

## ESTIMATION OF PHENOTYPIC VARIABILITY OF BODY MEASUREMENTS IN LIPIZZAN MARES

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**Abstract:** The aim of this work was a phenotypic description of the mare families of a Lipizzan horse breed from stud Vucijak. A total of 31 mares were measured, for every animal 28 measures were recorded. The mares are distributed by mare families in the following: Sana (3), Lipa (3), Bregava (3), Cremica (3), Ukrina (3), Visla (2), Neretva (3), Pliva (1), Drina (2), Sutjeska (2), Sitnica (1), Janja (2) and Sava. Simple analysis of variance was done to determine the difference in the morphological measures between mare families. Also, correlation between 28 measures was done. This study revealed phenotypic uniformity between mare families. Of the 28 measures recorded, a statistically significant difference was identified only for the length of cannon (front leg). The longest average length of the cannon (front leg) had at Sana (24.67 cm), and the shortest at Bregava (19.00 cm). The correlation ranged from slightly negative to highly positive with correlation coefficients from -0.465 to 0.779. Significant and highly significant correlation with height, length and depth was found in mare measures. The body shape of the mare families has a rectangular, which is in accordance with the Lipizzan horses from other stud in Europe. Also, the study revealed that mares from Vučijak are smaller than mares from other stud, which is in accordance with the breeding goals.

**Key words:** morphological measures, correlation, mare families, stud Vučijak

### Introduction

Lipizzan horse is a unique horse breed in Europe and the world. They characterized long history of existence, strict and systemic selection, small population, precision of stud books, great morphological and genetic variability, etc. For this reason Lipizzan is cosmopolitan horse breed, is bred in many countries as well as on more

continents. In addition to state-owned stud, the Lipizzan is widely spread in many private breeders over the world, as a reflection of royalty and prestige.

State-owned stud Vučijak is the only Lipizzan stud in Bosnia and Herzegovina. It was founded in 1946. The horses-founders originated from Croatian state-owned stud Lipik and Đakovo, and from different private breeders in Croatia. According Čačić and Čurik (2014) stud Vučijak is the direct genetic successor of the "old" stud from Lipik (1938-1959) and indirect of stud farm Stančić (1919-1938). Subsequently, stallion and mares from Slovenia and Serbia were integrated into the stud population (Rogić et al., 2018). Establishing stud Vučijak, very soon Lipizzan horses spread to almost entire Bosnia, thanks to selective work at the stud Vučijak. The desirable characteristics of Lipizzan have led, not only to the quality of pure breeding program on stud Vučijak, but also to the great influence, as a meliorator, on the horse breeding in the Bosnia.

According to Stipić (1980), today's Lipizzan horse breeds was completely developed, with all the present sire lines and mare families, in the 18th and early 19th century, regardless of the fact that the beginnings of the creation of Lipizzan breed were dated back to the 16th century. Today, the Lipizzan horse breeds have had 8 sire lines and 66 mare families. Of the total mare families 17 is from Slovenia, 16 Croatia, 17 Hungary and 16 Romania (LIF, 2019). Of the 66 mare families on stud Vučijak are bred 15 (Table 1).

Zechner et al. (2001) was done characterization of the breed in their morphometric study of Lipizzan horses from eight different state-owned studs in seven countries. The aim of the paper was to present the mean and differences for these studs of 37 body measurements following a standard procedure developed by Oulehla (1996). This work did not include all state-owned studs, as well as Vučijak, but served as a basis for similar research on the Lipizzan population at the national level. From this came the results of Važić et al. (2016) who worked on the morphometric characterization of Lipizzan horse breed in the stud Vučijak, both stallion and mares. The authors concluded that Lipizzan horse from Vučijak have a smaller body frame than Lipizzan horse from other state-owned stud, which is in accordance with breeding goals of stud Vučijak (Rogić et al. 2018). Also, at present day, the morphometric measurements and body shape have important role in research not only for Lipizzan but also for other horse breeds (Lopes et al., 2015; Martinon et al., 2014; Duml et al., 2018; Jenen et al., 2016; Fernandes et al., 2015; Ghezelsoflou et al., 2018).

The beauty of the Lipizzan horse breed is present in their exterior, royalty walk and the possibility of their dress. In the presence of these traits a great influence certainly had mare families. So, the aim of this study was to get inside at the phenotypic variability of the mare families from stud Vučijak and to compare them among themselves.

