

Phenotypic and genetic parameters of the complex assessment of BV in two-year-old tested horses from the east Bulgarian breed

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Abstract

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A study has been conducted on the parameters characterizing the value of the phenotypic and genetic variance for the complex assessment of BV in tested two-year-old horses from the East Bulgarian breed. No preliminary selection has been applied on the participants. The judge panel has been relatively constant. The 10 score system was applied with accuracy up to 0.5%. The statistical analysis and evaluation of the phenotypic and genetic variance have been performed on the mixed model methodology.

The evaluation of groups of traits forming the complex BV had a relatively symmetrical geometrical distribution. A large part of animals have been rated lower than the average, in terms of gaits (total), walk, trot and free jump, as a higher peakedness of distribution, established for the correctness and walk. The magnitude of the differences between the planned and realized selection weight, established for the type, exterior and the walk, can be an indicator of necessity for eventual change in the criteria forming the final estimation of group of traits, or for change in the planned selection weight.

Sources of mathematically proven specific variance in terms of the complex assessment have been the lines, birth months and gender. Well expressed superiority above the average had the representatives of the Zenger, Tihany and Da Kapo lines. Horses, originating from the formed abroad lines Ramzes, Cor de la Btyere, Cottage Son and Ladykiller, have received a high positive estimation.

The complex assessment has a moderate heritability and high in value phenotypic and genetic correlation relations with the other groups of traits, with the exception of free jump. Phenotypic and genetic correlation between type and exterior, gaits and complex assessment have been higher in value. The established correlation between type and free jump, between gaits and body measurements were low, and between type and body measurements, between free jump and exterior, and between free jump and movements – moderate. From a breeding point of view, existing are favorable opportunities for applying an indirect selection, in terms of type and body measurements.

Keywords: genetic parameters; breeding value; estimation; two-year old; tested horses

Introduction

The complex assessment is a classic method for determining the individual breeding value (BV) of horses by phenotype. It combines the final assessments of groups of traits, subject to selection and ensures information about the progeny testing and calculating the phenotypic and genetic parameters of the

populations. From an international point of view, the general goals for improving the breeds of horses, suitable for equestrian sport disciplines, are almost the same. Studies from Koennen & Arnhem (2002), Burns et al. (2004), Hellsten (2008) have shown that in most European countries' system of registration are included traits, characterizing jumping abilities, gaits, performance in the equestrian sport disciplines and exterior.

The algorithm forming the value of the complex assessment depends on the selection weight of each group of traits, set in the relevant breeding program. In horse-breeding, the assessment of most traits is made by sight, because of it the accuracy of received data to a large extent depends on the used registration methods. Different methods narrow the influence of environmental factors and the subjectivity to a various extent, during the assessment of criteria, characterizing the level of manifestation of traits. These differences, as well as the different accuracy of statistical procedures, different scales of measurements, the availability of preliminary selection and the different BV of paternal generation lead to bigger differences between the genetic parameters' values of the breeds for the same traits. Based on data from Halo et al. (2008) for tested two-year-old and three-year-old Slovak Warmblood horses the total marks have been between 7.10 and 8.96 scores, with a variation from 4.86% and heritability of 0.43. The authors have established a low genetic determination for type (0.16) and moderate for exterior (0.41), gaits (0.51) and free jump (0.57). Phenotypic correlations have been as followed: total mark and type – 0.73; total mark and exterior – 0.71; gaits (totally) – 0.46; and between total mark and free jump – 0.48. Rustin et al (2009) have established moderate additive variance (0.32) of the complex assessment for linear traits and gaits in Belgium Warmblood horses (BWH), which encompasses 33 traits, scaled from minus 20 to plus 20 scores. Leuehrs-Behnke et al. (2002) have studied 15 traits for an integrated estimation of genetic parameters of warm blood horses in Germany. The results of their research show tendencies for: moderate inheritance of the assessments for walk, trot, canter, riding abilities, free jump and jump under rider; low inheritance of the dressage and jump results; and high genetic correlations between assessments of corresponding traits, received from tests for stallions and mares. Analyzing the data for Oldenburg mares 'test, with the 10 score scale of measurement, Becker et al. (2011), established a range of additive variance from 0.19 for riding abilities, to 0.56 for free jump and high genetic correlations between assessments for allures under rider and free gaits. In the range of moderate values has been the heritability of traits, characterizing body development, gaits and free jump in the Hungarian Sport Horse mares (Posta et al., 2010). Genetic parameters of breeds, calculated on the basis of the results from equestrian sport competitions have a low inheritance and rarely moderate (Posta et al., 2010a,b; Prochniak et al., 2015; Rovere et al., 2015 and others).

