UNIWERYSTET PRZYRODNICZY W LUBLINIE

WYDZIAŁ BIOLOGII, NAUK O ZWIERZĘTACH I BIOGOSPODARKI

Tomasz Próchniak

Kryteria selekcyjne we wczesnej ocenie wartości hodowlanej koni sportowych

Selection criteria in early evaluation of the breeding value of sport horses

Praca doktorska

Doctoral thesis

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Streszczenie

Celem pracy była definicja kryteriów selekcyjnych, umożliwiających wczesną ocenę wartości hodowlanej koni sportowych w oparciu o wyniki Mistrzostw Polski Młodych Koni w skokach przez przeszkody.

Materiał do badań stanowiły wyniki sportowe koni uczestniczących w Mistrzostwach Polski Młodych Koni oraz wyniki konkursów Grand Prix rozgrywanych podczas zawodów ogólnopolskich. Analizowano dziewięć cech, wyodrębnionych z wyników Mistrzostw Polski Młodych Koni: ranking zwierzęcia w Mistrzostwach, eliminacja z konkursu, ocena pokroju koni 4 letnich, ocena stylu skoku i punkty karne uzyskane w pierwszym, drugim i trzecim dniu Mistrzostw. Dla wymienionych cech oszacowano parametry genetyczne (współczynnik odziedziczalności, powtarzalności oraz korelacje genetyczne). W oparciu o różne kombinacje cech oceniono wartość hodowlaną badanych koni. Następnie, wykorzystując korelacje rangowe, porównano zgodność rankingów wartości hodowlanych koni, oszacowanych na podstawie Mistrzostw Polski Młodych Koni oraz na podstawie wyników prób dzielności ogierów w Zakładach Treningowych.

Stwierdzono, że odziedziczalność analizowanych cech na poziomie 0,14-0,27 daje możliwość efektywnego wykorzystania ich w pracy hodowlanej. Wartość hodowlana przewidywana w oparciu o „liczbę punktów karnych" i „ocenę stylu skoku konia" stanowi wymierny wskaźnik genetycznych predyspozycji koni do dyscypliny skoków przez przeszkody, a przewidywanie jej powinno uwzględniać powtórzenia w poszczególnych dniach trwania Mistrzostw.

Należy przyjąć, że ocena w Zakładach Treningowych wzbogacona o wyniki z Mistrzostw Polski Młodych Koni powinna dawać wiarygodniejszy obraz genetycznych predyspozycji koni do skoków przez przeszkody, choć uzyskiwana jest dopiero w 6-7 roku życia zwierzęcia.

Słowa kluczowe: konie sportowe, skoki przez przeszkody, kryteria selekcyjne, wartość hodowlana

Summary

The aim of the study was to define selection criteria for early evaluation of the breeding value of sport horses based on scores achieved in show jumping during the Polish Championships for Young Horses

The study material included the scores achieved by horses in the Polish Championships for Young Horses and the results of Grand Prix national competitions. Nine traits defined based on the scores of the Polish Championships for Young Horses were analysed. They included overall animal ranking in the Championships, elimination from the competition, conformation of 4-year-old horses, as well as the jumping style and penalties on day 1, 2, and 3 of the Championships. Genetic parameters (heritability coefficient, repeatability coefficient, and genetic correlations) were estimated for these traits. In various combinations of traits, the breeding value of the horses was evaluated. Next, using rank correlations, the compatibility between the rankings of the breeding values of sport horses, estimated based on the results of the Polish Championships for Young Horses and the results of stallion performance tests from Training Centres.

It was found that the 0.14-0.27 heritability of the analysed traits renders them suitable to be used in breeding. The breeding value predicted from the "penalty scores" and the "jumping style" is a measurable indicator of horses' genetic predispositions to the show jumping discipline, and prediction of the value should take into account repetitions on each day of the Championships.

It can be assumed that the assessment in the Training Centres complemented with the scores from the Polish Championships for Young Horses should give the most complete picture of horses' genetic predisposition for show jumping, although it is obtained only in the 6th-7th year of life of the animal.

Wstęp

Sukcesy w sporcie jeździeckim w dużym stopniu uzależnione są od możliwości wyhodowania koni o genetycznych predyspozycjach do danej dyscypliny jeździectwa. Właściwości, jakie musi w sobie łączyć współczesny koń skoczek i trudności związane z ich pomiarem skłaniają naukowców do poszukiwania nowych rozwiązań wykorzystujących różne narzędzia genetyki populacyjnej i molekularnej (Brard i Ricard, 2015; Stock i wsp., 2016). Jednym z kluczowych elementów doskonalenia koni jest ocena wartości hodowlanej (Tavernier, 1990; Langlois i Blouin, 2004; Schubertová i wsp., 2016). Poprawność tej oceny, wymaga obiektywnego systemu rejestrowania użytkowości zwierząt oraz znajomości genetycznego podłoża cech uwzględnionych w programie hodowlanym. Praktykowane są różne metody oceny wartości użytkowej koni pod kątem predyspozycji sportowych. W Polsce zastosowanie znajduje próba dzielności po treningu 100-dniowym ogierów i 60-dniowym klaczy oraz Mistrzostwa Polski Młodych Koni. W praktyce wartość hodowlana przewidywana jest jedynie dla ogierów, które ukończyły Zakłady Treningowe. Polski Związek Hodowców Koni publikuje trzy rankingi indeksów wartości hodowlanej: ogólny, ujeżdżeniowy i skokowy (www.pzhk.pl, 2017).

Obecnie, jest większe zainteresowanie wśród hodowców i właścicieli koni wynikami Mistrzostw Polski Młodych Koni, gdzie zwierzęta oceniane są w warunkach autentycznej sportowej rywalizacji w czterech kategoriach wiekowych. Ten rodzaj sprawdzianu użytkowości jest dość obiektywny i daje możliwość porównania go z późniejszymi wynikami sportowymi koni. Niestety, ciągle zbyt mała liczba zwierząt oraz częste zmiany w regulaminie Mistrzostw, który określa zasady punktowania poszczególnych elementów oraz schemat obliczania końcowych wyników, w znacznym stopniu utrudniają wyodrębnienie cech i szacowanie parametrów genetycznych.