**Table 1. Mare families from stud Vučijak**

| No  | Name in Vučijak | Name in other studs          | Founding dam | Country  |
|-----|-----------------|------------------------------|--------------|----------|
| 1.  | Drina           | Traviata, Trofetta           | Troffeta     | Croatia  |
| 2.  | Sutjeska        | Siglavý, Toplica             | Toplica      | Hungary  |
| 3.  | Sava            | Pluto, Pakra                 | Pakra        | Slovenia |
| 4.  | Sana            | Argentina, Slava             | Slava        | Slovenia |
| 5.  | Bregava         | Anemone                      | Anemone      | Hungary  |
| 6.  | Ukrina          | Mima, Nana                   | Nana         | Croatia  |
| 7.  | Pliva           | Alka                         | Liza         | Croatia  |
| 8.  | Neretva         | Gidrana, Gaetana, Gaeta      | Gaetena      | Slovenia |
| 9.  | Lipa            | Afrika, Batosta              | Batosta      | Slovenia |
| 10. | Ilova           | Reseda, Adica                | Adica        | -        |
| 11. | Sitnica         | Almerina, Santa, Slovenia    | Santa        | Slovenia |
| 12. | Visla           | Virtuosa, Volga              | Volga        | -        |
| 13. | Jala            | Zenta, Rendes, Krabbe        | Zenta        | -        |
| 14. | Kremica         | Deflorata, Capriole, Canissa | Capriola     | Slovenia |
| 15. | Janja           | Karolina                     | Darinka      | Croatia  |

## Material and Methods

Morphological measurement was taken at the stud Vučijak. A total of 31 mares were measured, and for every animal 28 measures were taken following procedure described in *Zechner et al. (2001)*. The mares were measured by the measuring stick and tape. For the measurement procedure, horses put on a hard floor, and only mares 4 years or older were measured. Mares are measured from the left side and all measures were recorded by the same person. The total 31 mares are distributed by mare families in the following: Sana (3), Lipa (3), Bregava (3), Kremica (3), Ukrina (3), Visla (2), Neretva (3), Pliva (1), Drina (2), Sutjeska (2), Sitnica (1), Janja (2) and Sava (2). Mares from Ilova and Jala were less than 4 years old, and were not measured.

According the fact that mare families Sana, Lipa, Bregava, Kremica, Ukrina and Neretva have 3 measured animals older then 4 years, which is rare in Lipizzan population on stud, simple analysis of variance was done to determine the difference in the morphological measures, whereby the F-test was calculated. The significance of the difference ( $p < 0.01$ ) was tested based on the Duncan test. Also, correlation between 28 measures for 31 mares was done with significant of level 0.01 and 0.05. The statistical program SPSS17 was used for data processing.

**Table 2. Abbreviation of the 28 morphological measurements taken**

|                                          |                                                              |
|------------------------------------------|--------------------------------------------------------------|
| HW - Height at withers (measuring stick) | CC - Circumference of chest                                  |
| HB - Height of back                      | Ccc <sub>1</sub> - Circumference of cannon bone (metacarpal) |
| HR - Height of rump                      | Ccc <sub>2</sub> - Circumference of cannon bone (metatarsal) |
| BL - Body length                         | LH - Length of head                                          |
| LF - Length of forequarters              | WJ - Width of head (lower jaw)                               |
| LB - Length of barrel                    | Lua <sub>1</sub> - Length of upper arm 1                     |
| LR - Length of rearquarters              | Lua <sub>2</sub> - Length of upper arm 2                     |
| DC - Depth of chest                      | LoF - Length of forearm                                      |
| WC - Width of chest                      | LcF - Length of cannon (front leg)                           |
| WH - Width of hips                       | LpF - Length of pastern (front leg)                          |
| WT - Width of thurls                     | LoT - Length of thigh                                        |
| LN - Length of neck                      | LsT - Length of second thigh                                 |
| LS - Length of shoulder                  | LcH - Length of cannon (hind leg)                            |
| HWT - Height at withers (tape)           | LcP - Length of pastern (hind leg)                           |

