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EVALUATION OF BREEDING VALUE BASED ON SCORES ACHIEVED IN THE POLISH CHAMPIONSHIPS FOR YOUNG HORSES*

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Abstract
Genetic improvement of show jumping horses is problematic, given the multitude of physical traits that determine sport usability and the specific mental predispositions required during training and competitions. The Polish Championships for Young Horses (PCYH) provide an opportunity to evaluate usability traits in Polish horses, which, however, is not a basis for evaluation of the breeding value. The aim of the study was to propose a model for evaluation of the breeding value of horses taking part in the Championships. In total, 1232 starts of 894 4-, 5-, 6-, and 7-year-old horses were analysed. Indices of BLUP breeding values were calculated based on 7 traits with known genetic parameters (ranking in the championship, style rating on days 1, 2, and 3, and penalty points on days 1, 2, and 3). A low and irregular genetic trend, significant only in the case of penalties scored on days 1 and 2 of the championships, was shown. Compatibility of the evaluation of the breeding value estimated on the basis of scores achieved in the Polish Championships for Young Horses with the scores of the performance test carried out in Training Centres was shown. It was also demonstrated that the "sum penalty" and "sum style" measured during the three days of the Championships is sufficient for evaluation of the BLUP breeding value. It was suggested that the evaluation combined with the results achieved at the PCYH (in four age categories) would provide a more detailed picture of the genetic predispositions of jumping horses.

Key words: horse breeding, BLUP animal model, show jumping

An efficient system of evaluation of the breeding value of sport horses is one of the key elements of profitability of horse breeding worldwide. Profound knowledge of the genetic background of the desired traits helps to develop a model of assessment of the breeding value and to acquire individuals that will be likely to achieve high levels of sport performance (Thorén Hellsten et al., 2006). However, genetic

improvement of jumping horses is problematic, since there are many physical traits determining sport usability and specific mental predispositions required during training and competitions (Górecka-Bruzda et al., 2011). There is an ongoing discussion in the scientific community about the efficiency of different methods for evaluation of the usability and breeding value of sport horses, including search for quantitative trait loci determining jumping performance (Schröder et al., 2012) as well as genomic selection (Ricard et al., 2013). In Poland, the system of usability assessment is based on a performance test carried out after 100-day training for stallions and 60-day training for mares as well as the Polish Championships for Young Horses (PCYH). Although the result obtained at this stage is an indication for trainers and breeders, selection of individuals for mating should take into account the breeding value estimated with the BLUP method, similar as in breeders' associations in other countries (Koenen and Aldridge, 2002). Currently in Poland, the BLUP method is only used for estimation of the breeding value of stallions on the basis of a stationary performance test after a 100-day performance test in Training Centres. In this case, the estimates of the breeding value of 16 traits are grouped into three indices: general, jumping, and dressage. The methodology and animal breeding values are published on the official website of the Polish Horse Breeders Association (www. pzhk.pl, 2014). Due to the frequent changes in the PCYH rules and the subjectivity of some evaluations, development of a methodology for the breeding value evaluation based on this source of information is problematic, but necessary, given the growing breeders' and potential buyers' interest in PCYH scores. Comparison of the breeding BLUP ranks of the same animals developed on the basis of the data provided by Training Centres and the results of Polish Championships for Young Horses would facilitate verification of the breeding strategy adopted in Poland, according to which Polish Championships for Young Horses are an alternative usability estimation method to that used in Training Centres.

The aim of the paper was to develop a methodology for evaluation of the breeding value of horses taking part in the Polish Show Jumping Championships for Young Horses.

Material and methods

The investigations involved 894 horses taking part in the Polish Jumping Championships for Young Horses in 2005–2013. Information about 1232 starts of 4-, 5-, 6-, and 7-year-old horses was collected (Table 1). Horses of Polish breeds (Polish noble half-bred – 388 animals, Wielkopolska breed – 56 animals, Małopolska breed – 18 animals) and foreign breeds (Hanoverian – 373, Holstein – 27, Dutch Warmblood – 9, Oldenburg – 9, other breeds – 14) were estimated.