W obecnej sytuacji, gdy większość koni rozpoczynających karierę sportową, ocenianych jest podczas Mistrzostw Polski Młodych Koni, celowe staje się opracowanie modelu, który umożliwiałby ocenę zbiorczej wartości hodowlanej tych zwierząt.

Cel pracy

Definicja kryteriów selekcyjnych umożliwiających wczesną ocenę wartości hodowlanej koni sportowych w oparciu o wyniki Mistrzostw Polski Młodych Koni w skokach przez przeszkody.

Realizacja tego zadania wymagała:

1) Wstępnej oceny predyspozycji sportowych koni ras polskich w stosunku do ras zagranicznych, przeprowadzonej w oparciu o wyniki konkursów Grand Prix, rozgrywanych w ramach zawodów ogólnopolskich w skokach przez przeszkody.

2) Wyboru cech ocenianych podczas Mistrzostw Polski Młodych Koni, które mogłyby stanowić przyszłe kryterium oceny wartości hodowlanej koni sportowych

3) Opracowania metodyki oceny wartości hodowlanej koni biorących udział w Mistrzostwach Polski Młodych Koni w skokach przez przeszkody.

Materiał i metody

Materiał do badań stanowiły wyniki sportowe 223 koni startujących w konkursach finału tzw. „Dużej Rundy" (wysokość przeszkód: 140-150 cm), podczas zawodów ogólnopolskich w skokach przez przeszkody oraz 894 koni uczestniczących w Mistrzostwach Polski Młodych Koni w latach 2005-2013. Baza rodowodowa zawierała 23 242 zwierząt.

Wyniki zawodów ogólnopolskich posłużyły do analizy pochodzenia koni startujących w najtrudniejszych konkursach oraz określenia wpływu poszczególnych czynników (genetycznych i środowiskowych) na wyniki uzyskiwane przez konie w dyscyplinie skoków przez przeszkody. Wnioski z tych badań uwzględniono w konstruowaniu założeń metodycznych oceny zwierząt w oparciu o wyniki Mistrzostw Polski Młodych Koni.

Analizowano 9 cech, związanych z oceną koni podczas Mistrzostw Polski Młodych Koni w skokach przez przeszkody: ranking zwierzęcia w mistrzostwach, eliminacja z konkursu, ocena pokroju koni czteroletnich, ocena stylu skoków konia pierwszego, drugiego i trzeciego dnia zawodów oraz punkty karne zdobyte w pierwszym, drugim i trzecim dniu Mistrzostw. Komponenty wariancji (dla modeli progowo-liniowych) szacowano wykorzystując metodę próbkowania Gibbsa - program THRGIBBS1F90 (Tsuruta and Misztal, 2006).

Dla wymienionych cech oszacowano współczynniki odziedziczalności, powtarzalności i korelacje genetyczne między cechami. Na podstawie analizy parametrów genetycznych wybrano 7 cech (zrezygnowano z uwzględniania oceny pokroju koni czteroletnich i eliminacji z konkursu) na podstawie, których oceniono wartość hodowlaną koni startujących w Mistrzostwach - program BLUPF90 (Misztal, 2007). Utworzono trzy indeksy, charakteryzujące styl skoku konia, dokładność pokonywania przeszkód (wyrażoną, jako punkty karne) oraz sumę wartości obu cech w trzech dniach trwania Mistrzostw. Dla uzyskanych indeksów wyznaczono trendy genetyczne i obliczono współczynniki regresji. Wykorzystując korelacje rangowe Spearmana (SAS Institute, Cary, NC), porównano ocenę wartości hodowlanej z Zakładów Treningowych i Mistrzostw Polski Młodych Koni, 111 zwierząt, które posiadały obydwa źródła informacji o użytkowości.

Omówienie wyników

Stwierdzono, że w najtrudniejszych konkursach rozgrywanych w ramach zawodów ogólnopolskich (finał „Dużej Rundy"), przeważającą część (ponad 70%) stanowiły konie ras zagranicznych. Spośród niespełna 30% polskich koni, zwierzęta rasy małopolskiej i wielkopolskiej, stanowiły zaledwie 2%. Dodatkowo, pochodzenie osobników rasy polski koń szlachetny półkrwi, opierało się na zagranicznych reproduktorach, głównie niemieckich, belgijskich i holenderskich.

Analizy nie wykazały istotnego wpływu rasy i wieku koni na osiągane przez nie wyniki, co potwierdza, że w najbardziej wymagających konkursach rozgrywanych w kraju, startują najlepsze zwierzęta, które przeszły „selekcję" na zawodach niższych szczebli. Przeważający odsetek koni o zagranicznym pochodzeniu, wskazuje jednak na niewystarczające predyspozycje sportowe koni ras rodzimych.

Odziedziczalność cech, wyodrębnionych w oparciu o wyniki Mistrzostw Polski Młodych Koni wyniosła 0,14-0,27. Daje to możliwość efektywnego wykorzystania ich w pracy hodowlanej. Najwyższy współczynnik odziedziczalności odnotowano dla cech takich jak, ocena stylu skoku konia, rejestrowana pierwszego dnia (0,26) i punkty karne uzyskane w trzecim dniu Mistrzostw (0,27). Biorąc pod uwagę niską odziedziczalność oceny pokroju (0,08) oraz niewielką zależność pomiędzy pokrojem, a wynikami sportowymi, należy wskazać na poważne mankamenty przyjętej skali ocen, uniemożliwiające wykorzystanie tej informacji przy szacowaniu wartości hodowlanej. Podobnie, śladowa wariancja genetyczna cechy „eliminacja z konkursu", wskazuje na duży wpływ czynników środowiskowych na tę cechę.

Korelacje genetyczne na poziomie 0,23-0,45, pomiędzy ocenami cechy w poszczególnych dniach, wskazują na konieczność rejestrowania punktów karnych i oceny stylu skoku koni w poszczególnych dniach trwania mistrzostw.

