Body shape analysis of Bosnian mountain horses using Procrustes statistics

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ABSTRACT - Procrustes analysis was performed on 4 samples of horse populations (11 Bosniak horses from a private farm in Nevesinje, 2 Bosniak horses from a former state farm in Han Piesak, 12 Bosniak horses from the former state stud farm Borike and 18 purebred Arabian horses from Borike) in order to analyse the differences in body shape between the samples. The twodimensional shapes of the horses were presented as coordinates of 11 landmarks, which were constructed from measurements taken from living animals. Relative warp analysis revealed a separation between three of the samples. The private Bosniak horses are located between the Borike Bosniaks and purebred Arabian horses. Due to the similar shape of private Bosniaks and Arabian horses, which could be proven also by thin plate splines, we can conclude that the privat breeder selected Bosniak horses which were smaller than the Borike Bosniaks but more similar to the Arabian type of horse.

Key words: Horse, Morphology, Geometric-Morphometrics, Procrustes statistics.

Introduction - In the 1980s scientists began to analyse biological shapes and started to develop statistical methods suited for the use of coordinates. Especially anthropologists, paleobiologists and zoologists use landmark data for the analysis of systematics and evolutionary processes. Nowadays this scientific approach is called "Geometric Morphometrics (GM)" (Bookstein, 1996). In livestock sciences this statistical concept hasn't been used up to now. Therefore this paper should give an introduction to the concept of coordinate based statistical analysis and presents an application of these methods in the fields of animal breeding. In this special case we examine the differences of body shapes between three herds of Bosnian mountain horses (Bosanski brdski konj) and one herd of purebred Arabian horses which is used for a crossbreeding program.

Material and methods - "Geometric Morphometrics" provides a set of tools dealing with the shape of specimens while conventional multivariate statistics tend to distinguish samples differing in size (Bookstein, 1996). The data analysed here was derived from body

measurements taken from 43 horses in four different locations: 11 Bosniak horses from a private farm in Nevesinje, 2 Bosniak horses from a former state farm in Han Piesak, 12 Bosniak horses from the former state stud farm Borike and 18 purebred Arabian horses from Borike. The stud farm Borike had an important impact on the breeding of the Bosnian mountain horse throughout the 20th century. In Borike the Arabian stock is used for a cross-breeding program which was designed for the production of a modern multipurpose type of the Bosnian mountain horse. 11 body measurements per individual were used to derive the shape of a horse torso. By the following Procrustes alignment and the orthogonal projection to a shape space, the variation of the 43 specimens is largly reduced and the retained variation responds to the differences in shape. In this study we used shape variables as "Relative Warps" and "Univariate components" (Bookstein, 1989), to show variation and separation of the observed breeds and transformation grids, the so called thin-plate splines, to illustrate the changes in morphology and type. Following software was used: SAS (SAS, 1989) package for calculation of raw coordinates and analysis, tpsRelw v1.46 (Rohlf, 2003) for procrustes superimposition and the calculation of shape variables, and the software package Morpheus *et al.* (Slice, 1999) for graphical presentations and thin-plate splines.

Table 1.   Fixed factors tested for significance in a Manova using relative warp scores as dependend variables using following statistical model: $Y_{ijk} = \mu + Sex_i + Age_j + Location_k + \varepsilon_{ijk}$.

| Effect	Relative warp axis 1	Relative warp axis 2	Relative warp axis 3	Univariate component 1	Univariate component 2	Centroid size
Age	ns	*	ns	ns	ns	ns
Location	ns	*	**	***	ns	***
Sex	ns	ns	ns	ns	ns	ns

*Significance levels *<0.05; **<0.01; ***<0.001; ns=not significant.*

Results and conclusions - The results from the relative warp analysis are presented in Tab.1. and in Fig.1A. 25.3% of shape variation are explained by relative warp 1, 16% of variation by relative warp 2 and 13.9% of shape variation by relative warp 3. From the tested effects in the MANOVA mainly the location effect, i.e. the different stud farms revealed significant values. By plotting the first three warp axes the distinction between the stud farms can be observed. The private Bosniak horses are placed between the purebred Arabian and the Bosniak horses of the stud farm Borike.

Taking the size of these horses into account we can see in Figure 1B, that the private Bosniak horses are smaller than the Borike Bosniak horses. The relative warp scores tell us that the shape of private Bosniak horses tend to the shape of Arabian horses – so the type of these horses is more "orientalised" (Figure 1A). The horses of Han Piesak, where only two of the mares could be measured, were quite small (Figure 1B) and the type couldn't be differentiated well due to the sample size. Besides of these clustering analysis the transformation grids or the so called "thin plate splines" give an accurate impression about the differences in body shape of the animals under study. Considering the thin plate splines

(not presented in this short communication), the private breeder selected obviously horses standing in an Arabian type, though they were smaller than the Bosniak horses from the nucleus herd in Borike. We could show that body shape analysis using methods of Geometrics Morphometrics may be useful in the evaluation of conformation and other applications, especially in horses.

Figure 1. A) Plot of the first three relativ warp axes (rel1-rel3); pyramide=OX[1] horses in Borike, cube=Bosniaks in Borike, circle=Bosniaks private, cross=Bosniaks Han Piesak. B) In the right figure centroid size (size) is plotted against height at withers (wh).
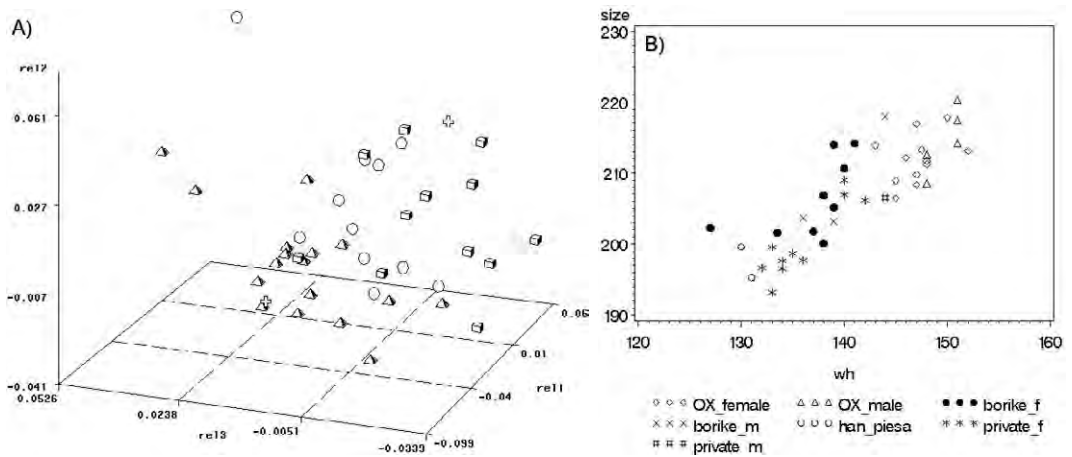
[1]OX=Pure bred Arabian horses.

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