Original scientific paper | DOI 10.7251/ZARS2401172R

Estimates of genetic parameters for some morphological traits of the Lipizzan horses

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Abstract

The aim of this study was to estimate genetic parameters for these morphological traits of Lipizzan horses from Vučijak. Basic morphological measurements (height at withers - HW, chest circumference - CC and cannon bone circumference - CBC) were recorded to characterise the population of Lipizzan horses from State Stud Vučijak. Genetic variances and covariances were estimated by the restricted maximum likelihood model (REML) using Wombat software, including the fixed effects of sex, birth month, birth year, month of measurement, year of measurement, age, and measurer, together with a random additive genetic animal component and the residual effect. The data file includes a total of 79 horses measurement, and pedigree data with 223 horses. The average values of HW, CC and CBC were 150.02 cm, 178.24 cm and 19.51 cm, respectively. Heritability estimates were 0.78 for HW, 0.67 for CC and 0.60 for CBC. Genetic correlations were positive and high (from 0.88 to 0.99), while phenotypic correlations were positive and moderately high (from 0.46 to 0.58).

Key words: morphological traits, pedigree, heritability, genetic and phenotypic correlations

INTRODUCTION

State-owned stud Vučijak is the only Lipizzan stud in Bosnia and Herzegovina. It was founded in 1946. Establishing stud Vučijak, very soon Lipizzan horses spread to almost the entire Bosnia, thanks to selective work at the stud Vučijak. The desirable characteristics of Lipizzan have led, not only to the quality of the pure breeding program on stud Vučijak but also to the great influence, as a meliorator, on horse breeding in Bosnia (Rogić et al., 2019).

Horse breeding has been based on the selection for conformation traits since the nineteenth century. Conformation traits were part of the definition of the breed standard when studbooks were created. The traditional assessment of conformation was based on subjective evaluation in relation to the breeding objective (Koenen et al., 2004). For centuries, morphology has been the most commonly selected trait in horses (Richard et al., 2023). The morphology of Lipizzan horses from Stud Farm Vučijak has been the subject of many researches so far (Rogić et al., 2022; Važić et al., 2016; Rogić et al., 2019).

The potential genetic improvement of traits of interest was largely dependent on its heritability and genetic relationship among the traits of economic importance upon which selection may be applied (Habtegiorgis et al., 2022). Information on heritability is essential for planning efficient breeding programs, and for prediction of response to selection (Falconer and Mackay, 1996).

The morphometric differences between the horse from different stud, depend on the breeding goal of stud, which differs from one country to another or even from one stud to another. Rogic et al. (2018) analyze the data of body measurements from founders from 1946 and today's horses on stud Vučijak.

The aim was to evaluate whether the selection created a smaller-format horse in the past period, suitable for driving and carrying. They concluded that Lipizzan horses from Stud Farm Vučijak have smaller body shapes in accordance with Lipizzan horses from other Stud Farm.

In accordance with propositions of body measures described by the Lipizzan International Federation, it is necessary to improve the body shape of Lipizzan horses from Vučijak in future. At this point, it is interesting to observe how these traits are connected to each other and how they can be used to improve the genetic progress of the breed. Withers height, chest and cannon bone circumference are important basic morphological measures that are useful to describe the horse's body conformation correctly. The aim of this study was to estimate genetic parameters for these morphological traits of Lipizzan horses from Vučijak.

MATERIAL AND METHODS

Data were recorded at stud farms Vučijak. With the aim to estimate genetic parameters for some morphological traits of Lipizzan horses from state stud Vučijak the data file includes a total of 79 horses measurement, and pedigree data with 223 horses. Basic morphological measurements (height at withers - HW, chest circumference - CC and cannon bone circumference - CBC) were recorded. As the Lipizzan horse is late maturing, only individuals 4 years or older were measured.

The Phenotypic expression of observed traits was calculated using the formula:

$$Y_{ijklmnopr} = \mu + S_i + Mb_j + Yb_k + Mm_l + Ym_m + M_n + Ag_o + A_p + e_{ijklmnopr}$$

Where Y is the phenotypic expression of observed traits; μ is the mean for the observed trait in the analyzed population; S is fixed effect of sex; Mb is fixed effect of month of birth; Yb is fixed effect of year of birth; Mm is fixed effect of month of measurement; Ym is fixed effect of year of measurement; M is fixed effect of measurer; Ag is fixed effect of age on measurement; A is random effect of animal and e is the effect of other factors not included in the model.

For the estimation the variance and covariance components and genetic parameters of analyzed traits we used the restricted maximum likelihood (REML) approach through the WOMBAT software (Meyer, 2007).

RESULTS AND DISCUSION

Observing the phenotypic parameters of the population is a very important step during the implementation of quantitative genetic analyses. These parameters give us an insight into the average values and variability of the analyzed trait, which is very important when defining breeding programs and their goals, and represent the first and easily accessible information that is of great importance for breeders. For this purpose, standard statistical parameters: the average value ($\overline{X}$), standard deviation (SD), minimum (Min), maximum (Max) and coefficient of variation (CV) are most often calculated.

