

MORPHOLOGICAL DYNAMICS OF THE SHAGYA ARABIAN HORSE BREED AT RĂDĂUȚI STUD FARM

C. Pânzaru^{1*}, R.M. Radu-Rusu¹, M.A. Davidescu¹,
I. Bolohan (Acornicesei)¹, M.L. Maftel², M.G. Doliș¹

¹Faculty of Food and Animal Sciences, “Ion Ionescu de la Brad” Iasi University of Life Sciences,
8 Mihail Sadoveanu Alley, 700489 Iasi, Romania

²University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

Abstract

The Shagya Arabian horse breed is highly appreciated for its unique combination of elegance, strength, and character. Regarding contributions to its morphological dynamics, the present study examined the height at withers, heart girth, and cannon girth of mares registered over a 30-year period and stallions registered over a 15-year period at the Rădăuți Stud Farm. The results showed that, for mares, the average height at withers ranged from 154.30 ± 0.26 cm to 154.80 ± 0.25 cm, the heart girth from 176.20 ± 0.80 cm to 177.10 ± 0.77 cm, and the cannon girth from 18.70 ± 0.19 cm to 18.90 ± 0.70 cm. For stallions, the average height at the withers ranged from 157.66 ± 1.21 cm to 161.22 ± 0.84 cm, the heart girth from 177.25 ± 4.09 cm to 183.33 ± 1.83 cm, and the cannon girth from 18.50 ± 0.77 cm to 19.16 ± 0.31 cm. In all cases, the coefficient of variation indicated that the studied traits are homogeneous. However, as the breeding objectives to improve these traits were not fully met for the cannon girth, changes should be implemented in the breeding management for this population.

Key words: Shagya, broodmares, stallions, breeding, management

INTRODUCTION

The regulations of Performance Shagya-Arabian Registry (PShR) aim to register, promote, and support the development of the Shagya Arabian breed according to the requirements of the International Shagya-Arabian Society (Internationale Shagya-Araber Gesellschaft - ISG) through the General Studbook Regulation Framework (RZBO). Thus, the PShR mandates the maintenance of the breed's genealogical registry, ensuring its perpetuation using the breeding methods of the state studs of Rădăuți, Bábolna, and Mezöhegyes. [1]

The breeding objectives are as previously mentioned – to perpetuate a horse suitable for riding and driving, with specific characteristics. The records of the Rădăuți Stud Farm reveal that endurance,

riding, show jumping, leisure, and hippotherapy are the main inclinations of the breed. In the same section, the breeding objectives are also listed, including: increasing body dimensions (for mares – height at withers of 156 cm, heart girth of 178 cm, cannon girth of 19.5 cm, and for stallions – height of 158 cm, chest circumference of 178 cm, and cannon bone circumference of 20.5 cm), improving energy capacity in gallop races, reproductive indices, and constitutional resilience. [2]

The purpose of this study was to analyze whether the breeding objectives at the Rădăuți Stud Farm, related to the increase in height at the withers, heart girth, and cannon girth in Shagya Arabian mares and stallions, have been achieved. The

*Corresponding author: claudia.panzaru@iuls.ro

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interpretation of the data was carried out by processing them in Microsoft Excel and GraphPad Prism 8.4.2. The calculated and statistically interpreted data could be analyzed in light of correlation with the mentioned observations and with reference to the findings recorded in the existing literature. These were interpreted by calculating the main descriptive estimators such as the arithmetic mean (\bar{X}), variance (S^2), standard deviation ($\pm StDev$), standard error of the mean ($\pm s_{\bar{x}}$), and the coefficient of variation ($CV\%$), both regarding the populations (females and males) and through inter-bloodline comparisons using the one-way ANOVA algorithm.

MATERIAL AND METHOD

To fulfill the purpose of this paper, were analyzed the mares and the stallions included in the breeding herd in a period of 30 years and 15 years of reproduction activity, respectively. The studied parameters were represented by the height at withers, the heart girth, and the cannon girth, as they represent important indicators that are analyzed in the ranking activity in every National Stud Farm.

