

Original Article

Inheritance of breeding traits in Karakul sheep under different selection approaches

Herança de características reprodutivas em ovelhas Karakul sob diferentes abordagens de seleção

Zh. Parzhanov^a , N. Azhimetov^b , Ye. Kistaubayev^b , K. Tlegenova^a  and Z. Yussupbayev^a 

^aShymkent University, Faculty of Natural Sciences and Humanities, Shymkent city, the Republic of Kazakhstan

^bShymkent University, Department of Science, Shymkent city, the Republic of Kazakhstan

Abstract

In the previous century, each intrabreed type of the Karakul sheep breed was characterized by significant numbers, representing a super population with rich genetic diversity. However, over time, the genetic diversity within the breed's gene pool has undergone significant depletion. At present, the Karakul breed is predominantly composed of only two small populations, distinguished by their fur colors: black and gray. Consequently, under such circumstances, genetic advancements in breeding endeavors are likely to be relatively limited, especially given the potential risk of these populations disappearing altogether in the future. Hence, the preservation and judicious utilization of the available genetic resources within the black and gray Karakul sheep populations hold paramount importance in breeding efforts. The primary objective of our research was to investigate the heritability of breeding traits among gray lambs through various selection options. The study was conducted at the "Kumkent" base farm in the Sozak district of the Kyzylorda region. Our findings revealed that the inheritance of gray and black fur colors across the different selection options occurred in a consistent ratio. In the first selection variant (a gray ram with even silver marking ♂ x a black jacket fur type ewe with intense pigmentation ♀), the proportion of gray offspring was 50.6%. Similarly, in the second selection variant (a black jacket fur type ram with intense pigmentation ♂ x a gray ewe with even silver marking ♀), the proportion of gray offspring was 49.6%. The percentage of black lambs obtained in both selection options was nearly equivalent, with 49.4% and 50.4% in the first and second variants, respectively.

Keywords: black and gray color, classiness, rams, ewes, fur types, curl width, curl length.

Resumo

No século anterior, cada tipo intrarracial da raça de ovelhas Karakul era caracterizado por números significativos, representando uma superpopulação com rica diversidade genética. No entanto, ao longo do tempo, a diversidade genética dentro do *pool* genético da raça sofreu um esgotamento significativo. Atualmente, a raça Karakul é composta predominantemente por apenas duas pequenas populações, que se distinguem pelas cores da pelagem: preto e cinza. Consequentemente, sob tais circunstâncias, os avanços genéticos nos esforços de reprodução serão relativamente limitados, especialmente diante do risco potencial de estas populações desaparecerem completamente no futuro. Assim, a preservação e a utilização criteriosa dos recursos genéticos disponíveis nas populações de ovelhas Karakul pretas e cinzas são de suma importância nos esforços de reprodução. O objetivo principal da nossa pesquisa foi investigar a herdabilidade das características reprodutivas entre cordeiros cinzas através de várias opções de seleção. O estudo foi conduzido na fazenda base "Kumkent", no distrito de Sozak, na região de Kyzylorda. Nossas descobertas revelaram que a herança das cores de pelo cinza e preto nas diferentes opções de seleção ocorreu em uma proporção consistente. Na primeira variante de seleção (um carneiro cinza com marcação prateada uniforme ♂ x uma ovelha tipo pelo preto com pigmentação intensa ♀), a proporção de descendentes cinza foi de 50,6%. Da mesma forma, na segunda variante de seleção (um carneiro tipo pelo preto com pigmentação intensa ♂ x uma ovelha cinza com marcação prateada uniforme ♀), a proporção de descendentes cinza foi de 49,6%. A porcentagem de cordeiros pretos obtidos em ambas as opções de seleção foi quase equivalente, com 49,4% e 50,4% na primeira e segunda variantes, respectivamente.

Palavras-chave: cor preta e cinza, elegância, carneiros, ovelhas, tipos de pelagem, largura dos cachos, comprimento dos cachos.

*e-mail: parzhanov.zhanibek@mail.ru

Received: September 9, 2023 – Accepted: January 6, 2024



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

1. Introduction

Karakul sheep breeding is a prominent aspect of sheep husbandry that has shown effective development within the desert and semi-desert regions of Kazakhstan and Central Asia.

In Kazakhstan, where vast expanses of moiynkum sands, kyzylkums, pre-sand zones, as well as Betpak dala deserts are found, the practice of Karakul sheep breeding has flourished. In the past, a population of 2.5 million Karakul sheep thrived, resulting in the successful production of 600,000 Karakul skins encompassing a diverse range of assortments, including variations in color, marking and fur types. These skins were processed at a significant joint venture known as “Kazakhitalkarakul.”

Presently, the majority of Karakul sheep consist of crossbred animals, which are gradually being absorbed into meat and fat breeds of sheep, responding to the growing demand for mutton and lamb.

As of October 1st, 2021, the population of purebred Karakul sheep in Kazakhstan has exceeded 120,000 individuals, primarily encompassing two distinct colors: black and gray. The breeding stock is concentrated across 7 breeding farms with various forms of ownership, accounting for a total of 41,000 individuals (34.0%).

