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Influence of Lipizzan stallions on body measurements of foals

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Abstract

The development of foals, from the moment of foaling to separation from the mother, is the most important and decisive period for the further life of the foal. This paper shows the influence of stallions on some body measurements of foals. The research was conducted in the period from 2019 to 2023 and a total of 60 foals were measured, which were offsprings of 5 sire lines at the Vučijak stud. The basic body measurements of foals at 7 days old were measured by tap: the withers height, the chest and cannon bone circumference and body weight. In order to monitor the significance of the influence of sire lines and individual stallions on body measurements of foals, a simple analysis of variance with an unequal number of repetitions was used. The results of the research were processed in Microsoft Excel and SPSS. The obtained results showed that there is no significant influence of sire lines on the body measurements of foals, but there is a highly significant influence of the individual stallions on the body measurements of foals. Stallion 675 Conversano Neretva XXIII had a statistically significant influence on chest girth and body weight in foals, where the average weight of his offspring was 55.3 kg and the average chest girth was 84.7 cm, while the smallest influence in foals was the stallion 695 Pluto Sutjeska XXXII with the smallest average body weight of 41.3 kg and an average chest girth of 76.7 cm in his offspring. The research showed that stallions can have a significant influence on body measures of offspring. The results can be used in future breeding programs, with the aim to improve the body conformation of the next generation of Lipizzan horses from Stud Vučijak.

Key words: Lipizzan, stallion, body measurements, foal

INTRODUCTION

The Lipizzan horses originated in 1580 in Lipica, a small place called Sežana in the Republic of Slovenia. The Lipizzan horse has a long tradition of breeding in pure breed and crossbreeding with other breeds is not allowed. In addition to Slovenia, the breeding of these horses has spread to other parts of the world, whether it's private breeding or state studs. Over 60 different mare families and 8 sire lines are recognized by Lipizzan International Federation - LIF. The Lipizzan horse breeding tradition in 8 countries (Slovenia, Italija, Austria, Hungary, Slovakia, Romania, Croatia and Bosnia and Herzegovina) has been inscribed on the Intangible Heritage List by UNESCO since December 2022. Although it has a long breeding tradition, the Lipizzan horses, not only from the Vučijak Stud Farm but also from other studs in Europe and around the World, arean inexhaustible source of research even today. Many authors have conducted research on Lipizzan horses using various methods, from morphometry (Važić et al. 2016, Rogić et al., 2019, Jovanovac 1995, Kaps 2014), pedigree analysis (Rogić et al. 2022, Zechner et al. 2002) to modern molecular methods (Felkel et al. 2019, Grilz-Seger et al. 2019).

Stud Farm Vučijak has been breeding and preserving Lipizzan horses since 1946. It is located in the municipality of Prnjavor, in Bosnia and Herzegovina. Currently, it has representatives of 6 sire lines and 15 mare families. The breeding goal of the Stud FarmVučijak was the breeding of smaller format horses for driving carriages and for jobs in agriculture (Pracek, 1999).

The development of foals, from the moment of foaling to separation from the mother at the age of 6 months, represents the most demanding and sensitive period for the foal's further progress. Rastija et al. (2004) state that it is the most important period to provide quality nutrition for foals and mares, accommodation and other factors that affect the normal growth and development of the offspring. Additionally, the intensity of growth and development is the weakest in the first six months, while they show their potential in the third year. In addition to paragenetic factors, genetic factors also play a major role, i.e. traits that foals inherit from their father and mother. The influence of various factors on the growth and development of Lipizzan foals as well as adult horses were the subject of many researchers so far: Romić 1951, Green 1961, Stipić 1980, Rastija et al. (1986, 1995a, 2001, 2004), Praček 1999, Baban et al. (1995) and others.

Research on the body measurements of Lipizzan foals of the Stud Farm Vučijak has not been the subject of research until now. Therefore, the aim of this paper was to show the influence of sire lines and individual stallions, on the basic body measurements of foals at birth.

