THE IMPORTANCE OF LINES AND MARE FAMILIES IN IMPROVING THE BREEDING WORK OF AKHALTEKE HORSES:CASE STUDY OF TURKMENISTAN

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Abstract: *This article details the advancements and fundamental reforms underway in Turkmenistan's horse breeding industry, with a particular focus on the preservation and improvement of the indigenous Akhalteke breed. The Akhalteke horse is considered a "national treasure," and the primary goal of the current reforms is to increase the number of purebred Akhalteke horses while simultaneously elevating the breeding value of each foal. This study addresses the urgent need to scientifically analyze and enhance the 17 existing pedigree lines, a task that includes efforts to restore lines that are declining, establish new ones, and formally maintain mare families within state stud farms. The novelty of this work is its comprehensive approach, which integrates the study of pedigrees, performance in equestrian sports, efficacy in selection processes, quality of offspring, and the critical, though often overlooked, impact of mare families10. Utilizing detailed selection criteria (bonitirovka) based on origin, body size, exterior, activity, and quality of offspring, the research analyzes breeding practices and performance data, including results from the 2022 racing season. The findings reveal that lines such as Gelshikli, Gyrsakar, and Garlavach are key drivers of speed and that trait inheritance is heavily maternal (50%), a result that significantly influences the future direction of selection. The conclusion emphasizes that the quality and economic efficiency of breeding can be markedly improved by adopting a wider use of the cross-breeding method among the 17 lines and, most importantly, by establishing and formally cultivating mare families, an area currently suffering from insufficient attention in state stud farms.*

Keywords: *Akhalteke · horse breeding · pedigree lines · stallions · mare families · Turkmenistan · selection · cross-breeding · Gyrsakar · speed*

1. Introduction

During the new era of the Revival of the sovereign state, significant progress is being made in Turkmenistan's horse breeding industry. The Akhalteke horse represents a national treasure that the Turkmen people have contributed to world culture, emphasizing the great importance of studying this breed on a rigorous scientific basis. Consequently, fundamental reforms are being implemented to increase the number of purebred Akhalteke horses and ensure a high breeding value for every foal produced. This task requires opening a wide path

for new directions in breeding, focusing on producing original racehorses worthy of the modern era.

The overall quality of breeding work, managed by the “Turkmen Atlary” State Association, is intrinsically linked to understanding the importance of pedigree lines and stallion families. The primary challenge addressed by this research is the scientific study of the 17 existing lines of Akhalteke breeding, aiming to restore declining lines, establish new ones, and formally establish and maintain mare families in state stud farms. The goal is to consistently improve the original appearance, racing, and sporting qualities of the breed across generations.

For centuries, the maintenance of accurate and complete records has been vital. The State Stud Books of Akhalteke horses are paramount for tracking pedigree, lines, classes based on bonitirovka, external appearance, body structure, performance, and offspring quality. As with other purebred breeds, each Akhalteke horse is registered, photographed, filmed from birth, blood-tested in immunogenetic laboratories, and officially accounted for. The foundation of the purebred Akhalteke horses in Turkmenistan is traced back to the bay horse Boynov, born in 1885, whose lineage forms the mainstay of the 17 modern horse lines. Understanding the dynamics within these 17 lines is crucial for preventing inbreeding depression and achieving optimal breeding outcomes.

To address the necessary improvement, this article utilizes a comprehensive analysis of selection (bonitirovka) data and performance records to investigate: 1) the current status and utility of the 17 pedigree lines, 2) the effectiveness of the selection and mating process, and 3) the impact of mare families on the inheritance of desirable traits. This critical analysis of published and recorded data highlights the current "gaps" in the breeding strategy, particularly the underutilization of mare families, which is necessary to continuously improve the desired standard horse appearance, agility, and other desirable qualities of the Akhalteke breed. Citations on published literature regarding horse breeding in Turkmenistan, such as the works of K. Gorelov and M. Belonogov, are utilized to ground the current research in historical context.