Na podstawie analizy trendów genetycznych zaobserwowano pozytywny postęp hodowlany w zakresie stylu skoku koni i dokładności pokonywania przeszkód, wyrażonej punktami karnymi. Jednocześnie należy wskazać na wahania szacunków wartości hodowlanej w poszczególnych latach oceny, które mogą być spowodowane zmianami w zasadach rozgrywania Mistrzostw Polski Młodych Koni.

Stwierdzono, istotne korelacje (sięgające 25%) pomiędzy rankingiem wartości hodowlanych z Zakładów Treningowych (indeks ogólny i indeks skokowy) i szacowanych w oparciu o wybrane cechy z Mistrzostw Polski Młodych Koni. Wysoką zgodność z indeksami

z Zakładów Treningowych wykazywały cechy o najwyższym współczynniku odziedziczalności, a więc: ocena stylu pierwszego dnia (0,19-0,21) oraz punkty karne uzyskane w 3 dniu trwania mistrzostw (0,22-0,25).

Wnioski

Zauważono wzrost znaczenia koni hodowli zagranicznej w krajowych sportach jeździeckich oraz niepokojąco mały udział koni ras rodzimych w najtrudniejszych konkursach rozgrywanych w Polsce. Dodatkowo wykazano wysoki udział zagranicznych przodków w rodowodach koni rasy polski koń szlachetny półkrwi.

Odziedziczalność cech, wyodrębnionych w oparciu o wyniki Mistrzostw Polski Młodych Koni na poziomie 0,14-0,27, daje możliwość efektywnego wykorzystania ich w pracy hodowlanej.

Wartość hodowlana przewidywana w oparciu o liczbę punktów karnych i ocenę stylu pokonywania przeszkód przez konie stanowi wymierny wskaźnik genetycznych predyspozycji tych zwierząt do dyscypliny skoków przez przeszkody, a przewidywanie jej powinno uwzględniać powtórzenia w poszczególnych dniach Mistrzostw.

Na podstawie analizy trendów genetycznych zaobserwowano pozytywny postęp hodowlany w zakresie stylu skoku koni i dokładności pokonywania przeszkód wyrażonej punktami karnymi.

Stwierdzono, istotne korelacje pomiędzy rankingami wartości hodowlanych z Zakładów Treningowych i szacowanych w oparciu o wyniki Mistrzostw Polski Młodych Koni.
Należy przyjąć, że ocena w Zakładach Treningowych wzbogacona o wyniki z MPMK (w czterech kategoriach wiekowych) powinna dawać wiarygodniejszy obraz genetycznych predyspozycji koni do skoków przez przeszkody, choć uzyskiwana jest dopiero w 6-7 roku życia zwierzęcia.

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PRELIMINARY EVALUATION OF THE USE VALUE OF JUMPING HORSES BASED ON THEIR RESULTS ACHIEVED IN GRAND PRIX COMPETITIONS*

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Abstract
The aim of the work was preliminary evaluation of predispositions of Polish racehorses to sports. The tests covered 273 horses taking part in CC class and CC1 class competitions in the finals of the big tour. The probability of achieving the best result in the competitions depending on the horse breed was evaluated using multivariate analysis of variance. With the use of Spearman's rank correlations, the initial correspondence between the horse's rank in breeders' ranking and the ranking based on sport results was defined. It was stated that horses starting in Grand Prix competitions represented only 6.85% of all horses registered in the Polish Equestrian Federation. In the group, foreign breeds were predominant. The proportion of native breeds was marginal. The lack of a significant influence of the race on differentiation of sports results of horses proves that the best specimens were chosen within individual races. The preliminary results revealed lack of rank agreement between the evaluation of the breeding value and sports achievements of an individual. This suggests the necessity of performing broader analyses covering different aspects.

Key words: horses, horse-jumping, use value, breeding value, performance test

Show jumping is the most popular horse riding discipline. Its development is influenced by the effectiveness of breeding and a number of environmental factors, which allow genetic exposition of horse's abilities (Gómez et al., 2006). The evaluation of the use and breeding values is broadly debated. Due to the comprehensibility of the term "vivaciousness", attempts are constantly made to define a universal model of evaluating horses' genetic predispositions for "Interstallion" sports use (Koenen, 2002; Ruhlmann et al., 2009). The problem has been dealt with in a number of foreign research projects (Koenen and Aldridge, 2002; Langlois and Blouin, 2004; Lührs-Behnke et al., 2002; Viklund et al., 2011). On the other hand, in Poland there has not been any research verifying the effectiveness of individual stages of breeding. The breeding value of stallions in Poland is assessed on the basis of perform-

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ance tests (100-day test) in Training Centres or on the basis of the results of Polish Young Horse Show Jumping Championships. Scientists, breeders, and users differ in their opinions about the efficiency of each variant of use value assessment, and consequently their breeding value. The underdeveloped system of evaluation forces riders and trainers to use foreign breeds whose estimated sports predispositions are more reliable (Ruhlmann et al., 2009; Viklund et al., 2011). The most fundamental method of verifying the effects of horse breeding is the analysis of the sports results that their offspring achieve (Wallin et al., 2003) in a given equestrian discipline. The results of horse riding competitions provide an important aspect of use value assessment and they are taken into account when breeders make their decisions on the choice of a sire.

At the same time, a decrease in the headage of native breeds (Janczarek and Próchniak, 2010) and their attendance in the most difficult classes of competitions is observed. These facts justify the need for a thorough analysis of the topic that is aimed at taking steps to make Polish horse breeds competitive in the market.

The aim of this work was to conduct a preliminary evaluation of sports predispositions in native bred horses in comparison to foreign breeds and to define the efficiency of horse breeding in Poland.