MATERIALS AND METHODS

The research was conducted in the period from 2019 to 2023. During the research, for each foal up to the age of 7 days, the following body measurements were taken using tape: the withers height, the chest girth, cannon bone circumference and body weight. A total of 60 foals were measured. Sire lines Pluto, Siglavy, Conversano, Neapolitano and Favory had three or more foals in the analyzed period and were taken for further analysis. In order to analyze the influence of an individual stallion on the body measurements of foals, the stallions that had three or more foals in the analyzed period were used. A total of eight stallions were analyzed: 695 Pluto Sutjeska XXXII, 631 SIglavy Bregava XLV, 670 Siglavy Janja XXX, 678 Conversano Kremica XIV, 675 Conversano Neretva XXIII, 650 Neapolitano Ukrina XL, 661 Neapolitano Lipa XXVI, 723 Favory Pliva XLII. In order to analyze the significance of the influence of sire lines and individual stallions, on body measurements of foals, a simple analysis of variance with an unequal number of repetitions was used. The significance of the obtained differences was tested with the Duncan test. Microsoft Excel and SPSS were used for data processing.

RESULTS AND DISCUSSION

Influence of sire lines on body measurements of foals

The results of the influence of sire lines on the wither height in foals are shown in tables 1 and 2. Stallions of the Neapolitano sire lines had the largest number of offspring (21) and stallions of the Pluto sire lines had the smallest number (7). The average wither height of the foals ranged from 89.57 cm (Pluto) to 94.31 cm (Siglavy). The greatest variations in the wither height were recorded in the Neapolitano sire lines, from 74 to 102 cm.

Table 1. Descriptive statistics analysis for the wither height of foals by sire lines

	Conversano	*Favory*	*Neapolitano*	*Pluto*	*Siglavy*
Count	10	9	21	7	13
Mean	91,7	91,89	91,43	89,57	94,31
Standard Error	1,69	1,51	1,58	2,93	1,65
Standard Deviation	5,33	4,54	7,22	7,74	5,94
Sample Variance	28,46	20,61	52,06	59,95	35,23
Minimum	85	86	74	76	84
Maximum	100	100	102	98	108

In order to determine the significance of the obtained differences in the wither height between the offspring of different sire lines, an analysis of variance with an unequal number of replicates was

performed. The results showed that there was no statistically significant ($p > 0.005$) difference in the withers height of the foals in representatives of different sires (table 2).

Table 2. Results of analysis of variance for the withers height of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	118,24	4	29,56	0,72	0,58	2,54
Within Groups	2244,62	55	40,81			
Total	2362,85	59				

Table 3 shows the results of the influence of sire lines representatives on chest girth in new-born foals. The results showed that foals from the Pluto sire lines have the smallest chest girth (74 cm), while foals from Siglavy, Conversano and Neapolitano sire lines have the largest chest girth. Representatives of the Pluto sire lines have the largest variation of chest girth, from 74 cm to 84 cm.

Table 3. Descriptive statistics for the chest girth of foals after foaling by sires

	Conversano	*Favory*	*Neapolitano*	*Pluto*	*Siglavy*
Count	10	9	21	7	13
Mean	81,8	81,78	80,81	79	80,69
Standard Error	0,93	0,55	0,60	1,25	0,87
Standard Deviation	2,94	1,64	2,75	3,32	3,12
Sample Variance	8,62	2,69	7,56	11	9,73
Minimum	77	79	77	74	78
Maximum	86	85	86	84	86

The smallest range of variation of chest girth in foals occurred in representatives of the Favory sire lines and is in the interval from 79 cm to 85 cm. Therefore, the foals of the Favory sire lines have a higher average chest girth value (81.78 cm). The ANOVA showed that there are no statistically significant differences in the chest girth of the foals between the sire lines (table 4).