In the evaluation of the biological material, the grading standards valid since 2008 and present in the Official Gazette of Romania, Part I, No. 571/29.VII.2008 were used; these were developed based on Article 7 of the Methodological Norms for the application of the Horse Law No. 389/2005, which appeared in Annex 1 of the same law; the mentioned criteria were published in the Official Gazette, Part I, No. 9, dated 9.01.2006, with subsequent amendments. [3]

The height at the withers represents the measurement determined from the ground to the highest point of the withers, using a special stick. This is the main method of assessing the degree of development of horses, which can be classified as tall (those with a height exceeding 160 cm), medium-

sized (150-160 cm), and small (with a height below 150 cm). By measuring various heights of an animal (at the withers, back, croup, and the base of the tail), one can determine if the croup is higher than the withers, if the back is straight or convex, the degree of withers development, etc. [4]

Additionally, the ratio between height and chest depth (the difference between height and the substernal void) provides information about the development of the rib cage, which is correlated with the horse's abilities and even its body development during the growth period it has undergone. [5-7]

The heart girth is determined with a measuring tape, immediately behind the shoulders (along the tangent bloodline of the upper-posterior angle of the shoulders) or at the highest point of the withers. The importance of determining this dimension is related to the development of the thoracic cavity and the overall body. [8]

The cannon girth is also measured with a tape, at the point where its middle third joins the upper third. The importance of this measurement lies in the fact that it provides information about the degree of skeletal development of the animals. [8]

These dimensions can be used in various formulas to generate indices, such as the constitutional index, the massiveness index, and the digital-thorax index, etc. By calculating different ratios between the height at the withers, the heart girth, and the cannon girth, it can be determined whether the horse has a specific constitution or is considered massive, among other characteristics.

DISCUSSIONS

Analyzing the population of mares recorded each year, over a period of 30 years, in terms of average height at the withers, it is observed that the studied population is very homogeneous, as this trait registered a coefficient of variation

(CV%) between 1.1-1.36%; the average values ranged between 154.30 ± 0.26 cm to 154.80 ± 0.25 cm. Furthermore, no statistically significant differences were observed between the values of the females in any of the compared years ($p > 0.99$).

Table 1 illustrates the average values of the height at withers calculated for the studied mares, where it is observed that the recorded average values for this parameter range between 154.3-154.8 cm.

Table 1 The analysis of average values of height at withers of Shagya Arabian mares (cm)

Year	N	\bar{X}	\pm StDev	$\pm s_{\bar{x}}$	CV%	Min.	Max.
2018	68	154.6	1.877	0.227	1.21	151	158
2017	71	154.6	1.891	0.224	1.22	151	158
2016	43	154.3	1.878	0.286	1.21	151	158
2015	69	154.4	1.843	0.221	1.19	151	158
2014	63	154.5	1.864	0.234	1.20	151	158
2013	62	154.5	1.878	0.238	1.21	151	158
2012	50	154.3	1.847	0.261	1.19	151	158
2011	43	154.4	1.824	0.281	1.18	151	158
2010	40	154.5	1.853	0.293	1.19	151	158
2009	43	154.4	1.804	0.275	1.16	151	158
2008	36	154.5	1.903	0.317	1.23	151	158
2007	39	154.6	1.927	0.308	1.24	151	158
2006	41	154.6	1.918	0.299	1.24	151	158
2005	43	154.6	1.883	0.287	1.21	151	158
2004	48	154.7	1.801	0.259	1.16	151	158
2003	52	154.8	1.768	0.245	1.14	151	158
2002	49	154.8	1.810	0.258	1.16	151	158
2001	58	154.8	1.771	0.232	1.14	151	158
2000	62	154.8	1.729	0.219	1.11	151	158
1999	59	154.8	1.756	0.228	1.13	151	158
1998	63	154.7	1.724	0.217	1.11	151	158
1997	64	154.8	1.717	0.214	1.10	151	158
1996	60	154.8	1.748	0.225	1.12	151	158
1995	58	154.8	1.771	0.232	1.14	151	158
1994	49	154.8	1.810	0.258	1.16	151	158
1993	44	154.7	1.862	0.277	1.20	151	158
1992	41	154.4	1.872	0.292	1.21	151	158
1991	42	154.3	1.858	0.286	1.20	151	158
1990	46	154.4	1.952	0.287	1.26	151	159
1989	47	154.7	2.108	0.307	1.36	151	159

