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FACTORS INFLUENCING THE SELECTED BODY PARAMETERS AND HIPPOMETRIC INDEXES IN DONKEY'S POPULATION

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Abstract

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The main focus of our work was to collect basic body measurements of donkey population in Czech republic and determine the factors that influence these body measurements and hipometric indexes. The following measurements were recorded: height at withers, chest circumference and metacarpus interference. Based on the collected data, we were able to calculate the hipometric indexes: index of boniness, skeleton strength index, body mass index and coup height index. From a total of 331 individuals of donkey species living in Czech republic we managed to collect 50 samples. These were subjected to a general linear model (GLM) and multiplex comparison statistical analysis. We managed to prove a statistically significant difference between donkeys born in Czech republic and the ones born abroad for all the measurements. Specifically the metacarpus circumference the gender dependency was also proved, having its impact on the hipometric indexes as well; the boniness index and skeleton strength index were also proved to be gender – dependent.

donkey, basic body measurements, hippometric index

The donkeys originally come from the northern parts of Africa. The Wild ass (*Equus asinus*) is an ancestor of the modern donkeys. All of the historical populations could be identified by specific phenotype features – there were differences in sizes of animals, stripes on their limbs and also in the type of donkey cross. Groves (1986) has also documented significant differences in skull and skeleton sizes. The process of domestication has brought even more changes; both genetic and morphologic ones. These changes were, however, very slow (Rossel *et al.*, 2008). Donkeys were migrating throughout the whole world and have diverged to recent breeds as we know them. In past times, the donkey stallions were bred at almost every stud farm specifically for mule production. Studbooks were established for breeding donkeys, all the records about animals were being kept and breeding standards were strictly observed.

Later on, when mechanization in agriculture has been implemented, many of the donkey breeders at stud farms were cancelled and consequently many donkey breeds have become extinct, or they were saved by various breeding associations (Hafner, 2009). Another reason for the population decrease of donkeys was that donkeys were never bread for meat production, and their breeding was therefore not financially interesting. The records of origin were lost for many breeds during that time, letting the uncontrolled crossbreeding begin.

Nowadays, the donkey breeding in Czech Republic does not have any structure at all, no records exist and the ancestors of current individuals are unknown. However, the popularity of the donkeys is on the rise and that is why it is needed to bring order and structure to donkey breeding once again. We are particularly interested in any eventual factors that have their influence on

morphology, or if there any phenotype changes in donkeys bred in the Czech Republic.

MATERIALS AND METHODS

A total of 15 donkey stallions and 35 donkey mares were measured, all of them being owned by private subjects in Czech Republic.

Four basic body dimensions were measured in order to set up standards and to create a concept of studbook for donkeys in Czech Republic.

All of the animals have been measured by the same person, who was using precisely the same measuring instrument. This was to minimize the subjective error, which usually occurs when more persons perform this task. The measuring stick has to be in an upright position to the ground when the measurement of height at withers (WH) and croup height is being conducted. Should a deviation from the vertical line occur, the data would be falsified and unusable for further processing. It is also needed to maintain the same adhesion and constriction of the measuring tape when obtaining data such as chest and chin circumference.

Each dimension has been measured three times and an average of the three obtained values was further processed.

The following body dimensions and hippometric indexes were used for our work:

- Withers Height (WH)
  – cane rate, the highest point of withers
- Croup Height (CH)
  – cane rate, the highest point of back
- Chest Circumference (CC)
  – tape rate, right behind the withers
- Shin Circumference (SC)
  – measured in upper third of shin (narrowest point).

The following hippometric indexes were calculated from the dimensions described above:

- Body Mass Index (BMI)
  – chest circumference × 100 / withers height
- Boniness Index (BI)
  – shin circumference × 100 / height at withers
- Skeleton Mass Index (SMI)
  – shin circumference × 100 / chest circumference
- Index of Build (IB)
  – croup height × 100 / height at withers.

We were collecting the data in Microsoft Office Excel 2007.