Table 4. Results of analysis of variance for chest girth of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	41,02	4	10,26	1,30	0,28	2,54
Within Groups	433,16	55	7,88			
Total	474,18	59				

The next important body measurement of the foals that was included in the research was cannon bone circumference. The results of this research are shown in table 5.

Table 5. Descriptive statistics for the cannon bone circumference of foals after foaling by sires

	Conversano	*Favory*	*Neapolitano*	*Pluto*	*Siglavy*
Count	10	9	21	7	13
Mean	11,8	11,67	11,95	11,71	11,92
Standard Error	0,33	0,24	0,25	0,64	0,29
Standard Deviation	1,03	0,71	1,16	1,70	1,04
Sample Variance	1,07	0,5	1,35	2,91	1,08
Minimum	10	11	10	9	10
Maximum	13	13	14	13	13

The smallest average value of the cannon bone circumference of 11.67 cm was in foals representing the Favory sire lines, while the largest was 11.95 cm in foals representing the Neapolitano sire lines. The smallest variations in the cannon bone circumference of the foals were in the Favory sire lines. Foals of the Pluto sire lines had the smallest cannon bone circumference of 9 cm, while foals of the Neapolitano sire lines had the largest cannon bone circumference of 14 cm.

To analyse the significance of differences, ANOVA was used. The results showed that there are no statistically significant differences in the cannon bone circumference of the foals of different representatives of the sire lines (table 6).

Table 6. Results of analysis of variance for the cannon bone circumference of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0,75	4	0,19	0,15	0,97	2,54
Within Groups	70,90	55	1,29			
Total	71,65	59				

In addition to the research and monitoring of the basic body measurements of the foals, the research also included the body weight of the foals at birth. The results of research on the influence of sire line representatives on the foals' body weight are shown in table 7. The highest average body weight was the foals of the Conversano sire lines (50.2 kg), while the lowest was the Pluto sire lines foals (45.14 kg). The biggest variations in body weight were in the Pluto sire lines and the least in the Favory sire lines. The range of variation in body weight in relation to all sire lines was from 37 kg to 58 kg, which shows the diversity and influence of mare families on the body weight of foals.

Table 7. Descriptive statistics for the body weight of foals after foaling by sires

	Conversano	*Favory*	*Neapolitano*	*Pluto*	*Siglavy*
Count	10	9	21	7	13
Mean	50,2	49,78	48,26	45,14	48,08
Standard Error	1,66	0,98	1,04	2,13	1,60
Standard Deviation	5,25	2,95	4,78	5,64	5,78
Sample Variance	27,51	8,69	22,81	31,81	33,41
Minimum	42	45	42	37	43
Maximum	58	56	58	54	58

The ANOVA results are shown in table 8. The F-test value shows that there are no statistically significant differences in the body weight of foals, representatives of different sire lines.

Table 8. Results of analysis of variance for the body weight of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	125,36	4	31,34	1,26	0,30	2,54
Within Groups	1365,22	55	24,82			
Total	1490,58	59				

Influence of stallions on body measurements of foals

Descriptive statistics for the withers height of foals by stallionsare presented in table 9. The stallion 661 Neapolitano Lipa XXVI had the largest number of offspring (13), and the stallion 675 Conversano Neretva XXIII and 695 Pluto Sutjeska XXXII had the smallest number of offspring (3).

Table 9. Descriptive statistics for the withers height of foals after foaling by stallions (fathers)

	631 S. Bregava	*650 N. Ukrina*	*661 N. Lipa*	*670 S. Janja*	*675 C. Neretva*	*678 C. Kremica*	*695 P. Sutjeska*	*723 F. Pliva*
Count	5	8	13	7	3	6	3	7
Mean	93	94,50	89,54	95,00	97,00	89,83	86,00	90,29
Standard Error	1,52	2,11	2,07	2,94	2,08	1,85	6,43	1,30
Standard Deviation	3,39	5,98	7,47	7,77	3,61	4,54	11,14	3,45
Sample Variance	11,5	35,71	55,77	60,33	13,00	20,57	124,00	11,90
Minimum	88	85	74	84	93	85	76	86
Maximum	97	102	100	108	100	97	98	94

The highest average withers height of the foals after birth was 97.00 cm in the offspring of the stallion 675 Conversano Neretva XXIII, while the lowest average withers height was 86.00 cm recorded in the foals of the stallion 695 Pluto Sutjeska XXXII.

