

Breeding Progress in Mugalzhar Horses: The Irtys Type as a Model for Meat Production Efficiency

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Abstract: The Mugalzhar horse breed holds significant value for meat production in Kazakhstan. Developed through targeted selection, the new Irtys stud type demonstrates outstanding adaptation and productivity, with stallions reaching an average live weight of 486.1 kg and mares 463.4 kg, an increase of up to 73 kg compared to the original group. The coefficient of variation for live weight and metacarpus girth is higher in the Irtys type (1.34-1.26 in stallions, 3.78-3.26 in mares), supporting efficient selective breeding. Statistically significant differences in body measurements and live weight ($P > 0.99$) and strong correlations between key traits ($r = 0.20-0.49$) highlight the effectiveness of selection for meat productivity. Importantly, SNP analysis of the LCORL gene revealed that the CT genotype is most frequent and is significantly associated with increased withers height, body length, chest girth, metacarpus girth, and body weight ($P < 0.05$). These findings suggest that LCORL can serve as a useful molecular marker for improving growth and productive traits in the Mugalzhar breed. The combination of genetic and phenotypic selection in this population provides a practical basis for further economic gains in horse meat production.

Keywords: Mugalzhar Horse, Irtys Type, Live Weight, Breeding, LCORL Gene

Introduction

In Kazakhstan, the horse has always held a universal significance: it has been used not only as a draft animal, but also as a source of meat and milk, as well as in sports. Today, technological advancements in agriculture are significantly changing the direction of horse breeding in Kazakhstan. The development of productive horse breeding for the purpose of producing horse meat and kumis is becoming increasingly important (Iskhan et al., 2025).

In recent years, the Ministry of Agriculture of the Republic of Kazakhstan has been paying great attention to the development of horse breeding in the agricultural sector. For example, the Beskaragai factory type of the Kazakh breed illustrates how line breeding can be effectively implemented to improve meat production and other economically valuable traits under specific regional conditions (Sharapatov et al., 2025). Achieving these goals largely depends on improving the effectiveness of breeding work by widely implementing advances in

population genetics, improving selection and mating methods, identifying and utilizing the genetic potential of productivity and breeding qualities in horses, as well as further enhancing existing breeds, types, and lines, and developing new ones (Pozharskiy et al., 2023).

The Mugalzhar horse breed plays a pivotal role in productive horse breeding in Kazakhstan, particularly as an improver of local Kazakh horses (Assilbekov et al., 2021). These horses are highly valued for their adaptability to environmental conditions, endurance, and meat and milk qualities. On natural pasture alone, they can reach a live weight of 390–410 kg by the age of 2.5 years, which ensures highly profitable meat production (Kassymbekova et al., 2024).

The shift to a market economy, as well as subsidies for breeding stock, has served as a real incentive for the breeding of Mugalzhar horses. Many agricultural enterprises have begun to specialize in breeding the Mugalzhar breed, which is in high demand across all regions of Kazakhstan (Orazymbetova et al., 2023). In

some areas of the country, distinctive populations of herd-raised horses have formed, which are quite similar in exterior and productivity. However, there are no specific recommendations for their breeding. This highlights the need for research-based guidelines tailored to the unique ecological and production contexts of local horse breeding (Akhmetov *et al.*, 2023).

In this regard, the development of scientific breeding principles for creating the Irtysh breed type and the Zaman and Bakai breeding lines, as well as for breeding Mugalzhar horses capable of producing the most affordable and ecologically clean horse meat and kumis under year-round pasture conditions in north-eastern Kazakhstan, becomes especially relevant.

Methodology

Work on improving the breeding and productive qualities of the Mugalzhar horse breed has been carried out at the agricultural production cooperative "Azamat" in the Beskaragai district of the Abai region. A key component of this work, the development of methods for creating the Irtysh stud type and breeding lines, commenced between 1975 and 1980 (Iskhan *et al.*, 2024). During this time, the Semiyarsky state farm in the Beskaragai district of the Semipalatinsk region (now Agricultural production cooperative Azamat 2) received young stallions and fillies from the Mugalzhar horse stud farm in the Aktobe region. These were descendants of stallions from the outstanding lines Zubr, Barkhat, and Baz, known for their tall stature, elongated body, large chest girth, and high live weight. From these stud stallions, the new breeding lines Zaman and Bakai were established, which became the most typical representatives of the Mugalzhar breed.

At the initial stage of creating the Irtysh breed type (1978–1988), mass selection was practiced based on pedigree, breed type, body measurements, live weight, exterior, adaptability to herd management conditions, and offspring quality. Selected breeding groups of mares were paired with stallions brought from the Mugalzhar stud farm, and outstanding genotypes of stallions and mares were identified for establishing new lines and maternal families.

At the second stage (1989–1999), selection of highly productive animals continued, with homogeneous mating conducted to consolidate valuable economically useful traits, and heterogeneous mating applied to correct certain deficiencies identified during the selection process.

At the third stage (2000–2018), the highly productive Zaman and Bakai lines were developed, along with the Irtysh type of the Mugalzhar breed, aimed at meat and meat-dairy production. During the creation of this type, standards for the new lines and the type itself were developed, which significantly exceeded the

requirements of the evaluation guidelines (Ministry of Agriculture of the Republic of Kazakhstan, 2020). The genotypic and phenotypic variability of the selected traits, as well as their heritability and repeatability, were determined.

Concurrently, the correlation between economically valuable traits was studied, along with the influence of paratypic (non-genetic) factors on the phenotypic expression of genetically determined productivity levels in horses. To determine the degree of variability in the selected traits, basic diversity indicators were calculated: variance, standard deviation, and coefficient of variation.

