Ann. Anim. Sci., Vol. 16, No. 2 (2016) 387–398 DOI: 10.1515/aoas-2015-0072

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GENETIC EVALUATION OF SHOW JUMPING HORSES IN THE SLOVAK REPUBLIC*

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Abstract

The aim of this study was to estimate genetic parameters and breeding values (BVs) of show jumping horses in the Slovak Republic. The data from show jumping competitions performed in 2004–2013 (The Slovak Equestrian Federation) and data from the Breeding Information Register (The National Stud Farm in Topoľčianky) were used in our work. There were 831 horses (4–21 years old) included in the analysis. The level of competitions ranged from LS (125 cm) to TT (160 cm). Profit of penalty points (PP) and ranking in the competition (R) were analyzed as the measures describing horse performance. The average profit of PP was 5.90±6.28, and mean R was 20.20±16.88. The software package CFC 1.0 was used for computation of inbreeding coefficient (F) in given population. The ratio of inbred animals was 74.49% from 831 investigated animals. The average F value was 0.0068 within inbred population. Input data (profit of PP and R) were not normally distributed, therefore the transformation by Blom formula was made. The height of obstacles was taken into account. The ranking in competition has been nearest to the normal distribution even though the tests of normality have not confirmed it significantly. The heritability coefficient was 0.17 in PP and 0.10 in R. The BVs were estimated for PP and R (BV_{PP}, BV_R). The BVs for R were modified to the form of relative breeding values (RBV_R). The increase of genetic level of R within population of show jumping horses has been observed in recent years.

Key words: breeding values, genetic evaluation, normal distribution, show jumping

Genetic evaluation of sport horses is performed in many countries. The approach can take different forms – either direct evaluation based on adult competition results,

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*This work has been supported by the grants:
The Grant Agency of the Ministry of Education Slovak Republic (Grant KEGA No. 027SPU 4/2012; Grant APVV No. 0636-11) and the Excellence Center for Agrobiodiversity Conservation and Benefit project (ITMS: 26220120015) implemented under the Operational Programme Research and Development financed by the European Fund for Regional Development.

or using an indirect measure of performance from traits examined at young horse tests, or a combination of both (Stewart et al., 2010). The most commonly used traits for the evaluation of sport horses are results from competition, ranking of horses (Tavernier, 1991; Reilly et al., 1998; Posta et al., 2010; Rudiné et al., 2015) and profit of penalty points (Kearsley et al., 2008; Zurovacová et al., 2008). Evaluation of performance can also be based on annual earnings (Ricard and Chanu, 2001; Langlois and Blouin, 2004). Estimated breeding values from many of these evaluations are routinely published, to inform and aid selection of sport horses for breeding to produce progeny with high performance ability. Success in breeding elite internationally competitive horses is evident among these studbooks, as demonstrated by the high representation of horses from these studbooks competing in the elite sports events (Stewart et al., 2010). The most commonly used method for the estimation of genetic parameters and breeding values is the Best Linear Unbiased Prediction (BLUP). The BLUP method was used first by Árnason (1980) in horse breeding for Icelandic Toelter horses. Utilization of this method spread very quickly. In general, the same methodology is used to perform routine evaluations across all countries (Koenen and Aldridge, 2002). Typically, mixed effects models, using Residual Maximum Likelihood (REML) are used to estimate variance components for random effects (e.g. additive genetic and horse permanent environment), while simultaneously assessing the effect of fixed variables on the horse's performance. After estimating these parameters the BLUP animal models are used to compute breeding values for all animals in the pedigree. A prerequisite for this analysis is sufficient genetic connectedness within the population, which is a function of the relationships among the horses (e.g. half-sibs, cousins) with records, and therefore an important aspect of developing genetic evaluations is accumulating the pedigree within the databases and ensuring its integrity (Stewart et al., 2010). The aim of this study was to estimate genetic parameters and breeding values of show jumping horses in the Slovak Republic.