The average withers height of a seven-day-old foal according to literature references by Romić, Stipić, Rastija, et al. was specific to a certain part of the country that breeds Lipizzaner: Hungary, Croatia, Slovenia, etc. Romić (1951) showed that the average withers height for male foals was 92.82 cm and for female foals 92.58 cm. According to research by Stipić (1980), the withers height of male foals was 101.12 cm, while that of females was 101.08 cm. Rastija et al. (1986) determined in their research that the withers height of seven-day-old male foals was 102.70 cm, and that of females was 103.85 cm. Rastija et al. (1995a) showed that the withers height of seven-day-old male Lipizzaner foals was 99.74 cm, and that of females was 98.68 cm. Research by Rastija et al. (2004b) showed that the average withers height of Lipizzan foals was 99.40 cm. According to Kaps et al (2014) a larger sample of foals showed that the average withers height of 7-day-old foals was 100.8 cm. The withers height of Lipizzan foals from Stud Farm Vučijak are smaller compared to other Lipizzan populations, according the previous research.

Table 10. Results of analysis of variance for the withers height of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	424,74	7	60,68	1,50	0,19	2,23
Within Groups	1775,49	44	40,35			
Total	2200,23	51				

Table 10 shows the results of the ANOVA. The influence of stallions on the withers height of foals is not statistically significant. The F-test value is significantly lower than the table value.

Table 11. Descriptive statistics for the chest girth of foals after foaling by stallions

	631 S. Bregava	*650 N. Ukrina*	*661 N. Lipa*	*670 S. Janja*	*675 C. Neretva*	*678 C. Kremica*	*695 P. Sutjeska*	*723 F. Pliva*
Count	5	8	13	7	3	6	3	7
Mean	78.4	82	80.08	82.43	84.67	80.67	76.67	81.29
Standard Error	0.4	0.89	0.75	1.25	1.33	1.02	1.76	0.47
Standard Deviation	0.89	2.51	2.72	3.31	2.31	2.50	3.06	1.25
Sample Variance	0.8	6.29	7.41	10.95	5.33	6.27	9.33	1.57
Minimum	78	79	77	78	82	77	74	79
Maximum	80	86	84	86	86	84	80	82

Table 11 shows the average values of chest girth of seven-day-old foals, which ranged from 76.67 cm to 84.67 cm. The highest value of chest girth was recorded in the foals of the stallion 675 Conversano Neretva XXIII (86 cm), while the lowest value was recorded in the offsprings of the stallion 695 Pluto Sutjeska XXXII (84 cm).

The Chest girth of male Lipizzan foals measured after birth according to Romić (1951) was 84.80 cm and female 83.12 cm. Rastija et al. (2001) showed that the chest girth of male Lipizzaner foals was 82.46 cm and females 81.77 cm. The average chest girth of foals measured 7 days after birth was 81 cm, by Kaps et al (2014). Rastija et al. (2004b) showed the comparison of the chest girth in Lipizzaner and Holstein foals. The average chest girth of Lipizzaner foals was 80.05 cm, while that of Holstein foals was 95.83 cm. The value of chest girth of Lipizzan foals from Vučijak wassimilar compared with other Lipizzan populations.