Statistical Data Processing

A set of methods corresponding to international standards for biometric research in animal science was used for the analysis of the results. All calculations were performed in R 4.3.1.

Descriptive Statistics

Quantitative traits (live weight, body measurements) are presented as (Plohinskij, 1961):

$$\bar{x} \pm m$$

where:

$$\bar{x} \text{ (arithmetic mean)} = \frac{\sum V}{n}$$

$$m \text{ (standard error of the mean)} = \frac{s}{\sqrt{n}}$$

The coefficient of variation (Cv) was calculated as (Plohinskij, 1961):

$$Cv = \left(\frac{s}{\bar{x}}\right) \times 100\%$$

Variance is calculated as the sum of the squared deviations of individual trait values from their arithmetic mean, divided by the number of degrees of freedom:

$$C = \sum V^2 - \frac{(\sum V)^2}{n}$$

In biometrics, the calculation of sigma (σ), that is, the standard deviation, is performed using the classical formula, which reflects the degree of variability of a trait in the sample:

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

where:

x_i = individual value of the trait,

$\bar{x}$ = arithmetic mean of all values,

n = number of observations in the sample

Pairwise Comparisons (Student's *t*-test)

To identify differences between the 1977 group (control) and other groups (1992, 2007, 2022), the *t*-test was used (Jeffers *et al.*, 2024):

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Hypotheses:

$$H_0: \bar{x}_1 = \bar{x}_2$$

$$H_a: \bar{x}_1 \neq \bar{x}_2$$

Significance thresholds: $p < 0.05$, $p < 0.01$, $p < 0.001$

To assess the influence of paratypic and age-related factors on the structure of trait variability, the repeatability coefficient was used (Aubakirov, 2011; Kozlov & Parfenov, 2012). After obtaining repeatability data for body measurements and live weight, heritability coefficients were calculated for these traits. Heritability was calculated using the method of correlation between offspring and the mean expression of the trait in both parents.

Heritability Coefficient (h^2)

The correlation coefficient between the expression of a trait in the offspring and the half-sum of this trait's values in the parents is used (Plohinskij, 1961).

$$h^2 = r_{\text{offspring}, (\text{parent}_1 + \text{parent}_2)/2}$$

where, r is the correlation coefficient between the trait in the offspring and the mean value of the trait in the parents.

Repeatability Coefficient (r)

The correlation coefficient is calculated between the results of repeated measurements of the same trait in the same animals:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \cdot \sum (y_i - \bar{y})^2}}$$

where, x_i and y_i are the values of the trait at the first and second measurements, respectively.

The evaluation of differences between the mean trait values in animals of different genotypes was performed using one-way analysis of variance (ANOVA) followed by multiple comparisons of means using Tukey's test.

The chi-square (χ^2) test was used to assess whether the observed genotype frequencies deviated from those expected under Hardy-Weinberg equilibrium. The expected frequencies were calculated based on allele frequencies in the population. The χ^2 statistic was computed as $\chi^2 = \sum \frac{(O-E)^2}{E}$, where O and E represent observed and expected genotype counts, respectively. Degrees of freedom were determined as the number of genotype categories minus the number of estimated allele frequencies minus one. The resulting χ^2 value was compared to the critical value from the chi-square distribution table at the 0.05 significance level (Serrote *et al.*, 2020).

In our study, two age categories, 1.5 years and 2.5 years, were identified, as these periods are characterized by active growth and the development of key productive traits, as well as by the initial and intermediate grading of animals according to breed standards.

Division by sex and age allows for a more accurate assessment of the growth, development, and productivity characteristics of stallions and mares, as well as the identification of sex and age differences in the expression of selection traits. This approach is consistent with established zootechnical methods for evaluating young stock of meat-and-dairy horse breeds.

Class Descriptions

The "Elite" category includes animals that meet or exceed the breed standard requirements for a set of traits: live weight, conformation, constitution, pedigree (genotype), as well as productive qualities. Such animals exhibit pronounced breed characteristics, harmonious body structure, excellent development, and high productivity. Among young stock, the "Elite" class is assigned when the evaluation for key traits exceeds the requirements of Class I.

"Class I" is assigned to animals that meet the standard breed requirements for the main economically valuable traits but fall short of the "Elite" category. These are animals with good development and correct body structure, without major faults, meeting the requirements for live weight, conformation, and pedigree, but lacking outstanding characteristics.

The "Class II" category includes animals that meet the minimum breed requirements for a set of traits but have certain deficiencies in development, conformation, or productivity. Such animals may have less pronounced breed characteristics or minor deviations from the standards; however, they do not have serious defects that would preclude their use in production (Ministry of Agriculture of the Republic of Kazakhstan, 2020).

Evaluation of Stallions

The evaluation of stallions based on the quality of their offspring was carried out in accordance with the Instruction on the Grading of Productive Horses, approved by the Order of the Minister of Agriculture of the Republic of Kazakhstan dated October 10, 2014, No. 3-3/517, as amended on July 28, 2023. According to this methodology, stallions are classified by their influence on the quality of offspring as follows: a stallion receiving a score of 9–8 points is considered an improver, 6–7 points neutral, and 5–4 points deteriorator (Ministry of Agriculture of the Republic of Kazakhstan, 2020).

Results and Discussion

One of the common breeding methods for the Mugalzhar horse breed is purebred breeding, whose main objective is the preservation and development of breed

qualities (Kabyzbekova *et al.*, 2024). The biological feature of this breeding method lies in maintaining and enhancing the heredity and productivity of Mugalzhar horses, which have been used for breeding purposes at the Azamat 2 farm. Currently, this farm has 21 breeding stallions (all classified in the elite class) and 184 mares (Table 1).