The first complex assessment for horses from the East Bulgarian breed is conducted at turning two years of age, when the influence of environmental factors still does not have a significant influence, as during their sports carrier.

From an economic point of view, to organize and put into effect the tests is necessary a significantly lower financial resource, compared to stationary tests. The collected information allows foreseeing the main direction of performance in an earlier age, and to accelerate the parents' progeny testing.

The goal of the present research was to establish phenotypic and genetic parameters of the complex assessment of BV in tested two-year-old horses from the East Bulgarian breed.

Methods and Materials

The research covers data from the complex assessment of the breeding value (BV) of the 228 two-year-old East Bulgarian horses that took a part in breeding tests at the period 2006-2016. The tests were conducted in two consecutive days with one week preliminary adaptive period to the environment. Preliminary selection was not applied on the participants. The judge panel was relatively constant. The 10 score system was applied with accuracy up to 0.5%. The registration of animals and the traits that were subjects of selection was conducted by the Association East Bulgarian horse.

The final value of the complex assessment (BV) is an average from the assessment of following groups of traits: type, body measurements, exterior, gaits (total and differentiated by allures) and free jump.

The statistical analysis and the evaluation of phenotypic and genetic variance were conducted on the mixed model methodology. The effect of the fathers was investigated ($SIR_i = 50$), as well as the linear ($L_j, j = 18$) and family ($F_k, k = 17$) belonging of horses, genealogical origin of mothers ($LM_l, l = 28$), months ($MB_m, m = 11$) and years ($YB_n, n = 11$) of birth and gender ($S_o, o = 2$). The regression effects of the type (t), body measurements (bm), gaits including walk, trot (tr), gallop (g), correctness (c), and of free jump (fj), as well as correlations between them were calculated using the corresponding regression models.

Results and Discussion

The average arithmetic estimate for the complex valuation of BV was 7.18 scores with a standard deviation of 0.47 score and a coefficient of variation - 6.65%. The variation width of the trait ranged from 5.75 to 8.55 scores. The Breeding Program of the East Bulgarian horse has planned an equal selection weight for the type, body measurements, exterior, gaits (total) and free jump.

The statistical parameters characterizing the distribution of the phenotypic values of the traits are given in Table 1. The variation coefficients of the traits forming the estimation of breeding values were in the range of 5.86 to 18.57%.

Table 1. Statistical parameters of phenotypic values (10-score system of evaluation)

Parameters	Type	Body measurements	Exterior	Gaits (total)	Walk	Trot	Gallop	Correctness	Free jump	Complex assessment
Average	7.251	8.205	6.949	6.784	6.751	6.766	6.861	6.757	6.812	7.195
CV	8.70	18.57	8.35	5.86	7.85	7.29	7.22	6.76	7.43	6.71
Max	9.300	10.000	8.800	7.925	8.667	8.375	8.333	8.125	8.833	8.545
Min	4.500	4.000	4.750	5.706	5.143	5.375	5.375	4.500	5.400	4.532
Median	7.300	8.000	7.000	6.750	6.714	6.800	6.857	6.750	6.766	7.213
Mode	7.000	8.000	7.000	6.875	6.500	7.000	6.750	6.500	6.750	7.213
Skewness	-0.298	-0.833	-0.006	0.137	0.391	0.130	-0.029	-0.265	0.300	-0.452
Kurtosis	0.662	0.314	0.094	-0.121	0.743	0.123	-0.094	0.883	0.019	1.533

Average arithmetic values, mode and median are close in value, which displays a relatively symmetric distribution of estimates for the studied groups of traits. A more significant asymmetry is displayed in the estimates for body measurements (skewness = -0.833), where a larger part of the cases have exceeded the average for the sample. To a lesser extent, such a tendency is also present for the traits of a total score, type and correctness. In case of the qualities of the movement (total) and the qualities of the free jump, the skewness and kurtosis values show that most of the animals had scores under the average, as a higher peakedness of the distribution being established for the correctness of the walk. The distribution of the exterior and the free jump traits is close to the ideal normal.