N= the number of mares/year; \bar{X} = the average values of height at withers/herd (cm); \pm StDev= standard deviation; $\pm s_{\bar{x}}$ = standard error of mean; CV%= coefficient of variation; Min. = minimum value of height at withers (cm); Max.= maximum value of height at withers (cm).

Analyzing the height at withers values of the bloodlines within the Shagya Arabian breed raised at the Rădăuți Stud (broodmares), between 1989 and 2018, it is observed that the minimum height was identified at Mersuch bloodline (156 cm), while the maximum for this parameter was recorded in the El-Sbaa bloodline (161.2 cm).

Regarding the average height of each analyzed bloodline, calculated for the entire period, it was observed that the minimum value was calculated for the Koheilan bloodline (156.7 ± 0.069 cm), and the maximum for the El-Sbaa bloodline (159.9 ± 0.102 cm). Given that the El-Sbaa bloodline is known to have a higher average height than the other bloodlines, it can be

stated that the study aligns with the specialized literature. For the analyzed bloodlines, the coefficient of variation (CV%) fluctuated between 0.21-0.42%, indicating that height is a very homogeneous character.

In Figure 1, the dynamics of the average heart girth values of mares is revealed, where this parameter remained relatively

constant. While the differences in height at withers were pronounced in terms of an increase, regarding chest circumference, the values remained between 176.2 and 177.1 cm. There was even a slight decrease in 2018, as the current preference is for a horse with a refined or at most fine-robust constitution, which represents the image of an athletic horse.

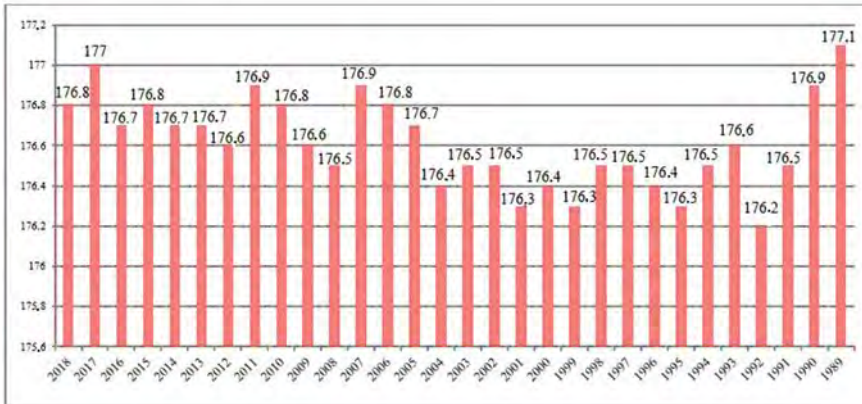


Fig. 1 The average values of heart girth of Shagya Arabian broodmares (cm)

The analysis of the average heart girth values calculated for the genealogical bloodlines which the Shagya Arabian broodmares belong, indicated that the minimum value was recorded for the Shagya bloodline (180.1 ± 0.151 cm), while the maximum value was calculated for the Mersuch bloodline (180.8 ± 0.153 cm), showing very small differences between the bloodlines from this perspective.

By conducting an inter-bloodline comparison to determine the extremes, it was observed that the minimum value was 178.5 cm, identified for the Hadban, Dahoman, Shagya, Siglavy-Bagdady, and El-Sbaa bloodlines, while the maximum one was calculated for the Mersuch bloodline (182.3 cm).

