 11].

On the basis of their research, scientists in Argentina [12] confirm the relevance of the environment in generating seasonal fluctuations in the diameter of wool fibers, which may be associated with stressful circumstances of animals. However, future research is needed to better understand the effects of climatic conditions and other stressful circumstances on animals.

It is established that there are certain relationships between animals and environmental factors. So, for example, according to the research results of A.I. Abilova et al. [13], the effect of atmospheric pressure on the day of sperm collection on the quantity and quality of sperm from breeding bulls. In this regard, for the effective use of the potential of each climatic zone, it became necessary to study adaptive capabilities [14] and improve the productive qualities of local fine-wool sheep, and what was the relevance of our research.

Kyrgyz scientists have identified several zonal types of Kyrgyz mountain Merino sheep bred in different climatic zones of the country. In the northwestern part of the country, the Talas type [15], in the eastern part - the Issykkul type [16] and in the southern part of the country - the southern Kyrgyz [17] type of sheep was cretaed.

**METHODS.** The study was conducted on fine-wooled Kyrgyz mountain Merino sheep in the North-West, East and South of the country.

To study the effect of atmospheric pressure on the productive qualities of sheep, we used the website data "Gismeteo.ru". The method of variation statistics is used to calculate (X±Sx) the maximum and minimum atmospheric pressure in a year and the reliability of the difference between them (td) using the following formula (1):

$$t\_{d}=\frac{d}{s\_{d}}=\frac{\overbar{X}\_{1}-\overbar{X}\_{2}}{\sqrt{S\_{X\_{1}}^{\\_\\_^{1}}+S\_{X\_{2}}^{\\_\\_^{2}}}} (1)$$

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

$S\_{\overbar{X}}=\frac{σ\_{x}}{\sqrt{n-1}}$ (2)

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

For the study, the live weight of sheep of different zonal types was selected as one of the main indicators of meat productivity. According to wool productivity, the length and thinness of wool were taken into account, since these indicators are not very dependent on the size of animals in comparison with wool shearing.

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

$r=\frac{\sum\_{}^{}a\_{x}×a\_{y}}{n×σ\_{x}×σ\_{y}}$ (3)

The correlation coefficient is expressed as a decimal fraction and can take values from 0 to ±1. If r =0 or has a small fractional value (up to 0.1), this indicates that there is 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 discussions.** According to Gismeteo.ru in Talas [19], located in the North-West of the country, the average monthly maximum atmospheric pressure of 663.5 mm Hg was recorded in December, and the minimum 656.8 mm Hg was recorded in June 2017. The difference between them is significant (P<0.001). The height above sea level is 1238 meters [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 pressure, a negative relationship is observed.

**Table 1.** The correlation coefficients of atmospheric pressure with

 productivity in sheep of North-Western

|  |
| --- |
| Atmospheric pressure per year, mm Hg: maximum: (X±Sx) 663.47+0.85 minimum: (X±Sx) 656.83+0.64 (P<0.001)Height above sea level: 1238 m. |
| Productivity | Atmosphericpressure | 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 |
| Thinness 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 in all age and gender groups has a negative relationship.

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 thinness of wool shows that at high atmospheric pressure, all groups have no relationship, except for young rams, where there is a slight relationship, which is equal to r= + 0.078. The main and young rams at low atmospheric pressure also have no connections, while there is a slight connection in 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.

The average monthly atmospheric pressure in the Karakol [21], Eastern part of the country compared to the North – Western part, the maximum pressure was 32.84 mm Hg, and the minimum pressure was 39.75 mm Hg lower (table 2). The difference in altitude is 513 meters higher [22].

**Table 2.** Coefficients of correlation of atmospheric pressure with

productivity in sheep of the eastern type

|  |
| --- |
| Atmospheric pressure per year, mm Hg.: maximum: (X + Sx) 630.63 + 0.63 minimum: (X + Sx) 617.08 + 0.13 (P <0.001)Height above sea level: 1751 m |
| Productivity | Atmosphericpressure | 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 |
| Thinness 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, the relationship with live weight among sex and age groups, there is a noticeable relationship, where r= +0.345, in young ewes - an insignificant relationship (r= +0.107), in young rams – missing (r= +0.020). At minimum or low atmospheric pressure, 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, along the length of the wool, 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 along the length of the wool in the main rams (r= -0.132) and young rams (r= -0.178), and in the groups of ewes and young ewes - a positive relationship (r= +0.022 and r= +0.013).

