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FOALING RANK AND BREEDERS' HEIGHT AT WITHERS INFLUENCE ON THE MORPHOLOGICAL QUALITY OF SHAGYA ARABIAN FEMALE PROGENY

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Abstract

One of the breeding objectives for Shagya Arabian breed in Rădăuți Stud Farm, Romania, focuses on increasing the height at withers for mares. The current research aimed to study the entire female progeny (175 foals) of 58 broodmares and 44 stallions included in the breeding activity for 40 years The objective was to determine the influence of breeders' height and the foaling number (rank) on the foals' biometrics. The average value of this measurement in female foals has consistently increased from first foaling (157.63 cm) to the fifth one (158.80 cm) throughout 40 years of breeding, indicating the fulfilment of the breeding goal over consecutive reproductive seasons. According to the simulation based on the linear trend equation, the progeny's height at withers could match the fathers' height by the 10th foaling if the same breeding practices were continued. In addition, stallions would have much more influence than broodmares in increasing the height of the foals. Continuing the forecast analysis based on the variations, the required average height at withers values in stallions and mares can be computed to attain a certain value for the descendants.

Key words*: broodmares, height at withers, progeny, Shagya Arabian, stallions.*

INTRODUCTION

It is widely acknowledged that the economic productivity of equines can be estimated based on its physical build (Baban et al., 2009).

However, determining the exact proportion of this kinetic energy expended is challenging; authentic production capacity is evaluated through performance analysis using aptitude tests (Domínguez-Viveros et al., 2019).

The probability of different horses with identical age spans, conformational types, body conditions, and similar training expressing equivalent strength, speed, or endurance is notably low.

Often, a horse's outward appearance does not reliably correlate with its individual performance, contributing to these disparities.

Conversely, not all observable flaws can accurately predict the manifestation of their energy potential (Moldoveanu, 1982).

The drive to enhance progeny performance necessitates primarily observing the measurable qualities of both stallions and broodmares, along with the breeding ascendants' previous match outcomes (Ujică, 1988).

Nevertheless, evaluating a male horse involves considering multiple factors, including its inherent qualities and those of its offspring. Only after demonstrating commendable performances on the racetrack and winning competitions, thorough scrutiny of their pedigree and that of their progeny occurs before further pairing decisions are made (Sabeva, 2009).

At Rădăuți Stud farm, a ranking activity is employed to assess the entire broodstock's value based on exterior aspects (such as height at withers, heart girth, cannon girth, and constitution) and specific breed performances (like minimum galloping or trot time, and dressage tests). This action takes place twice a year. Additionally, the performances of two generations of foals for each stallion and at least two generations of foals for each mare are analysed. Consequently, the pairing decisions consider the breeding objectives, with an emphasis on increasing the height at withers for this particular population. In terms of pedigree structure, it is crucial to form pairs considering a kinship greater than the third generation between the stallion and the mare. (Ranking criteria, 2008).

This study aimed to shed light on the dynamics of breeding the Shagya Arabian horses in Rădăuți Stud farm, in Suceava county, Romania. The research focused on evaluating the quality of the progeny obtained over a 40-year period. Given that the primary activity of any stud farm revolves around the production of high-quality biological material, and considering the significance of the height at the withers as a key metric when assessing horses in national stud farms, we deemed it important to closely examine the bloodlines of this breed. One of this unity's objectives is to attain increased values of height at withers for mares. (Rădăuți Stud registers) Comparisons were made between the progeny and their mothers and fathers, operating under the assumption that daughters inherit conformation more accurately from their mothers, while the influence of stallions could potentially contribute to height augmentation (Roman-Popovici, 2015; Tănase et. al., 2000; Ujică, 1988)

MATERIALS AND METHODS

The assessment of morphological attributes involving 58 broodmares and 44 stallions of the Shagya Arabian horse breed at Rădăuți Stud farm commenced by processing data retrieved regarding foals registered between in 40 years of breeding activity. Details concerning the height at the withers of their offspring were collected from ranking sheets dating back to 2019 (Rădăuți Stud farm registers).