Table 1. Descriptive statistics for basic morphological measurements in a Lipizzan horses

Traits	n	$\overline{X}$	SD	Min	Max	CV
HW, cm	79	150.03	3.61	140.00	157.00	2.41
CC, cm	79	178.24	7.07	158.00	193.00	3.94
CBC, cm	79	19.51	0.99	18.00	24.00	5.12

Results showed that the average values of HW were 150.03 cm, ranging from 140 to 157 cm. The average value of CC was 178.24 cm, ranging from 158 to 193 cm. The average values of CBC were 19.51, ranging from 18 to 24 cm (Table 1). The Coefficient of variation (CV) ranged from 2.41 (HW) to 5.12 (CBC).

Table 2. Component of genetic (co)variance for basic morphological measurements in a Lipizzan horses

Traits	HW	CC	CBC
HW	12.95±5.82	22.20±8.05	2.79±1.34
CC		38.09±17.36	4.88±2.14
CBC			0.77±0.44

Variances on diagonal, covariance above

Table 2 shows the estimated values of genetic variances and covariances. The highest value genetic variance was calculated for CC (38.09 cm^2) and the lowest value was for CBC (0.77 cm^2). All values of genetic covariances were positive, and the highest calculated value was between HW and CC (22.20) and the lowest was between CBC and HW (2.79).

The estimated component of phenotypic (co)variance is shown in table 3. The estimated phenotypic variance was ranged from 1.30 (CBC cm^2) to 56.53 (CC cm^2), and the covariance were positive and ranged from 2.70 (CBC to HW) to 14.85 (CC to HW).

Table 3. Component of phenotypic (co)variance for basic morphological measurements in a Lipizzan horses

Traits	HW	CC	CBC
HW	16.62±3.89	14.85±5.42	2.70±0.89
CC		56.53±11.61	3.98±1.46
CBC			1.30±0.299

Variances on diagonal, covariance above

The estimated values of residual (co) variance and environmental correlation are shown in table 4. The estimated variance ranged from 0.53 (CBC cm^2) to 18.44 (CC cm^2), and the covariance was negative and ranged from -0.07 (CBC to HW) to -0.89 (CC to HW). The environmental correlations were negative and showed lower values, with a minimum of -0.07 (CBC and HW) and a maximum of -0.89 (CC and HW).

Table 4. Component of residual (co)variance and environmental correlation for basic morphological measurements in a Lipizzan horses

Traits	HW	CC	CBC
HW	**3.66±3.07**	-7.34±4.05	-0.09±0.73
CC	-0.89±0.81	**18.44±9.92**	-0.90±1.19
CBC	-0.07±0.56	-0.29±0.44	**0.53±0.281**

Variances on diagonal, covariance above, correlation below

The heritability, phenotypic and genetic correlations with standard errors (SE) are shown in table 5. Heritability estimates were 0.78 for HW, 0.67 for CC and 0.60 for CBC. The phenotypic correlations were all positive, ranging from 0.46 (CBC and CC) to 0.58 (CBC and HW). The genetic correlations were also positive, ranging from 0.88 (HW to CBC) to 0.99 (HW to CC).

Table 5. Heritability (diagonal), phenotypic (below diagonal) and genetic correlations (above diagonal) for basic morphological measurements in a Lipizzan horses

Measures	HW	CC	CBC
HW	**0.78±0.21**	0.99±0.18	0.88±0.17
CC	0.48±0.12	**0.67±0.21**	0.90±0.27
CBC	0.58±0.11	0.46±0.12	**0.60±0.25**

The heritability (h^2) of WH (0.78 ± 0.21) was equal or similar to that in Sardinian Anglo Arab h^2=0.78 ± 0.02 (Giontella et al., 2020) and Horse Pura Raza Española h^2= 0.80 ± 0.03 (Sanchez-Guerro et al., 2016), although it was higher than the h^2 reported by other authors in different breeds. In the Arab breed,

it was 0.48 (Seidlitz et al., 1991); in the Wielkopolsky, it was 0.57 ± 0.01 (Gomez et al., 2009) and, finally, in the Pantaneiro breed, it increased to 0.61 (Miserani et al., 2002).

The estimate of h^2 for CC (0.67 ± 0.21) put this trait among those with high heritability as was reported in the Pura Raza Española, reaching 0.67 ± 0.03 (Sanchez-Guerro et al., 2016). In the Arab horse, this value was 0.31 ± 0.01 (Seidlitz et al., 1991), in the Wielkopolsky it was 0.35 ± 0.01 (Gomez et al., 2009) and in the Sardinian Anglo Arab it was h^2=0.47 ± 0.02 (Giontella et al., 2020). The heritability estimation of the CBC trait was equal to 0.60 ± 0.25 and it was higher than the value 0.44 ± 0.03 computed on the Pura Raza Española (Sanchez-Guerro et al., 2016) and on Wielkopolsky (0.42 ± 0.01) (Gomez et al., 2009).

Miserani et al. (2022) reported a negative genetic correlation between CC and CBC (-1) and between CC and HW (-1) for Pantaneiro horses, which indicates that there is a difference in genetic correlation for morphological traits in Pantaneiro in accordance with Lipizzan horses.

CONCLUSION

Conformation traits are important selection criteria in Lipizzan horse breeding because they describe the horse's exterior. The results obtained in this research might be valuable for the selection scheme in order to gain genetic improvement for some morphological traits of Lipizzan horses in stud farm Vučijak. The high heritability estimates indicate that selection based on horse phenotypic value can contribute to genetic change in these traits and that an animal's phenotype is a good indicator of genetic merit or breeding value.

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