The following factors were considered (n = individuals count):

Gender: donkey stallions (n = 15), donkey mares (n = 35).

Place of Birth: imported individuals (n = 15), individuals born in CZ (n = 35).

Year of Birth: division into three groups considering the age of every individual.

1. Aged 3 – 4 (n = 19)
2. Aged 5 – 10 (n = 17)
3. Aged 11 and older (n = 14).

The influence of these factors on the actual body dimensions was tested using a General Linear Model (GLM) in the Unistat ver. 5.1 program. To calculate the eventual effects on the morphology of donkeys, the following equations were used:

A model equation:

$$Y_{ijk} = \mu + p_i + s_j + y_k + e_{ijkl},$$

where:
μ ..... general mean value
p_i ..... i^{th} place of birth effect (i = 1, 2)
s_j ..... j^{th} gender effect (j = 1, 2)
y_k ..... l^{th} age effect (k = 1, 2, 3)
e_{ijkl} .... residuum.

The differences in genders, age groups and places of birth were determined by a multiple comparison Tukey – B test for each case of a statistically provable effect.

RESULTS AND DISCUSSION

By applying the General Linear Model (GLM) on defined body measurements and hippometric indexes we determined a statistically significant influence ($P < 0.05$) for some of the tested factors. A statistically significant influence for all observed body measurements could be defined for place of birth (Tab. I), and also the shin circumference was evidently influenced by the gender of each individual. On the other hand, no statistically significant influence was observed for different age groups. Statistically significant influence was also observed between genders in hippometric indexes calculated on shin circumference basis (Tab. II).

Statistically highly significant differences ($P < 0.01$) were not found.

I: *Statistically provable influence on observed body measurement effects*

Body measurements	Significance		
	gender	Place of birth	Age groups
WH	0.0507	0.0298	0.4398
CH	0.0575	0.0434	0.5278
CC	0.0156	0.1339	0.6185
SC	0.0013	0.0405	0.8329

II: *Statistically provable influence of body measurements on hippometric indexes*

Index	Significance		
	Gender	Place of birth	Age groups
Boniness Index	0.0019	0.5037	0.2234
Body Mass Index	0.0815	0.7787	0.2647
Skeleton Strength Index	0.0003	0.4178	0.4359
Index of Built	0.7871	0.5072	0.7886

Withers Height (WH) Evaluation

Height at withers is a basic measurement for many animals as it is a primary indicator of skeleton growth. It is measured with a stadiometer at the highest point of withers.

In the African Wild ass, the height at withers usually varies between 113–118 centimeters (Volf, 1977), but the average height of population in Czech Republic is only 104 centimeters. By a comparison of recent donkeys and their wild ancestors, we can observe a slight decrease in the height of individuals. This can be a result of domestication and breeding processes in various parts of the world. A vast majority of donkey individuals living within the borders of Czech Republic has been imported from eastern parts of Europe; their growth was influenced by the local conditions, workload, food quality etc. For many generations, the growth is also impacted by an early parturition, which is quite common in those areas; the access to quality feed accelerates the process of sexual pubescence and the first parturition often happens before the growth zones of skeleton. The parturition itself is a very exhausting for any organism, as the nutrients needed for self-development and further growth are provided to the fetus. This results in growth slowdown and generally smaller individuals in population.

A statistically significant influence has been detected between the animals born in Czech Republic and the ones imported from abroad (Tab. III). The height at withers can be influenced by many factors, the most common are: workload and geographical conditions, the breeder him/herself and specifically in Czech Republic also lack of stallions with higher KVH. Our results might have been impacted by measurements take in the southern part of Bohemia; one of the local breeders had a larger herd of donkeys, in which many individuals were ancestors of her stallion with KVH 91 centimeters. The recent breeding trend is to demand higher animals and this is the main reason of the difference between the local and imported portion of the population.