Table 12. Results of the analysis of variance for the chest girth of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	163,51	7	23,36	3,78	0,003	2,22
Within Groups	271,93	44	6,18			
Total	435,44	51				

The analysis of variance with an unequal number of repetitions was used to analyze the significance of the differences. From table 12, we see that the value of the F-test is higher than the table value, so we can conclude that there is a statistically highly significant influence of the stallion on this body measure. The highest average value of the cannon bone circumference was 12.33 cm in foals of the stallion 675 Conversano Neretva XXIII, while the smallest average value of the cannon bone circumference was 10.67 cm in the foals of the stallion 695 Pluto Sutjeska XXXII. The range of variation for foal cannon bone circumference was from 9 cm to 14 cm. It was most pronounced in the foals of the stallion 695 Pluto Sutjeska XXXII with the lowest value and in the stallions 661 Neapolitano Lipa XXVI and 650 Neapolitano Ukrina XL with the highest value (Table 13).

Jovanovac (1995) showed that the cannon bone circumference in male foals was 11.6 cm and in females 11.7. According to Rastija et al. (2001), the cannon bone circumference in male foals was 11.86 cm and in females 11.64 cm. A few years later, the study was repeated with a new sample of foals and produced similar results. Rastija et al. (2004b) concluded that the cannon bone circumference in the male foal was 11.75 cm and in the female 11.49 cm. A comparison with other breeds, such as the Holstein breed, also contributed to the research on the size of the cannon bone circumference in Lipizzaner foals.

Table 13. Descriptive statistics for the cannon bone circumferences of foals after foaling by stallions

	631 S. Bregava	*650 N. Ukrina*	*661 N. Lipa*	*670 S. Janja*	*675 C. Neretva*	*678 C. Kremica*	*695 P. Sutjeska*	*723 F. Pliva*
Count	5	8	13	7	3	6	3	7
Mean	12	12.31	11.77	12.00	12.33	11.58	10.67	11.43
Standard Error	0.32	0.39	0.32	0.49	0.67	0.42	1.20	0.20
Standard Deviation	0.71	1.10	1.17	1.29	1.15	1.02	2.08	0.53
Sample Variance	0.5	1.21	1.36	1.67	1.33	1.04	4.33	0.29
Minimum	11	11	10	10	11	10	9	11
Maximum	13	14	14	13	13	13	13	12

The average of the cannon bone circumference of Lipizzaner foals at birth was 11.81 cm, while that of Holsteins was 13.58 cm. An unequal number of offspring of both races was used for the research (Rastija et al., 2004b).

Table 14. Results of analysis of variance for the cannon bone circumference of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8,55	7	1,22	0,98	0,46	2,23
Within Groups	55,03	44	1,25			
Total	63,58	51				

The ANOVA showed that the value of the F-test is lower than the table values. We can conclude that there is no statistically significant influence of stallions on the cannon bone circumference.

Table 15. Descriptive statistics for the body weight of foals after foaling by stallions

	631 S. Bregava	*650 N. Ukrina*	*661 N. Lipa*	*670 S. Janja*	*675 C. Neretva*	*678 C. Kremica*	*695 P. Sutjeska*	*723 F. Pliva*
Count	5	8	13	7	3	6	3	7
Mean	43.80	50.38	47.00	51.29	55.33	48.17	41.33	48.86
Standard Error	0.80	1.61	1.28	2.31	2.67	1.74	2.96	0.77
Standard Deviation	1.79	4.57	4.60	6.10	4.62	4.26	5.13	2.04
Sample Variance	3.20	20.84	21.17	37.24	21.33	18.17	26.33	4.14
Minimum	43	45	42	43	50	42	37	45
Maximum	47	58	54	58	58	54	47	50

The foals of the stallion 675 Conversano Neretva XXIII had the highest average body weight (55.33 kg), and the foals of the stallion 695 Pluto Sutjeska XXXII had the lowest (41.33 kg). The body weight of the foals was in the interval from 37 kg to 58 kg. The reason for large variations in the body weight of foals shows that in addition to the influence of stallions, there wasalso the influence of mares on the body weight of new-born foals (Table 15).