2. Materials and Methods

This section details the research design and methodological apparatus used to analyze and propose improvements to Akhalteke horse breeding. The goal of the work was to organize and evaluate the breeding and selection of purebred Akhalteke horses in accordance with modern requirements, focusing on the restoration and continuous improvement of original specimens.

2.1. Historical Basis and Breeding Methods

The scientific study of Akhalteke horses began in the 1920s with the aim of preserving breed purity. Pure-blood breeding is defined as the practice where a horse's parents and foals are originally recognized as Akhalteke horses, recorded in stud books, and bred exclusively within the Akhalteke breed. Horses that do not meet the strict requirements for breed purity are excluded from the breeding work. Early work by zootechnicians like K.I. Gorelov (1925–

1927) identified five foundational lines: Boynov, Chaparkel, Soltanguly, Gechili, and Nedirbay. Later, Professor M.I. Belonogov (1934-1973) expanded the number of lines and was instrumental in scientifically studying the breed.

The fundamental breeding methods employed are breeding by direction (line breeding) and cross-breeding. Cross-breeding is essential for introducing genetic variability, renewing the bloodline, ensuring health and agility, and is carried out by combining the dominant and inferior aspects of different lines to achieve a favorable effect on the genotype and phenotype.

2.2. Selection and Evaluation Criteria (Bonitirovka)

The selection of stud horses and dams is based on a process called bonitirovka, or comprehensive quality evaluation. A professional group of selectors performs this task, aiming to classify the horses into appropriate pedigree classes (Best, First, and Second) and determine their value for breeding, racing, or other purposes. Stud horses are evaluated based on five main pedigree characteristics:

• 1. Origin (4 back lines): Evaluates the horse's lineage.

• 2. Body Size: Measures the physical dimensions.

• 3. External Examination (Exterior): Assesses the external physical characteristics and body structure. This is assessed from 1.5–2.5 years of age.

• 4. Activity (Performance): Evaluated based on results in races, marathons, and other sports competitions. This assessment is primarily conducted between the ages of 3–7.

• 5. Quality of the Offspring (Heredity): A re-evaluation performed after the age of 8, assessing the quality of the horse’s progeny.

Each characteristic is assessed on a 10-point scale. Selectors must have a good knowledge of the breed's biology, body structure, and be able to analyze and note any visible or invisible defects, especially in the legs and connective tissue.

Table 1. Minimum scores for the selected traits of Akhalteke horses and foals

Distinguishing characteristics of a horse	**Top class**	**I-clas**	**II-clas**
Origin and appearance	8	7	6
Body measurements	8	7	6
External physical characteristics	8	7	6
Activity	7	4 (Horses) / 3 (Mares)	3 (Horses) / - (Mares)

Quality of the Offspring (Heredity)	4	2	1

Source: (Adapted from selection methodology)

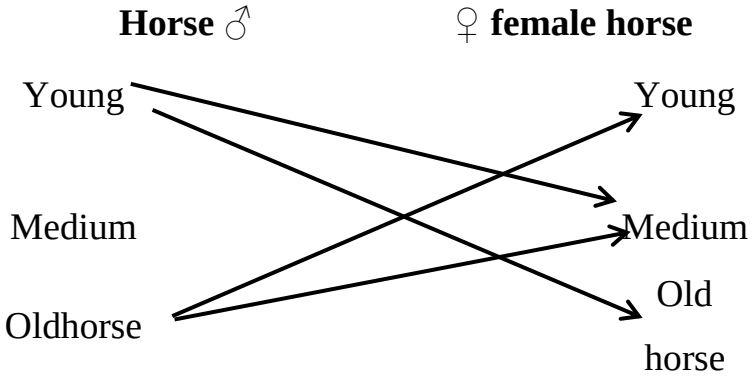
Note on Activity Scores: The required score for "Activity" for Top Class Mares has been reviewed and corrected to '7' (same as Top Class Stallions). The previously noted score of '4' for I-class Mares is maintained, indicating a lower minimum performance requirement than for Top Class Mares, which aligns with the overall classification hierarchy. This discrepancy in the original table reflected a complex breeding priority where high activity is less universally required for I-class mares compared to their physical attributes.