Analyzing the coefficient of variation for the genealogical bloodlines studied, it was observed that the heart girth values, ranging from 0.43% to 3.76%, indicate a

relatively low individuality, a characteristic that can be described as being very homogeneous in this case.

However, using the unifactorial variance analysis algorithm for inter-bloodline comparison, distinctly significant differences were observed between the Shagya vs. Mersuch bloodlines ($p=0.005$) and significant differences in the case of Siglavy-Bagdady vs. Mersuch ($p=0.03$). The same algorithm applied to the comparison of values obtained for each year showed no significant differences in this situation ($p>0.99$).

Analyzing the average values of the cannon girth of broodmares (Figure 2), the results showed that they ranged between 18.7 ± 0.19 cm (in 1998) and 18.9 ± 0.70 cm (in 1989). Considering that in each year of the studied period, the maximum recorded value was 20.5 cm, it can be stated that the potential targeted in the Rădăuți Stud Farm

Registers, which suggests that the cannon bone circumference of mares could increase to 19.5 cm, is achievable through the infusion of genetic material with potential in this regard. For all the years representing the studied period, the coefficient of variation ranged between 1.02% and 3.71%, highlighting the low degree of individuality

in each year regarding the cannon girth, a characteristic that can be considered very homogeneous.

The variance analysis algorithm indicated that, during the studied years, there were no significant differences ($p>0.99$) between the average values of this trait.

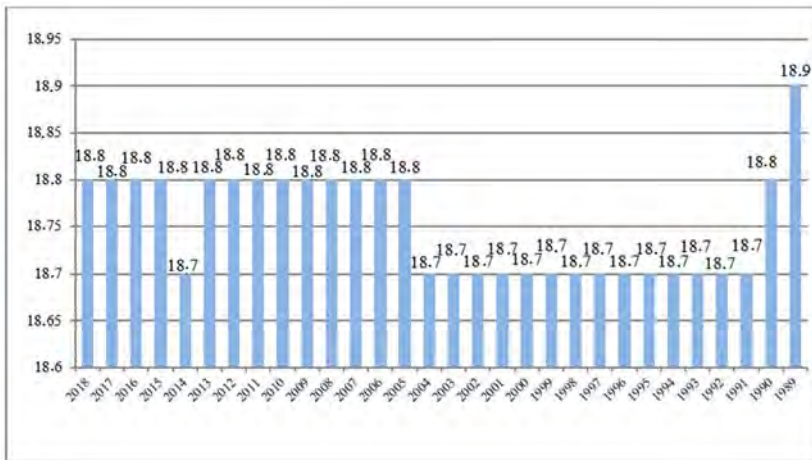


Fig. 2 The average values of cannon girth of Shagya Arabian mares (cm)

The analysis of the average cannon girth values for Shagya Arabian mares, based on genealogical bloodlines, indicated that it ranged between 18.0 ± 0.112 cm (Mersuch) and 18.8 ± 0.096 cm (El-Sbaa). Additionally, it was observed that in different years and across all genealogical bloodlines, the calculated average was 19.5 cm, which signifies that the breeding objective of increasing the cannon bone circumference to 19.5 cm in mares' case is achievable.

In all cases, the coefficient of variation fluctuated between 2.81% and 3.73%, indicating a low influence of individuality on the cannon bone circumference in each of the studied genealogical bloodlines, thus suggesting the homogeneity of this trait. However, the use of the variance analysis algorithm to determine inter-bloodline differences for the cannon bone parameter

revealed the following: significant differences in the comparison of the Dahoman vs. Shagya bloodlines ($p=0.01$), Dahoman vs. Siglavy-Bagdady ($p=0.01$), and Dahoman vs. Koheilan ($p=0.03$); distinctly significant differences in the Hadban vs. Mersuch ($p=0.003$) and El-Sbaa vs. Koheilan ($p=0.003$) comparisons; and very significant differences in the comparisons of Dahoman vs. Mersuch, Shagya vs. El-Sbaa, Siglavy-Bagdady vs. El-Sbaa, and El-Sbaa vs. Mersuch ($p<0.001$). In all other cases, the differences were non-significant.