We analysed the so-called "assessment of horse's style" competitions and "not-against-the-clock" competitions, in which the score was determined by the penalty sum as well as "against-the-clock" competitions, in which the time score was additionally taken into account in the case of an equal penalty sum. Seven traits (Ta-

ble 2) were selected on the basis of the results of authors' previous investigations presenting genetic parameters (heritability and reproducibility coefficients) and genetic correlations between traits estimated at Polish Championships for Young Horses (Próchniak et al., 2015). The analysed traits comprised (1) overall rank in the championships determined on the basis of the scores achieved on each of the three competition days; (2–4) style rating (on days 1, 2, and 3), which was a sum (without weight coefficients) of penalties (0.5 for pole knockdown, 1 for the first and 2 for the second disobedience, 0.1 for each second of exceeded time), and bonus scores (from 0 to 10) granted by two judges of the jury for the jumping style presented by the horse; (5–7) penalties (on days 1, 2, and 3) scored in the so-called "against-the-clock" and "not-against-the-clock" competitions (4 for pole knockdown, 4 for the first disobedience, 8 for the second disobedience – permissible only in competitions with up to 125 cm high obstacles, 1 for each 4 started seconds of exceeded time).

Table 1. Number of horses and starts (in parentheses) across sex and age

Age category (years)	♂	♀	Total
4	264	166	430
	(265)	(167)	(432)
5	161	114	275
	(242)	(164)	(406)
6	89	56	145
	(155)	(118)	(273)
7	27	17	44
	(71)	(50)	(121)
Total	541	353	894
	(733)	(499)	(1232)

Table 2. Simple statistics and genetic parameters (heritability – h^2 and repeatability – r^2) of traits recorded during the Polish Jumping Championship for Young Horses (Próchniak et al., 2015)

Trait	$\overline{x}$	SD	Min	Max	h^2	se_{h2}	r^2	se_{r2}
Overall ranking	–	–	1	49	0.14	0.02	0.19	0.03
Day 1 style	7.09	1.08	1.10	8.80	0.26	0.06	0.44	0.07
Day 2 style	7.29	1.02	–0.60	9.20	0.14	0.03	0.28	0.05
Day 3 style	7.18	1.35	–1.90	9.20	0.16	0.03	0.40	0.05
Day 1 penalties	4.21	5.26	0	36.00	0.20	0.05	0.46	0.05
Day 2 penalties	4.52	5.29	0	27.00	0.19	0.04	0.40	0.05
Day 3 penalties	5.52	5.30	0	25.00	0.27	0.05	0.47	0.05

The depth of the analysed animals was at least 4 generations.

The breeding value (EBV) was estimated with the BLUP method using the BLUPF90 program (Misztal, 2007). The variances and covariances were evaluated with the Gibbs sampling method (Próchniak et al., 2015). Factors included in the mathematical models are presented in Table 3.

Table 3. Effects[1] fitted in the models for 2 groups of traits

Traits Effects	No. of classes	Type of effect[2]	Overall ranking	Style score (day 1, 2, 3) Penalties (day 1, 2, 3)
Additive genetic	23,242	A	X	X
Permanent environment	191	R	X	X
Rider	326	R	X	X
Championship year	9	F	X	X
Site of the championships	3	F	X	X
Age category	4	F	X	X
Sex	3	F	X	X
Number of competing horses	894	C	X	

[1] X – presence of an effect in the model for a particular trait.
[2] A – random, associated with the relationship matrix; R – random, diagonal; F – fixed; C – fixed covariate.

Next, three indices were developed according to the following scheme:

Sum style = BLUP (day 1 style) + BLUP (day 2 style) + BLUP (day 3 style).

Sum penalties = BLUP (day 1 penalties) + BLUP (day 2 penalties) + BLUP (day 3 penalties).

Sum BLUP = sum style + sum penalties + BLUP (rank).

For the developed indices, genetic trends were determined in the analysed period and Spearman's rank correlations between them were estimated (version 9.4 by SAS Institute Inc Cary, NC).

Additionally, 111 horses that had attended Training Centres and participated in the Polish Championships for Young Horses were listed. Using Spearman's rank correlations (version 9.4 by SAS Institute Inc Cary, NC), the compatibility of the BLUP rankings estimated with the two methods for usability value assessment was established.

Results

An increase in the breeding value (BV) of the analysed traits was noted in the analysed period. However, the increase was found to be statistically significant only in the case of penalties scored on day 1 and 2 of the championships (Table 4). Simultaneously, the graph of the genetic indices of the sum style and sum penalties indicates variations in the estimates of the breeding value in the respective years of the evaluation (Figure 1).

The compatibility of the BLUP estimates from the PCYH scores with the general and jumping indices estimated in a performance test in Training Centres reached a level of 25% (Table 5). The correlations proved significant for such traits as the horse ranking in the championships, day 1 style, day 3 penalties, and the sum style index. The highest correlation (0.25) was noted between the BLUP value estimated on the basis of the horse ranking in the championships and day 3 penalties and the general index obtained in a stationary performance test. Simultaneously, there were no significant correlations between the BLUP values obtained from the PCYH scores and the dressage index.