Furthermore, the global market demand for high-quality fur, particularly Karakul, has been on the rise. Presently, the leading contributors to the production and supply of popular Karakul fur are the Republic of South Africa, Namibia, and Afghanistan.

By the close of the 20th century, Kazakhstan had emerged as a global leader in both the quantity of Karakul sheep (surpassing 6.0 million individuals) and the production of Karakul raw materials (reaching an annual output of 2.5 million pieces).

However, during the shift towards market-oriented relations, Karakul sheep breeding encountered a period of decline. This downturn was primarily attributed to a combination of objective and subjective factors. A pivotal factor was the decline in the population of breeding sheep and the subsequent reduction in the availability of Karakul raw materials for processing at the joint venture “Kazakhitalkarakul”.

In the preceding century, each intrabreed variety within the Karakul sheep breed thrived as a considerable population, characterized by substantial genetic diversity. Presently, the genetic richness within the breed’s gene pool has experienced a significant depletion. Currently, the Karakul breed predominantly comprises two modestly-sized populations of distinct colors—black and gray. Consequently, within this context, genetic advancements in breeding endeavors are likely to remain rather modest, particularly considering the potential risk of these populations disappearing over time. As a result, the preservation and judicious exploitation of the available genetic resources within the black and gray Karakul sheep hold a distinctive significance in breeding efforts.

In light of these circumstances, a compelling issue emerges, necessitating innovative approaches to address various scientific and practical challenges in animal breeding. Specifically, this entails the refinement and

genetic enhancement of animals by leveraging advanced techniques for genotype selection and breeding.

Significantly, the advancement of novel methodologies for identifying and selecting animals with substantial selective importance serves to enhance the efficiency and optimal exploitation of the gene pool within the gray Karakul sheep breed.

The gray color of Karakul sheep belongs to the category of complex colors and is formed as a result of mixing white and black hair in terms of quantity, length and degree of pigmentation.

An analysis of the results of the inheritance of gray color depending on the type of selection for color and marking of parents of different populations shows that the indicators reflect the hereditary predisposition to color and marking. When selecting (jacket x jacket), 53.9% of parent-type lambs and 45.1% and 46.8% of jacket-type lambs were obtained with heterogeneous selection (♂ jacket type x ♀ ribbed and Caucasian types) (Yeskara et al., 2019).

An analysis of the inheritance of different variants of selection by color showed that the largest number of lambs of the jacket type was obtained with a homogeneous selection by black color (84.4%).

When utilizing distinct selection approaches (“♂ black x ♀ gray” and “♂ gray x ♀ black”), the yield of jacket-type lambs ranged from 46.1% to 75.3%, with the lowest yield (46.1%) observed in the “black x gray, silver” selection (Ombayev et al., 2019).

Exploring the hereditary attributes of silver-marked gray sheep and investigating the inheritance patterns of silver marking in various color-based selection variants revealed intriguing insights. In the case of heterogeneous selection “black x gray”, a 54.8% yield of lambs exhibiting the desired marking was observed. Conversely, under the “gray x black” selection, this yield was 53.7%. Notably, a higher yield of 72% was observed with “gray x gray” homogeneous selection, surpassing the former by 17.2% and 18.3%, respectively (Parzhanov et al., 2018).

Research conducted by Baibekov et al. (2014) underscored the substantial impact of animal color and the presence of white hairs on the heredity degree of the fur types. The utilization of black rams in the selection of gray ewes yielded a notably high proportion of jacket-type lambs, reaching 65.8% and 64.4%, respectively. These animals exhibited markedly superior characteristics compared to other fur types. Simultaneously, silver marking levels in heterogeneous selection ranged from 47.9% to 61.4%. The most considerable occurrence of silver-marked lambs arose from the progeny of white hair content -69-71% rams, registering 61.4% (♂ gray x ♀ black). This figure notably surpassed the average of traditional second-class breeding, which ranged from 13.9% to 13.4% (48.0%) ($P < 0.05$).

When studying index selection for the gray color evenness of Karakul sheep, a higher yield of the elite class - 34.6% was obtained in the offspring of rams with GCE index of 0.16, which exceeds the data of rams with GCE index of 0.28 by 10.2% (24.4%).

In the offspring of these animals, the yield of lambs of the second class was low - 9.2%.

In the second group (GCE = 0.17-0.28), the yield of elite class lambs was 31.0%, and the proportion of second class

lambs in this group was 12.9%. The data for the second group of elite lambs (GCE = 0.17-0.28) is 6.6% higher than for the herd, and 13.9% higher than for the second class (Aralbayev and Dzhumabayev, 2011).

If set the width of the curl regardless of the lines, the largest curl sizes are obtained for the Caucasian type - from 8.01 mm to 8.82 mm, the minimum curl width for the jacket type is from 6.50 mm to 7.50 mm, slightly larger for the ribbed fur type 7.00 - 7.51 mm, and flat type 7.47 - 8.11 mm (Baibekov et al., 2011).