The structure of the preliminary studied models and the components of the variance are shown in Table 2. Sources of a mathematically proven specific variance were the lines, birth months and gender (model 1). The intra-class correlation value is 0.25, indicating a significant rate of genetic diversity among individuals. Superiority over the average had representatives of Zenger (a = 0.51), Tihany (a = 0.34) and Da Kapo (a = 0.29) lines. Horses, originating from the foreign lines Ramzes, Cor de la Bryere, Cottage Son and Ladykiller's (Table 3) have also been obtained a high-value positive assessment. The gender difference is in favor of the female animals (a = 0.09). Over the past year, there is a tendency where owners planned the foaling at the beginning of the calendar year, which guarantees them better body de-

velopment of the horses involved in autumn breeding tests. From the sublevels of factors with a higher representation of groups, better performance had horses born in winter and spring months (a = from 0.13 to 0.30), including March (a = 0.30) and January (a = 0.23). The influence of the linear and family belongings is not statistically proven for the analyzed

Table 3. Effect of genealogical lines

Lines	n	a	BLUE±SE
Tihany	9	0.34	7.01±0.27
Zenger	5	0.51	7.19±0.33
Vustershire	9	-0.08	6.59±0.28
Aster	4	-0.14	6.52±0.33
Galego	4	-0.41	6.26±0.36
Da Kapo/Devis Own	16	0.29	6.97±0.22
Eistanzer/Adeptus XX	10	0.07	6.74±0.24
with origin from:			
Goldschaum	2	-1.05	5.61±0.59
Jupiter	2	-2.00	4.67±0.54
Ramzes	8	0.60	7.28±0.30
Alme Z	22	0.17	6.85±0.18
Cor de la Bryere	32	0.44	7.11±0.16
Cottage Son	35	0.36	7.03±0.18
Ladykiller	49	0.22	6.90±0.17
Furioso II / SF	3	0.51	7.18±0.44
Gagne Si Peu	9	0.19	6.86±0.27
μ	228		6.67±0.11

Table 2. Structure of the used operational models and variance components

Models	Structure and levels of factors' significance (F-test)
1	$Y_{ijklmnop} = \mu + SIR(R)_i + L_j^* + F_k + LM_l + MB_m^* + YB_n + S_o^* + e_{ijklmnop}$
(R ² = 0.60)	var(A) = 0.079354; var(E) = 0.0=2122419; Rep = 0.2505
2	$Y_{ijklmn} = b_0 + t_i^{***} + bm_j^{***} + ex_k^{***} + mov_l^{***} + fj_m^{***} + e_{ijklmn}$
(R ² = 0.95)	
3	$Y_{ijklmnopq} = b_0 + t_i^{***} + bm_j^{***} + ex_k^{***} + w_l^{***} + tr_m^* + g_n + c_o^* + fj_p^{***} + e_{ijklmnopq}$
(R ² = 0.97)	

*** P ≤ 0.001 ** P ≤ 0.01 * P ≤ 0.05

set of data. It should be noted, however, about the significant positive effects of mothers originating from Da Kapo - Devis Own ($a = 0.39$), Tihany ($a = 0.20$) and Zenger ($a = 0.17$) lines, and mothers from the genealogical groups of the stallions Makar ($a = 0.34$), Cor de la Bryere ($a = 0.27$) and Gagne Si Peu ($a = 0.17$).

The breeding program provides an equal selection weight (by 0.2) for the five groups of traits, forming the complex assessment of BV. The weight of the allures, on which is based the total scores of movements is 0.05 for each one of them. On Table 4 are shown the regression effects of traits and differences between the planned and the realized selection weight. Significant differences between the planned and realized weights have been established for the type, exterior and walk. Weight fluctuation for type and exterior may be due to a larger variation of these traits, consequence of change of the productive type – from racing performance to that appropriate for classic equestrian sport disciplines (Table 1). Compared by allures, the walk has the highest variation coefficient, most horses have possessed scores above the average for the sample, and the realized weight is 2.7% higher than planned.