Table 16. Results of analysis of variance for the body weight of foals after foaling

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	516,32	7	73,76	3,83	0,003	2,23
Within Groups	847,13	44	19,25			
Total	1363,44	51				

The value of the F-test showed that there is a high significant statistical influence of the stallion on the body weight of the foals (Table 16).

Table 17. Results of Duncan's test for body measurements of foals

	631 S. Bregava	*650 N. Ukrina*	*661 N. Lipa*	*670 S. Janja*	*675 C. Neretva*	*678 C. Kremica*	*695 P. Sutjeska*	*723 F. Pliva*	*P value*
HW	93	94,50	89,54	95,00	97,00	89,83	86,00	90,29	ns
CG	78.4^{BCcd}	82^{ABab}	$80,1^{BCbc}$	82.4^{ABab}	84.7^{Aa}	80.7^{ABCbc}	76.7^{Cd}	81.2^{ABbc}	<0.01
CCC	12	12.31	11.77	12.00	12.33	11.58	10.67	11.43	ns
BW	43.8^{BCcd}	50.4^{ABab}	47^{BCcbd}	51.3^{ABab}	55.3^{Ac}	48.2^{ABCbc}	41.3^{Cd}	48.9^{ABCbc}	<0.01

NS: non-significant; values by letters (^{a,b,c}) in one row describe significant differences; values marked by small letter differ significantly ($p < 0.05$); values marked by capital letter differ high-significantly ($p < 0.01$); HW - high of withers; CG – chest girth; CCC – cannon bone circumferences; BW – body weight;

Table 17 shows the results of the average values of body measurements of foals by stallions and the influence of stallions on those measurements. The stallion 675 Conversano Neretva XXIII had the greatest influence on the chest girth and the body weight in foals, where the average weight of his offspring was 55.3 kg and the average chest girth was 84.7 cm, while stallion 695 Pluto Sutjeska XXXII had the smallest influence in foals with the smallest average body weight of 41.3 kg and an average chest girth of 76.7 cm in his offspring. The average chest girth value of the foals of stallion 675 Conversano Neretva XXIII wasstatistically highly significant compared to the average chest girth of the foals of stallions 631 Siglavy Bregava XLV, 661 Neapolitano Lipa XXVI and 695 Pluto Sutjeska XXXII, while the average chest girth of the foals of stallion 675 Conversano Neretva XXIII wasstatistically significant in relation to the average chest girth values of the foals of stallions 631 Siglavy Bregava XLV, 661 Neapolitano Lipa XXVI, 678 Conversano Kremica XIV, 695 Pluto Sutjeska XXXII and 723 Favory Pliva XLII. The average body weight of the foals of stallion 675 Conversano Neretva XXIII is statistically highly significant compared to the average body weight of the foals of some of the stallions: 631 Siglavy Bregava XLV, 661 Neapolitano Lipa XXVI, etc., While the average body weight of the foals of stallion 675 Conversano Neretva XXIII is statistically significant in relation to the average body weight of the foals of stallions 650 Neapolitano Ukrina XL, 670 Siglavy Janja XXX and 695 Pluto Sutjeska XXXII. Average values of the wither heights were from 86.00 cm to 97.00 cm, but in that case, the stallions did not have a greater influence, so no statistically significant differences appeared. It was similar to the cannon bone circumference. The average cannon bone circumference was in the interval from 10.67 cm to 12.33 cm, and the stallions did not have a statistically significant influence on the cannon bone circumference of the foals.

CONCLUSION

Based on the obtained results and the influence of representatives of sire lines and individual stallions on body measurements of new-born foals, we can conclude that sire lines do not have a significant impact in body measures of foals. On the other hand, the impact of some stallions on the chest girth and cannon bone circumference was statistically high. The stallion 675 Conversano Neretva XXIII produced foals with the best body measurements. It is highly recommended to continue research in the next generation of foals, in order to get better insight on impact of stallions to the body measurement of new-born foals. These results can be used in the future breeding programme with the aim to improve the body conformation of the next generation of Lipizzan horses from Stud Vučijak.

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