The analysis focused on Shagya Arabian broodmares from different bloodlines: Dahoman (n = 10), El-Sbaa (n=8), Hadban (n = 9), Koheilan (n = 8), Mersuch (n = 8), Shagya (n = 8), and Siglavy-Bagdady (n = 7). The progeny comprised 175 female foals, with 7 bloodlines having 5 foalings per bloodline and 5 female foals per foaling. To gauge the influence of stallions' height on the offspring, 44 fathers from 9 bloodlines were involved in the study (Dahoman, El-Sbaa, Mersuch, Shagya, Siglavy-Bagdady, O'Bajan, Koheilan, Hadban, Gazal).
Considering that one of the breeding objectives is to increase the average height at withers for mares within the Rădăuți stud population, we suggested that the selection and pairing process could be guided by utilizing taller stallions. Analysing successive foal dynamics, regressions, and forecasts might assist in achieving a specific targeted height in the progeny when selecting breeders.
For the assessment of horses' external appearance, precise techniques need to be employed to provide accurate information on the studied parameters. To ensure comprehensive results, horse evaluation requires both analytical and synthetic examinations (Pânzaru et.al., 2020; Roman-Popovici, 2015; Dulugeac, 2005).
The height at the withers, measured from the ground to the highest point of the withers (Figure 1), serves as a metric for evaluating horse development. This measurement categorizes horses as tall (> 160 cm), medium (150-160 cm), or small (<150 cm).

Figure 1. Height at withers, biometrics landmarks (source: original)

Data issued from bio-morphometry run in consecutive foalings (1 to 5) and carried on stallions (data group coded S), broodmares (data group coded B) and on their progeny - female foals (data group coded P), were introduced in a database, separately for each of the 7 analyzed bloodlines (Dahoman, El-Sbaa, Hadban, Koheilan, Mersuch, Shagya, and Siglavy-Bagdady). Then a separate database was setup to comprise the whole population, for each foaling: 7 bloodlines x 5 individuals = 35 individual values in groups S, B, P.

GraphPad Prism statistical application, v. 9.4.1 (681) (GraphPad Software, 1992-2022, CA, USA) was used to run statistical calculations. Data inputs were submitted to descriptive statistics analysis (mean, standard deviation) followed by relative comparisons (%) of the differences between progeny average values and breeders' means, as well as by the significance testing. Analysis of variance was performed, in pairs (P vs. S and P vs. B) using the Brown Forsythe and Welch ANOVA test, assuming non-equal standard deviations analysis of variance, and followed by Dunnet-T3 post-hoc algorithm. The ANOVA *p* values depicts the significance of divergence between breeders and progeny, so as *p* was below the significance threshold, the differences between the fathers, mothers and foals were higher. Following this reasoning, *p* values above 0.05 and closer to 1 suggested more and more resemblance between parental and progeny.

Pearson correlations were also performed to find out to what extent (%), direction (positive or negative) and significance (*p* values) the breeders' height at withers have influenced the progeny results. Both in ANOVA and Pearson correlation, the commonly used *p* thresholds were applied in testing (p=0.05; p=0.01; p=0.001).

Then, MsExcel 2016 (Microsoft, CA, USA), was used to chart the data for the whole population, as histogram of average means per foaling, then trend lines of progeny versus parents were traced and a regression equation was calculated, to predict the dynamics of height at the withers in progeny, for each next foaling. The applying of the regression equation in further calculus could predict the rank of foaling in which the progeny will intercept the breeders mean value, considering that in our study the main effect of the stallions' selection for pairing was to massif the height at withers in female progeny. Also, the forecast function MsExcel 2016 was applied, using the data gathered from F1 to F5, to suggest the most appropriate mean height at withers for breeders (both stallions and broodmares) to be paired, to achieve the desired level of this trait in progeny, in the upcoming foaling.

RESULTS AND DISCUSSIONS

From the statistical data slightly increased average values of height at withers for progeny compared with the broodmares is observed (only significant differences being revealed in F2, F4, and F5 (p<0.05) and lower average values compared with the stallions, where many differences were registered (significant for p<0.05 in F3, significant for p<0.01 in F1, and very significant differences for p<0.001 in F2 and F5). The results indicate the influence of stallions' height over the progeny when the pair matching is done correctly, for the breeding objectives to be fulfilled.