In the comparison of each year regarding cannon girth dimensions, the results indicated significant differences in 2.07% of cases, distinctly significant differences in 4.83%, and very significant differences in 5.06%. In all other cases, the calculated differences were not significant.

For the analyzed stallions in terms of body dimensions, a total of 47 heads were studied, recorded between 2010 and 2015 in the ranking tables of the Rădăuți Stud Farm. Thus, the average values of height at withers, heart girth, and cannon girth were analyzed, making it possible at the end of the study to present the calculation of body indices, which more accurately highlight the conformation of the horses.

Table 2 presents the average height at withers values of the stallions, calculated for each genealogical bloodline. It can be observed that the minimum calculated value was recorded for the Hadban bloodline (157.66 ± 1.21 cm), while the maximum was for the Koheilan bloodline (161.22 ± 0.84 cm), highlighting the massiveness of the second one, which is a well-known fact.

Comparing this calculated range within which the average height of the analyzed

bloodlines falls with the data mentioned in the literature (according to Velea, 1980, the average value was 152.80 ± 1.21 cm [9]), it can be stated that the breeding objectives (to increase the height of the stallions to 158 cm) have been pursued and, in most cases, even exceeded (in the Dahoman, Gazal, El-Sbaa, Mersuch, Koheilan, Shagya, and Siglavy-Bagdady bloodlines).

For the genealogical bloodlines analyzed, the coefficient of variation ranged between 0.99% and 2.32% for the genealogical bloodlines to which the breeding stallions belong; this indicates a low level of individuality within each bloodline regarding the average height at withers, and the trait can be considered very homogeneous. Moreover, using the variance analysis algorithm, no significant differences were recorded in the inter-bloodline comparisons.

Table 2 The analysis of average values of height at withers of Shagya Arabian stallions (cm)

Genealogical bloodline	N	\bar{x}	S ²	±StDev	±s _x	V%	Min.	Max.
Dahoman	8	158.50	2.50	1.581	0.55	0.99	156	160
El-Sbaa	8	158.76	3.02	1.739	0.61	1.09	156	161
Koheilan	7	161.22	4.94	2.223	0.84	1.37	158	166
Shagya	7	158.90	13.69	3.700	1.39	2.32	151	164
Siglavy-Bagdady	5	158.62	4.83	2.199	0.98	1.38	157	162
Gazal	5	158.87	5.26	2.295	1.02	1.44	157	164
Hadban	4	157.66	5.86	2.422	1.21	1.53	154	160
Mersuch	3	159.00	7.33	2.708	1.56	1.70	157	163

X = average values of height at withers for stallions; ±StDev = standard deviation; ±s_x = standard error of mean; Min. = minimum value of height in case of genealogical bloodline (cm); Max. = maximum value of height in case of genealogical bloodline (cm).

In Figure 3, a situation of the average heart girth values calculated for stallions existing during the period 2000-2015 is represented. It can be observed that the values ranged between 177.25 and 183.33 cm.

Comparing the results obtained with those mentioned in the specialized literature [10], it can be concluded that the stallions analyzed during the period 2000-2015 fall, in terms of average chest circumference

values, within the limits mentioned in studies conducted by other authors. These values are also in accordance with both the breed standard and the breeding objectives described in the Rădăuți Stud Farm Registers, which stated that the aim was to increase this parameter to 178 cm (thus maintaining a fine or at most fine-robust constitution, specific to the breed).