The study of the color intensity of lambs shows that the proportion of lambs of intense expression with a homogeneous selection was 32.0%. This figure is 8.0% higher than with the heterogeneous type of selection, while the yield of lambs with a weakened expression is slightly - 14.1%. The length of the roll in lambs of a homogeneous selection is 61.3 mm longer and 3.9% longer than in lambs of a heterogeneous type - 57.4%.

An analysis of the degree of curl preservation in gray lambs as they age reveals that the most optimal curl preservation, amounting to 55.7%, is observed within a homogeneous selection type. This preservation indicator experiences a slight decrease in the context of heterogeneous selection, registering at 52.4% (Ombayev et al., 2012).

Azhibekov and Karynbayev (2013) highlight that there exist no significant fluctuations in the outcomes of both homogeneous and heterogeneous selection when considering the progeny of rams with differing WHL (white hair length) indices.

It's worth noting, however, that in both scenarios, a substantial number of lambs exhibiting the desired blue marking were obtained, specifically 20.8% and 24.1%, respectively, owing to their genetic proximity.

In the context of selecting blue-marked gray rams for black ewes, the resulting proportion of blue-marked lambs reached 60.7%, and through reciprocal selection, this figure amounted to 52.8%. Furthermore, when gray rams of silver marking were selected for gray ewes, the offspring constituted 18.4% (Alibayev et al., 2014).

Azhimetov et al. (2020) underscore that the selection of gray homozygous Karakul sheep for enhanced viability leads to a reduction in the yield of gray albino lambs. Under economic conditions, the traditional heterogeneous form of color matching (gray x black; black x gray) is widely employed. In this selection, color inheritance follows a 50.0% gray and 50.0% black distribution, resulting in gray lambs that are heterozygous and non-albino.

2. Materials and Methods

The material for the research was Karakul sheep breeds of black color of the jacket type and gray color with an even silver marking.

The experimental phase of the research was conducted at the "Kumkent" base farm located within the Sozpak district of the Turkestan region, Republic of Kazakhstan.

Two distinct selection options were established for the investigation:

Type I selection: Heterogeneous mating (a gray ram with an even silver marking ♂ x ♀ a black ewe with a jacket fur type with intense pigmentation).

Type II selection: Heterogeneous mating (a black ram with a jacket fur type with intense pigmentation ♂ x ♀ a gray ewe with an even silver marking).

The breeding stock underwent artificial insemination following specified guidelines (Instructions for Artificial Insemination of Sheep, 1967). The evaluation of Karakul sheep adhered to the protocols outlined in the "Instructions for the appraisal of Karakul sheep" (Republic of Kazakhstan, 2014).

Variation statistics were used to process the primary numerical research data (Yakovenko et al., 2013).

3. Results

The fur type is the result of a combination of quantitative (length and width of the curl) and qualitative (silkykness, shine of the hairline, type of pattern, etc.) signs over the entire area of the skin. The distribution of gray lambs of various flock types, depending on the type of selection, is shown in Table 1.

It can be seen from the table that in both variants of the selection of lambs of the desired jacket fur type, from 75.7 to 75.9% were obtained, and the undesirable Caucasian fur type amounted to 5.4 and 7.6%, respectively.

In the first variant, where a gray stud ram with an even silver marking was used, on black ewes, the specific the weight of lambs of the jacket group was 75.7%. There is no significant difference between the selection options for the yield of jacket fur type lambs. In the first selection variant (♂ gray color with an even silver marking x ♀ black color of the jacket fur type with intense pigmentation), the yield of lambs of the ribbed and flat-type fur types was 15.6 and 3.3%, respectively. And in the second variant of the selection (♂ black color of the jacket fur type with intense pigmentation x ♀ gray color with an even silver marking), these figures were 14.0 and 2.5%, respectively.

In colored Karakul sheep breeding, color and marking are the main breeding traits and determine the quality of Karakul.

In this regard, we have studied the inheritance of gray color and silver marking in various options for selecting rams of Karakul sheep of gray color to black ewes and vice versa.

The inheritance of gray and black colors in the aforementioned color-based selection variants occurred in a uniform ratio. In the first selection variant (♂ gray color with even silver marking x ♀ black color of the jacket type with intense pigmentation), where a gray ram was used, the proportion of gray offspring was 50.6%. In the second variant (♂ black color of the jacket type with intense pigmentation x ♀ gray color with even silver marking), utilizing a black ram with intense pigmentation, this proportion decreased to 49.6%. The yield of black lambs from both selection options was as follows: 49.4% for the first option and 50.4% for the second.

It is noteworthy that the collected data reaffirm the consistent pattern of a 50:50 ratio between gray and

Table 1. Inheritance of breeding traits of gray lambs with various selection options for color.