Material and methods

The research involved 273 horses of native and foreign breeds which competed in 30 competitions of Grand Prix finals with obstacle height 140 cm (CC class) and 145 cm (CC1 class) at all national show jumping (ZO*) single-star, two-star (ZO**), and three-star (ZO***) competitions and national competitions with participation of foreign riders (CSN) in 2012. In total, 774 entries of horse-rider pairs were obtained. The competition against the clock with jump-off and the so-called "winning round", where rider-horse pairs qualified together were considered as one due to the similar system of scoring. Competitions over two rounds were analysed separately as their results consisted of points obtained in two rounds in the courses with different numbers of obstacles and a different route.

With the use of multivariate analysis of variance (SAS 9.3), the probability of a clear round (0 penalty points) depending on the course was determined. The model takes into account the fixed effect of breed, age, sex, competition class, the random effect of the rider, and the regression of height at withers. With the use of Spearman's rank correlations, the preliminary correspondence between horse's rank in BLUP evaluation (published officially on the Polish Horse Breeders Association website) and the ranking was defined on the basis of Grand Prix competition results and rank correlations between the results of the basic round and the jump-off and the results of the first and second rounds. With the use of the MIXED procedure (SAS 9.3), the authors calculated the repeatability of results obtained by horses in the analysed competitions. The models included the following features: the fixed effect of breed, age, sex, competition class, and the random effect of the rider. Standard errors of

repeatability were estimated with the delta method (Lynch and Walsh, 1998). The analyses involved 9 groups of purebred horse breeds: Polish breeds (Polish Noble Half-Bred Horse – pksp, Małopolski Horse – m, Wielkopolski Horse – wlkp), Dutch (Dutch Warmblood – kwpn, Dutch Warmblood Saddle Horse – nrps), Zangersheide, Selle Français, Holsteiner, Hanoverian, Westphalian, and other German breeds. The tenth group ("other") was made of individuals with the number of starts under 20 (Table 2). The percentage of horses from each age group was also determined (Table 3).

Table 1. Distribution of the number of analysed starts, depending on the competition level, class and season: indoor competitions (H), outdoor competitions (O)

Competition	Class	Competition rank								Sum
		ZO*		ZO**		ZO***		CSN		
		H	O	H	O	H	O	H	O	
Competition against the clock with jump-off and a winning round	CC	-	29	-	-	-	-	-	32	577
	CC1	-	-	143	69	52	43	23	186	
Competition over two rounds	CC	-	21	-	-	-	-	-	51	197
	CC1	-	-	-	32	-	-	-	93	
Total		50		244		95		385		774

Table 2. The distribution of starts in each group of horses

Breed	No. of starts	%
Polish (pksp, m, wlkp)*	228	29.92
Dutch (kwpn, nrps)**	154	20.21
Oldenburger (old)	84	11.02
Holsteiner (hol)	70	9.19
Hanoverian (han)	57	7.48
Westphalian (westf)	35	4.59
Zangersheide (z)	27	3.54
Selle Français (sf)	22	2.89
Other German	27	3.53
Other	58	7.61

* pksp – Polish Noble Half-Bred Horse, m – Małopolski Horse, wlkp – Wielkopolski Horse.
** kwpn – Dutch Warmblood Horse, nrps – Dutch Warmblood Saddle Horse.

Table 3. The distribution of horses' starts with regard to horse age

Horse's age	% of starts	Horse age	% of starts
7	6.19	13	4.61
8	23.72	14	1.32
9	23.85	15	1.32
10	14.62	16	0.53
11	15.68	17	0.13
12	7.91	19	0.13

Results

The analyses showed no significant influence of the breed, age, or rider on the results achieved by horses.

The probability of a clear ride in the competition was significantly different in the cases of competitions against the clock and the competitions with the "winning round" only for the group of Polish horses (0.25) and those characterised as "other" (0.05) as well as between the group "other" and "Selle Français" (0.44). In the case of two-round competitions, a higher probability of a clear round was recorded for Hanoverian horses (0.61) against the Holsteiners (0.25) (Table 4).

Table 4. Probability of achieving the best result in a competition (0 penalty points) by horses from each breed group

Breed	Competition against the clock with jump-off and a winning round		Two round	
	lsm	se	lsm	se
Hanoverian	0.13	0.10	0.61 a	0.24
Holsteiner	0.13	0.09	0.25 b	0.16
Oldenburger	0.19	0.08	0.25	0.19
Selle Français	0.44 a	0.18	-	-
Westphalian	0.34	0.17	0	0.31
Zangersheide	0.36	0.16	0.37	0.22
Other German	0.30	0.15	-	-
Dutch	0.19	0.07	0.04	0.17
Polish	0.28 a	0.07	0.25	0.14
Other	0.05 b	0.10	0.41	0.24

lsm – least squares mean, se – standard error.
Breed groups marked with different letters differ significantly for P≤0.05.
Breed groups without marks do not differ between one another.

It was shown that although the native breeds constituted the most numerous group, their share in starts was only 29.92%. Among the foreign breeds, the most numerous ones were Dutch (20.21%) and German horses: Oldenburger (11.02%), Holsteiner (9.09%), and Hanoverian (7.45%) (Table 2).

There was no correlation between the BLUP ranking, based on the evaluation in training centres, and horses' sports results (Table 6). The highest agreement was noted for the BLUP index and the results of jump-off (0.44). In other cases, the correlation was negligible.

Discussion

The lack of the effect of the breed on the final result coincides with research results obtained by other authors who deal with similar investigations (Gómez et al., 2006). However, the lack of such results in the case of the other factors can be

justified by the fact that the best rider-horse pairs competing in the most difficult competitions were selected. They underwent all stages of training and met all the requirements imposed by the Polish Equestrian Federation on admission to the Big Round competition. The results obtained by Gomez (2006) were focused on lower rank competitions, in which the level of horses' and riders' training is lower.

Justifying such uncharacteristic differences in the probability of a clear round for individual groups of horses, one should consider the fact that among all the horses in a given breed there is a proportion of individuals predisposed to compete in equestrian competitions and achieve satisfactory results. In the case of specialised western breeds, a significant proportion of the population is predisposed to sport, whereas, in other breeds only a small number of individuals are able to meet the requirements they face in the tracks. The qualification of horses to the Big Round is a selection process, thus the analysis of the percentage of horses representing individual breeds in the above-mentioned competitions allows verification and initial evaluation of their sports predispositions (Olsson and Philipsson, 1992).

