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Study on Phenotypic, Genotypic and Environmental Correlations Between the Main Body Dimensions Used in the Selection Process in Horses

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ABSTRACT

Background: Knowledge of the interdependence of characters, especially in terms of genetic correlation, is very important in the process of genetic improvement of domestic animal populations, as it is a basic condition in establishing the objective of selection.
Methods: In this study, during 2017-2020, in order to analyze the phenotypic, genotypic and environmental correlations, we used the analysis of covariance with two sources of variation. The material was represented by 538 individuals from Hucul horse breed analyzed at 18, 30 and 42 months age. Analyzed characters were wither's height, thoracic perimeter and cannon bone perimeter.
Result: All characters measured at the age of 1.5 years were closely correlated with each other. At the age of 2.5 years, all the measured characters were correlated positively with each other, registering a very close correlation between the wither's height and the thoracic perimeter and a weak correlation between the wither's height and the cannon bone perimeter and between the thoracic perimeter and the cannon bone perimeter. At the third age, there were intensely positive correlations between the wither's height and the thoracic perimeter and between the thoracic perimeter and the cannon bone perimeter. There was a weak positive correlation between the wither's height and the cannon bone perimeter.

Key words: Correlation, Covariance, Genetics, Horse, Phenotype.

INTRODUCTION

The body is a well-balanced set of forms and functions. By virtue of this general correlation, the exterior was, throughout the period of unconscious selection and especially between the two technical-scientific revolutions, one of the basic objectives of improvement. However, it was often forgot that, in fact, the selection on the exterior characters was made to improve production (Molina *et al.*, 1999). The correlation between exterior and production is usually small, the external differences between individuals within the breed giving less indications in relation to production, than the external differences between races (Marginean *et al.*, 2005). In horses, however, the appreciation of external characters, especially those that can highlight the growth process, has a special importance (Maftei *et al.*, 2008; 2009). In this species, the main production is represented by the skills for running, riding, training, traction and, as a result, there is a very close link between conformation, constitution, growth and the listed skills.

MATERIALS AND METHODS

The biological material, used in this study, was represented by a sample of 538 individuals from Hucul horse breed (males and females), belonging to National Studfarm Lucina, between 2017-2020. The individuals belonging to 20 stallion families (half-siblings), from 5 genealogical bloodlines (Table 1). The research and analysis were performed in the profile laboratories of Animal Sciences Faculties from Bucharest and Timisoara.

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The sample extracted from the population was studied during three ages, respectively at three different classifications/rankings:
Ranking I - at 1.5 years (18 months) old.
Ranking II - at 2.5 years (30 months) old.
Ranking III - at the age of 3.5 years (42 months) old.

The sample was extracted in such a way that the analyzed individuals had a performance recorded in each of the three classifications.

The main body dimensions analyzed in this study were the wither's height, the thoracic perimeter and the cannon bone perimeter. The correlation between these three characters, especially the correlation between wither's height and the other two, are very important in order to establish the objective of selection, due to great importance

Table 1: Biological material.

Stallion's bloodline	Family size	Males family	Females family
Goral	87	35	52
- Goral XV	10	5	5
- Goral XVI	50	17	33
- Goral XVII	1	0	1
- Goral XVIII	12	5	7
- Goral XIX	14	8	6
Hroby	177	84	93
- Hroby XVI	10	3	7
- Hroby XVII	13	6	7
- Hroby XVIII	3	1	2
- Hroby XIX	31	15	16
- Hroby XX	54	29	25
- Hroby XXI	66	30	36
Ouşor	90	35	55
- Ouşor VII	29	9	20
- Ouşor VIII	39	15	24
- Ouşor IX	22	11	11
Pietrosu	91	44	47
- Pietrosu VIII	6	2	4
- Pietrosu IX	65	31	34
- Pietrosu X	20	11	9
Prislop	93	44	49
- Prislop VIII	26	14	12
- Prislop IX	62	27	35
- Prislop X	5	3	2
Total	538	242	296

of wither's height character in horse's selection and evaluation process (Maftei *et al.*, 2022).

In order to quantify the different components of the sources of variability, we applied the analysis of covariance with two sources of variation (ANCOVA). The phenotypic correlation was calculated from the phenotypic variances and covariances. The genotypic correlation was estimated from the component between families. The error of estimating the genotypic correlation was calculated according to the model predicted by Reeve and resumed by Robertson (Falconer and Mackay, 1997). The environmental correlation was estimated from the inter and intra family components.

RESULTS AND DISCUSSION

In order to follow the existence of a common gene background from the polygenic complexes that determine the characters in question, phenotypic, genotypic and environmental correlations were determined, whose values and associated errors are presented in Table 2. It can be seen that all the characters measured at ranking 1 were closely correlated with each other. These values of the genotypic correlations prove the existence of a very large number of genes with pleiotropic effect in the genotypes of the characters analyzed at ranking I. Thus, the selection for any of these traits entails the improvement of the others.