Table 4. Regression coefficient (β) and standard error (se) of genetic trends for the breeding values of individual traits

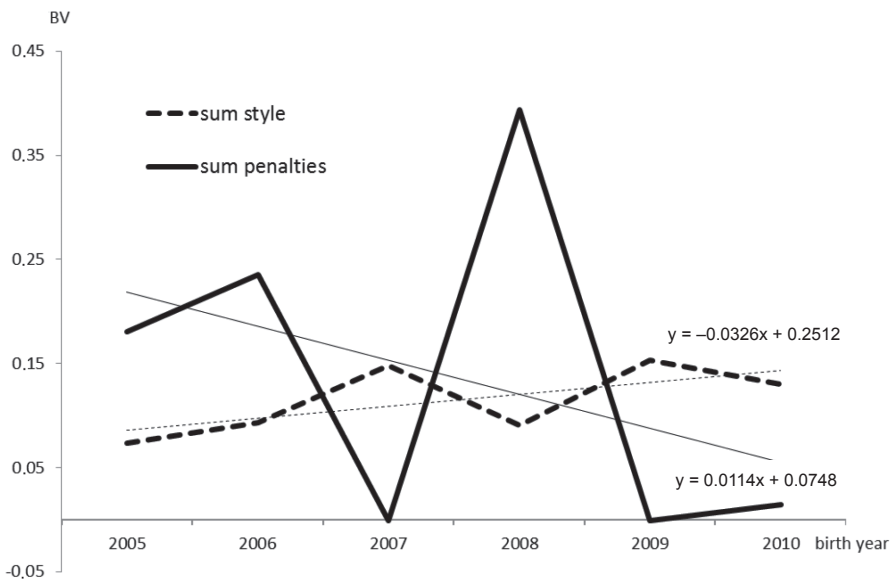| Traits	β	se
Overall ranking	−0.000026	0.000030
Day 1 style	0.000006	0.000005
Day 2 style	0.000002	0.000004
Day 3 style	0.000009	0.000010
Day 1 penalties	0.000059 *	0.000027
Day 2 penalties	0.000090 *	0.000037
Day 3 penalties	−0.000012	0.000033

* significant correlations at α=0.05.

Figure 1. Genetic trends in the breeding value in the analysed period

Table 5. Rank correlations between the BLUP value of the analysed traits and the BLUP indices from the training centres

Training Centres Traits PCYH	General index	Jumping index	Dressage index
Overall ranking	−0.25 *	−0.23 *	−0.09
Day 1 style	0.19 *	0.21 *	0.09
Day 2 style	0.05	0.08	−0.09
Day 3 style	0.21 *	0.18	0.10
Day 1 penalties	−0.10	−0.11	0.06
Day 2 penalties	−0.01	−0.02	0.09
Day 3 penalties	−0.25 *	−0.22 *	−0.10
Sum BLUP	−0.18	−0.17	−0.01
Sum style	0.22 *	0.21 *	0.07
Sum penalties	−0.17	−0.16	−0.01

* significant correlations at α=0.05.

Table 6. Rank correlations between the estimates of the breeding value (BLUP)

	Overall ranking	Day 1 style	Day 2 Style	Day 3 style	Day 1 penalties	Day 2 penalties	Day 3 penalties	Sum style	Sum penalties
Sum BLUP	0.68	−0.40	−0.33	−0.62	0.73	0.69	0.72	−0.61	0.99
Sum style	−0.93	0.82	0.58	0.92	−0.23	−0.25	−0.77	–	−0.58
Sum penalties	0.62	−0.36	−0.35	−0.57	0.76	0.73	0.68	−0.58	–

All correlations significant at $\alpha=0.05$.

Analyses of the relationships between the estimates (Table 6) demonstrated high correlations reaching a level of 0.99 between the sum BLUP and sum penalties, 0.93 between the ranking and sum style, and 0.92 between the sum style and day 3 style. The correlations between the sum style and sum penalties were found to have lower values of 0.65. The lowest correlation (0.23) was found between the sum style and the BLUP value based on day 1 penalties.