Table 5. The origin of pksp breed horses competing in Grand Prix competitions with regard to ancestors' breeds

Breed	Father	Father's father	Mother	Father's mother
Polish breeds (pksp, m, wlkp)*	29.41	5.88	76.47	23.53
German breeds	41.18	52.94	10.29	45.59
French breeds	2.94	17.65	-	4.41
Belgian and Dutch breeds	26.47	20.59	1.47	13.24
Other	-	-	10.29	8.82

* pksp – Polish Noble Half-Bred Horse, m – Małopolski Horse, wlkp – Wielkopolski Horse.

Table 6. Spearman rank correlation between the BLUP rank and sports results

Ranking		rs
Competition against the clock	35	−0.27
Jump-off	11	0.44
1st round	20	−0.05
2nd round	13	−0.05
Ranking in competition	74	0.22*

* significant for $P \leq 0.05$.

Although the group of Polish horses was the most numerous (29.92% of starts), a drastic decrease in its participation was observed, with a simultaneous increase in foreign horses' attendance: Dutch, mainly kwpn (20.21% of starts) and German, mainly the Oldenburger (11.02% of starts), Holsteiner (9.09% of starts), and Hanoverian breeds (7.45% of starts), in comparison to national competitions in the 1980s (Sasimowski and Pietrzak, 1983) when virtually only Polish bred horses participated. The attendance of Małopolski and Wielkopolski breeds was merely 2%. A greater concern is the fact that the access to competitions is easier for these horses and that numerous steps are taken to promote conservation of breeds, mainly in a form of

a genetic resources conservation programme (Janczarek and Próchniak, 2010). It may be anticipated that multidirectional selection of native horses contributes to the situation in which they are not fully predisposed to the show-jumping disciplines.

Polish Noble Half-Bred Horses (Table 5) were characterised by a high number of foreign ancestors (primarily from father's side), which additionally implies an increasing role of foreign breeders in Polish equestrian sports. The above-mentioned facts prove the trend of suppressing Polish breeds from equestrian disciplines by the foreign ones and a situation where riders and trainers prefer foreign bred horses, selected for sports gameness.

The analysis did not reveal any clear relations between the results achieved by horses in basic rounds or jump-off and the results from the first and second round. This is justified by the specificity of individual competitions in which riders take risks in the jump-off and the second round to obtain a satisfactory timing, even at the cost of making a mistake with an obstacle. Such a situation disrupts the real use value of the individual, just like other accidental factors (e.g. insignificant exceeding of the time limit, rider's faults), which do not negate the genetic potential of the horse. The biological background of such features as "precision" and "speed" cannot be neglected. Horses that are characterised by precision in running the course are particularly sensitive to any stimuli from physical contact with obstacle bars. This is a desirable feature and a condition of a clear course in the basic and the first round of the competition. In the jump-off and the second round, the horse's rank is determined by the time it runs the course, which depends on organism function and good quality of canter (Clayton and Barlow, 1991). Yet, the most significant factor determining sports successes is the precision of running the course, which is the most fundamental element influencing the final rank of the horse in the competition. This feature should be emphasised most intensively while evaluating the breeding value.

The lack of a correlation between the BLUP index and horses' sports results should be considered as a signal concerning the problem of discrepancy between the evaluation in training centres and the real use value of an individual horse. It is surprising that out of the 273 horses competing in such a prestigious event, as few as 9% had been assessed in Training Centres and obtained BLUP evaluation. These two elements imply that the system of evaluating horses' breeding value, and the methods of use value estimation in particular, should be reconsidered.

Using sports results as a source of evaluating breeding values of horses is difficult due to low repeatability of sports results for a given group of horses, which was a mere $r^2=0.19$ (se=0.03) for the examined group. This proves a significant influence of environmental conditions on the results obtained by horses, and supports the need to search for the features with lower environmental variance in the total changeability of a feature.

Due to the fact that the tests on foreign breeds proved the efficiency of the BLUP method (Wallin et al., 2003), it seems justified to make a fundamental analysis of the topic in order to prove the correctness of the national breeding strategy. The German system of evaluation (bringing satisfactory results) is based on training centre evaluation and the results of equestrian competitions in a given discipline (Koenen, 2002;

Lührs-Behnke et al., 2002), as well as information about ancestors', relatives', and offspring's breed values (Wikström et al., 2005).

Another factor determining the correctness of breeding value evaluation is horse's age, which allows genuine evaluation of its sports predispositions. The age limits for horses competing in CC and CC1 classes (7 years) are defined by the regulations of the Polish Equestrian Federation; however, as shown in Table 4, the most numerous group included 8-year-olds (23.72%) and 9-year-olds (23.85%). It can be assumed that at this age most horses are prepared for physical and mental effort involved in competitions of this type. On the one hand, the evaluation of younger horses may be erroneous; on the other hand, the results of the most difficult competitions generate the most reliable image of the use value of an individual horse.

The observed situation of lowering attendance of Polish horses in highest-rank competitions proves the necessity of reconsidering the problem. The low number of horses covered by breeding value assessment and the disproportions between BLUP evaluation and sports results suggest that it is necessary to modify the criteria of breeding value assessment by adapting them to the requirements faced by sports horses. The most important problem is the selection of features that will serve as a selection criterion, which is difficult due to the low level of repeatability of sports results and the fact the horses are usually over 8 years old. One should emphasise the need to modify the previous evaluation, whose new form can constitute valuable guidance for Polish horse breeders and users.

It can be concluded that, regrettably, the importance of foreign breeding in the national equestrian sports is on the increase through a substantial proportion of foreign ancestors in the breeds of the Polish noble half-bred horse. The discrepancy between the BLUP rank and horses' sports achievements should be regarded as a signal indicating a problem in evaluation of the use and breeding value of horses in Poland. Simultaneously, the low repeatability of results achieved by horses in sports competitions may limit the use of this source of information in estimation of the breeding value.