III: *Differences in WH dependent on place of birth*

Group	Occurrences	Average	CZ	import
CZ	35	102.44		*
Import	15	110.03	*	

According to Gubitz *et al.* (2000), the morphological traits of donkeys are affected by geographical locality. The morphology of each individual is subject to change according to ecological conditions of each given locality (Kefena *et al.*, 2011). These changes are a sign of adaptation to major ecological variables and biophysical resources.

Croup Height (CH) evaluation

The croup height and withers height together are indicators of the body build (uphill or downhill). According to Hafner (2009) the downhill build should not occur in donkey population, but in a horse evolution study performed by Doležal (2005), some important facts are mentioned: *the size of donkey's head is relatively bigger considering the body size, the pelvis of donkeys is higher, steeper and narrower and there is no fifth lumbar vertebra in donkeys…* – all of these traits being pointed out in comparison to horses.

The horses have generally higher value of WH than CH. The donkey population we measured, did, however, equip us with contradicting data. The values of CH were higher than of WH for all measured donkey individuals.

All the individuals born abroad have significantly higher WH and CH than animals born in Czech Republic; which was also documented by a statistically significant difference in CH for place of birth (Tab. IV). Based on the results for WH, a statistically significant difference was also expected for CH.

IV: *Differences in CH dependent on place of birth*

Group	Occurrences	Average	CZ	import
CZ	35	105.32		*
Import	15	112.70	*	

Chest circumference (CC) evaluation

The chest circumference is measured with a tape right behind the withers of an individual. The circumference is dependent on many factors, from which the most important are the following: physical condition of the given individual, feed composition, gravidity progress etc. CC is one of the most variable values amongst all; contrary to that for example withers height does not change anymore after the growth zones of bones ossify.

An average value for males was 129.83 centimetres, for females 129.53. It is quite common horse mares

have larger CC than stallions, which is usually caused by gravidity, parturitions, nutritional state etc. The same can be applied to donkeys; a higher value of CC would be expected for donkey mares. However, even though the values of WH were (103.56) for mares and (107.43) for studs, the CC was 0.3 centimetre larger for studs.

Even though the values obtained from variance analysis do not themselves identify any statistical significance for the place of birth, their further examining with Tukey-B test brought contradictory results (Tab. V). On the other hand, the multiple comparison did not prove any statistically significant difference between genders.

V: *CC differences dependent on place of birth*

Group	Occurrences	Average	CZ	import
CZ	35	127.50		*
Import	15	134.56	*	

The results document that the imported individuals are not only reaching higher values in terms of WH, but also when it comes to comparing CC.

Shin Circumference (SC) evaluation

The Shin circumference serves as an indicator of skeleton strength and as a basis for Skeleton Strength Index and Boniness Index calculations. It is measured in the narrowest point of the upper third of shin (Dušek, 2001).

A statistically significant effect was proved for all watched factors excluding the differentiation into age groups. The multiple-comparison test brought us to determining a significant difference between the male and female gender; average values for the two of them were more than 1 centimetre far from each other.

VI: *Gender-dependent Shin Circumference (SC) differences*

Group	Occurrences	Average	Mares	Stallions
Mares	35	13.67		*
Stallions	15	14.86	*	

Table VI clearly shows a statistically significant fact; the shin circumference is on average higher for stallions than for mares. Kefen *et al.* (2011) suggest there are no significant anatomic differences and / or sexual dimorphism in donkeys, but Folch and Jordana (1997) were able to identify sexual dimorphism in Catalan donkey. We managed to prove the shin circumference being affected by gender of the individual. The stallions are significantly bonier than mares.

The place of birth was also found to be an important factor when it comes to identifying the skeleton strength; donkeys imported from abroad clearly dispose with a stronger shin, the difference is more than 1 centimetre (Tab. VII).

VII: *Shin circumference (SC) differences based on place of birth*

Group	Occurrences	Average	CZ	import
CZ	35	13.70		*
Import	15	14.80	*	

Taking into consideration the fact imported individuals reach higher values for withers height and chest circumference, it can be assumed they will also need to have stronger chin (higher figures for chin circumference) to keep the skeleton strength and boniness values on the same or at least similar level. This assumption (or thesis) has been successfully proven as a statistically significant influence on SC was found for the place of birth.