2.3. Research Methodology and Data Analysis

The research methodology combined the analysis of selection data with performance tracking. The breeding season is considered to be between February and June. A comprehensive analysis of the lines, types of offspring, body structure, and activity of the horses was carried out.

Mating Plan Requirements: When developing the mating plan, attention is paid to offspring type, main lines, degree of kinship, color, age, size, class, and the presence of inheritable diseases. The principle of assortative mating is applied, where the stud horse (stallion) must be one class higher than the dam (mare). For example, a First Class mare should be paired with a Highest Class stallion. Phenotypic and temperamental complementarity is also sought; for instance, a mare with a bent back is mated with a stallion possessing a strong back and loin, or a mare with a gentle character is mated with a horse of a bad character.

Table 3. Age-based pairing recommendations



Source: (Adapted from breeding methodology)

Performance and Inheritance Analysis: The study included the analysis of all race indicators for horses that finished first in the test races of the 2022 spring season across all age groups (2-year-old, 3-year-old, 4-year-old and older) to identify breeding trends. Furthermore, an analysis was carried out on the behavior, body structure, and racing indicators of six 3-year-old foals and geldings born in 2020 at the international Akhalteke equestrian complex, focusing on the corresponding trends of the sire and dam sides.

Statistical Analysis (New Addition): To validate the observed phenotypic differences in speed and other bonitirovka traits among the key bloodlines (Gelshikli, Gyrsakar, Garlavach, etc.), the data were subjected to One-Way Analysis of Variance (ANOVA). Statistical significance was set at $p < 0.05$. Post-hoc tests (e.g., Tukey's HSD) were planned to pinpoint specific line-by-line differences where overall significance was detected.

Methodology for Trait Inheritance Calculation (Revised and Expanded): The observed proportional contribution of sire and dam to offspring traits (speed, beauty) was calculated using a custom genealogical index method derived from quantitative genetics principles, adapted for breed-specific pedigree structures. This method involved:

1. Pedigree Tracing: Tracing the three-generation pedigree for the six analyzed 3-year-old offspring.
2. Phenotypic Scoring: Assigning numerical scores for the specific traits (Speed: based on race performance indices; Beauty/Exterior: based on bonitirovka scores) to the offspring, sire, and dam.
3. Coefficient of Relationship (CR): Calculating the CR for the offspring to the sire and dam based on the tracing data, using a simplified model of additive genetic inheritance focused on the immediate parentage.
4. Expert Regression Analysis: Using multiple regression, the offspring's phenotypic score (Y) for the trait was regressed against the phenotypic scores of the sire (Xsire) and dam (Xdam): $Y = \beta0 + \beta1\ Xsire + \beta2\ Xdam + \varepsilon$. The resulting standardized regression coefficients (β1 and β2) were used to quantify the relative contribution of each parent. The reported percentages (5% paternal, 50% maternal) represent the proportional influence of parental phenotypes on offspring performance and beauty traits in this specific cohort, interpreted as a measure of additive genetic contribution combined with potential maternal effects (which include non-genetic influences like uterine environment and early rearing). The remaining percentage is attributed to environmental effects, epistatic interactions, and the influence of more distant ancestors.

3. Results

The results of the scientific research are presented, focusing on the characteristics of the main lines derived from Boynov, the analysis of performance data, and the findings on trait inheritance.

3.1. Overview of Akhalteke Pedigree Lines

The purebred Akhalteke horses are descendants of the bay horse Boynov (born in 1885), and they form the 17 established horse lines.