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Genetic Variability of Show Jumping Attributes in Young Horses Commencing Competing

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ABSTRACT: The aim of the study was to select traits that may constitute a prospective criterion for breeding value prediction of young horses. The results of 1,232 starts of 894 four-, five-, six-, and seven-year-old horses, obtained during jumping championships for young horses which had not been evaluated in, alternative to championships, training centres were analyed. Nine traits were chosen of those recorded: ranking in the championship, elimination (y/n), conformation, rating of style on day one, two, and three, and penalty points on day one, two, and three of a championship. (Co)variance components were estimated via the Gibbs sampling procedure and adequate (co)variance component ratios were calculated. Statistical classifications were trait dependent but all fitted random additive genetic and permanent environment effects. It was found that such characteristics as penalty points and jumping style are potential indicators of jumping ability, and the genetic variability of the traits was within the range of 14% to 27%. Given the low genetic correlations between the conformation and other results achieved on the parkour, the relevance of assessment of conformation in four-years-old horses has been questioned. (**Key Words:** Horse Breeding, Show Jumping, Variance Components)

INTRODUCTION

Due to the complexity of jumping performance, the issue of breeding value prediction has been addressed in many research papers (e.g. Koenen and Aldridge, 2002; Langlois and Blouin, 2004; Viklund et al., 2011). There are various approaches for assessment of the quality of show jumping horses. In Poland, the approaches comprise either performance test after 100-day training for stallions and 60-day training for mares or the Polish Jumping Championships for Young Horses (PJCYH) or, rarely, both; breeding value is predicted only for horses that have attended training centres. The breeding value of an individual is predicted for general, jumping, and dressage indices comprising different sets of traits recorded at the final performance test. In the recent years, an alternative method for evaluation of sport ability has gained

importance—the PJCYH, where horses that have not attended training centres for various reasons are evaluated. Frequent amendments to the PJCYH rules referring to scoring of the individual traits and calculating the final score significantly impede the estimation of genetic parameters of traits evaluated during competitions.

Currently, given the growing interest among horse breeders and riders in PJCYH scores, it seems advisable that a model for prediction of the breeding value of horses starting in the PJCYH should be developed. The choice of traits included in the breeding programme requires knowledge of their genetic variability and information about correlations between the traits (e.g., Thorén Hellsten et al., 2006).

The aim of the study was to select traits out of those recorded during PJCYH that may constitute a prospective criterion for genetic evaluation of jumping ability of young horses.

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MATERIALS AND METHODS

The investigation involved 1,232 starts of 894 four-, five-, six-, and seven-years-old horses taking part in the

PJCYH in the years 2005 through 2013 (Table 1). "Start" means participation of the horse in three days of championships in the year.

Two general types of show jumping rounds were practised during any championship—style assessing and precision jumping. The latter type of a round could have two variants—no allotted time (just penalty points for jumping faults) or against the clock (penalty for faults and for exceeding time allowance).

In an one and only round on each day of competition a horse could be evaluated for a set of traits out of nine traits evaluated in all age categories over three days of a championship (Table 2). The nine traits were: 1) overall ranking in the championship based on the scores obtained on each of the three competition days according to rules effective in given year; 2) elimination of a horse from the competition due to the second (or third – permissible only in competitions for younger horses with up to 125 cm-high obstacles) refusal at an obstacle, or horse lameness; 3) to 5) rating of style on day one, two, and three comprising the sum of penalties (a half for pole knockdown, one for the first disobedience, two for the second disobedience, one-tenth for each second of exceeded time) and bonus points granted by two judges of the jury for the jumping style; 6) to 8) penalty points on day one, two, and three scored either in regular precision jumping rounds or rounds against the clock (four for pole knockdown, four for the first disobedience, eight for the second disobedience – permissible only in competitions with up to 125 cm-high obstacles, one for each four started seconds of exceeded time), and 9) conformation (quality of walk and trot, and overall impression) of the four-year-old horses. Differences between the observation numbers for particular traits (Table 2) result primarily from switching between the two types of courses on consecutive days of a championship.

For the above traits we estimated the heritability (h^2) and repeatability (r^2) coefficients, as well as the genetic correlations (r_g) between them. Genetic correlations were estimated using a multi-trait model which takes into account nine analysed traits simultaneously.

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	84	275
	(242)	(164)	(406)
6	89	56	145
	(155)	(118)	(273)
7	27	17	44
	(71)	(50)	(121)
Total	541	353	894
	(733)	(499)	(1,232)

Statistical models for (co)variance component estimation were decided following introductory runs of analysis of variance testing the significance of identifiable effects (Table 3). The pedigree comprised 23,242 entries with a minimum depth of four generations for a single horse.

The variance components were estimated via Gibbs sampling with flat priors, employing the THRGIBBS1F90 software of Tsuruta and Misztal (2006). Three hundred thousand sampling rounds were run for all the models. Convergence was determined by visual inspection of trace plots, and 50,000 first iterations were discarded as burn-in.

RESULTS AND DISCUSSION

The overall ranking heritability coefficient of 0.14 (Table 4) can be considered moderate. A possibility, however, exists that its magnitude is in fact higher as the frequent changes to the PJCYH rules, e.g. introduction of assessment of the jump style, have introduced some noise to the consistency of the trait and horse ranking would be somewhat different in the consecutive years if the rules were stable. However, it was impossible to take these changes in the rules into account due to the insufficient number of observations within particular variants of a trait. Nevertheless, the trait is of limited use in an objective assessment of an individual. Low repeatability of the

Table 2. Simple statistics of the traits recorded during the Polish Jumping Championships for Young Horses

Trait		$\bar{x}$	Standard deviation	Min	Max	Number of horses	Number of starts
Overall ranking	(linear)	-	-	1	49	894	1,232
Elimination	(threshold)	0.18	0.39	0	1	894	1,232
Conformation	(linear)	1.18	0.09	0.90	1.38	429	431
Day 1 style	(linear)	7.09	1.08	1.10	8.80	203	388
Day 2 style	(linear)	7.29	1.02	–0.60	9.20	586	715
Day 3 style	(linear)	7.18	1.35	–1.90	9.20	527	623
Day 1 penalties	(linear)	4.21	5.26	0	36.00	247	385
Day 2 penalties	(linear)	4.52	5.29	0	27.00	252	401
Day 3 penalties	(linear)	5.52	5.30	0	25.00	191	324

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

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

[1] x - presence of an effect in the model for particular trait.