## Results and Discussion

Comparing the obtained results (table 3) with the results of *Važić et al. (2016)* it can be noticed that the mare families Sana, Ukrina and Neretva have higher height at withers than the average of the mares of stud Vučijak, while the Lipa, Bregava and Cremica have the smaller. The chest circumference at Cremica, Ukrina and Neretva are higher, while Sana, Lipa and Bregava smaller than average. The third basic measure in horses, circumference of cannone bone, was higher at Neretva, smaller at Sana, Lipa and Bregava, and the same at Cremica and Ukrina. According results we can concluded that mares from Vučijak were smaller then mares from Đakovo (*Rastija et al., 2004*) and other state-owned studs (*Zechner et al., 2001*). This conclusion are in accordance with the report of *Rogić et al. (2018)*.

Of 28 analyzed morphometric measures, only statistically significant differences were found between the mare families for the length of the cannon (front leg). The longest average length of the cannon (front leg) had at Sana (24.67 cm), and the shortest at Bregava (19.00 cm). The statistically significant smallest the length of the cannon (front leg) has Bregava and Cremica in regards to Sana, Ukrina, Neretva and Lipa.

The measuring results showed that mare families have a rectangular (height at wither: body length) format. The difference between body length and height at withers was the lowest at Sana (2.66 cm), and the highest at Cremica (7.33 cm). The obtained data correspond to results of *Zechnera et al. (2001)* conducted on the other state-owned stud of the Lipizzan horses. The authors showed that the mean value of height at withers were 3-8 cm smaller than values for body length.

**Table 3. Differences in morphometric measures between six mare families from stud Vučijak**

|                        | <i>Sana</i>        | <i>Lipa</i>        | <i>Bregava</i>     | <i>Cremlca</i>     | <i>Ukrina</i>      | <i>Neretva</i>     |
|------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <i>HW</i>              | 149.67             | 144.00             | 146.33             | 146.00             | 150.33             | 148.00             |
| <i>HB</i>              | 144.00             | 141.00             | 142.67             | 143.33             | 147.00             | 141.67             |
| <i>HR</i>              | 149.67             | 146.33             | 149.67             | 147.33             | 153.33             | 149.00             |
| <i>BL</i>              | 152.33             | 149.67             | 151.00             | 153.33             | 153.33             | 153.67             |
| <i>LF</i>              | 36.33              | 35.67              | 35.33              | 37.00              | 36.33              | 35.00              |
| <i>LB</i>              | 74.67              | 68.33              | 72.33              | 70.67              | 75.00              | 73.33              |
| <i>LR</i>              | 50.33              | 51.33              | 49.00              | 45.67              | 46.33              | 46.67              |
| <i>DC</i>              | 69.00              | 67.67              | 66.00              | 64.67              | 69.00              | 66.33              |
| <i>WC</i>              | 37.00              | 38.00              | 34.33              | 34.67              | 40.33              | 37.33              |
| <i>WH</i>              | 52.00              | 51.33              | 49.00              | 53.33              | 52.33              | 50.67              |
| <i>WT</i>              | 50.00              | 49.33              | 47.67              | 48.00              | 50.00              | 48.67              |
| <i>LN</i>              | 66.33              | 67.33              | 67.67              | 65.33              | 68.33              | 64.33              |
| <i>LS</i>              | 60.67              | 57.00              | 59.33              | 61.67              | 63.33              | 61.00              |
| <i>HWt</i>             | 159.00             | 154.00             | 156.33             | 150.67             | 158.33             | 156.67             |
| <i>CC</i>              | 167.33             | 174.67             | 174.00             | 180.67             | 176.33             | 175.67             |
| <i>Ccc<sub>1</sub></i> | 19.17              | 19.33              | 19.17              | 19.50              | 20.50              | 19.83              |
| <i>Ccc<sub>2</sub></i> | 22.17              | 22.00              | 22.00              | 22.00              | 22.17              | 21.50              |
| <i>LH</i>              | 52.33              | 49.33              | 51.33              | 49.33              | 54.00              | 48.33              |
| <i>WJ</i>              | 15.00              | 15.67              | 14.00              | 16.00              | 15.00              | 15.67              |
| <i>Lua<sub>1</sub></i> | 33.67              | 33.00              | 33.00              | 30.33              | 33.67              | 32.67              |
| <i>Lua<sub>2</sub></i> | 38.00              | 36.33              | 37.33              | 35.33              | 37.67              | 37.33              |
| <i>LoF</i>             | 39.00              | 34.67              | 37.67              | 37.67              | 36.33              | 38.00              |
| <i>LcF</i>             | 24.67 <sup>B</sup> | 22.33 <sup>B</sup> | 19.00 <sup>A</sup> | 19.67 <sup>A</sup> | 23.33 <sup>B</sup> | 22.67 <sup>B</sup> |
| <i>LpF</i>             | 14.33              | 15.67              | 14.33              | 14.33              | 15.67              | 14.33              |
| <i>LoT</i>             | 41.00              | 38.67              | 39.67              | 39.67              | 39.33              | 37.67              |
| <i>LsT</i>             | 46.67              | 44.67              | 45.33              | 44.33              | 41.33              | 45.33              |
| <i>LcH</i>             | 26.67              | 23.33              | 24.00              | 24.00              | 25.67              | 26.67              |
| <i>LcP</i>             | 16.33              | 17.67              | 16.67              | 17.67              | 17.33              | 17.83              |