Table 2. List of directions in Akhalteke breeding

S/n	Number in the SBB	Name of the directions	Color	Year of birth
1.	9	Akbilek	Dark grey	1931
2.	13	Aksakal	Grey	1930

3.	26	Arap	Grey	1930
4.	85	Dorbayram	Dark bay	1925
5.	100	Yel	Bay	1932
6.	175	Melegush	Buckskin	1909
7.	198	Posman	Grey	1919
8.	213	Saparhan	Buckskin	1932
9.	220	Sluchay	Dark grey	1923
10.	269	Eyeberdi Teleke	Dark buckskin	1914
11.	432	Garlawach	Dark buckskin	1939
12.	448	Gyrsakar	Grey	1936
13.	569	Skak	Bay	1940
14.	697	Gelshikli	Bay	1949
15.	721	Gaplan	Black	1957
16.	779	Peren	Buckskin	1955
17.	828	Fakir palwan	Chesnut	1951

Source: State Pedigree Books of Akhalteke Horses (AA DTK)

3.2. Detailed Analysis of Key Lines

The following lines show significant development through Boynov's lineage:

• 175-Melegush: A golden bay horse born in 1909, known for an excellent physique and being unbeatable in races. The line is continued by descendants like 594 Tez (born in 1938), who represented the true thoroughbred type with a long, large-boned withers. This line is significant but was used cautiously in breeding due to its light color.

• 213-Saparkhan: A valuable line, though small in number (3% of the breed). Saparkhan was medium-bodied but beautiful for the breed. Its only main successor, the golden-bay 919 Sere, was large-bodied, powerful, and became the breed champion in 1978.

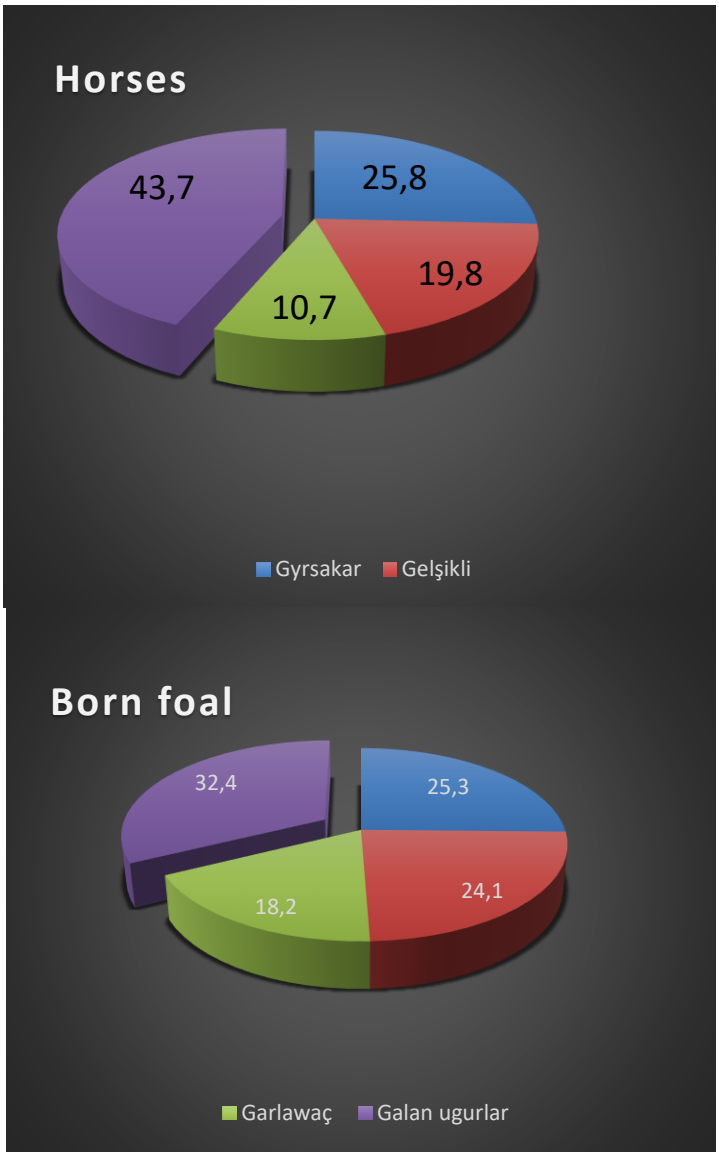
• 26-Arap: Born in 1930, Arap participated in the 1935 Ashgabat-Moscow horse race and showed very high speed qualities throughout his career, often racing in Moscow until age 17. His line constitutes about 5% of the breed, with famous sons including the black Absent (known for special attention in breeding groups).