[2] A, random, associated with relationship matrix; R, random, diagonal; F, fixed; C, fixed covariate.

ranking confirms that the rank depends on many environmental factors independent of an animal which the "background", i.e. the sport performance of competitors is probably of greatest importance. There are high beneficial genetic correlations between the ranking and penalty and style points (Table 5), but the overall ranking includes both of these traits.

The magnitudes of the estimated genetic correlations indicate that the rank in the group of competing horses is largely dependent on jumping precision and refusals at obstacles which, additionally, may be indicative of a horse's temperament. In that, our results confirm the findings reported by Górecka-Bruzda et al. (2011), Górecka-Bruzda and Jezierski (2010). Horse's overall ranking in a championship is greatly determined by penalty scores, i.e. precision and time as well as by the style of covering the course. It appears that these are traits largely determined by the additive genetic effect of an individual (Table 4), thus they can be used as selection criteria for genetic improvement of sport horses. The low genetic correlations within the penalty points on each day of the championships confirm the distinctiveness of these traits. The same holds for the style scoring. The highest heritability estimate of h^2 = 0.27 was found for the "day three penalties" trait. Undoubtedly, on competition day three horses are expected to express their potential more fully having accustomed to

Table 4. Estimates of heritability (h^2), repeatability (r^2), and their standard errors (SE) for the analysed traits

Trait	h^2	SE	r^2	SE
Overall ranking	0.14	0.02	0.19	0.03
Elimination	0.00	0.00	0.26	0.05
Conformation	0.08	0.04	0.16	0.05
Day 1 style	0.26	0.06	0.44	0.07
Day 2 style	0.14	0.03	0.28	0.05
Day 3 style	0.16	0.03	0.40	0.05
Day 1 penalties	0.20	0.05	0.46	0.05
Day 2 penalties	0.19	0.04	0.40	0.05
Day 3 penalties	0.27	0.05	0.47	0.05

the competition site environment. So, the third day results may provide even more objective information about the abilities of an individual. Simultaneously, high repeatability of these traits is indicative of the predisposition of a horse for show jumping as both additive genetic and permanent environment effects contribute to its value. Estimates of genetic parameters based on penalty points are comparable very much with the scores achieved in regular show jumping competitions. As such they may provide information on the jumping abilities of siblings and offspring of an evaluated horse (Wallin et al., 2003; Ducro et al., 2009).

A group of traits essential for horse overall ranking is also the style rating on consecutive days of championships (Table 5). According to the binding rules, four- and five-year-old horses are evaluated in the so-called "horse style assessment competitions". This comprises the sum of penalties for the faults committed on the parkour (pole knockdown, jump refusal, exceeding the time limit) and bonus points for style. The bonus points for style is a subjective measure and includes such elements as maintaining a steady pace of galloping, position of neck and back during the jump (bascule), horse's sensitivity to rider's assistance, and precision of overcoming obstacles, absence of which is manifested by e.g. touching the pole usually without a knockdown. The trait defined as the jump style (evaluated on day one) exhibits moderate heritability and repeatability (Table 4). However, fluctuation of the estimated heritability coefficient (from 0.14 to 0.26) was observed for this trait during the consecutive days of the championships. Simultaneously, a very low correlation was found between the jump style scores achieved on the consecutive days at decently high repeatabilities on each evaluation day; in particular on day one and three. It could be expected that style rating on each day of competition is a manifestation of the same trait at correlations close to unity. Apparently our results suggest that different components are in fact assessed on the consecutive days, and the style ratings on days one, two, and three are indeed determined

Table 5. Genetic correlations (above) and their standard errors (below) between the traits

	Ranking	Elimination	Conformation	Day 1 style	Day 2 style	Day 3 style	Day 1 penalties	Day 2 penalties
Elimination	−0.01							
	0.17							
Conformation	−0.17	−0.01						
	0.18	*0.17*						
Day 1 style	−0.66	0.01	0.03					
	0.10	*0.16*	*0.21*					
Day 2 style	−0.56	0.01	0.16	0.31				
	0.11	*0.16*	*0.21*	*0.16*				
Day 3 style	−0.60	0.01	0.04	0.35	0.27			
	0.09	*0.18*	*0.21*	*0.16*	*0.15*			
Day 1 penalties	0.46	−0.01	−0.07	−0.29	−0.21	−0.26		
	0.15	*0.16*	*0.25*	*0.18*	*0.18*	*0.17*		
Day 2 penalties	0.82	−0.01	−0.08	−0.25	−0.29	−0.39	0.23	
	0.05	*0.18*	*0.22*	*0.18*	*0.15*	*0.13*	*0.17*	
Day 3 penalties	0.66	0.00	−0.16	−0.56	−0.37	−0.39	0.33	0.45
	0.10	*0.19*	*0.21*	*0.15*	*0.16*	*0.14*	*0.17*	*0.14*