In terms of thinness of wool, a weak connection is observed in the group of main rams at minimum atmospheric pressure (r= +0.270), in other groups the connection is not high, but 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), and 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 the difference is 763 meters between Karakol and 250 meters between Talas. There is also a significant difference in atmospheric pressure [24]. It is on average higher by 80.8 mm Hg from Karakol and 39.6 mm Hg from Talas (table 3).

The relationship of atmospheric pressure with the productive qualities of the southern type of sheep is more pronounced. For example, for live weight at maximum and minimum atmospheric pressure, 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. The negative influence of the maximum (r= -0.218) and the positive influence of the minimum atmospheric pressure (r= +0.178) is well expressed in the South Kyrgyz zonal type of young ewes.

**Table 3.** Correlation coefficients of atmospheric pressure with

productivity in southern type of sheep

|  |
| --- |
| Atmospheric pressure per year, mm Hg: maximum: (X+Sx) 703.70+0.94 minimum: (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 |
| Thinness 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 |

According to 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 (+0.238; r= +0.242). A weak negative relationship is observed in young rams-r= -0.111.

According to the thinness of wool, a positive relationship is observed in ewes and young ewes at maximum and minimum atmospheric pressure equal to r= +0.265; r= +0.060 and r= +0.095; r= +0.050, respectively. In other cases, it is missing or insignificant negative relationship.

To judge the degree of environmental sustainability and adaptation in the conditions of vertical zoning of exploitation, M.S. Gabaev and V.M. Gukezhev studied [25] the level of realization of the productivity potential in the conditions of the mountain zone. The results of the study indicate that the choice of breed is of great practical importance in the case of mountain pasture keeping of sheep, while the degree of adaptation depends on economic and natural conditions, especially the height above sea level, the adaptability of individual breeds, as well as individual characteristics of animals. It is proved that making adjustments to the placement of different breeds of sheep in high-altitude zones, with a driving-mountain system of maintenance, will contribute to a more rational use of their genetic resources, effective use of the productive potential of animals and mountain forage lands.

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

In a value from 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 8 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 with values from 0.1 to 0.39, compared with live weight, are slightly higher and the positive relationship was four positions, which is one more. The negative relationship was 6 positions. This suggests that there is a weak correlation between atmospheric pressure and wool length.

For thinness of wool, most of the distribution of positive and negative correlation is in the direction of values from 0.05 to 0.1 and below 0.05, which indicates an absence or insignificant 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 | Thinness of wool | Live weight | Length of wool | Thinness of wool | Liveweight | Length ofwool | Thinness 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 | - |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

The distribution of the correlation between atmospheric pressure and sheep productivity in the positive (r+) or negative (r-) direction is shown in diagram 1.



Figure 1. The distribution of the correlation coefficient

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

Obviously, this phenomenon can be explained by the prolonged action of atmospheric pressure within the zone where animals are bred and the adaptive ability of sheep. Thus, scientists V. A. Afanasyev and others [26; 27] from the Friendship University of Russia, studying the life support of animals with different cosmophysical activity, found that in years of low solar activity, atmospheric pressure negatively correlates with milk yields, and in years of high solar activity, the correlation was positive.

**Conclusion.** The research results showed that correlations of meat and wool productivity of zonal sheep with atmospheric pressure in our studies have different and not high relationships. This is probably due to the cosmophysical activity of the planet in a specific natural and climatic zone of animal habitat and 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 provide important support to regions for ecosystem management.