At the second ranking, all characters were correlate positively with each other, registering an intense correlation between the wither's height and the thoracic perimeter and a weak correlation between the wither's height and the cannon bone perimeter and between the thoracic perimeter and the cannon bone perimeter. This situation proves the existence of a common gene background involved in the genetic determination of the three characters, but in different proportions.

The situation was similar at ranking III. There were intensely positive correlations between the wither's height and the thoracic perimeter and between the thoracic perimeter and the cannon bone perimeter. There was a weak positive correlation between the wither's height and the cannon bone perimeter.

Analyzing the presented data, it is found that, regardless the age, the wither's height character is certainly determined by the same polygenic complex. This statement is based on the values of genetic correlations (0.7624, 0.4089 and 0.8839).

Studying the genotypic correlation of the thoracic perimeter at the three ages of measurement, the results may seem contradictory because the genetic correlation between the values recorded for the same character, at 1.5 years and 3.5 years, should have been positive and close. In such situations, a high genotypic correlation involves an activity of the same set of genes (Sadek *et al.*, 2006) and a low genotypic correlation, the activity of different sets of genes, the hypothesis of a sequential action of different sets of minor genes can be advanced. The negative correlation between the character values measured at 1.5 years and at 3.5 years, leads us to the idea that until the age of 18 months, the thoracic perimeter is controlled by physiological mechanisms different from those existing after 3.5 years.

Analyzing the presented results regarding the genotypic correlation of the cannon bone perimeter, at all the three classifications, the values obtained denote an activity of different sets of genes at different ages.

The environmental correlations had positive values between all analyzed pairs of characters, presenting different degrees of intensity. The environmental conditions affect the evolution of pairs of characters in the same sense, having a capital importance in the process of horse breeding (Saastamoinen *et al.*, 1998).

The values of the environmental correlations are, for the most part, lower than the values of the genotypic correlations. The environmental factors exerted a weaker positive action, than that of the genes, in the phenotypic manifestation of the characters. For this reason, the phenotypic correlations between the analyzed pairs of characters are, for the most part, weaker than the genotypic correlations. Also, there are differences of algebraic sign between genotypic and environmental correlations which denotes that the genetic and environmental sources of the variance affect the characters by different physiological mechanisms. Between the first two ages of measurement, regarding wither's height and thoracic perimeter, is a strong positive genetic correlation (0.8159), highlighting the practical action of the same set of genes.

Regarding the wither's height at 1.5 years and the cannon bone perimeter, measured at the other two ages, there are weak and intensely negative correlations, which definitely inhibit the application of an indirect selection, as the selection for wither's height, at 1.5 years implicitly means selection against the cannon bone perimeter at the other two ages.

At first ranking, the cannon bone perimeter correlated intensely positively with the wither's height and thoracic

Table 2: Phenotypic, genotypic and environmental correlations between analysed characters.

Pairs of characters	$r_F \pm S r_F$	$r_G \pm S r_F$	r_M
Wither's height-ranking I x			
Thoracic perimeter-ranking I	0.6147±0.0267	0.6862±0.0286	0.6652
Cannon bone perimeter-ranking I	0.9372±0.0108	0.8774±0.0133	0.6100
Wither's height-ranking II	0.6479±0.0256	0.7624±0.0159	0.7314
Thoracic perimeter-ranking II	0.4561±0.0319	0.7501±0.0213	0.4576
Cannon bone perimeter-ranking II	0.3412±0.0351	-0.0220±0.9900	0.3978
Wither's height-ranking III	0.5014±0.0305	0.4089±0.0506	0.6000
Thoracic perimeter-ranking III	0.2850±0.0365	-0.1337±0.3730	0.3687
Cannon bone perimeter-ranking III	0.1214±0.0405	-0.5666±0.2121	0.3217
Thoricic perimeter-ranking I x			
Cannon bone perimeter-ranking I	0.4339±0.0325	0.5021±0.0815	0.4435
Wither's height-ranking II	0.4250±0.0328	0.2759±0.0841	0.5343
Thoracic perimeter-ranking II	0.4121±0.0331	0.8159±0.0187	0.3972
Cannon bone perimeter-ranking II	0.2215±0.0381	0.2746±0.2866	0.2285
Wither's height-ranking III	0.2388±0.0377	-0.2964±0.3462	0.3547
Thoracic perimeter-ranking III	0.3247±0.0355	-0.2948±0.4036	0.3848
Cannon bone perimeter-ranking III	0.0513±0.0421	-0.3889±0.3237	0.1231
Cannon bone perimeter-ranking I x			
Wither's height-ranking II	0.3561±0.0347	0.7899±0.0223	0.3837
Thoracic perimeter-ranking II	0.3669±0.0344	0.6178±0.0563	0.3670
Cannon bone perimeter-ranking II	0.4640±0.0316	0.0014±1.2028	0.4758
Wither's height-ranking III	0.4264±0.0327	0.4290±0.0773	0.4928
Thoracic perimeter-ranking III	0.2545±0.0373	0.4874±0.0817	0.2518
Cannon bone perimeter-ranking III	0.2602±0.0372	-0.0634±0.4622	0.3279
Wither's height-ranking II x			
Thoracic perimeter-ranking II	0.5257±0.0297	0.8686±0.0100	0.5581
Cannon bone perimeter-ranking II	0.4071±0.0333	0.2014±0.2643	0.5247
Wither's height-ranking III	0.6134±0.0269	0.8839±0.0071	0.6312
Thoracic perimeter-ranking III	0.3117±0.0358	0.280±0.0800	0.3768
Cannon bone perimeter-ranking III	0.1812±0.0391	-0.1032±0.2897	0.3270
Thoracic perimeter-ranking II x			
Cannon bone perimeter-ranking II	0.4397±0.0323	0.1108±0.4336	0.4653
Wither's height-ranking III	0.3609±0.0345	0.7591±0.0197	0.3436
Thoracic perimeter-ranking III	0.4108±0.0332	0.4819±0.0612	0.4218
Cannon bone perimeter-ranking III	0.2053±0.0385	0.1766±0.1083	0.2353
Cannon bone perimeter-ranking II x			
Wither's height-ranking III	0.3107±0.0359	-0.1828±0.3169	0.3913
Thoracic perimeter-ranking III	0.2158±0.0383	0.7259±0.0753	0.2143
Cannon bone perimeter-ranking III	0.4428±0.0322	0.8228±0.0380	0.5046
Wither's height-ranking III x			
Thoracic perimeter-ranking III	0.3921±0.0337	0.5546±0.0406	0.4178
Cannon bone perimeter-ranking III	0.3836±0.0339	0.2109±0.0801	0.5025
Thoracic perimeter-ranking III x			
Cannon bone perimeter-ranking III	0.3914±0.0337	0.7405±0.0215	0.3837