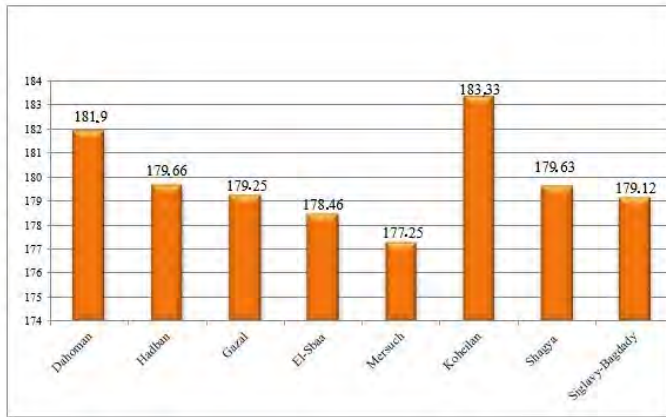


Fig. 2 The average values of cannon girth of Shagya Arabian mares (cm)

In Table 3, the average heart girth values calculated for the genealogical bloodlines representing the Shagya Arabian stallions are described, where it can be observed that the limits ranged from 177.25 ± 4.09 cm (Mersuch bloodline) to 183.33 ± 1.83 cm (Koheilan bloodline); once again, it is obvious that the latter is more massive than the other bloodlines. Furthermore, large fluctuations can be observed both in the minimum values obtained for the genealogical bloodlines (156 cm – Shagya bloodline and 176 cm – Koheilan bloodline) and in the maximum values (184 cm – El-Sbaa and Shagya bloodlines). These aspects

highlight the differences in the characteristics of each bloodline that constitutes the Shagya Arabian breed.

Within the genealogical bloodlines studied, the coefficient of variation ranged between 1.30% and 3.99% for all the bloodlines to which the analyzed stallions belong. This indicates a low degree of individuality within each bloodline regarding the average chest circumference, a trait that can be considered highly homogeneous. Moreover, using the variance analysis algorithm, no significant differences were recorded in the inter-bloodline comparisons.

Table 3 The analysis of heart girth of Shagya Arabian stallions (cm)

Genealogical bloodline	N	\bar{X}	S ²	±StDev	±s _x	V%	Min.	Max.
Dahoman	8	181.90	19.43	4.408	1.55	2.42	156	190
Hadban	4	179.66	38.66	6.218	3.10	3.46	168	186
Gazal	5	179.25	22.21	4.713	2.10	2.62	172	185
El-Sbaa	8	178.46	9.43	3.071	1.08	1.72	173	184
Mersuch	3	177.25	50.25	7.088	4.09	3.99	171	186
Koheilan	7	183.33	23.50	4.847	1.83	2.64	176	190
Shagya	7	179.63	5.45	2.335	0.88	1.30	175	184
Siglavyy-Bagdady	5	179.12	36.69	6.057	2.70	3.38	171	187

\bar{X} = average values of heart girth for stallions; ±StDev = standard deviation; ±s_x = standard error of mean; Min. = minimum value of heart girth in case of genealogical bloodline (cm); Max. = maximum value of heart girth in case of genealogical bloodline (cm).

Regarding the average cannon bone circumference values calculated for the genealogical bloodlines to which the

stallions listed in the classification tables between 2000-2015 belong, it was revealed that the limits of this parameter ranged from



18.5 ± 0.77 cm (Gazal bloodline) to 19.16 ± 0.31 cm (Koheilan bloodline), placing the analyzed males within the breed's specific characteristics [11] (the results are centralized in table 4). Considering that the cannon girth should reach a value of 20.5 cm, as mentioned in the breeding objectives present in the Stud Farm Registers, and that for 5 of the 8 bloodlines analyzed, the maximum value was 20 cm, it can be stated that selection should be guided in this direction to successfully meet the stated objectives. [2]

In terms of the genealogical bloodlines studied, the coefficient of variation ranged between 2.88% and 4.80% for the bloodlines to which the analyzed stallions belong, indicating a low degree of individuality within each bloodline regarding the average cannon bone circumference. Ultimately, it can be concluded that this trait is very homogeneous (the maximum limit of the coefficient of variation was 4.80%).

Using the variance analysis algorithm, no significant differences were recorded in the inter-bloodline comparisons.