Table 1 showcased the comparisons between the height values of the progeny and of their parents, related to the foaling rank, on the overall population. Progeny achieved higher values than mothers in all the studied cases: F1 (+1.16%), F2 (+0.64%), F3 (+0.73%), F4 (+1.07%), F5 (+0.89%), with significant differences in F2 (p=0.014), F4 (p=0.012), and in F5 (p=0.031). Also, the height gap between daughters and fathers decreased progressively from F1 (–0.99%) until F4 (– 0.39) and significantly till F3 (p<0.05). In F5 it seemed that certain stallions conducted to the decrease of height in progeny, because the difference came back to – 0.77% (p<0.001) and the correlation was moderated to high (55%) (p<0.001).

Table 1. Height at withers (cm) of parents and progeny, in Dahoman bloodline, throughout five consecutive foalings

Foaling rank	Stallions (Fathers) (S)		Broodmares (Mothers) (B)		Progeny (female foals) (P)		Progeny vs. parents Comparisons			
							ANOVA		Correlations	
	Mean	±SD	Mean	±SD	Mean	±SD	± %	*p*-values	r (Pearson)	*p*-values
F1	159.20	±1.66	157.37	±3.65	157.63	±2.30	P vs. S = - 0.99 P vs. B = + 1.16	**0.002 0.726	P vs. F = + 0.159 P vs. M = + 0.430	0.363 **0.009
F2	159.17	±1.32	156.80	±3.30	157.80	±1.94	P vs. S = – 0.86 P vs. B = + 0.64	***0.0009 *0.014	P vs. B = + 0.127 P vs. S = + 0.210	0.826 0.500
F3	159.69	±1.55	157.29	±3.08	158.43	±2.36	P vs. S = – 0.79 P vs. B = + 0.73	*0.011 0.086	P vs. B = + 0.352 P vs. S = + 0.432	*0.037 *0.009
F4	159.54	±1.44	157.23	±3.26	158.91	±1.88	P vs. S = – 0.39 P vs. B = + 1.07	0.135 *0.012	P vs. B = + 0.242 P vs. S = + 0.293	0.161 0.088
F5	160.03	±1.50	157.40	±3.47	158.80	±1.35	P vs. S = – 0.77 P vs. B = + 0.89	***0.0006 *0.031	P vs. B = + 0.555 P vs. S = + 0.527	***0.005 **0.001

S = average values of stallions' height at withers; B = average values of broodmares' height at withers; P = average values of progeny's height at withers; SD = standard deviation; F1 = 1st foaling… F5 = 5th foaling.

*significant for $p < 0.05$; **significant for $p < 0.01$, ***significant for $p < 0.001$.

Through the processing of statistical data, the linear trend of the studied progeny simulated for the next six foalings (F6-F11). This simulation is derived from the analysis conducted on the basis of the first five foalings, along with the computation of regression equations related to foaling rank. Additionally, forecasting computations have been employed to determine the necessary parental values for achieving a specific height at withers in the progeny. (Figure 2 and Table 2).

The dynamics of height at withers throughout successive foalings (Figure 2) revealed the fact that the average value of height at withers for progeny increased constantly from F1 (157.63 cm) to F5 (158.80 cm), suggesting that the breading objective to increase the average height at the withers was fulfilled when the pair matching was done on this purpose (Rădăuți Stud farm registers). In addition, the trend line traced on the basis of foalings 1 to 5 depicts a clear tendency of increasing the height at withers in progeny with every next pairing step, using the selection and the right matching (Figure 2). The regression equation calculated for progeny ($y = 0.3457x + 157.28$), where x is the foaling rank, returns the progeny's mean expected value in the next foaling. According to the simulation based on the equation (Table 2), the progeny height at withers will intercept the fathers' one in the 10th foaling if the same breeders used in our study would be paired. In theory, this pairing would work mathematically and seems to be easy to implement. In reality, it is less likely to be able to use the same broodmares for 10 consecutive reproduction seasons, due to ageing and biological limitations. However, breed stock backed up from younger generations, that would have passed the other examination and qualifying tests, and would have the average height at withers close to the actual values of the parents in our study could be used to generate comparable results. Moreover, carrying on the forecast analysis, based on the variations recorded throughout the 5 studied reproductive cycles, the needed average values of height at withers in stallions and broodmares can be calculated in order to achieve a desired value for progeny. For instance, forecasting a mean expected value of 160 cm height at withers in progeny will return recommended values of 160.52 cm in stallions and of 157.60 cm in broodmares (Table 2). Such forecast would be more useful when selecting the breeders for the upcoming matches, especially when the whole population of the stud farm is used, regardless the bloodline belonging of the individuals. If one would need to modify the biometric trait within the bloodline, the selection pool becomes narrowed and certain other elements should be taken onto account such as inbreeding level.