Correlation between some body measures plays important role in successful performance of breeding-selection work in horse breeding. If the correlation is positive, improvement on one property will result in other interrelated properties, improvement effecting selection success (*Rastija et al., 2003*). Correlation of 28 body measures of Lipizzan mares at Vučijak stud was presented in table 4.

The correlation ranged from slightly negative to highly positive with correlation coefficients from -0.465 (between length of pastern (front leg) and length of second thigh) to 0.779 (between height of wither and height of rump). The similar rang of correlation between mare families, from -0.304 to 0.826, found in Lipizzan mares from stud Đakovo (*Rastija et al., 2003*). Mostly positive and statistically highly significant or significant correlation showed measures made of tubular bones, such as the height: at withers (both, tape and stick), of back, of rump etc. Such correlation is logically because the development of animals in height at wither is accompanied by the development of other mentioned measures. In

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addition, also statistically highly significant or significant correlation showed the measures made of plump bones, such as the length of: body, forequarters, barrel etc. Depth of chest showed the greatest correlation with other measures, with 15 measures showed significant and highly significant correlation. Significant and highly significant correlation with height, length and depth measures at Lipizzan mares from stud Đakovo also reported *Rastija et al. (2003)*. A negative correlation in this work was recorded only for one measure, length of second thigh. Width of head (lower jaw) does not show correlation with any measures. For other measures correlation significance was less pronounced.

Our results represent the first report of phenotypic description of mare families from stud Vučijak. The results of this study indicate that during the past century and breeding Lipizzan horses on stud Vučijak have led to a mares with smaller body shape, which was in accordance with the breeding goal on stud Vučijak (*Rogić et al., 2018*). Furthermore, new modern methods such as pedigree analysis, genetic analysis based on mtDNA, microsatellites as well as SNPs should be applied in future research of Lipizzan horses from stud Vučijak.



## Conclusion

This study revealed phenotypic uniformity between mare families. Of the 28 measures recorded, a statistically significant difference was identified only for Length of cannon (front leg). Also, the study revealed that mares from Vučijak are smaller than mares from other stud. Significant and highly significant correlation with height, length and depth was found in mare measures.

The obtained results indicate a need for further study of Lipizzan horses from stud Vučijak, and its genetic and reproductive parameters, which would contribute to the improvement of selection and breeding program on stud Vučijak. The reported correlation can also be useful to improve breeding-selection work in Lipizzan breeding. Also, the obtained results are applicable in the field of conservation genetics, and protection of the genetic potential of Lipizzan horses, which is one of most valuable animal genetic resources from Bosnia and Herzegovina.