Table 1: Number and class composition of Mugalzhar horses

Age and Gender Groups	Total		Total by Classes					
			Elite I class			II class		
	n	%	n	%	n	%	n	%
Studhorses	21	4.9	21	100	-	-	-	-
Mares	184	42.9	68	37.0	83	45.1	33	17.9
Stallions 2.5 years old	9	2.1	9	100	-	-	-	-
Fillies 2.5 years old	68	15.9	23	33.5	33	48.2	12	18.3
Stallions 1.5 years old	70	16.3	21	30.0	34	48.6	15	21.4
Fillies 1.5 years old	77	17.9	22	28.6	38	49.3	17	22.1
Total	429	100	164	38.2	188	43.8	77	18.0

As shown by the data in Table 1, the herd structure includes: 4.9% breeding stallions, 42.9% mares, 2.1% 2.5-year-old colts, 15.9% 2.5-year-old fillies, 16.3% 1.5-year-old colts, 17.9% 1.5-year-old fillies. Among the mares, the proportion by class is: Elite – 37.0%, Class I – 45.1%, Class II – 17.9%.

Among the 79 colts (2.5 and 1.5 years old):

- Elite – 38.0%
- Class I – 43.0%
- Class II – 19.0%

Among the 145 fillies (2.5 and 1.5 years old):

- Elite – 31.0%
- Class I – 49.0%
- Class II – 20.0%

At APC "Azamat 2", special attention is given to the selection of parent pairs based on both phenotype and genotype. Mare selection for stallions aims to consolidate wide-bodied, massive conformation, high adaptability to pasture and tebenevka (winter grazing) conditions, and to enhance desirable traits such as greater height and live weight (Akimbekov *et al.*, 2017; Assanbayev *et al.*, 2019).

To strengthen these desired traits, the best mares are paired with the best breeding stallions. As a result of targeted breeding and selection work with Mugalzhar horses at this farm resulted in significant progress. This can be seen by comparing the average body measurements and live weight of the original group of adult horses and those of the new Irtysh stud type (Table 2).

According to Table 2, the new Irtysh stud type demonstrates significant improvements across all measured parameters compared to original groups from 1977, 1992, and 2007. Mares of the Irtysh type showed superior performance in height at the withers (by 6.7 cm, 3.8 cm, and 1.9 cm), oblique body length (by 8.7 cm, 5.6

cm, and 2.1 cm), chest girth (by 9.4 cm, 6.0 cm, and 3.4 cm), and live weight (by 83.0 kg, 71.7 kg, and 47.7 kg), respectively. Similarly, stallions exhibited enhanced characteristics with increases in height at the withers (6.9 cm, 4.0 cm, and 1.8 cm), oblique body length (8.9 cm, 5.2 cm, and 2.3 cm), chest girth (9.4 cm, 6.6 cm, and 3.3 cm), and live weight (73.3 kg, 49.6 kg, and 30.8 kg), respectively. The differences in all body measurements and live weight between stallions and mares are statistically significant according to Student's t-test at $P > 0.99$ and $P > 0.999$, meaning a very high level of reliability.

It should be noted that the coefficient of variation (CV) in the Irtysh stud type Mugalzhar horses, as well as in the original groups of 1977, 1992, and 2007, was higher for live weight and metacarpus girth. The high variability of these traits creates more favorable conditions for further breeding work, increasing its efficiency.

From the provided materials, it is clear that the current stock of stallions and mares of the Irtysh stud type of Mugalzhar breed at SPC "Azamat 2" differs from the original horse groups by better meat conformation and higher live weight.

Purebred breeding of the new Irtysh stud type Mugalzhar horses helps preserve the gene pool of these horses and is an important measure not only for the present but also for future breeding work.

In addition, the influence of the genetic polymorphism of the LCORL gene on the growth and development of horses of the Mugalzhar breed has been studied. The LCORL gene can potentially serve as a molecular marker to further improve the breeding qualities of the Mugalzhar horse breed (Metzger *et al.*, 2013).

The highest form of breeding work in purebred horse breeding is line breeding. This involves creating highly productive and genetically stable groups of breeding animals within the breed, based on the use of outstanding sires and their most valuable offspring. The main goal of line breeding is to divide the breed into distinct quality groups, create and maintain the breed's structure, creating conditions not only to preserve the desirable traits of the breed but also to further improve them. Line breeding allows the creation of a strictly defined genealogical structure within the breed, maintaining an optimal level of heterozygosity and preventing the uncontrolled increase of homozygosity. This method makes it possible to select and pair animals based on a complex of selected traits and to maintain genetic diversity in the population.

Moreover, successful genetic combinations can be utilized as a combination effect in practical breeding. Since there is relatively high genetic similarity within a line, successful combinations are often successful for the line as a whole, simplifying the use of the line-breeding effect (Khrabrova *et al.*, 2019).