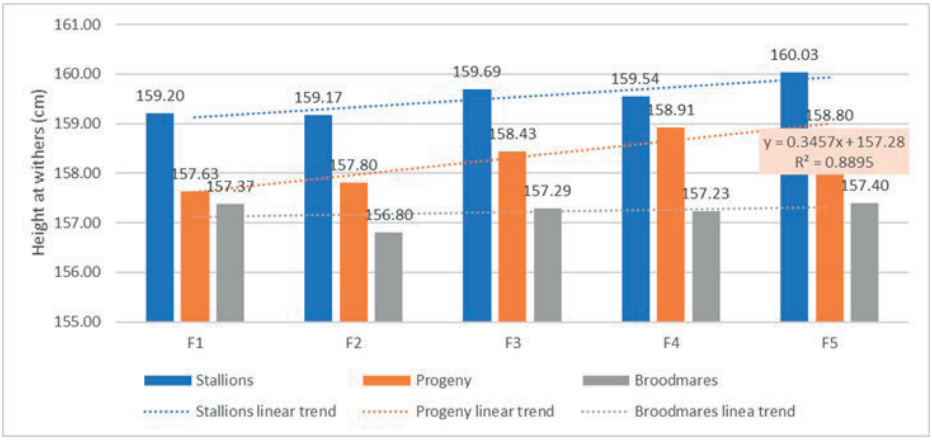

Figure 2. Linear trend for height at withers across successive foalings

Table 2. Simulation of the height at withers dynamics, using linear trend functions and forecast of breeders' height at withers values, related to desired foals' performance and basing on F1-F5 data

Simulated foaling rank	Linear trend			Forecasting (variation of a dependent variable – S or B, related to a fixed variable - P, basing on the variation throughout previous 5 foalings)		
	Stallions (Fathers) (S) y = 0.2029x + 158.92	Broodmares (Mothers) (B) y = 0.0486x + 157.07	Progeny (female foals) (P) y = 0.3457x + 157.28	Desired mean of progeny (P)	Forecasted mean of Stallions (S)	Forecasted mean of Broodmares (B)
F6	160.14	157.36	159.35	157	158.76	157.03
F7	160.34	157.41	159.70	158	159.34	157.17
F8	160.54	157.46	160.05	159	159.93	157.39
F9	160.75	157.51	160.39	**160**	**160.52**	**157.45**
F10	160.95	157.56	160.74	161	161.10	157.59
F11	**161.15**	157.60	**161.08**	162	161.69	157.73

The progeny of Dahoman bloodline presented higher values for height at withers than their mothers F3 (+0.51%), in F4 (+0.51%), in F5 (+0.25%). Pearson correlation analysis revealed that the differences between progeny and fathers' height (–0.63% in F2) was negatively influenced by stallions (r = –0.72). The differences between mothers and progeny were not statistically significant (p>0.05). No significant influence of mothers was observed on the height at withers, situation that occurred in other similar studies. (Sabeva, 2009; Sabeva, 2011)

The results of El-Sbaa bloodline indicated that the foals had higher values in F3 (+1.00%) and in F4 (+1.01%). When progeny vs. fathers were analysed, the differences were significant in F2 (p=0.039, p<0.05). Pearson correlation analysis revealed that such differences between progeny and fathers' height (–1.62%) were negatively influenced by stallions (r = –0.72) in F2 then the new pair matching in F3 re-increased progeny height (correlated positively with fathers' height in a proportion of 19%). Fathers have influenced progeny height dynamics on a greater proportion than the broodmares, fact underlined also by other authors. (Sabeva, 2009; Sabeva, 2011) The differences between mothers and progeny were not statistically significant (p>0.05), aspect revealed also by other studies. (Sabeva, 2009; Sabeva, 2011; Dulugeac, 2005)