Discussion

In consequence of effective breeding, the BLUP value should be regularly increasing over the years. This has been confirmed by investigation results reported by other authors, e.g. Viklund et al. (2011). Analysis of the regression of genetic trends observed in the analysed period (Table 4) showed that the increase in the breeding value was not statistically significant in a majority of the traits. No significant increase in the breeding value for the jumping style and day 3 penalties traits was observed, which may imply errors in the estimation of the phenotypic value of the trait. Given the increasing participation of foreign breeds in the lineages of the analysed horses (Próchniak et al., 2014) and the selection of the domestic material, the results obtained are unsatisfactory. This is also confirmed by the stepwise character of the genetic trends for traits referred to as both sum penalties and sum style (Figure 1). The correct style and horse's sensibility manifested by avoidance of a pole knockdown are the major factors determining animals' sport success (Próchniak et al., 2015). Obviously, many environmental factors, also reported by other researchers who investigate similar problems, exert an influence on the correctness of the evaluation of these parameters (Novotná et al., 2014). The most important factors included in the models are the level of rider's skills and the effect of the site, which comprises e.g. the difficulty of the parkour, the size of the hippodrome, and the effect of judges. Since not all factors can be characterised in the model, the environment should be standardised at the level of breeding value evaluation. This is particularly important for the scheme of assessment of the jumping style, which is not explicitly specified in the regulations.

By 2014, 1542 horses assessed in Training Centres and 894 starting in PCYH had been registered. However, comparison of both estimations was only possible for 111 horses. Although statistically significant correlations were found between

the breeding values estimated based on both sources of information, further investigations in this field are necessary due to the low number of analysed individuals. It should be emphasised that the horses underwent prior selection by qualification either to Training Centres or to competitions qualifying them to the PCYH final. The rank correlations confirm the low, although in some cases significant (Table 5) correlation between the BLUP ranking from PCYH and the general and jumping indices. Importantly, the general index is primarily determined by the assessment of jumping predispositions, as follows from the principles of usability evaluation at Training Centres. However, the correlations obtained are clearly lower than the results reported by Wallin et al. (2003) and Viklund et al. (2010), who investigated the relationships between test results achieved by 4-year-old horses and their later sport results in selected disciplines in a population of Swedish Warmblood Riding Horses. Simultaneously, correlations between the BLUP ranking from the PCYH and the dressage index are almost zero, which suggests a different genetic background of dressage predispositions from that of show jumping predispositions. Similar relationships were shown by Ducro et al. (2007) and Rovere et al. (2014) in a population of Dutch Warmblood horses. It should be acknowledged that the demonstrated compliance is insufficient to undermine the sense of existence of Training Centres or organisation of PCYH. Probably, compilation of data about usability based on the aforementioned sources of information will ensure a more precise estimation of genetic sport predisposition of individuals. Development of a scheme of breeding value evaluation based on PCYH scores must involve thorough assessment of the usability value. This, however, is difficult due to the commercial and sport nature of the PCYH. Reliable assessment is particularly important in the case of the subjective rating of the style, where adjustment of the score scale to the participating horses and taking the lineage of the horse into account should be avoided. The rank correlations between the BLUP estimates presented in Table 6 imply a need for treating the jumping style evaluation separately from the parkour precision, which is manifested by penalties. The high correlation (0.99) between the indices of sum penalties and sum BLUP makes it possible to disregard the latter, which requires evaluation of a larger number of traits and more complex analyses. In turn, the sum style index is highly correlated with the BLUP value calculated from the horse ranking in the Championships. The combination of the sum style and sum penalties in the evaluation additionally allows inclusion of the information obtained during each day of the competitions. This is important in view of the changing regulations and the differences arising between the not-against-the-clock competition held on day 1 of the Championships and the against-the-clock competitions, where the time of completing the parkour is an important element in the entire result. The use of the sum style and sum penalties is easy to implement, does not require changes in the championship rules, and gives a possibility to evaluate the breeding value of all horses that have participated in the Championships so far. However, the current regulations of championships, according to which 4- and 5-year-old horses are evaluated only in the "horse style" competitions provides full information about the breeding value at 6–7 year of horse's life at the earliest, when horses have an opportunity of presenting their predispositions for flawless and fast completion of the parkour.

Conclusions

It was found that the breeding value estimated on the basis of "sum penalties" and "sum style" is a measurable indicator of genetic show jumping predispositions of horses and estimation thereof should take into account repetitions from each day of championships. The use of indices referred to as sum style and sum penalties seems most appropriate for BLUP estimation, as this does not require changing the current rules of the championships.

It should be assumed that evaluation carried out at Training Centres in combination with the PCYH scores (in four age categories) provides the most complete picture of the genetic show jumping predispositions, although this information is only obtained in the 6–7 year of animal's life.

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