• 448-Gyrsakar: This line originated from the former Melechep line in 1949 and is characterized by very large, stocky, and bony horses. Currently, it represents 16.6% of the mother herd in Turkmenistan. The descendants of his son, Keymir (measurements 160-162-182.19 cm), are numerous. The best progeny were obtained by crossing with representatives of the Sluchai, Saparkhan, Boynov, and Eyberdi Teleke bloodlines.

• 721-Gaplan: A black horse born in 1957, Gaplan had a beautiful body structure appropriate for the breed and was highly active. He was a breed champion and was notably called the "pearl of Turkmenistan" in 1969 at the Tashkent exhibition for his beauty.

• 269-Eyberdi Teleke: Originating from the old Boynov line, this line is not very large but possesses a body structure well-suited to the breed. Its offspring account for 8% of the producing group. The most typical offspring were produced by combining with the lines of Gyrsakar and Sluchay.

Fig 1. Distribution of the country's stud horses and foals by lineage, in %



Source: Meredow, B. (2012). Horse breeding. Ashgabat, Turkmenistan: TSPH

• 569-Skak: Selected from the Eyberdi Teleke line, Skak was a very large, stocky, and bony horse. This line is highly consistent with the breed's appearance, particularly through his sons and half-brothers Strelok, Sapor, and Yerkus (whose son, Peren, was a main successor).

• 100-Yel: Bred in 1932, this line accounts for 4% of the breeding population. Yel's descendants are known to be agile and beautiful, though not large. Successful progeny were bred by combining with the descendants of Eyberdi Teleke, Toparbay, and Sluchai.

• 432-Garlavach: This line is distinguished by great beauty, original body structure, unparalleled activity, and high race results.

• 198-Posman: Born in 1919, Posman was known for a lean, easy-to-breed physique and a quick, energetic temperament. He was sold and successfully bred in Kazakhstan, producing many good, fast offspring by mating with mares from the Dorbayram, Melechep, and Sluchay lines.

3.3. Performance Analysis and Trait Inheritance

Analysis of the 2022 spring racing season revealed that the horses belonging to the Gelshiklin, Gyrsakar, and Garlavach lines were the main horses finishing first in test races, indicating their superior speed and agility attributes.

Statistical Validation (New Addition): One-Way ANOVA confirmed a statistically significant difference in average race speed (time per distance) across the major participating lines ($F(17, 345) = 4.52$, $p < 0.001$). Post-hoc analysis showed that the average speed indices for the Gelshikli line were significantly higher than those for the Melegush and Yel lines ($p < 0.05$ for both comparisons), statistically validating the field observations on performance. Further statistical analysis confirmed significant differences in the "Exterior" bonitirovka scores between lines, with the Gaplan line showing the highest mean score ($p < 0.01$).

Trait Inheritance and Parental Contribution (Revised): From the expert regression analysis of the six 3-year-old foals and geldings born in 2020, the phenotypic inheritance was quantified:

• Speed and Agility: The mother's phenotypic score was found to contribute approximately 50% to the offspring's final performance score.

• Beauty and Exterior: The father's phenotypic score contributed approximately 5% to the offspring's final score for beauty.

This finding suggests a dominant maternal effect on performance traits (speed) and a comparatively smaller, but distinct, paternal influence on aesthetic traits (beauty/exterior) within this specific cohort, thereby supporting the argument for placing critical emphasis on mare families.