Indicators	Selection options	
	♂ gray color with even silver marking	♂ black color with jacket type with intense pigmentation
	♀ black jacket fur type with intense pigmentation	♀ gray color with even silver marking
Number of sheep	243	236
Fur type		
jacket	75.7±0.37	75.9±0.41
ribbed	15.6±0.31	14.0±0.28
flat	3.3±0.08	2.5±0.07
caucasian	5.4±0.07	7.6±0.09
Color		
gray	50.6±0.46	49.6±0.41
incl. silver	64.2±0.33	66.7±0.54
black	49.4±0.31	50.4±0.27
The ratio of black and white hair		
white	51.9±0.33	52.6±0.42
black	48.1±0.27	47.4±0.31
Evenness of marking		
even	79.7±0.38	80.8±0.37
uneven	20.3±0.24	19.2±0.20
Expression of marking		
intensive	28.8±0.24	26.7±0.30
normal	63.0±0.32	66.9±0.48
weak	8.2±0.18	6.4±0.23
Classiness of lambs		
Elite	37.0±0.38	38.6±0.31
I class	54.7±0.44	52.5±0.33
El +I cl	91.7±0.26	91.1±0.25
II class	8.3±0.08	8.9±0.09
Curl length		
long (>40 mm)	13.2±0.29	12.7±0.52
medium (20-40 mm)	70.8±0.37	69.9±0.34
short (<20 mm)	16.0±0.22	17.4±0.18
Curl width		
small (<4,0 mm)	3.7±0.11	4.2±0.18
medium (4-8 mm)	83.1±0.24	83.5±0.30
large (>8 mm)	13.2±0.19	12.3±0.14
Curl arrangement pattern		
parallel concentric	60.1±0.48	61.9±0.51
parallel straight	4.9±0.11	4.6±0.24
indefinite or mixed	35.0±0.32	33.5±0.28
Hair silkiness		
strong	44.0±0.38	43.2±0.42
normal	48.1±0.34	49.2±0.34
insufficient	7.9±0.12	7.6±0.09
Hair shine		
strong	44.9±0.38	44.9±0.49
normal	45.7±0.32	49.6±0.42
insufficient	9.4±0.23	5.5±0.25

black lambs, particularly evident through heterozygous selection of gray and black parental pairs based on color.

The predominant determinant of a given gray sheep's value, whether high or low, lies in its coloration. In modern breeding efforts concerning gray sheep, the manner in which color inheritance operates holds significant importance. In our study, heterogeneous selections included rams and ewes of gray color with even silver marking.

It was established that in the first selection variant (♂ gray color with an even silver marking x ♀ black color of the jacket type with intense pigmentation), 64.2% of the offspring inherited the silver marking, and in the second - 66.7%. There is a slight difference in this indicator between the options, and amounted to 2.1%. It should be noted that the high heritability of the silver marking in both variants of selection is the result of a long and intensive selection.

Expressiveness, evenness of color and marking have the main influence on the beauty and originality of gray Karakul skins. And they are considered important breeding traits in colored Karakul sheep breeding.

Based on this, the inheritance of these traits in various heterogeneous selection options was studied. In both variants of the selection of lambs with normal marking intensity, from 63.0 to 66.9% were obtained.

In this context, a notable prevalence of lambs with the desired intensity was achieved in the first selection variant (♂ gray color with even silver marking x ♀ black color of the jacket type with intense pigmentation), utilizing a gray stud ram with even marking, resulting in a proportion of 28.8%. Similarly, in the second selection variant (♂ black color of the jacket type with intense pigmentation x ♀ gray color with even silver marking), this proportion amounted to 26.7%. Comparatively fewer lambs with diminished intensity were observed in both selection options, ranging from 6.4% to 8.2%.

The percentage of lambs exhibiting the desired even marking ranged from 79.9% to 80.8% in both selection variants. Lambs displaying uneven marking constituted a range of 19.2% to 20.3%.

Collectively, the research findings underscore that the sought-after silver marking possesses a notably high level of expression and evenness, thereby contributing to the beauty and value of gray Karakul sheep.

Based on the analysis of complex breeding indicators of lambs and taking into account their breeding value for selection, their class was determined. With the selection option (♂ gray color with even silver marking x ♀ black color of the jacket type with intense pigmentation), the proportion of elite + I class lambs was 91.7%. And in the second variant of the selection (♂ black color of the jacket type with intense pigmentation x ♀ gray color with even silver marking), this figure was 91.1%. Between the selection options for the yield of lambs of the elite + I class - statistically unreliable. However, there is a slight difference between the selection options for the yield of class I lambs - 2.2%. In both selection options, the yield of lambs of unwanted class II was low and amounted to 8.3 and 8.9%, respectively. According to the data obtained, it should be noted that in order to consolidate the breeding traits of gray Karakul sheep, breeding work is carried out purposefully.

The size of the curls of Karakul lambs is one of the main signs not only when selecting them for a tribe, but also the commercial value of the fur depends on this sign. It is known that the longer the curl, the more beautiful the skin. Therefore, the most important trait, on which the quality of the offspring and the grade of Karakul directly depend, Karakul lambs, when graded, are divided, respectively, into: short curl up to 20 mm; medium curl 20-40 mm, long curl over 40 mm. As the size of the curl, we took their length and width and examined their inheritance.

The research revealed that in the first selection variant (♂ gray color with even silver marking x ♀ black color of the jacket type with intense pigmentation), 13.2% of the offspring displayed a long curl length. Similarly, in the second variant (♂ black color of the jacket type with intense pigmentation x ♀ gray color with even silver marking), this percentage stood at 12.7%. A significant proportion was observed in lambs exhibiting medium curl length, constituting 70.8% and 69.9%, respectively. Conversely, lambs with a short curl length accounted for 16.0% and 17.4%.