*r_F= Phenotypic correlation; r_G= Genotypic correlation; r_M= Environmental correlation.

perimeter, measured at 2nd and 3rd ranking (polygenic complexes with pleiotropism in their genetic determination).

Between the wither's height values, measured at 2nd ranking, and the other characters appreciated at the 2nd and 3rd ranking, it is found the existence of a medium to intense genetic interdependence, except for the pair of wither's height (2nd ranking) - the cannon bone perimeter (3rd ranking), where the value of the genotypic correlation has a negative sign. Also a positive genetic interdependence is observed between the thoracic perimeter (ranking II) and the other characters appreciated in 2nd and 3rd ranking. A negative genetic correlation is found between the cannon bone perimeter, measured in the (second grade) and the wither's height recorded in the third grade (-0.1828), which means that the selection in favor of the first character is a selection against the second.

CONCLUSION

Regarding the wither's height, the values calculated in this study provide the scope that the selection at an early age of individuals for this character, has favorable repercussions, because regardless of which of the rankings the candidates are assessed, the hierarchy will not change.

Regarding the thoracic perimeter, it is not possible to apply a very early selection for this character, because a selection at 1.5 years, entails a change in the hierarchy of candidates at 3.5 years. However, the selection for the thoracic perimeter can be applied at 2.5 years, because, as a result of the positive genetic correlation registered, there is the certainty that the hierarchy of candidates will not change at the ranking at which normally the selection decision is made.

The small values of the genotypic correlations between the the cannon bone perimeters at 1st and 2nd ranking and 1st and 3rd, suggest that there is no correlation. It can be stated that, at first grading, the cannon bone perimeter is genetically determined by another polygenic complex. In other words, the same character is determined at different ages by other "gene constellations". The intensely positive correlation between the measurements performed at second and third ranking, allows the application of an early selection, there is a scope that the candidates' hierarchy remains unchanged, meaning that the selection for the cannon bone perimeter at second grading means implicit selection in favor of this character at third grading.

At the third grading, all pairs of characters generated positive genetic correlations, emphasizing the existence of similar physiological mechanisms involved in their control.

The application of an indirect selection for wither's height and cannon bone perimeter is excluded, based on the character of the thoracic perimeter measured at first ranking, due to genetic correlations that vary as an algebraic sign from one age to another, which highlights the existence of different polygenic complexes involved in phenotypic coordination of the characters, from one age to another.

The values of the environmental correlations are, for the most part, lower than the values of the genotypic correlations. As a result, the environmental factors exerted a weaker positive action than that of the genes in the phenotypic manifestation of the characters. For this reason, the phenotypic correlations between the analyzed pairs of characters are, for the most part, weaker than the genotypic correlations.

The existence of algebraic sign differences between genetic and environmental correlations indicates that the genetic and environmental sources of variance affect the characters through different physiological mechanisms.

It should be very clear that the genetic interdependence of characters, quantified by genotypic correlation, as a parameter determined based on breeding values, will depend on the effect and frequency of genes in the population, which makes this parameter specific to certain characters, certain populations, certain environmental conditions and certain generations.

Conflict of interest: None.

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