Material and methods

The data used for analysis were obtained from the Slovak Equestrian Federation. Data from Breeding Information Register (The National Stud Farm in Topoľčianky) were used as well. The basic database of show jumping competitions consisted of the results of horses, which competed in different levels of competitions (125, 130, 135, 140, 145, 150, 155, 160 centimetres). The original dataset consisted of 12,350 sport competition records from 831 horses that took part in show-jumping competitions between 2004 and 2013 in the Slovak Republic (Table 1).

The age of involved horses was from 4 to 21 years. Profit of penalty points and ranking of horses in the competition (ranking was obtained from the ranking of all horses within each competition based on the number of faults and the times in each round) were analysed. Input data were not normally distributed, therefore the transformation to normal score by Blom formula was made. In the transformation we took height of obstacles into account. Genetic parameters and BVs from competitions data and pedigree information were estimated. Pedigree information of 102,221 animals from the database of The National Stud Farm in Topoľčianky was used. Pedigree information up the 10th generation was taken into account. In total, the pedigree comprised 21,024 animals. Heritability and genetic correlation for two parameters were estimated (PP and R).

Table 1. The list of horse numbers of each breed

Breed	Number of horses
Slovak Warmblood Horse	189
Other (Zangersheide, Westfalen, Selle Français ...)	166
Holsteiner	144
Czech Warmblood Horse	80
Oldenburger	74
Dutch Warmblood	64
Belgian Warmblood Horses	46
Unidentified	39
Hanoverian	29

Basic statistical analyses were performed using SAS System v. 9.2. The CAPABILITY procedure, the RANK procedure (transformation of input data to normalized score), the CORR procedure and the GLM procedure in SAS 9.2. for further detailed analyses were used.

For the genetic evaluation and BVs predictions (traits PP and R transformed to normal score by Blom formula) by the BLUP method, the single and multi-trait mixed model was used:

$$Y_{ijklmnop} = \mu + Y_i + B_j + BRE_k + SC_l + SR_m + AS_n + A_o + e_{ijklmnop}$$

where:

$Y_{ijklmnop}$ = dependent variable,
μ = mean value,
Y_i = fixed effect year of birth (i = 1, 2, 3, …, 17),
B_j = fixed effect breed (j = 1, 2, 3, …,30),
BRE_k + fixed effect breeder (k = 1, 2, 3, …, 179),
SC_l = fixed effect year of season/level of competition (l = 1, 2, 3, …, 42),
SR_m = fixed effect year of season/rider (m = 1, 2, 3, …, 578),
AS_n = fixed effect age/sex (n = 1, 2, 3, …, 38),
A_o = random effect of animal,
$e_{ijklmnop}$ = random error related with observation $Y_{ijklmnop}$.

An analysis of variance was performed to test which effects to consider in the final analyses. The analysis of variance showed that all effects were highly statistically significant for both competition traits (P<0.001).

All BVs were standardized to a relative basis with a mean of 100 and a standard deviation of the true BV of 12 points.

The BLUP animal model for estimation of BVs and genetic parameters was used (Misztal, 2002). Reliability of estimated BVs by ACCF90 ver. 1 (Misztal, 1998) was computed. Generally, the inbreeding may negatively influence performance, and for this reason the inbreeding coefficient (F) of the competition animals by CFC 1.0 – Monitor Genetic Diversity was calculated (Sargolzaei et al., 2006). The effect of inbreeding on the sport performance was investigated.

Results

Representation of gender in competitions was as follows: geldings 51.87%, mares 34.65% and stallions 13.48%. There were 619 inbred individuals (74.49%) in the analysed population with a mean inbreeding level of 0.0068. Correlation between increasing of inbreeding level and performance of animals was not found. Average profit of PP was 5.90±6.28, average R was 20.20±16.88. Profit of PP was not normal distributed (Figure 1). This fact was confirmed by tests of normality (Table 2). Profit of PP was transformed to normally distributed variable using Blom score whereby we took height of obstacles into account (Figure 2), graphical assessment and the individual tests (Table 2) do not confirm normal distribution. Ranking of horses in show jumping competitions showed asymmetrical distribution of data (Figure 3). The rankings of sport horses in competitions were transformed using the Blom score to normal distribution as well. We took the height of obstacles into account (Figure 4). Graphical assessment clearly indicates approximation to normal distribution even if the individual tests (Table 2) do not confirm this fact. Even if the tests of normality do not confirm normal distributed variable, ranking of horses is more suitable for genetic evaluation of sport horses. Transformed R of horses is more approximate to normal score than transformed profit of PP.