Table 2: Body measurements and live weight of horses from the original group and the new Irtysh stud type of the Mugalzhar breed

Indicators	Initial Groups			
	1977	1992	2007	Irtysh Stud Type 2022
Stallions - producers				
n	27	10	11	16
Height at withers (cm)	138.5± 0.61	141.4± 0.53	143.6± 0.47	145.4 ± 0.25
C _v	1.35	1.06	0.96	0.38
t-statistic	-	3.58	6.62	10.61
Oblique body length (cm)	142.6± 0.68	146.3± 0.61	149.2± 0.52	151.5 ± 0.37
C _v	1.46	1.17	1.12	0.55
t-statistic	-	4.06	7.76	11.56
Chest girth (cm)	172.4± 0.72	175.2± 0.69	178.5± 0.61	181.8 ± 0.45
C _v	1.51	1.22	1.09	0.57
t-statistic	-	2.80	6.49	11.06
Metacarpus girth (cm)	18.5 ± 0.16	19.0 ± 0.14	19.5 ± 0.13	20.2 ± 0.12
C _v	2.47	2.39	2.24	1.34
t-statistic	-	2.38	4.76	8.50
Live weight (kg)	412.8± 3.37	436.5± 3.12	455.3± 3.04	486.1 ± 2.75
C _v	2.31	2.34	2.12	1.26
t-statistic	-	5.16	9.36	16.85
Mares				
Number of animals	320	95	102	149
Height at withers (cm)	136.5± 0.47	139.4 ± 42.00	141.3± 0.51	143.2 ± 0.54
C _v	2.93	2.71	2.28	2.09
t-statistic	-	2.14	6.96	9.44
Oblique body length (cm)	141.1± 0.58	144.2± 0.51	147.7± 0.62	149.8 ± 0.68
C _v	3.17	2.98	2.79	2.64
t-statistic	-	4.02	7.76	9.77
Chest girth (cm)	171.2± 0.61	174.6± 0.58	177.2± 0.60	180.6 ± 0.71
C _v	2.87	2.62	2.48	2.09
t-statistic	-	4.05	7.06	10.11
Metacarpus girth (cm)	17.5 ± 0.19	18.0 ± 0.13	18.3 ± 0.14	19.1 ± 0.12
C _v	3.21	3.83	3.65	3.78
t-statistic	-	2.17	3.33	7.27
Live weight (kg)	380.4 ± 3.40	391.7 ± 2.90	415.7 ± 3.20	463.4 ± 3.70
C _v	3.45	3.06	3.47	3.26
t-statistic	-	2.53	7.56	16.53

Determining the genealogical structure is crucial for developing methods of working with the breed as a whole and with specific genealogical groups. When selection, pairing, and inbreeding are carried out, many valuable genotypes accumulate in the breed, significantly influencing breed improvement.

The ratio of these genotypes changes depending on which genealogical groups have greater representation at a particular time in the breeding stock. This enables the identification of the most important genealogical lines, analyzing their development, determining the best combinations, and outlining the most promising selection methods.

At APC "Azamat 2" in the Beskargay district of the Abay region, two lines of the Mugalzhar horse breed have been formed: the Zaman 55-88 line and the Bakai 71-89 line.

Zaman 55-88 Line

The founder of the line is the bay dun stallion Zaman 55, born in 1988, an outstanding horse in terms of body

conformation and the quality of his offspring. He was widely used in the "Semiarysky" state farm of the Semipalatinsk region, now known as Abay region. His sire, Zavitok 203-82 (by Zubader 121-76 out of a dun mare 98-77), came from the famous Zubr 46-59 stud line and was purchased at two years of age from the Mugalzhar Stud Farm in Aktobe region. Starting from the age of four, Zavitok was used to breed Kazakh-type mares at the "Semiarysky" state farm.

As a result of pairing Zavitok with massive-type Kazakh mares, the foundation sire of the new highly productive stud line was obtained: the dun stallion Zaman 55-88. Zaman's dam was a Kazakh mare 6-83, also dun-colored, with a height at the withers of 140 cm and a massive body structure, and a chest girth of 177 cm.

Zaman inherited from his ancestors of the Zubr 46-59 line excellent conformation, a well-developed body, abundant mane, tail, and feathering, as well as high adaptability to pasture and winter grazing (tebenevka) conditions. The Zaman line continues to develop

through: 4 sons, 5 grandsons, 5 great-grandsons, 5 great-great-grandsons. The line has five branches through the stallions: Zaman 61-00, Zanbar 43-00, Zalom 53-01, Zamshit 9-02, Zatish 67-03. Measurements and live weight of adult stallions and mares from the Zaman 55-88 line are presented in Table 3.

Data presented in Table 3 indicate that, it is evident that the stallions of the Zaman 55-88 line, along with good height, possess an elongated body, deep chest, and high live weight. The mares of this line are fairly tall (143.9 cm), have a long body (151.2 cm), meaning the oblique body length exceeds the withers height by 7.3 cm, a large chest girth (181.7 cm), and a sufficient Metacarpus girth (19.5 cm), a high live weight (478.6 kg), and are very massive, with a massiveness index of 160.6. The degree of variability (C_v) for body measurements was higher for both stallions and mares in metacarpus girth (2.01 and 2.41, respectively), while for live weight it was 2.36 for stallions and 3.70 for mares.

The Bakai 71-89 Line

The founder of the line is the bay dun stallion Bakai 71, born in 1989, bred at the "Semiarysky" state farm of Beskaragai district, Semipalatinsk region (now Abay region). He descended from the stallion Barbaris 201-83 (by Burny 85-76 out of dun mare 82-77), who was imported at the age of two from the Mugalzhar Stud Farm of Aktobe region in 1985, and a dun Kazakh mare of the jabe type 15-84.

Bakai's sire, Barbaris 201-83, came from one branch of the famous Baz 114-60 line, whose offspring were widely used across many regions of Kazakhstan and

contributed to the recognition (approval) of the Mugalzhar horse breed.

Bakai 71-89 was an extremely hardy and undemanding stallion under year-round pasture conditions. He had a well-developed chest, a long body, strong and durable hooves, abundant body hair coverage, and maintained good body condition throughout the year.

At the age of five, Bakai had: height at the withers: 143 cm, oblique body length: 149 cm, chest girth: 178 cm, metacarpus girth: 19.0 cm, live weight: 440 kg. During his breeding career, Bakai was consistently paired with tall and massive jabe-type mares, resulting in offspring that had sufficient height and a massive body structure.