The Hadban bloodline performance and the progeny presented higher values than their mothers in F3 (+0.64%), in F4 (+0.09%), and in F5 (+1.42%). When progeny vs. fathers were analysed, the differences were significant in F2 (p=0.105), F5 (p=0.037) and F4 (p=0.008). Pearson correlation analysis revealed that such differences be-tween progeny and fathers' height (–1.25%) was negatively influenced by stallions (r = –0.25) in F4 then the new pair matching in F5 re-increased progenys' height at withers (correlated positively with fathers' height in a proportion of 63%). The differences between mothers and progeny were not statistically significant (p>0.05).

For Koheilan bloodline, the average values of progeny were higher in F2 (+0.77%), F3 (+0.64%), in F4 (+1.65%), and in F5 (+1.80%); when progeny vs. fathers were analysed, the differences were significant in F5 (p=0.129). Pearson correlation analysis revealed that such differences between progeny and fathers' height (–0.63%) were influenced mostly by broodmares (r = 0.74) than by stallions (r = 0.08). Similar facts related to significant differences were also identified in other studies. (Baban et.al., 2009; Pânzaru et.al., 2020)

In Mersuch bloodline there were registered higher values of progeny compared with their mothers in all cases: in F1 (+2.09%), F2 (+2.62%), F3 (+1.55%), F4 (+3.01%), F5 (+3.53%). When progeny vs. fathers were analysed, the differences were significant in F3 (p=0.016), F4 (p=0.019) and F5 (p=0.002); when progeny vs. mothers were analysed, the differences were distinctly significant in F2 (p=0.001), F4 (p=0.003), and F5 (p=0.002) and significant in F3 (p=0.011). The fact that broodmares have influenced progeny height dynamics on a greater proportion than the stallions, was also by other authors. (Baban et.al., 2009; Pânzaru et.al., 2020)

For Shagya bloodline the average values of the progeny were higher than their mothers in F1 (+0.77%), in F2 (+1.68%), and in F3 (+0.25%). Pearson correlation analysis revealed that such differences between progeny and mothers' height (–1.75%) were negatively influenced by the broodmares (r = 0.36). The differences between the average values of parents and of their foals were not statistically significant (p>0.05) in all the cases.

The Siglavy-Bagdady bloodline highlighted that the progeny presented higher values for height at withers than their mothers in all cases: in F1 (+0.25%), F2 (+1.39%), in F3 (+0.25%), in F4 (+1.27%), and in F5 (+0.25%). The differences between mothers and progeny were not statistically significant (p>0.05).

When progeny vs. fathers were studied. Pearson correlation analysis revealed that such differences between progeny and fathers' height (–1.11% and –0.87%) was negatively influenced by stallions (r = –0.38 and r = –0.87). The differences between mothers and progeny were not statistically significant (p>0.05).

CONCLUSIONS

Constant increasing of the progeny's height at withers occurred, from 157.63 cm (in F1) to 158.80 cm (in F5). This aspect suggests that breeding goal objective to obtain higher average height at withers was fulfilled when the pair matching was done on this purpose. In addition, according to the linear trend simulation, stallions would have much more influence than broodmares in increasing the height of the progeny. Following the same height progression when selecting parents from one reproductive cycle to another, the progeny can intercept the fathers' height in the 10th foaling. Forecasting a mean targeted value of 160 cm height at withers in progeny have returned recommended values of 160.52 cm in stallions and of 157.60 cm in broodmares. Acquired data for 5 consecutive foalings allow to forecast the most likely trait value to be used in breeders, to achieve the expected value in progeny. Therefore, this study highlights the necessity for genetic improvement, informed breeding decisions, long-term planning in reproductive activities, optimization of selection criteria for breeders, efficiency in achieving breeding objectives, and the economic impact of producing horses with a higher value of wither height, which is preferred in sports.

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