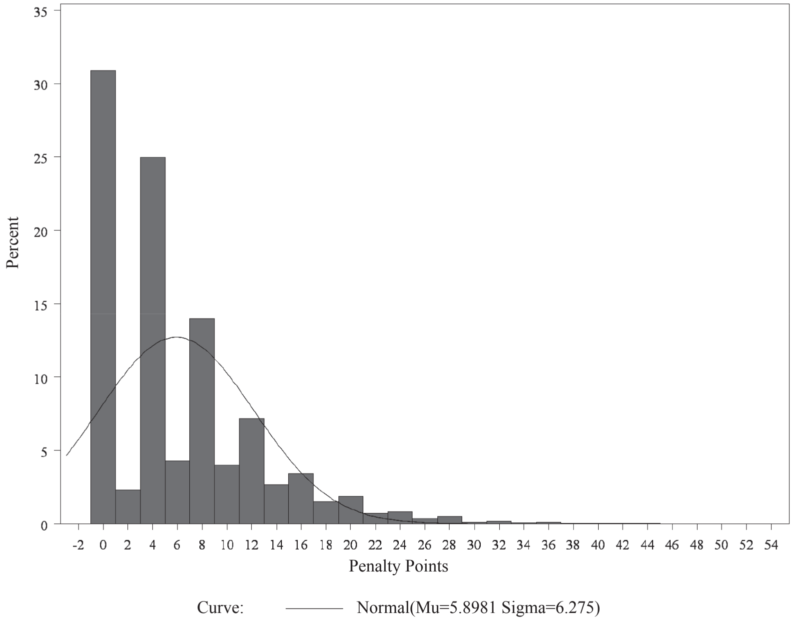

Figure 1. Asymmetrical distribution of PP

Table 2. Tests of normality of input data and of data after transformation by Blom formula

Data	KS test Pr > D		CM test Pr > W-Sq		AD test Pr > A-Sq	
	D	P-Value	W-Sq	P-Value	A-Sq	P-Value
PP						
input data	0.200	<0.010	69.486	<0.005	420.080	<0.005
transformed data	0.183	<0.010	31.977	<0.005	234.867	<0.005
R						
input data	0.128	<0.010	43.488	<0.005	260.002	<0.005
transformed data	0.020	<0.010	0.258	<0.005	3.812	<0.005

PP – penalty points; R – ranking; KS – Kolmogorov-Smirnov test; CM – Cramer-von Mises test; AD – Anderson-Darling test.