differently. A vague definition of the jump style can impede appropriate and unambiguous evaluation by a judge. On the other hand, the style rounds run by a horse on different days of championship are spread across horse's age (difficulty of a run) and championship sites. In practice, each day of the competition, horses are faced with obstacles giving a different optical impression, which are additionally arranged in different configurations. Therefore, faultless completion of a competition on each of the championship days requires slightly different predispositions. This can explain the low correlations between single trait scores on different days. An analogous situation was recognised in the trait of penalties scored during the consecutive days. Undoubtedly, in this case, the low correlations are caused by the competition type (against the clock/not against the clock). Although in both cases the score is based on penalties, the time is decisive in competitions against the clock. This can lead to a situation, in which horses scoring certain points in competitions not against the clock may commit more faults in competitions against the clock, where the rider shortens the route in order to achieve the best time. Consequently, on different days different traits can contribute to faults and determine the final score. In fact, penalty points inform about not only the jumping precision but also the ability to concentrate, physical and mental strength, and other biological predispositions that are difficult to identify unambiguously. Simultaneously, penalty points are closely related to the jump style (Table 5), which is obvious, as penalties are components of the jump style determining the value of the trait. Negative genetic correlations were observed between the style score and penalties scored by horses for faults committed on the course in competitions evaluated in accordance with the rules of the Polish Equestrian Federation. The highest

correlation was obtained between the day one style score and day three penalties. This implies that horses with the best jump style are also characterised by sensitivity and precision in overcoming obstacles.

Another studied trait was elimination of a horse from the competition. The most common cause of elimination is the third refusal to jump and, less frequently, an animal injury or rider's withdrawal. The proportion of animals eliminated from the competition was 4.62%, 32.51%, 20.15%, and 19.83% in the group of four-, five-, six-, and seven-year-old horses, respectively. Since the heritability of elimination is practically non-existing (Table 4) elimination of a horse from competition may imply insufficient preparation of the animal for particular competition class. Moreover, it is vital for the organisers, horse owners, and competitors that all horses should finish championships. This undoubtedly increases their value, whereas elimination (in particular due to disobedience) is interpreted as lack of sport aptitude. These circumstances have an impact of the Course Designer's work, whose task is to match the difficulty of the parkour to the age group and number of horses in each age group. It should also be noted that elimination and the other traits are not genetically correlated (r_g = −0.01 to 0.01, Table 5). This proves that the trait mainly depends on environmental factors and is not a result of an additive effect on certain predispositions of the individual. Therefore, this trait is of little importance in assessment of the breeding value of sport horses.

In horse breeding, great importance is still attached to proper conformation. During the PJCYH, four-year-old horses undergo "arena assessment", at which a commission of three judges scores the horses for type and conformation, overall impression, and the quality of walk and trot. The heritability of conformation was estimated at h^2 = 0.08. The

heritability values lower than those reported by Ducro et al. (2009) can be explained by the usage of only a part of the available scale by the judges while evaluating conformation during PJCYH. The subjectivity of the assessment prevents judges from differentiation of horses. On the other hand, the evaluation comprises also the so-called overall impression, where exclusively environmental traits are assessed, e.g. animal fitness and hoof grooming. An interesting phenomenon is the low correlation between the conformation score and sport performance (Table 5), also observed by other authors (Koenen et al., 1995; Ducro et al., 2009). The principles and relevance of the assessment of conformation in four-year-old horses at PJCYH is debatable, since horses are subjected to this type of evaluation at an earlier age.

Unfortunately, due to the very small number of horses that had competed repeatedly in PJCYH, it was impossible to estimate correlations between the assessments in the 4th, 5th, 6th, and 7th year of horse's life. Similar investigations conducted by Huizinga et al. (1989) on Dutch horses demonstrated repeatability of $r^2 = 0.75$.

CONCLUSION

The current results indicate that decisive effect upon horses' overall evaluation exert precision, speed, and environment factors. These elements primarily contribute to traits defined as "penalties" and "jump style". The 14% to 27% genetic variability of these traits is a good prognosis for their effective usage in breeding work aimed at improvement of jumping performance in horses so, analysis of the style and penalties regarded as separate traits that reveal horses' predispositions is indispensable during the consecutive days of the championship. Concurrently, evaluation based on penalties is easy to perform and provides information about the most important predispositions of sport horses.

Given the low genetic correlations between the conformation and results scored on the parkour, the validity of evaluation of conformation in four-year-old horses should be considered; low heritability of this trait additionally points to serious shortcomings in the rating scale used.

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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

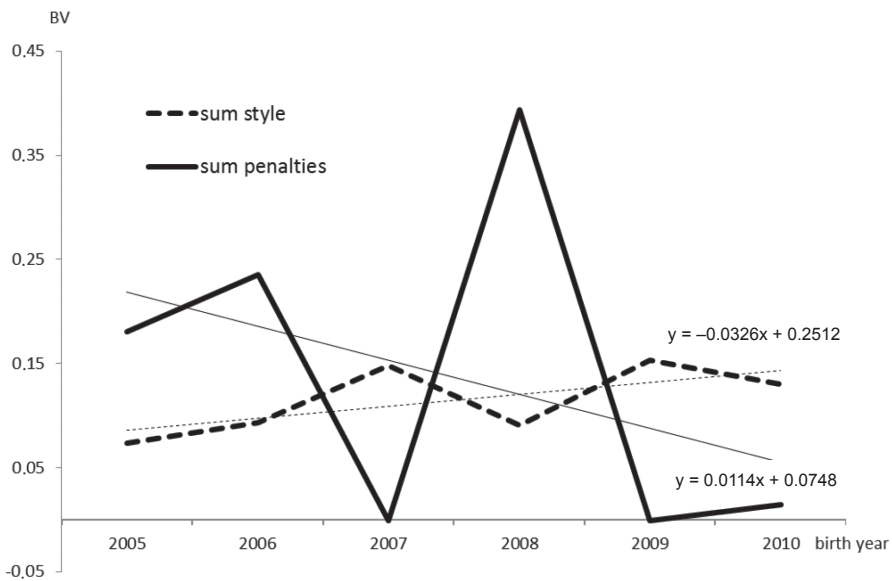| Traits	β	se
Overall ranking	−0.000026	0.000030
Day 1 style	0.000006	0.000005
Day 2 style	0.000002	0.000004
Day 3 style	0.000009	0.000010
Day 1 penalties	0.000059 *	0.000027
Day 2 penalties	0.000090 *	0.000037
Day 3 penalties	−0.000012	0.000033

* 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 α=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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