The Bakai line mainly develops through: three sons: Baget 9-95, Bastau 15-95, and Balgyn 3-96, five grandsons, five great-grandsons, six great-great-grandsons. The line has worthy successors up to the fourth generation, most of whom show a significant phenotypic and genotypic resemblance to the founder.

Male descendants, in terms of body measurements, live weight, and development, reliably exceed the standards for the Mugalzhar breed outlined in the Instruction for the Appraisal of Local Horse Breeds of Meat-and-Milk Production (Ministry of Agriculture of the Republic of Kazakhstan, 2020) for most indicators, as well as in exterior quality (Table 4).

As evidenced in Table 4, it can be seen that the breeding stallions exceed the Class I standard in body measurements by: 1.4 cm in height at the withers, 2.6 cm in oblique body length, 2.8 cm in chest girth, 1.1 cm in metacarpus girth, and they surpass the standard in live weight by 25.0 kg (5.3%).

Table 3: Body measurements and live weight of adult stallions and mares from the Zaman 55-88 line

Indicators	Stallions				Mares					
	n=5			Standard I class	n=51			Standard I class		
	$\bar{X} \pm m$	$\bar{x}$	σ		C_v	$\bar{X} \pm m$	$\bar{x}$		σ	C_v
Height at withers (cm)	146.0± 0.32		0.71	0.49	144	143.9±0.41		1.12	0.78	142
Oblique body length (cm)	153.4± 0.51		1.14	0.74	150	151.2±0.49		1.49	0.98	148
Chest girth (cm)	183.6± 0.56		1.25	0.68	180	181.7±0.50		1.57	0.86	179
Metacarpus girth (cm)	20.9 ± 0.19		0.42	2.01	19.5	19.5 ±0.17		0.47	2.41	19.0
Live weight, kg	504.6± 5.31		11.90	2.36	470	478.6±3.89		17.73	3.70	450
Massiveness index	162.2		-	-	157.7	160.6		-	-	157.3

$\bar{X}$ – arithmetic mean, m – standard error of the mean (SEM), σ – standard deviation, C_v – coefficient of variation.

Table 4: Body measurements and live weight of stud stallions and mares from the Bakai 71-89 line

Indicators	Stallions				Mares					
	n=5			Standard I class	n=51			Standard I class		
	$\bar{X} \pm m$	$\bar{x}$	σ		C_v	$\bar{X} \pm m$	$\bar{x}$		σ	C_v
Height at withers (cm)	145.4± 0.22		0.50	0.34	144	143.1±0.38		1.08	0.75	142
Oblique body length (cm)	152.6± 0.39		0.87	0.57	150	150.3± 0.45		1.46	0.97	148
Chest girth (cm)	182.8± 0.58		1.30	0.71	180	180.4± 0.52		1.52	0.84	179
Metacarpus girth (cm)	20.6± 0.10		0.22	1.07	19.5	19.5± 0.16		0.44	2.36	19.0
Live weight (kg)	495.0± 2.73		6.12	1.24	470	469.7±2.68		16.57	3.53	450
Massiveness index	161.2		-	-	157.7	160.3		-	-	157.3

The mares exceed the standard by: 1.1 cm in height at the withers, 2.3 cm in oblique body length, 1.4 cm in chest girth, 0.5 cm in metacarpus girth, and their live weight exceeds the standard by 19.7 kg (1.0%). The most stable variability results (C_v) among breeding stallions were observed for: height at the withers: 0.34, oblique body length: 0.57, chest girth: 0.71, and for mares: 0.75, 0.97, and 0.84, respectively.

Higher variability was found among stallions for: metacarpus girth (1.07), live weight (1.24), and among mares: 2.36 and 3.53, respectively. From this, it follows that when selecting horses, priority should be given to selecting based on live weight and bone strength (metacarpus girth), and only afterward based on other measurements.

The LCORL (ligand-dependent nuclear receptor corepressor-like) gene is located on chromosome 3 in horses and has been identified as a significant candidate gene influencing body size traits. Genome-wide association studies (GWAS) have pinpointed a major quantitative trait locus (QTL) near the LCORL gene associated with withers height in various horse breeds, including Hanoverian and German Warmblood horses (Lindtke *et al.*, 2024).

In cattle, polymorphisms within the LCORL gene have been linked to growth and body size traits. For instance, studies have demonstrated associations between LCORL variants and average daily gain, feed intake, and carcass weight in beef cattle (Akanno *et al.*, 2018; Bouwman *et al.*, 2018; Sahana *et al.*, 2015). These findings suggest a conserved role of LCORL across species in regulating growth-related traits.

Research on the Kazakh Mugalzhar horse breed has indicated that the LCORL gene may influence growth and development, potentially serving as a molecular marker to enhance breeding programs. However, specific studies focusing on this breed are limited, and further research is needed to elucidate the gene's role in this context (Kabylbekova *et al.*, 2023).

Based on the research findings mentioned above, it can be concluded that the LCORL gene plays a significant role in the development of horse breeds and in improving their productivity. In this study, we employed the SNP genetic analysis method to investigate mutational changes in the gene sequences of the LCORL gene using DNA samples extracted from the hair follicles of the Mugalzhar horse breed. Furthermore, we analyzed the association between the identified genotypes and qualitative traits.