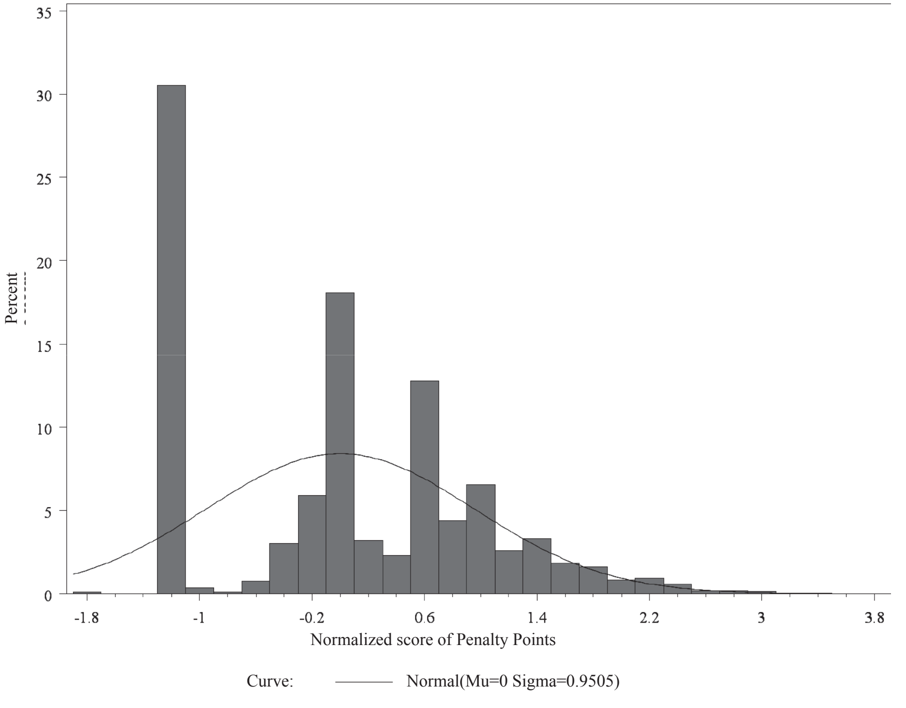

Figure 2. Asymmetrical distribution of normalized PP

Heritability for PP profit 0.17, and for R 0.10 was found. Genetic correlation between these traits was 0.86. In Table 3, breeding values for PP and R are presented. The highest BVs corresponds to having the genetic ability to receive the lowest penalty points and ranking. Reliability of estimated BVs was estimated together with BVs.