The complex assessment has moderate heritability and high-value phenotypic and genetic correlative relationships with the other groups of traits, excluding the free jump (Table

5). The heritability of the type was 0.62 to 0.69, depending on the calculated procedure. The inheritance of the exterior, gaits and free jumping is in the range of 0.30 to 0.43. The phenotypic and genetic correlations between type and exterior, movement and complex estimation have had a high value. The established correlations between type and free jump, between movements and body measurements were low, but between type and body measurements, between free jump and exterior and between free jump and gaits – moderate. The negative correlations between the body measurements and the jump have been confirmed by other authors' studies showing that the increase in height and body size above a certain level is associated with a deterioration of the jumping skills.

Reviewing the correlation between the traits and genetic tendencies for inheritance, we should note the favorable, from a breeding point of view, abilities to apply indirect selection in terms of type and body measurements, where a large number of animals have productivity over the population average (Table 1). Another important element of the complex evaluation of BV is the selection weight of group of traits. A deviation from the planned weight has been established, in the estimation of type, the exterior and walk is an indicator for necessity of eventual change of the criteria, forming the final score of groups of traits or for the change

Table 4. Regression effects and planned selection weights of the groups of traits

	Estimation of:	Regression effects	Planned weights	Deviation	Deviation %	Selection difference
	Model 2					
1	Types	0.245±0.025	0.2	0.045	4.5	4.80
2	Body measurements	0.210±0.006	0.2	0.010	1.0	6.00
3	Exterior	0.152±0.028	0.2	-0.048	-4.8	4.05
4	Gaits (total)	0.205±0.029	0.2	0.005	0.5	2.22
	Walk (model 3)	0.077±0.022	0.05	0.027	2.7	3.52
	Trot (model 3)	0.042±0.023	0.05	-0.008	-0.8	3.00
	Gallop (model 3)	0.034±0.026	0.05	-0.016	-1.6	2.96
	Correctness (model 3)	0.059±0.025	0.05	0.009	0.9	3.63
5	Free jump	0.206±0.015	0.2	0.006	0.6	3.43
6	Complex assessment		1.0	0.018	1.8	4.01

Table 5. Heritability (diagonally), phenotypic (under the diagonal) and genetic correlations (above the diagonal)

r_p \ r_g	type	Body measurements	Gaits (total)	Exterior	Free jump	Complex assessment
Type	0.62-0.69	0.54	0.85	0.73	0.04	0.85
Body measurements	0.33	0.57	0.81	0.27	-0.036	0.75
Gaits (total)	0.87	0.24	0.34-0.53	0.72	0.39	0.85
Exterior	0.64	0.20	0.63	0.30-0.49	0.29	0.78
Free jump	0.14	-0.017	0.13	0.40	0.43	0.16
Complex assessment	0.78	0.72	0.72	0.67	0.34	0.64

of planned selection weight (Table 4). A necessary condition to achieve an accurate assessment for the phenotype of horses in horse-breeding is ensuring a highly classified and relatively permanent judge panel, as all judgments, excluding the body measurements, are estimated by sight.

Conclusions

The evaluations of groups of traits, forming the complex BV have had a relatively symmetric geometric distribution. A large part of the animals have been rated lower than the average, in regards to gaits (total), walk, trot and free jump, as a higher peakedness for distribution is established in correctness and walk. The difference magnitude between the planned and realized selection weight, established for the type, exterior and walk, can be an indicator of necessity for eventual change in the criteria forming the final estimation of group of traits or for change in the planned selection weight.

Sources of mathematically proven specific variance, in terms of the complex assessment have been the lines, birth months and gender. Well expressed superiority above the average had representatives of the Zenger, Tihany and Da Kapo lines. High in value positive estimation possessed horses from the formed-abroad lines Razmes, Cor de la Bryere, Cottage Son and Ladykiller.

The complex evaluation has a moderate heritability and high in value phenotypic and genetic correlations with the other group of traits, excluding free jump. Phenotypic and genetic correlations between type and exterior, movement and complex evaluation have been high in value. The established correlations between type and free jump, between movement and body measurements have been low, and between type and body measurements, between free jump and exterior, and between free jump and movement – moderate. From a breeding point of view, there are favorable opportunities for applying an indirect selection in terms of type and body measurements.

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