Table 5: Genotypic and allelic frequency of the LCORL gene in Mugalzhar horse breed

SNP	Number	Genotype Frequency			Allelic Frequency		X^2	PIC	Ne
g.226 C/T	52	CC	CT	TT	C	T	0.6490	0.3739	1.1944
		0.2667	0.4000	0.3333	0.4667	0.5333			
		(n=7)	(n=15)	(n=9)					

X^2 = chi-square (used for Hardy–Weinberg equilibrium testing, with critical values $\chi^2_{0.05} = 5.991$ and $\chi^2_{0.01} = 9.21$); PIC = polymorphic information content; Ne = effective allele number.

Table 6: Association of LCORL gene with body weight and measurement traits

Genotype	Wither Height (cm)	Diagonal Body Length (cm)	Girth Measurement (cm)	Metacarpus Girth (cm)	Body Weight (kg)
CC	141.5±4.59 ^a	149.5±2.44 ^a	178.5±2.77 ^a	18.0±1.06 ^a	453.6±3.29 ^a
CT	149.6±1.54 ^c	152.17±3.04 ^b	181.33±1.37 ^b	20.2±1.20 ^b	462.6±3.55 ^b
TT	146.2±1.39 ^b	148.9±2.51 ^a	178.3±3.74 ^a	19.1±1.13 ^b	461.6±3.94 ^b
p-value	0.0001	0.021	0.026	0.001	0.0001

Means within a row with different superscript letters (a, b, c) differ significantly ($P < 0.05$)

Our results indicated that among the genotypes of the g.226 C/T SNP in the coding region of the LCORL gene, the CT genotype had the highest frequency (Table 5). Furthermore, analysis of the association between the CT genotype and body measurements in Mugalzhar horses revealed significant correlations with traits such as withers height, diagonal body length, chest girth, metacarpus girth, and body weight (Table 6).

Table 6 presents the mean values of the main morphometric parameters and body weight of Mugalzhar horses for three genotypes (CC, CT, TT). The values are presented with standard errors ($\pm$), and significance levels (P-values) are also indicated to assess the statistical significance of differences between groups.

Differences between means were assessed using one-way ANOVA followed by Tukey's post hoc test. Means within a row marked with different superscript letters (a, b, c) are significantly different at $P < 0.05$.

In the analysis of the data presented in Table 6, a significant association between genotype and key morphometric parameters, as well as body weight, was established. Horses carrying the CT genotype demonstrated the highest mean withers height (149.6 cm), which was significantly greater than that observed in individuals with the CC (141.5 cm) and TT (146.2 cm) genotypes ($P=0.0001$). This finding indicates a pronounced effect of the CT genotype on increased stature.

Regarding oblique body length, the mean value for the CT genotype was 152.17 cm, which was statistically significantly higher compared to both the CC (149.5 cm) and TT (148.9 cm) genotypes ($P=0.021$). Notably, no significant differences were detected between the CC and TT genotypes for this parameter.

Analysis of chest girth revealed that animals with the CT genotype had a mean value of 181.33 cm, which was significantly greater than those of the CC (178.5 cm) and TT (178.3 cm) genotypes ($P=0.026$), suggesting that the CT genotype is associated with increased body volume.

For metacarpus girth, the CT and TT genotypes exhibited mean values of 20.2 cm and 19.1 cm, respectively, while the CC genotype had a mean of 18.0 cm. The differences among genotypes were statistically significant ($P=0.001$), with the CT genotype showing the greatest contribution to increased metacarpus girth.

In terms of body weight, both CT and TT genotypes were characterized by higher mean values (462.6 kg and 461.6 kg, respectively) compared to the CC genotype (453.6 kg), with the differences reaching statistical significance ($P=0.0001$). The CT genotype, in particular, was associated with greater body weight.

In summary, the CT genotype exhibited an advantage in most morphometric traits and body weight, while the CC genotype was characterized by the lowest values for these parameters. The TT genotype occupied an intermediate position, being closer to the CT genotype in some traits and to the CC genotype in others. All observed differences between genotypes were statistically significant, underscoring the influence of genotype on the phenotypic expression of key morphometric and productive characteristics in the studied horse population.

The meat productivity of horses from the Bakai 71-89 line is quite high. Thus, when slaughtering a 2.5-year-old stallion in November with a live weight of 386 kg, a carcass weight of 219 kg was obtained. The dressing percentage was 56.7% (Iskhan *et al.*, 2019). The mares from the Bakai line are distinguished by high fertility, producing 85–90 foals per 100 mares annually. Their daily milk production averages 14.21 liters, and total milk yield over 105 days of lactation is 1492.05 liters.

Correlational dependencies between traits that ensure the productivity of farm animals are of great importance in breeding work. When selecting for an individual trait, changes may occur in the variability of other traits due to genetic and phenotypic correlations between them. In some cases, directional selection can lead to enhancement, reduction, or stabilization of variability in correlated traits, depending on the nature of their interrelationship.

High live weight and meat productivity of Mugalzhar horses are determined by the following main traits: height at the withers, oblique body length, chest girth, Metacarpus girth, exterior, type and massiveness of body conformation. When studying the correlation relationships between traits in mares of different genealogical lines, certain differences were identified (Table 7).

Table 7 demonstrates that the strongest and statistically significant correlations within both lines are observed between live weight and metacarpus girth ($r = 0.485$ for Zaman, $r = 0.461$ for Bakai) and between live weight and chest girth ($r = 0.462$ for Zaman, $r = 0.458$ for Bakai), with confidence levels of 0.999 ($P \approx 0.001$). Correlations between live weight and oblique body length are moderate and at the threshold of significance ($r = 0.331$ for Zaman, $r = 0.327$ for Bakai; confidence level 0.95, $p \approx 0.05$). Correlations with withers height are weak and not statistically significant (confidence level 0.9, $p \approx 0.1$). Correlations are considered statistically significant at $p < 0.05$ (confidence level > 0.95).