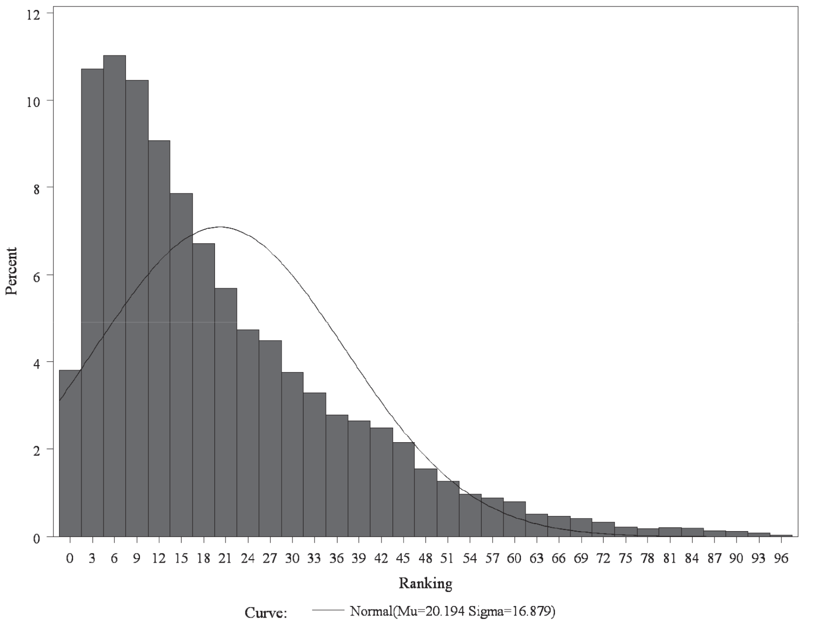

Figure 3. Asymmetrical distribution of R

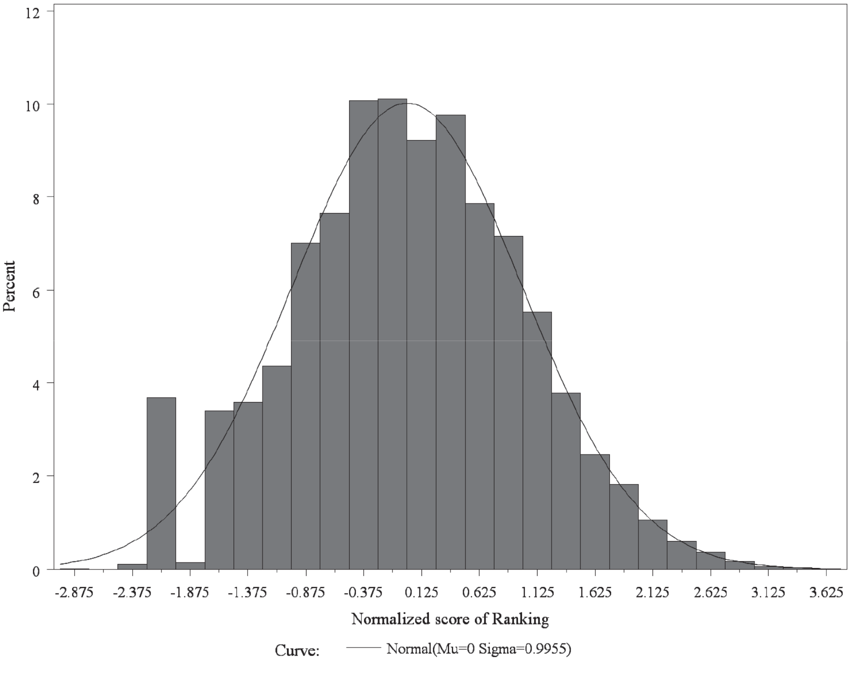

Figure 4. Distribution of normalized R

Table 3. Basic statistic of estimated breeding values

Breeding value	Mean	σ	Min	Max	n	rel
BV_{PP}	0.000	0.046	–0.551	0.586	21,024	0.34
BV_R	0.000	0.034	–0.477	0.422	21,024	0.25

BV_{PP} – breeding values for penalty points; BV_R – breeding values for ranking; σ – standard deviation; n – number of horses; rel – average of reliability.

Reliability of estimated BV_{PP} for sport animals (831 animals) was in the range from 0.00 to 0.83, the average was 0.34. The average of reliability 0.25 for estimated BV_R was calculated. The range of reliability was from 0.00 to 0.73.

Genetic trend of RBV_R is presented in Figure 5. In the analysis average RBV_R of horses according to year of birth were used. Four years moving average was taken into account. For the last twenty years it has been possible to observe positive improvement of genetic disposition. Although in recent years there has been observed a decrease in the genetic level of animals. Average genetic improvement during one generation interval (approximately 10 years) was 3%, 0.303 relative BV_R per year respectively.

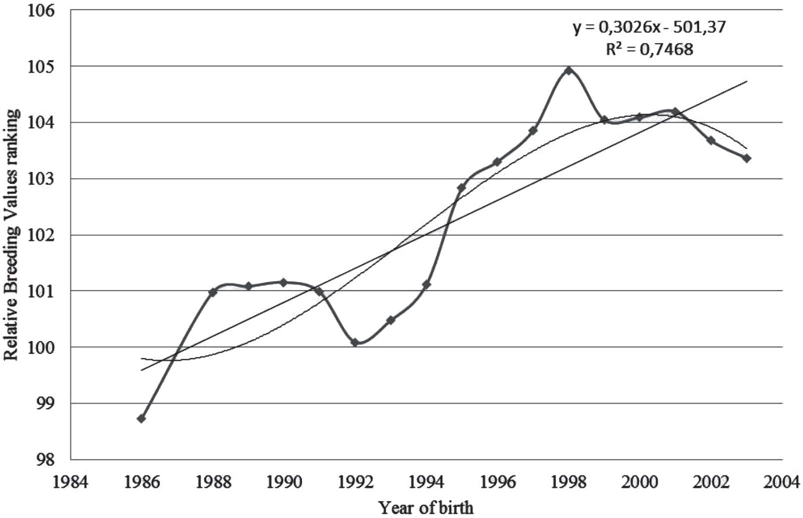

Figure 5. Genetic trend of RBV_R of show jumping horses in the Slovak Republic

Discussion

We observed similar representation of breed in competition as Zurovacová et al. (2008). Slovak Warmblood horse was the most representative breed. Viklund et al. (2010) published highest ratio of mares (45%) in show jumping competitions.