**Keyword.** Ecology, climate, atmospheric pressure, correlation, live weight, length and thinness of wool

**References**

1. *Land fund area by type of agricultural land* <http://www.stat.kg/ru/opendata/category/131/>
2. Murali, R., Ikhagvajav, P., Amankul, V., Jumabay, K., Sharma, K., Bhatnagar, Y.V., Suryawanshi, K. *Journal of Arid Environments,* *Ecosystem service dependence in livestock and crop-based production systems in Asia's high mountains,* [V. 180](https://www.sciencedirect.com/science/journal/01401963/180/supp/C), 2020, 104204. <https://doi.org/10.1016/j.jaridenv.2020.104204>
3. Karimi, V., Karami, E., Keshavarz, M. *Rangeland Ecology & Management, Vulnerability and Adaptation of Livestock Producers to Climate Variability and Change,* [V. 71, I. 2](https://www.sciencedirect.com/science/journal/15507424/71/2)**,** P. 175-184 (2018) <https://doi.org/10.1016/j.rama.2017.09.006>
4. Theusme, C., Avendaño-Reyes, L., Macías-Cruz, U., Correa-Calderón, A., García-Cueto, R.O., Mellado, M., Vargas-Villamil, L., Vicente-Pérez, A. *Science of The Total Environment,Climate change vulnerability of confined livestock systems predicted using bioclimatic indexes in an arid region of México,* [*V. 751*](V.%20751)*,* (2021) <https://doi.org/10.1016/j.scitotenv.2020.141779>
5. Bai, Y., Deng, X., Zhang, Y., Wang, C., Liu, Y. *Journal of Cleaner Production, Does climate adaptation of vulnerable households to extreme events benefit livestock production?* **V. 210,** P. 358-365 (2019) <https://doi.org/10.1016/j.jclepro.2018.10.250>
6. Kuraz, B., Tesfaye, M., Mekonenn, S. Climate Change Impacts on Animal Production and Contribution of Animal Production Sector to Global Climate Change: A Review <https://arccjournals.com/journal/agricultural-science-digest/D-344>
7. G. Pardo,.A. del Prado, *Small Ruminant Research, Guidelines for small ruminant production systems under climate emergency in Europe,* [V. 193](https://www.sciencedirect.com/science/journal/09214488/193/supp/C)**,** (2020) <https://doi.org/10.1016/j.smallrumres.2020.106261>
8. Rojas-Downing, M.M., Nejadhashemi, A.P., Harrigan, T., Woznicki, S.A. *Climate Risk Management, Climate change and livestock: Impacts, adaptation, and mitigation,* [V. 16](https://www.sciencedirect.com/science/journal/22120963/16/supp/C)**,** P. 145-163 (2017) <https://doi.org/10.1016/j.crm.2017.02.001>
9. Shitikov, A. Yu., Afanasyev, V. A., Chibisov, S. M. *Fundamental study, Dairy productivity of cattle and milk quality at different levels of Cosmo physical activity on the scale of 11-year solar activity,* **№ 9,** P.25-29 (2005), <https://elibrary.ru/item.asp?id=10539724>
10. M.Bell, R.J.Eckard, B.R.Cullena, *Livestock Science, The effect of future climate scenarios on the balance between productivity and greenhouse gas emissions from sheep grazing systems,* [**V. 147, I. 1–3**](https://www.sciencedirect.com/science/journal/18711413/147/1)**,** P. 126-138 (2012) <https://doi.org/10.1016/j.livsci.2012.04.012>
11. Leu, S. T. Quiring K., Leggett K.E.A., Griffith S.C. Consistent behavioural responses to heatwaves provide body condition benefits in rangeland sheep, Applied Animal Behaviour Science, V. 234, 2021, 105204, <https://doi.org/10.1016/j.applanim.2020.105204>
12. Gonzalez, E. B., Sacchero, D. M., Easdale, M. H. Environmental influence on Merino sheep wool quality through the lens of seasonal variations in fibre diameter, Journal of Arid Environments, V. 181, 2020, 104248, ISSN 0140-1963. <https://doi.org/10.1016/j.jaridenv.2020.104248>.