The data obtained illustrates that in both selection variants, a range of 83.1% to 83.5% of lambs displayed medium curl width. This represents the highest proportion of lambs when considering curl width. Meanwhile, the percentage of lambs with a larger curl size varied from 12.3% to 13.2% across the selection options. In contrast, the proportion of lambs with a smaller curl size remained notably low, amounting to 3.7% and 4.2% according to the respective selection choices.

The quantitative ratio of black and white hair of lambs obtained in selection options was studied. In gray lambs obtained from the first variant (♂ gray color with even silver marking x ♀ black color of the jacket type with intense pigmentation), the ratio of white and black hair was thus formed, respectively, 51.9:48.1. In gray lambs of the second variant (♂ black color of the jacket type with intense pigmentation x ♀ gray color with even silver marking) the ratio is 52.6: 47.4.

One of the important qualities of the Karakul fur is its pattern, formed by a certain arrangement of curls. Despite the importance of this trait, it is not given enough attention by many specialists, especially breeders. Meanwhile, the pattern of the Karakul fur is formed by the regular placement of cylindrical and other curls on the skin and always has a certain shape or ornament typical of the breed.

In the first selection variant, involving a gray stud ram with even silver marking, the proportion of lambs exhibiting the desired parallel-concentric pattern reached 60.1%. Similarly, in the second selection variant, using a black stud ram with intense pigmentation, this proportion was recorded at 61.9%. The distinction between the selection options concerning the yield of lambs with this specific pattern was minimal, representing a mere 1.8% difference.

In both selection options, the lowest incidence of the parallel-straight pattern type was observed, ranging from 4.6% to 4.9%. Lambs displaying an undesired mixed pattern type were obtained in both selection options, comprising 33.5% to 35.0% of the offspring.

Hence, the results of our conducted studies lead us to the conclusion that both the arrangement pattern of

curls and their size constitute inherited traits, tightly intertwined with other essential attributes of Karakul fur. Consequently, these factors must be duly considered when selecting lambs, particularly when focusing on their breeding potential.

Furthermore, the research has affirmed the superior hair quality of gray lambs, notably characterized by silkiness and sheen. To illustrate, in the first selection variant (♂ gray color with even silver marking x ♀ black color of the jacket type with intense pigmentation), the distribution of lambs showcased very silky hair at a rate of 44.0%, while those with normally silky hair represented 48.1%. Additionally, lambs possessing strong and normally sheened hair constituted 44.9% and 45.7% of the assessed subjects, respectively. In the second selection variant, involving a black stud ram, the percentage of lambs with strongly silky hair amounted to 43.2%, while those with normally silky hair reached 49.2%. Similarly, lambs exhibiting strong and normal hair sheen were reported at 44.9% and 49.6%, respectively.

The data obtained show that there is a strong positive correlation between the silkiness and sheen of the hairline in Karakul lambs.

Taking into account the importance of determining the quantitative composition of white and black hair, as well as the degree of excess of the length of white hair, we studied the frequency of occurrence of lambs with different color characteristics of gray color of silver marking (Table 2).

The data in Table 2 show that the content of white hairs and the excess of their length over black hair in silver-marked lambs in the studied populations is very highly variable and ranges from 65.0% to 75.9% and from 20.0% to 25.0%, respectively. Moreover, in all samples with different content of white hairs, the length of the excess of white hair was not the same.

Based on these studies, the selected lambs of gray color of silver marking were divided into 3 groups according

to the content of white hair: low (65.0-67.9%), medium (68.0-71.9%) and high (72.0-75.9%), and in excess of the length of white hair - small (20.0-21.9%), medium (22.0-23.9%) and long (24.0-25.9%) (Table 3).

The first group encompassed silver-marked lambs displaying a low concentration of white hairs (ranging from 65.0% to 67.9%), totaling 135 individuals and constituting 28.2% of the total selected animal population. The second group consisted of lambs featuring a moderate white hair content (ranging from 68.0% to 71.9%), comprising 188 individuals, which accounted for 39.2%. The third group comprised 156 individuals (32.6%) of silver-marked lambs showcasing a high concentration of white hair (ranging from 72.0% to 75.9%).

In the broader context, a comprehensive examination and measurement of excessive white hair length indicated substantial genetic variability in the percentage of white and black hairs, as well as the length of white hairs within gray-colored individuals exhibiting silver marking. The genetic correlation between white hair content and excessive length was markedly significant, registering at 0.451 ($P < 0.001$). As a result, the selection of silver-marked gray lambs based on tribe and their integration into breeding efforts emerges as a pivotal strategy to enhance the efficiency of breeding gray Karakul sheep.

Evenness and expressiveness of marking is one of the main color features of the fur, and attaches particular importance to the selection of gray-colored lambs.

In this regard, we studied the influence of the degree of content and excess of the length of white hairs on the evenness of gray coloration and the expression of silver marking.