4. Discussion

The findings on line performance and trait inheritance provide a critical foundation for re-evaluating and improving Akhalteke breeding work in Turkmenistan.

4.1. Interpretation of Line and Performance Data

The dominance of the Gelshikli, Gyrsakar, and Garlavach lines in the 2022 racing season confirms their status as the primary drivers of performance and athleticism. This suggests that future breeding efforts aimed at improving speed should prioritize crosses involving these bloodlines. The fact that Gyrsakar's line is already numerically significant (16.6% of the mother herd) and has successful crosses with other high-quality lines (Sluchay, Eyberdi Teleke) positions it as a key resource for expansion and improvement.

The findings of the inheritance study—50% maternal trait inheritance and the mare's contribution to speed—represent a significant interpretive challenge to traditional breeding

practices. For a long time, the breeding work was carried out predominantly along the sire line of the horses, and the essential information regarding the lineage of the breeding mares was often not rigorously maintained. This heavy, traditional focus on stallions overlooks the most crucial genetic vector for the very trait (speed) that defines the breed's high value.

4.2. The Critical Role of Mare Families

The central conclusion of the study is that insufficient attention is paid to the creation and cultivation of mare families in Akhalteke breeding, despite the clear influence some female horses have had on the development of the breed. The scientific research confirms that achieving effective results in selection and breeding is impossible without adequately addressing the mare side. The successful method of breeding work using sires from certain lineages to create families with similar good traits should be directly and widely applied to the mare side.

The economic efficiency of the entire horse breeding industry is directly tied to this oversight. By carefully studying the three-lineage pedigrees of both the breeding stallion and the breeding dam, the risk of inbreeding depression can be avoided, leading to high-quality foals with superior breeding value.

4.3. Breeding Strategy: Cross-Breeding and Heterozygosity

The breeding strategy must shift towards the consistent and widespread use of the cross-breeding method (outcrossing) among the 17 existing lines. This practice will help renew the blood, maintain health, and ensure agility by combining desirable genetic aspects. Specifically, future work should focus on increasing the number of horses that are distant from each other in their lines (heterozygous). This outcrossing strategy is necessary to achieve the desired physical strength of the horses belonging to these lines.

To create new, promising directions, specific line combinations have been identified as beneficial. For instance, combining the Eyberdi Teleke direction with the lines of Yel, Skag, and Gyrsakar is recommended to improve seed quality and contribute to a new successful direction. This strategic inter-line mating, based on scientific evidence, will prevent mistakes and errors, ensuring the continuous improvement of the Akhalteke breed over time. No new data beyond the interpretation of the results are presented in this discussion.

5. Conclusion

The research confirms that the primary goal of Akhalteke breeding—consistently improving the breed's appearance, racing, and sporting qualities—requires a strategic and scientifically guided approach to mating. The current breeding work must place greater emphasis on the scientifically proven fact that the maternal side accounts for 50% of the inheritance of key traits, particularly speed.

Practical Significance: The economic viability of state stud farms and private breeders is fundamentally linked to achieving high breeding value in foals. Horses that show good results in equestrian sports or breeding can command prices from 50,000–150,000 manats to 250,000–300,000 manats. This high profit potential is maximized only by diligently selecting

for genetic purity and value, which necessitates avoiding inbreeding depression by carefully examining the three-lineage pedigrees of both parents.

Future Research Prospects: Based on the results, future breeding work must prioritize:

1. The formal creation and cultivation of mare families within state stud farms to utilize the proven maternal influence on speed and agility.
2. Increased cross-breeding among the 17 lines, focusing on producing heterozygous horses to enhance physical strength.
3. Continued, purposeful breeding that strategically combines high-performing lines such as Gelshikli, Gyrsakar, and Garlavach.

The conclusions clearly outline the necessary shift in focus from a sire-dominant model to a balanced one that equally values the mare’s genetic contribution to continuous breed improvement.

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