Boniness index (BI) evaluation

The boniness index expresses the physical constitution of animals. It is calculated by dividing shin circumference with the withers height. Koubek (1933) presents the value of 12.1 as a minimal value of boniness index for horses (thoroughbred) and 16.2 as a maximum value (cold-blooded horses). The donkeys reached an average of 13.41 and the interval obtained by applying the standard deviation was 12.7–14.12.

The difference between mares and stallions was identified using a multiple comparison test. Once the male and female gender of an animal species can be safely identified based on biochemical and physical factors, this occurrence is called sexual dimorphism. Each specific trait has it very own purpose; it can be advantageous in terms of surviving, competing for resources, reproducing etc.

In a variety of species throughout many taxons, the males have developed different physiological and biochemical traits, which make them differ from females (Andersson, M., 1994) in Purzyc, H., *et al.*, 2007). The traits considered forming a sexual dimorphism are generally more accentuated in males, in female gender they are usually expressed more delicately. According to Koch (1954), the sexual dimorphism in horses is not very picturesque (the same applies for example for rabbits and guinea pigs). However, there are differences in biometric traits that have been focused upon recently (Purzyc, H., Kobrynczuk F., Bojarski, J., 2007).

VIII: *Boniness Index (BI) dependency on gender*

Group	Occurrences	Average	Mares	Stallions
Mares	35	13.21		*
Stallions	15	13.86	*	

As seen in Tab. VIII, we were able to identify a statistically provable difference between male and female gender. It is good to point out Boniness Index is calculated from Shin Circumference.

Skeleton Mass Index (SMI) evaluation

The Skeleton Strength Index is calculated by dividing the chest circumference with shin circumference. As the title states, its purpose is to determine the skeleton mass. The males and females have slightly different values of SMI (see Tab. IX) because of a different ratio of CC to SC. The males have in general lower values for chest circumference and higher values in shin circumference, while in females the chest circumference is affected by different physiological processes (gravidity) and different metabolism from males (Koubek *et al.*, 1933).

IX: *Skeleton Mass Index (SMI) differences related to genders*

Group	Occurrences	Average	Mares	Stallions
Mares	35	10.58		*
Stallions	15	11.48	*	

SUMMARY

The main goal of this work was to identify any factors that have any influence on basic body measurements and hippometric indexes of donkey population in Czech Republic.

All measurements were carried out on individuals older than 3 years of age, because animals that have passed this milestone do not grow significantly anymore. A total of 15 donkey stallions and 35 mares have been measured and the values were recorded. Form the total of 50 samples, 15 come from imported donkeys (5 stallions and 10 mares), while the remaining 35 individuals were born in the Czech Republic. The population was analyzed using three factors – gender, place of birth and age group. The statistical evaluation was carried out using the General Linear Model (GLM).

A statistically provable difference was found between the population imported from abroad and the population born in Czech Republic. The donkeys born in Czech Republic generally have lower values in all 4 basic measurements: withers height (CZ – 102.44, import – 110.03), chest circumference (CZ –127.50, import –134.56), shin circumference (CZ – 13.70, import – 14.80), and croup height (CZ – 105.32, import – 112.70). This fact could be a consequence of discontinuous donkey import and lack of stallions with higher withers height in Czech Republic. Another statistically significant difference was proven for the gender effect on shin circumference. Values of shin circumference were significantly lower for mares (13.67) than for stallions (14.86). Even though the donkeys do not show a visual sexual dimorphism, it was identified in this body measurement.

The hippometric indexes calculated from values obtained by measuring described above indicated a statistically provable difference only for the gender effect on indexes that are calculated from the shin circumference (boniness index, skeleton mass index). Stallions generally have stronger (thicker) chin in order to keep a skeleton strength corresponding to other body measurements. Index values for remaining factors were relatively balanced; there were little differences between tested populations.

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