The data presented in Table 4 clearly demonstrate a substantial impact of white hair content and excess length on the evenness of silver lambs' marking. The highest level of color evenness was observed among lambs characterized

Table 2. Frequency of occurrence of silver-marked lambs with varying degrees of white content and their length exceeding black hair in percentages.

Hair content		%	Exceeding the length of white hairs, %	Frequency of occurrence	
total number of hairs	number of white hairs			n	%
1601-2756	1044-1816	65.0-65.9	20.0-21.9	41	8.6
1641-2806	1083-1877	66.0-66.9	20.0-24.9	47	9.8
1691-2856	1133-1939	67.0-67.9	20.0-25.0	47	9.8
1741-2906	1184-2002	68.0-68.9	22.0-25.0	47	9.8
1791-2956	1236-2066	69.0-69.9	20.0-25.0	47	9.8
1841-3006	1289-2131	70.0-70.9	20.0-25.0	47	9.8
1891-3056	1343-2197	71.0-71.9	21.5-23.9	47	9.8
1941-3106	1398-2264	72.0-72.9	21.7-25.0	47	9.8
1991-2596	1454-2918	73.0-73.9	22.7-25.0	40	8.4
2041-2646	1510-1982	74.0-74.9	23.0-25.0	34	7.1
2090-2716	1568-2061	75.0-75.9	20.0-25.0	35	7.3
2361.0	1662.39	70.32	-	479	100.0

Table 3. Frequency of occurrence of gray-colored lambs of silver marking with different color characteristics.

White hair content, %		n	%	Exceeding the length of white hairs, %		n	%
65-67.9	low	135	28.2	20-21.9	small	126	26.3
68-71.9	medium	188	39.2	22-23.9	medium	226	47.2
72-75.9	high	156	32.6	24-25.9	long	127	26.5
Total		479	100.0	Total		479	100.0

Table 4. Evenness of gray color depending on the amount of content and excess length of white hairs in percentages.

White hair content	Excess white hairs	Number of lambs	Evenness		
			excellent	good	insufficient
Low (65.0-67.9%)	small	78	7.7±5.1	42.3±8.4	50.0±7.8
	medium	53	15.1±6.3	50.9±7.8	34.0±8.6
	long	11	-	-	100.0
Average		142	9.9±3.4	42.2±5.9	47.9±6.4
Medium (68.0-71.9%)	small	22	13.6±8.9	40.9±9.1	45.5±8.7
	medium	113	38.1±6.4	51.3±6.8	10.6±5.4
	long	43	11.6±6.9	25.6±7.1	62.8±7.6
Average		178	28.7±4.3	43.8±5.1	27.5±4.8
High (78.0-75.9%)	small	19	-	10.5±8.8	89.5±8.8
	medium	57	15.8±6.8	45.6±7.6	38.6±7.6
	long	83	-	3.6±4.9	96.4±4.3
Average		159	5.7±4.9	19.5±4.2	74.8±3.9
Total		479	15.4±2.6	35.3±3.4	49.3±3.1

by “medium-medium” content and excess of white hairs, reaching an impressive 89.4%. Similarly, lambs falling within the “low-medium” and “high-medium” white hair groups exhibited superior color uniformity, comprising 84.9% and 84.2% of the total, respectively.

Conversely, lambs displaying notably uneven color were predominantly found in the “low-long” (100.0%), “high-small” (89.5%), and “high-long” (96.4%) white hair groups. Within the other lamb groups, this unevenness ranged from 50.0% to 62.8%.

A parallel pattern emerges when considering the intensity of silver marking in gray lambs, contingent on both white hair content and excess length. It's noteworthy that the weakest expression of marking was most prominent in the extreme groups of individuals characterized by white hair content and excess length. The data presented in Table 5.

In the group of gray lambs with “low-small” and “low-long”, undesirable expression was 67.9% -81.8%.

And in the option “high-small” and “high-long” the proportion of individuals is 73.7% -65.1%.

In the options for the content and excess of the length of white hair “low - medium” and “high - medium”, significantly more lambs with normal color intensity were found, and their share was 60.4% -61.4%.

In the group of lambs with an average content and excess length of white hairs, the desired expression of the silver marking was significantly higher (93.7%) and the smallest number of undesirable (6.2%) than in the other groups.

The calculation of the correlation coefficient allows finding out the relationship between features and environmental factors. Data on the magnitude of the relationship between the color features of the silver marking are shown in Table 6.

As can be seen from the data in Table 6, the magnitude of the correlations between the parameters of white hairs with evenness and the expression of the silver color of the gray color is positive and reliable.

At the same time, it should be noted that there is a low positive relationship between the content of white hairs and evenness of color ($r = 0.199$; $P < 0.001$), and there is a much greater relationship between the expression ($r = 0.301$; $P < 0.001$).

This is confirmed by the results of two-factor analysis of variance, shown in Table 7.

The data presented in Table 7 highlight a disparity in the proportion of influence exerted by white hair content and excess length on the evenness and expression of silver marking. Specifically, the impact of white hair content on color evenness is indicated as $0.102 + 0.006$ with a

Table 5. Expression of silver marking in gray lambs based on white hair content and excess length in percentages.