Table 4 The analysis of cannon girth of Shagya Arabian stallions (cm)

Genealogical bloodline	N	\bar{X}	S ²	±StDev	±s _x	V%	Min.	Max.
Dahoman	8	19.05	0.63	0.797	0.28	4.18	18	20
Hadban	4	18.41	0.74	0.861	0.43	4.67	17.5	19.5
Gazal	5	18.5	0.28	0.534	0.77	2.88	18	19.5
El-Sbaa	8	18.76	0.60	0.780	0.27	4.15	17.5	20
Mersuch	3	19.00	0.83	0.912	0.52	4.80	18	20
Koheilan	7	19.16	0.68	0.829	0.31	4.32	18	20
Shagya	7	18.59	0.49	0.700	0.26	3.76	17.5	20
Siglavy-Bagdady	5	18.68	0.35	0.593	0.26	3.17	18	19.5

\bar{X} = average values of cannon girth for stallions; ±StDev = standard deviation; ±s_x = standard error of mean; Min. = minimum value of cannon girth in case of genealogical bloodline (cm); Max. = maximum value of cannon girth in case of genealogical bloodline (cm).

In Figure 4, the results regarding the average values per each Shagya Arabian bloodline is illustrated. It reveals that the minimum value was registered in Hadban

bloodline (18.41 cm) and the maximum one in Koheilan bloodline (19.16 cm).

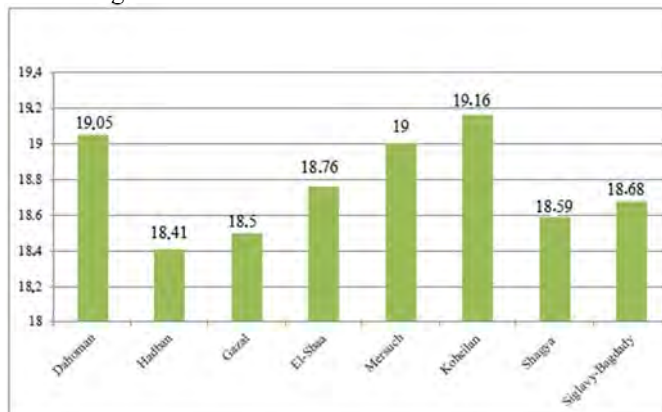


Fig. 3 The average values of cannon girth of Shagya Arabian stallions (cm)

CONCLUSIONS

The following aspects can be affirmed regarding the analysis of the morphological and reproductive parameters of Shagya Arabian mares:

- the height at withers: the average values ranged between 154.30 ± 0.261 cm and 154.80 ± 0.258 cm; the minimum average value calculated for the genealogical bloodlines was recorded in the Koheilan bloodline (156.7 ± 0.069 cm), while the maximum was in the El-Sbaa bloodline (159.9 ± 0.102 cm).

- the heart girth: the average values ranged between 176.2 ± 0.885 cm and 177.1 ± 0.787 cm; the minimum average value recorded was in the Shagya's bloodline case (180.1 ± 0.151 cm), while the maximum value was calculated for Mersuch bloodline (180.8 ± 0.153 cm). Inter-line comparisons revealed a minimum value of 178.5 cm (Hadban, Dahoman, Shagya, Siglavy-Bagdady, and El-Sbaa bloodlines) and a maximum of 182.3 cm (Mersuch bloodline).

- the cannon girth: the minimum average value was 18.7 ± 0.19 cm, and the maximum 18.9 ± 0.70 cm; the average values for the genealogical bloodlines ranged from 18.0 ± 0.11 cm (Mersuch) to 18.8 ± 0.09 cm (El-Sbaa).

- the breeding objectives registered in Rădăuți Stud Farm included increasing the height at withers for mares to 156 cm, the heart girth to 178 cm, and the cannon girth to 19.5 cm and for stallions – height to 158 cm, heart girth to 178 cm, and cannon girth to 20.5 cm. All these aspects were completed, as the study revealed, except for the cannon girth where interventions are needed regarding the breeding management.

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