Different ratio of gender was presented by Posta et al. (2010). The highest proportion was characteristic of mares (41%), followed by geldings (32%) and the lowest proportion was found for stallions (27%).

The ratio of inbred animals was 74.49% from 831 investigated animals. The average F value was 0.0068 within inbred population. Mean inbreeding coefficient of 0.079 was observed by Posta et al. (2006) in the Hungarian sport horse population. Highest inbreeding coefficient was 0.25. The authors found that inbreeding is not typical in the examined population. These results corresponded with our investigation. In general, the level of inbreeding depends on the specific characteristics of the population, for example population size, breeding management, breeding program, and the intensity of selection. There have been a number of studies that examined the breeding influence to morphology traits and performance (Klemetsdal, 1998; Curik et al., 2003). There were different results across populations. Gómez et al. (2009) reported the existence of significant inbreeding depression for body measurements in Spanish Purebred horses, which affects both performance and the estimated breeding values ranking order. However, Sierszchulski et al. (2005) observed mean inbreeding level of 0.0088. They found no considerable effect of inbred rate on body conformation traits. The situation in our assessment population was the same. Correlation analysis did not demonstrate a relationship between increasing of inbreeding and animal performance.

Similar methods of PP transformation of eventing competition, which is necessary for subsequent genetic evaluation of sport horses and BVs estimation, were performed by Kearsley et al. (2008) as well. Blom score was used for transformation of ranking of Irish sport horses (Foran et al., 1995), Belgian Sporthorse population (Janssens et al., 2007) and Czech Sporthorse population (Novotná et al., 2014) as well. The same process transformation of input data using Blom formula was used in our previous study (Schubertová et al., 2014). Rudiné et al. (2015) measured the performance with transformation of ranks, taking into account the number of starters at competition and the competition level. The used transformations were logarithmic, square root and an inverse normal transformation known as Blom method.

In measuring of sport horses performance, it is difficult to quantify the effects produced by interaction with the environment, not only during horse breeding (e.g. stud conditions) but also between and during sports competitions, e.g. location, weather, and other competitors (Bartolomé et al., 2013). Nutrition may be included among these random factors too (Hajková et al., 2014). The classification of various effects as random versus fixed varies among investigations. A year of birth effect has been used in some analyses of horse performance (Olsson et al., 2008; Viklund et al., 2010). The effect of breed was significant to performance data, the same results are presented in work of Pietrzak and Próchniak (2014). They concluded that the native breeds obtained statistically worse results than foreign ones, proportionally to the level of competition difficulty. The effect of breeder was highly significant to performance data, for this reason we included effect of breeder in our model. This effect was used by Jiskrová (2009) as well. Bruns (1990) and Novotná et al. (2014) contended that the breeder's impact on the subsequent performance is minimal or non-existent. Similar to our strategy, the effect year of season (year of event) was considered fixed in analyses of horse performance by Novotná et al. (2014). We used this effect in the form of combined effect season/level of competition according to Zurovacová (2008) investigation. Age at performance is often considered when analysing competition traits (Reilly et al., 1998; Zurovacová, 2008; Novotná et al., 2014). Several studies have shown changes in horse performance in relation to the age (Gómez et al., 2010 a, b; Viklund et al., 2011). The analysis of variance showed that the effect of sex was not highly significant for competition traits. In our investigation, combination of fixed effect age/sex was used. This type of combined effect was used by Lührs-Behnke et al. (2006) and Ducro et al. (2007). The fixed effects solutions from the genetic analyses of competition data showed that males (stallions and geldings) were more successful in competition than mares. But differences among gender were not large, therefore combined effect was used. Inclusion of the effect of age/sex was justified.