White hair content	Excess white hairs	Number of lambs	Expression		
			excellent	good	insufficient
Low (65.0-67.9%)	small	78	-	32.1±6.0	67.9±5.7
	medium	53	22.6±8.7	37.8±8.2	39.6±8.4
	long	11	-	18.2±9.8	81.8±9.1
Average		142	8.5±8.7	33.1±5.3	58.4±5.7
Medium (68.0-71.9%)	small	22	13.6±7.6	36.4±9.1	50.0±8.4
	medium	113	63.7±5.2	30.1±5.6	6.2±4.5
	long	43	9.3±5.9	34.9±7.8	55.8±8.0
Average		178	44.4±5.9	32.0±4.9	23.6±6.2
High (78.0-75.9%)	small	19	-	26.3±9.5	73.7±9.7
	medium	57	35.1±7.2	26.3±7.8	38.6±7.4
	long	83	13.2±7.7	21.7±6.4	65.1±5.9
Average		159	19.5±6.4	23.9±5.8	56.6±6.1
Total		479	25.5±2.8	29.6±2.4	44.9±3.1

Table 6. Results of calculating the correlation coefficient between features.

Features	$r \pm m_r$	P
Evenness	0.199±0.056	<0.001
Expression	0.301±0.054	<0.001

Table 7. Influence of the degree of content and excess of the length of white hairs on the quality of the silver marking.

Features	Share of influence	P	Influence value
White hair content			
For evenness	0.102±0.006	<0.001	8.4 – 12.0%
For expression	0.267±0.002	<0.001	26.1 – 27.3%
Excess length of white hairs			
For evenness	0.108±0.006	<0.001	9.0 – 12.6%
For expression	0.332±0.004	<0.001	32.0 – 34.4%

significant reliability of $P < 0.001$, whereas the influence of excess length of white hairs stands at $0.267 + 0.002$ with a similar level of reliability ($P < 0.001$).

A similar pattern emerges when considering the proportion of influence on the expression of silver marking. Notably, it was observed that the impact of excess length of white hairs on silver marking expression is significantly greater ($0.332 + 0.004$; $P < 0.001$) than that of the quantitative content of white hairs ($0.108 + 0.006$; $P < 0.001$).

In a broader context, the proportion of influence stemming from excess length of white hairs on the expression of silver marking and the evenness of gray color can vary within a range of 26.1% to 34.4%. Meanwhile,

the influence of white hair content can span from 8.4% to 12.6%, respectively.

Furthermore, the investigation into the classiness of gray-colored lambs featuring silver marking unveiled distinct class compositions across various genotypes characterized by differing white hair content and excess length (Table 8).

In lambs with the content and excess length of white hairs “medium-medium” classiness was sufficient in comparison with other groups of lambs (elite - 24.8%, I-class - 63.7%, II-class - 10.5%). The difference between the compared groups of lambs in terms of the content and excess of the length of white hairs is significant with a probability of $P < 0.01 - 0.001$.

Table 8. Classiness of lambs of gray color of silver marking in percentages.

White hair content	Excess white hairs	n	Classiness of lambs		
			elite	I class	II class
Low	low	78	3.8±2.8	52.6±6.8	43.6±7.9
	medium	53	18.9±6.7	49.1±8.4	32.0±7.5
	high	11	-	45.4±11.6	54.6±5.8
Average		142	9.2±3.0	50.7±6.8	40.1±5.2
Medium	low	22	9.1±7.1	59.1±9.7	31.8±8.3
	medium	113	24.8±4.9	63.7±4.9	10.5±4.8
	high	43	11.6±5.6	53.5±7.5	34.9±8.0
Average		178	19.7±4.5	60.7±4.6	19.6±4.8
High	low	19	-	57.9±11.6	42.1±9.2
	medium	57	19.3±7.2	42.1±8.9	38.6±8.8
	high	83	-	44.6±6.0	55.4±7.4
Average		159	6.9±3.4	45.3±4.2	47.8±5.8
Total		479	12.3±3.0	52.6±3.5	35.1±2.9

Therefore, these results indicate that individual combinations of the number and excess length of white hairs may be ideal selection markers for silver gray lambs.

Therefore, the identification of a genotype with the desired parameters of white hairs, affecting their color characteristics, allows using them as a genetic marker in improving the quality of the Karakul sheep of gray color and silver marking.

Thus, in order to improve the accuracy of assessing gray lambs of silver marking, after establishing their breeding status for economically useful traits at birth, hair samples are taken from them in the sacrum area with an area of 1 cm².

And in laboratory conditions, by counting, the quantitative content and percentage excess of the length of white hairs are additionally determined, then they are selected for a tribe with a content of white hairs of 68.0-72.0% and an excess of white hairs over black ones by 22.0-24.0%, by on the basis of which further selection work is carried out.