## Procena fenotipske varijabilnosti telesnih mera kobila ergele Vučijak

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### Rezime

Cilj rada bio je fenotipski opis rodova lipicanera ergele Vučijak. Ukupno je izmerena 31 kobila, a za svaku životinju je uzeto 28 telesnih mera. Merene kobile su pripadale sledećim rodovima: Sana (3), Lipa (3), Bregava (3), Cremica (3), Ukrina (3), Visla (2), Neretva (3), Pliva (1), Drina (2), Sutjeska (2), Sitnica (1), Janja (2) i Sava. Urađena je prosta analiza varijanse kako bi se utvrdila razlika u telesnim merama između rodova. Takođe je urađena korelacija između 28 telesnih mera. Ova studija otkrila je fenotipsku ujednačenost između rodova. Od 28 zabeleženih mera utvrđena je statistički značajna razlika samo za dužinu prednje cevanice. Najdužu prosečnu dužinu prednje cevanice imale su kobile roda Sana (24,67 cm), a najkraću kobile roda Bregava (19,00 cm). Koeficijent korelacije se kretao od neznatno negativnih do visoko pozitivnih, odnosno od -0,465 do 0,779. Utvrđena je značajna i visoko značajna povezanost sa merama visine, dužine i dubine kod kobila. Oblik tela kobila je pravougaoni, koji je u skladu sa lipicanerima iz drugih ergela u Evropi. Takođe, istraživanje je pokazalo da su kobile ergele Vučijak manje od kobila sa drugih ergela, što je u skladu s odgajivačkim ciljevima.

**Ključne reči:** morfometrijske mere, korelacije, rodovi, ergela Vučijak



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## References

- ČAČIĆ M., I. ČURIK (2014): The most significant ancestors in Lipizzan horse breed. *Stočarstvo*, 68(4), 101-106.
- DRUML T., M. HORNA, G. GRILZ-SEGER, M. DOBRETSBERGER, G. BREM (2018): Association of body shape with amount of Arabian genetic contribution in the Lipizzan horse. *Archives Animal Breeding*, 61, 79–85.
- FERNANDES K.A., C.W. ROGERS, E.K. GEE, C.F. BOLWELL, D.G. THOMAS (2015): Body condition and morphometric measures of adiposity in a cohort of Pony Club horses and ponies in New Zealand. *Proceedings of the New Zealand Society of Animal Production*, Dunedin, 75, 195-199.
- GHEZELSOFLOU H., P. HAMIDI, S. GHARAHVEYSI (2018): Study of factors affecting the body conformation traits of Iranian Turkoman horses. *Journal of Equine Science*, 29(4), 91–96.
- JENEN R.B., S.H. DANIELSEN, A. TAUSON (2016): Body condition score, morphometric measurements and estimation of body weight in mature Icelandic horses in Denmark. *Acta Veterinaria Scandinavica*, 58(1), 59.
- LIPIZZAN INTERNATIONAL FEDERATION (2019): Population, Mare families, [www.lipizzan-online.com](http://www.lipizzan-online.com)
- LOPES S.M., D. MENDONCA, R. HORST, V. CABRAL, S.X. BETTENCOURT, A. CAMARA MACHADO (2015): Morphological and genetic characterization of an emerging Azorean horse breed: the Terceira Pony. *Frontier in Genetics*, 6, 62.
- MARTINON K.L., R.C. COLEMAN, A.K. RENDAHL, Z. FANG, M.E. MCCUE (2014): Estimation of body weight and development of a body weight score for adult equids using morphometric measurements. *Journal of Animal Science*, 92, 2230-2238.
- OULEHLA, J. (1996): Züchterische Standards in der Lipizzanerpfede-Population. Habilitationarbeit, Brno-Piber.
- RASTIJA T., Z. ANTUNOVIC, M. BABAN, I. BOGUT, Đ. SENČIĆ (2003): Correlation between body measures in Lipizzaner mares and stallion. *Poljoprivreda*, 9(2), 1-7.
- ROGIĆ B., B. VAŽIĆ, Đ. SARAJLIĆ (2018): Breeding goals and selection effort in the breeding of Lipizzan horses in the stud farm Vučijak from 1946 to 2015. *Genetika*, 50(1), 253-259.

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STIPIĆ L. (1980): Ispitivanje populacije i uzgojnog procesa đakovačkog lipicanca. *Stočarstvo*, 34 (7–8), 291-300.

VAŽIĆ B., Đ. SARAJLIĆ, B. ROGIĆ (2016): Morphometric characterization of the Lipizzaner horse breed in The Stud “Vučijak”. *Biotechnology in Animal Husbandry*, 32(2), 219-227.

ZECHNER P., F. ZOHMANN, J. SÖLKNER, I. BODO, F. HABE, G. BREM (2001): Morphological description of the Lipizzan horse population. *Livestock production Science*, 69(2), 163-177.

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