The heritability of live weight in Mugalzhar horses was determined by comparing the parental and offspring generations. The research material consisted of horses born in 2019, 2020, 2021, and 2022. All horses were weighed at 2.5 years old during their evaluation, and their live weight was compared with that of their parents. We selected three groups of horses, and the heritability coefficient was calculated by analysis of variance (Zhao *et al.*, 2023): Group I included fully mature mares and their daughters, Group II included fully mature mares and their 2.5-year-old daughters, Group III included fully mature sires and their 2.5-year-old sons (Table 8).

Table 7: Correlation coefficients between body measurements and live weight in mares of different lines

Correlated Features	Correlation Coefficient ($r \pm m_r$)	t-statistic	Confidence Level (p)
Zaman Line			
Height at withers - live weight	0.203±0.137	1.48	0.90
Oblique body length - live weight	0.331 ± 0.132	2.51	0.95
Chest girth - live weight	0.462±0.124	3.71	0.999
Metacarpus girth - live weight	0.485 ± 0.122	3.93	0.999
Bakai line			
Height at withers - live weight	0.216±0.141	1.55	0.90
Oblique body length - live weight	0.327 ± 0.136	2.41	0.95
Chest girth - live weight	0.458±0.128	3.56	0.999
Metacarpus girth - live weight	0.461 ± 0.127	3.58	0.999

Table 8: Heritability coefficient of live weight in Mugalzhar horses

Groups	Age, years	n	Live weight, kg	$C_v, \%$	h^2	t-statistic
I	mother	5 years and older	140	458.3 ± 3.75	3.32	-
	daughter	5 years and older	140	472.6 ± 4.01	3.57	0.45
II	mother	5 years and older	95	451.8 ± 3.62	3.12	-
	daughter	2.5 years	95	385.7 ± 3.78	3.25	0.51
III	father	7 years	12	488.4 ± 3.26	1.27	-
	son	2.5 years	47	408.9 ± 3.17	2.34	0.63

Table 9: Age repeatability of measurements and live weight in linear fillies of the Mugalzhar breed

Measurements (cm) and live weight (kg)	Indicators	Age of foals (months)				
		6	12	18	24	30
Zaman line (n = 38)						
Height at withers	$\bar{x} \pm m_{\bar{x}}$	120.4 ± 0.37	126.2± 0.41	136.5± 0.39	138.9± 0.43	140.7± 0.46
	C_v	1.32	1.37	1.24	1.31	1.37
	r	-	0.567	0.873	0.863	0.881
Oblique body length	$\bar{x} \pm m_{\bar{x}}$	113.7 ± 0.39	125.7± 0.45	138.2± 0.41	140.2± 0.47	144.2± 0.50
	C_v	1.53	1.57	1.24	1.31	1.54
	r	-	0.628	0.873	0.863	0.801
Chest girth	$\bar{x} \pm m_{\bar{x}}$	124.5 ± 0.51	140.2 ± 0.56	161.6 ± 0.53	162.8 ± 0.59	164.5 ± 0.62
	C_v	1.62	1.60	1.45	1.63	1.67
	r	-	0.781	0.706	0.737	0.839
Metacarpus girth	$\bar{x} \pm m_{\bar{x}}$	15.5 ± 0.10	16.0 ± 0.09	16.5 ± 0.08	17.5 ± 0.10	18.0 ± 0.11
	C_v	2.72	2.37	2.28	2.42	2.53
	r	-	0.874	0.849	0.509	0.406
Live weight	$\bar{x} \pm m_x$	182.8 ± 1.31	225.7 ± 1.75	312.2 ± 1.68	351.4 ± 2.02	388.6 ± 2.35
	C_v	2.91	3.23	2.25	2.51	2.53
	r	-	0.982	0.944	0.862	0.901
Bakaii line (n = 35)						
Height at withers	$\bar{x} \pm m_{\bar{x}}$	121.2 ± 0.35	127.4 ± 0.38	139.4 ± 0.41	140.5 ± 0.45	141.6 ± 0.51
	C_v	1.52	1.70	1.72	1.80	2.03
	r	-	0.422	0.780	0.763	0.806
Oblique body length	$\bar{x} \pm m_x$	114.5 ± 0.38	126.2 ± 0.42	138.6 ± 0.39	141.3 ± 0.37	144.8 ± 0.44
	C_v	1.86	1.95	1.67	1.48	1.70
	r	-	0.496	0.768	0.734	0.763
Chest girth	$\bar{x} \pm m_x$	125.2 ± 0.42	141.5 ± 0.45	162.8 ± 0.39	163.4 ± 0.40	165.1 ± 0.54
	C_v	1.87	1.75	1.41	1.38	1.79
	r	-	0.691	0.638	0.605	0.788
Metacarpus girth	$\bar{x} \pm m_x$	15.5 ± 0.08	16.0 ± 0.09	17.0 ± 0.08	17.5 ± 0.11	18.5 ± 0.10
	C_v	2.88	3.18	2.74	3.54	3.04
	r	-	0.874	0.849	0.509	0.406
Live weight	$\bar{x} \pm m_x$	183.6 ± 1.42	227.6 ± 1.58	319.5 ± 1.76	355.7 ± 2.17	391.2 ± 2.53
	C_v	4.43	3.96	3.62	3.83	3.79
	r	-	0.886	0.853	0.832	0.861

Table 8 clearly shows that, in Group I (mature mares and their daughters), the heritability coefficient was 0.45. It should be noted that over five years of rotation, the live weight of mature daughters increased by 14.3 kg compared to the live weight of the mature mares. In Group II (mature mares and their 2.5-year-old daughters), the heritability coefficient was 0.51. In Group III (mature sires and their 2.5-year-old sons), the heritability coefficient reached 0.63 with a high level of statistical significance ($P > 0.999$). An increase in heritability values was observed with a decrease in trait

variability: when $cv = 3.57$, $h^2 = 0.45$, and with $C_v = 3.25$ and 2.34 , $h^2 = 0.51-0.63$. This provides a guarantee of increasing the live weight of the offspring as a result of targeted selection.