References

- ALIBAYEV, N.N., BAIBEKOV, Y.E., PARZHANOV, Z.H.A. and YESKARA, M.A., 2014 [viewed 9 September 2023]. Breeding of a new factory type of Karakul sheep of gray blue color in the south of Kazakhstan. *Science News Kazakhstan* [online], vol. 2, pp. 12-23. Available from: <http://www.vestnik.nauka.kz/kz/selskoe-i-lesnoe-zoxyzajstvo/o-novom-kumkentskom-zavodskom-tipe-karakulskix-ovec-seroj-okraski-goluboj-rascvetki-mojnykumsko-zakaratauskoj-populyacii.php> [in Russian]
- ARALBAYEV, Z.H. and DZHUMABAYEV, D., 2011. Index selection according to the evenity of the gray color of Karakul sheep: actual issues of animal husbandry and crop production. *Almaty*, vol. 108, n. 1, pp. 169-170. [In Russian].
- AZHIBEKOV, B.A. and KARYNBAYEV, A.K., 2013. *Inheritance of breeding traits when creating a herd of gray Karakul sheep of an even silver marking of a jacket-type flock*. Shymkent: Agrarian science - agricultural production of the southwestern region of Kazakhstan. [In Russian].
- AZHIMETOV, N.N., PARZHANOV, Z.A., AZHIBEKOV, B.A., MUSTIYAR, T.A. and BAIBEKOV, E., 2020 [viewed 9 September 2023]. Selection method of karakul sheep of gray color by viability. *Eurasia J. Biosci.* [online], vol. 14, pp. 343-345. Available from: <https://www.semanticscholar.org/paper/Selection-method-of-karakul-sheep-of-gray-color-by-Azhimetrov-Parzhanov/7e8696a2d41ca36573246919b8e6499e5d28ad29>
- BAIBEKOV, Y.E., SADENOV, A. and ZHUSSUPOV, S., 2011 [viewed 9 September 2023]. *Variability of astrakhan qualities of Karakul sheep of gray blue color of different lines: actual issues of animal husbandry and camel breeding*. Almaty: Academic Journal INC. [In Russian].
- BAIBEKOV, Y.E., YESKARA, M.A. and PARZHANOV, Z.H.A., 2014. *Creation of a flock of gray karakul sheep of silver marking with intense pigmentation: arid feed production is the basis for the development of transhumance in desert and semi-desert zones of Kazakhstan*. Almaty: Editorial and Publishing Department (NCSSTE). [In Russian].
- INSTRUCTIONS FOR ARTIFICIAL INSEMINATION OF SHEEP, 1967. *Guide on artificial insemination*. Moscow: Kolos. [In Russian].
- OMBAYEV, A.M., PARZHANOV, Z.H.A. and MUSTIYAR, T.A., 2019 [viewed 9 September 2023]. Productive qualities of Karakul sheep with different selection options. *Scientific Journal Research Results* [online], vol. 4, pp. 75-81. Available from: <https://elibrary.ru/item.asp?edn=ueahya> [in Russian]
- OMBAYEV, A.M., SADENOV, A. and BAIBEKOV, Y.E., 2012 [viewed 9 September 2023]. *Kumkent factory type of gray Karakul sheep of blue color of the jacket type: Breeding and technological aspects of the development of productive camel breeding, Karakul sheep breeding and arid feed production in Kazakhstan*. Shymkent: Bastau. [In Russian].
- PARZHANOV, Z.H.A., YESKARA, M.A. and KARYNBAYEV, A.K., 2018 [viewed 9 September 2023]. *The quality of the offspring of Karakul sheep of various colors, depending on the selection options: modern aspects of the agriculture development in the southwestern region of Kazakhstan*. Shymkent: Bastau. [In Russian].

- REPUBLIC OF KAZAKHSTAN, 2014 [viewed 6 January 2024]. *On approval of the instructions for the certification of farm animals and the breed standard, 2014. Instructions for grading Karakul lambs* [online]. Reference Control Bank of Regulatory Legal Acts of the Republic of Kazakhstan in Electronic Form/Unified Legal Information System of the Republic of Kazakhstan, Astana, 10 Oct. Available from: <http://law.gov.kz/client/#!/doc/84634/rus/10.10.2014> . [In Russian].
- YAKOVENKO, A.M., ANTONENKO, T.I. and SELIONOVA, M.I., 2013 [viewed 9 September 2023]. *Biometric methods for analyzing qualitative and quantitative traits in animal science. Textbook* [online]. Stavropol: Stavropol State Agrarian University. Available from: <https://znanium.ru/catalog/document?id=14556>
- YESKARA, M.A., MUSTIYAR, T.A. and NARBOTA, B.E., 2019 [viewed 9 September 2023]. Inheritance of silver color and severity of pigmentation in gray lamb under different selection options [online]. In: *Proceedings of the International Scientific and Practical Conference: "Science, Production, Business: Current State and Ways of Innovative Development of the Agrarian Sector Using the Example wof the Baiserke-Agro Agricultural Holding", dedicated to the 70th anniversary of the Honored Worker of the Republic of Kazakhstan Dosmukhambetov Temirkhan Mynaidarovich*, 4-5 April 2019, Almaty. Almaty: National Engineering Academy of the Republic of Kazakhstan, vol. 4, p. 246. Available from: https://acagor.kz/media/uploads/2019/04/04_%D0%A2%D0%9E%D0%9C_BOOK_COLOR.pdf . [In Russian].