13. Abilov, A.I., Amerkhanov, H.A., Korneenko-Jilyaev, Y.A., Pyzhova, E.A., Kombarov, N.A., Vinogradova, I.V., Ye, E.H. *Qualitative and quantitative indicators of sperm from breeding bulls depending on atmospheric pressure on the day of collection of ejaculates. Dubrovitsy settlement: All-Russian Scientific Research Institute of Animal Husbandry named after Academician L.K. Ernst, 2017. - Pages. 64-66.* [*https://elibrary.ru/item.asp?id=29293537*](https://elibrary.ru/item.asp?id=29293537)
14. Wreford, A. Topp,C.F.E. *Agricultural Syst ems, Impacts of climate change on livestock and possible adaptations: A case study of the United Kingdom,* [**V. 178**](https://www.sciencedirect.com/science/journal/0308521X/178/supp/C)**,** (2020), <https://doi.org/10.1016/j.agsy.2019.102737>
15. Bekturov, A.В., Chortonbaev, T.J., Lushchikhina, E.M., Chebodaev, D.V. *Topical issues of livestock and fish farming production, Talas type of sheep of the Kyrgyz mountain merino breed and their productivity,* Saratov State Agrarian University named after N.I. Vavilov, P. 40-44 (2017), <https://elibrary.ru/item.asp?id=30249064>
16. Chebodaev, D.V., Bekturov, A.B., Ibraev, R.A., Turdubaev, T. Zh., Azhibekov, A.S., Chortonbaev, T. Zh. *Bulletin KNAU named after K.I.Skryabina, Wool productivity and wool quality of the Issykkul intra-breed sheep of the Kyrgyz mountain merino breed,* **№3(44),** P. 23-27 (2017), <https://elibrary.ru/item.asp?id=29406660>
17. Bekturov, A.В., Chortonbaev, T.J., Chebodaev, D.V. *Bulletin KNAU named after K.I. Skryabina, Adaptive productivity of the southern type of sheep of the Kyrgyz mountain merino breed,* **№1(42),** P. 55-57 (2017), <https://elibrary.ru/item.asp?id=28961345>
18. N.I. Korosteleva I.S. Kondrashkovova, N.M. Rudishina, I.A. Kamardin, *Biometrics in livestock,* Barnaul, 210 p. (2009)
19. Weather Diary in Talas for 2017, <https://www.gismeteo.ru/diary/5326/2017/1/> [Electronic resource]
20. Geographic coordinates of Talas, Kyrgyzstan <https://dateandtime.info/ru/citycoordinates.php?id=1527299> [Electronic resource]
21. Weather Diary in Karakol for 2017, <https://www.gismeteo.ru/diary/5209/2017/1/> [Electronic resource]
22. Geographic coordinates of Karakol, Kyrgyzstan, <https://dateandtime.info/ru/citycoordinates.php?id=1528121> [Electronic resource]
23. Geographic coordinates of Osh, Kyrgyzstan, <https://dateandtime.info/ru/citycoordinates.php?id=1527534> [Electronic resource]
24. Weather Diary in Osh for 2017, <https://www.gismeteo.ru/diary/5344/2017/1/> [Electronic resource]
25. Gabaev, M.S., Gukezhev, V.M. *Agrarian Bulletin of the Urals, Adaptive plasticity of sheep of different breeds to the conditions of the highlands,* **№ 8 (126),** P. 23-26 (2014) <https://elibrary.ru/item.asp?id=22399295>
26. Afanasyev, V.A., Nikishov, A.A., Romanov, E.S., Krasnoshchekov, E.V., Svirid, A.I., Skugarev, A.S. *Bulletin of the Peoples' Friendship University of Russia. Series: Agronomy and Livestock,* *The productivity and quality of products of farm animals with different cosmophysical activity (space, solar, earth's magnetic field, atmospheric pressure),* **№3,**P. 34-46 (2009), <https://elibrary.ru/item.asp?id=12834137>
27. *Afanasyev, V.A., Simonov, G.A., Maklakhov, A.V., Zoteev, V.S. Influence of solar activity on cow milk yield, Mining agriculture. - 2019. - No. 3. - Р. 120-124.* [*https://doi.org/10.25691/GSH.2019.3.025*](https://doi.org/10.25691/GSH.2019.3.025)