One of the most important effects in the evaluation of sport horses performance is the effect rider. A well-balanced rider-horse interaction resulted in better animal behaviour, reduced the stress associated with the competition and the possible accidents that it may cause (Bartolomé et al., 2013). The inclusion of a rider effect in the breeding value prediction model for sport horses is often discussed. For this reason, the rider effect has been included in several studies, either as a fixed or random effect (Aldridge et al., 2000; Kearsley et al., 2008; Zurovacová et al., 2008; Gómez et al., 2010 a, b). Differences among riders are generally large, especially in their experience and the number of events in which they participate. Many riders compete with only one horse, which makes accurate estimation of the rider effect difficult (Novotná et al., 2014). The effect of rider was included in our model because many riders competed with various number of horses and could positively or negatively influence the horses performance. According to our investigation many riders competed in each season on different horses. For this reason, effect of rider was used in our evaluation in the form of combined fixed effect year of season/rider.

Viklund et al. (2013) estimated the heritability coefficients 0.34 and 0.30 in Swedish and Danish show jumping horses, respectively. There were lifetime accumulated points used. Kearsley et al. (2008) for show jumping horses in Britain estimated heritability ranged from 0.08 to 0.23. Ranking of horses was used. Ducro et al. (2007) estimated heritability of Dutch show jumping horses at 0.14. For the Belgium show jumping horses, heritabilities 0.10 and 0.11 were estimated for trait ranking in the low and high level of competition (Ruhlmann et al., 2009). Novotná et al. (2014) estimated heritability 0.044 for penalty points and 0.074 for transformed penalty points by Blom formula. Level of estimated heritability was approximately corresponding to our results. However, the comparison of results from different studies is difficult because of the use of different definition of traits, transformation and statistical model. In general, heritabilities for competition traits are low to moderate. This is mainly because the traits are influenced by several non-genetic factors (Viklund et al., 2010).

Correlation between PP profit and R were calculated using the multitrait model (0.86). High genetic correlations are the logical consequence of the evaluated traits. These traits represent different way of expressing the performance of sport horses.

Similarly, a high correlation was also mentioned by Zurovacová et al. (2008) in a population of Slovak sport horses.

Figure 5 shows the positive genetic trends of RBV_R across the time. Genetic trends of sport horses population have not been estimated before in the Slovak Republic. There was small population size of sport horses in the evaluation, and due to this fact four years moving average was taken into account. The RBV_R genetic gain of animals born between 1986 and 2007 was increased by 0.0303 of a phenotypic standard deviation per year. The results presented by Novotná et al. (2014) reported estimated values of the genetic trend of horses born between 1990 and 2006 in the Czech Republic. Average phenotypic standard deviation was greater than in our investigation (0.061). Higher genetic trend (0.056 of a phenotypic standard deviation) was presented by Viklund et al. (2011) as well.

From the presented results, it is possible to suggest a more appropriate way of evaluating sport horses performance in the Slovak Republic. The current evaluation system that uses only phenotypic data of equine performance is not sufficient. It is not based on genetic predisposition of horses. Breeding stallions are usually involved in the breeding process only according to the results of performance tests, which do not reflect the real genetic quality of the horses. Another suitable criterion for including animal in breeding could be a breeding value estimated by BLUP animal model. BLUP AM reflects the genetic disposition of animal and eliminates environmental factors that affect performance of horses (training, nutrition). The above process of sport horses evaluation is utilized in many countries. The most objective indicator of horses performance according to our results is ranking of horses. Reflecting the horses performance, it takes profit of penalty points and time in the competition into account. After transformation, only ranking was normally distributed or clearly indicating approximation to normal distribution variable. Normal distribution of the input data is a direct assumption of estimation of genetic parameters and breeding values. For the improvement of breeding value estimation in the Slovak Republic, the application and correction of widely used methods is needed.

Acknowledgement

We thank the Slovak Equestrian Federation and the Breeding Information Register (The National Stud Farm in Topoľčianky) for providing the data.

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Received: 22 V 2015
Accepted: 22 X 2015