In Table 8, dashes (–) in the t-statistic column indicate that the statistical significance was calculated only for one of the groups being compared in each pair.

In Group I, daughters were compared with their mothers; therefore, the t-statistic value (2.60) is given only for the daughters, while a dash is shown for the mothers.

In Group II, the comparison was made between mothers and their 2.5-year-old daughters; t-statistic (12.64) was calculated for the mothers, and a dash appears for the daughters.

In Group III, fathers were compared with their 2.5-year-old sons; therefore, t-statistic (17.47) is provided only for the fathers, while a dash is shown for the sons.

The determination of age repeatability of live weight in horses was carried out by comparing the body weight of young animals at early and later ages (Table 9).

When studying the dynamics of productivity of linear horses depending on age, it was found that horses of the Bakai line are larger, with a particularly noticeable trend of higher live weight and chest girth measurements compared to the fillies of the Zaman line (Iskhan *et al.*, 2024).

Overall, there is a high positive correlation between measurements and live weight of animals at 6 months of age and at older ages in both lines. Therefore, selection can already be carried out at an earlier age, upon reaching 12 months.

In herd horse breeding, the most convenient method for evaluating stallions is by the quality class of their offspring. The evaluation of sires by offspring quality is

carried out across the entire progeny, with at least 10 animals being assessed. Each animal is evaluated using a 10-point system; then the points are summed up, divided by the number of offspring, and the result is rounded to the nearest whole point.

Young stock that have not reached 2.5 years of age are evaluated visually. The possible class and point score of each foal are determined presumptively, taking into account their type, conformation details, and overall development (Table 10).

As detailed in Table 10, during the evaluation of stallions by the quality of their offspring in the Zaman line, one stallion, Zolotnik 20-15, was found to be neutral, while the other four stallions were classified as improvers. In the Bakai line, similarly, out of five evaluated stallions, one stallion, Brest 7-13, was neutral, while the other four stallions were classified as improvers.

Thus, the method we applied for evaluating the quality of offspring and the breeding value of producers from both lines makes it possible to correctly assess the genotype of stallions and obtain more complete information about the significance of each producer in the herds.

Table 10: Evaluation of stud stallions of different lines according to the quality of their offspring

Stallion's Name	2.5 year old young animals rates 2020, 2021, 2022				
	Sex	n	Live weight (kg)	Score	Evaluation Results
Zaman Line					
Zumrat 75-12	colt	13	409.7 ± 2.76	8	improver
	filly	17	385.3 ± 1.98	8	
Zator 11-14	colt	15	411.8 ± 2.03	9	improver
	filly	18	398.8 ± 2.61	8	
Zolotnik 20-15	colt	11	375.6 ± 2.42	6	neutral
	filly	14	354.3 ± 1.98	6	
Zmeevik 3-14	colt	16	405.9 ± 2.45	8	improver
	filly	13	386.7 ± 2.97	8	
Zdezdochet 7-13	colt	12	413.5 ± 2.72	9	improver
	filly	11	391.2 ± 2.36	9	
Bakai Line					
Batyl 63-15	colt	15	420.7 ± 2.31	9	improver
	filly	14	398.2 ± 2.02	9	
Bestay 24-15	colt	12	418.6 ± 2.84	9	improver
	filly	16	395.3 ± 2.65	9	
Brest 7-13	colt	13	381.2 ± 2.72	6	neutral
	filly	15	362.4 ± 2.36	6	
Biser 76-15	colt	12	422.8 ± 2.02	10	improver
	filly	17	396.7 ± 1.98	9	
Bufer 66-15	colt	14	419.8 ± 2.27	9	improver
	filly	11	389.5 ± 2.19	8	

Conclusion

A new Irtysh type of the Mugalzhar horse breed was developed under year-round pasture management in Northeastern Kazakhstan, demonstrating excellent adaptation and significantly higher live weight and body

measurements compared to the original group. High trait variability and heritability coefficients (0.45–0.63) indicate strong potential for further genetic improvement, with early-age repeatability (0.79–0.98) enabling effective selection from 6 months. SNP analysis of the LCORL gene revealed the CT genotype is significantly

associated with increased body size and weight, supporting its use as a molecular marker for selection. Enhanced meat productivity provides clear economic benefits for horse breeding.

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Author's Contributions

Akimbekov Amin: Conceptualization, Formal analysis, Data curation.

Uskenov Rashit: Writing - original draft (abstract and discussion), Visualization.

Nurgulsim Kaster: Supervision, Writing - review & editing, Project administration.

Otebayev Zhassulan: Investigation (practical implementation of the study), Data acquisition, Literature analysis and integration, Critical revision of the manuscript for important intellectual content.

Orynaliev Korgan: Methodology, Data interpretation (Formal analysis).

Iskhan Kairat: Writing - original draft, Project administration, Supervision.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved. All experimental studies involving laboratory and agricultural animals will be carried out in strict compliance with ethical standards and principles of humane treatment, as well as the rules of biological safety and the ethical principles of the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (Strasbourg, 1987) and the OIE Terrestrial Animal Health Code (Paris, 2017).

Conflicts of Interest

There are no conflicts of interest to declare.

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