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Exploring the possibility to include competition traits in the genetic evaluation of Icelandic horses

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Summary

The possibility of including competition traits in the genetic evaluation of Icelandic horses, which is currently based on breeding field-test data, was explored. Linear animals models were used to analyse 18 982 records of 3790 horses competing in Iceland and Sweden 1998–2004. The traits included were seven original competition traits: two measures of four-gait, five-gait and tölt, and one pace trait. Additionally, three new combined competition traits were formed and analysed. The estimated heritabilities were low to moderate (0.18–0.35) for all competition traits. Genetic correlations estimated among competition traits were generally strong and favourable. Genetic correlations were estimated between breeding field-test traits and combined competition traits, along with one original competition trait. The breeding field-test data included 16 401 individual records of Icelandic horses evaluated in 11 countries during 1990–2005. High genetic correlations were generally estimated between field-test riding ability traits and competition traits. Moderate genetic correlations were estimated between some field-test conformation traits and most of the competition traits. It was concluded that the combined competition traits and one original competition trait could be added to the current genetic evaluation.

Introduction

The Icelandic horse is a multi-gaited riding horse for pleasure riding and sport competitions, suitable for adults and children. The breeding goal includes definitions of the goal traits specifying eight conformation traits, eight riding ability traits and height of withers. These traits are measured on a linear scale (5–10) by authorized officials at breeding field-tests. Since 2005 genetic evaluations have been based on records from breeding field-tests run in 11 countries.

Special competitions for Icelandic horses are popular. There are three types of Icelandic horse competitions: sport competition, pace racing competition and gæðinga competition. Three or five authorized officials judge the sport and gæðinga competitions on a linear scale in the range of 0–10 (best) and 5–10 (best), respectively. In pace racing competitions, the horses are ridden in pace (continuous) of given length and their time measured (in seconds). In sport competitions the quality of the gaits, and also various technical features of the performance, are important. In gæðinga competitions general impression and spirit are judged in addition to the quality of the gaits. Otherwise these two forms of competition do not differ from each other.

Records from competitions are not used in the current genetic evaluation and no direct selection criterion are applied in the selection of competition horses. The aim of this research was to investigate the possibility of including competition traits in the genetic evaluation of Icelandic horses. Genetic parameters for competition traits were estimated and relationships between competition traits and breeding field-test traits were studied.

Material and methods

Records from breeding field-tests were collected from the global data-base WorldFengur. 16 401 individual records from horses tested in 11 countries between 1990 and 2005 were included. All records for all traits were used. For the pace trait, an additional set of records was used where records equal to 5 were excluded. The reason for this was that it is believed that the score of 5 provides a skewed estimate of pacing ability, reflecting not solely a genuine lack of pacing ability. The following 17 breeding field-test traits were studied: height of withers; mane and tail; head; neck, withers and shoulders; back and hindquarters; proportions; leg quality; leg stance; hooves; walk; slow tölt; tölt; trot; pace; gallop; general impression and spirit.

Competition data was collected from The National Association of Riding Clubs in Iceland and The Swedish Icelandic Horse Association. The data from the two countries were merged on the basis of strong genetic correlations between similar competition traits in Iceland and Sweden, and similar means and standard deviations in Icelandic and Swedish competition data. The data included competition results from sport and gæðinga competitions from the period 1998 to 2004 with a total of 18 982 records of 3790 horses in 379 different events. The competition traits analysed were 7 original ones: T1, T2, V1, F1, PP1, B-Class and A-Class. Additionally 3 combined competition traits were formed, by merging highly correlated and similar traits, and analysed: Tölt(comp), 4-gait and 5-gait. Tölt(comp) was a combination of the tölting disciplines (T1 and T2), 4-gait was a combination of the four-gaited disciplines (V1 and B-Class) and 5-gait was a combination of the five-gaited disciplines (F1 and A-Class). All traits were normally distributed, based on estimated skewness and kurtosis.

Pedigree information used from the international Icelandic horse database included 10 generations, with a total of 30 198 individuals. The data is described in detail in Albertsdóttir et al. (2007a, 2007b).

Statistical models

The same statistical model was used for the breeding field-test traits as is used in current genetic evaluation (Árnason and Sigurdsson, 2004). This model included two fixed effects: age by sex interaction and year by country interaction. It also included the random additive genetic effect of the horse and the random residual effect.

Statistical models for the competition traits were evaluated using the GLM procedure in the SAS package (SAS institute Inc., 2004). The fixed effects of age, sex and event were statistically significant for all traits and the fixed effect of level (of discipline) was statistically significant for T1, T2, V1, and F1. Rider was significant but as most of the riders rode only one or two horses the effect could not be included. The models used for the genetic analysis for competition traits also included the random additive genetic effect of the horse, the random permanent environmental effect and the random residual effect.

Genetic parameters were estimated using the DMU package (Jensen and Madsen, 2000). Analyses were performed with univariate and bivariate models. Variance and covariance components were estimated using the average information (AI) algorithm for restricted maximum likelihood and the asymptotic standard error of (co)variance components was computed from the inverse AI matrix. Residual correlations between breeding field-test traits and competition traits were constrained to zero as almost no horses participated in both the competitions and the breeding field-tests.

Results

Heritabilities and genetic correlations among breeding field-test traits

Estimated heritabilities and genetic correlations among breeding field-test traits were in accordance with previous results (Árnason and Sigurdsson, 2004). Estimated heritabilities from univariate analyses and bivariate analyses were similar ranging between 0.20 and 0.67 (Table 1). Additionally, similar estimates of heritabilities for the breeding field-test traits were found when one breeding field-test trait and one competition trait were analysed together in a bivariate analyses.

Table 1. Heritabilities (h^2) with standard errors as subscripts estimated in single trait analyses.

Breeding field-test traits	h^2	Competition traits	h^2
Height of withers	$0.67_{0.02}$	T1	$0.18_{0.05}$
Mane and tail	$0.46_{0.03}$	T2	$0.23_{0.14}$
Head	$0.29_{0.02}$	V1	$0.19_{0.05}$
Neck, withers, shoulders	$0.39_{0.02}$	F1	$0.19_{0.07}$
Back and hindquarters	$0.29_{0.02}$	Pace test (PP1)	$0.21_{0.11}$
Proportions	$0.38_{0.02}$	B-Class	$0.33_{0.21}$
Leg quality	$0.37_{0.02}$	A-Class	$0.35_{0.23}$
Leg stance	$0.22_{0.02}$	Tölt(comp)	$0.19_{0.05}$
Hooves	$0.36_{0.02}$	4-gait	$0.22_{0.05}$
Slow tölt	$0.38_{0.04}$	5-gait	$0.22_{0.07}$
Walk	$0.20_{0.03}$		
Tölt	$0.39_{0.02}$		
Trot	$0.38_{0.02}$		
Pace (all records)	$0.58_{0.08}$		
Pace (records $\geq$ 5.5)	$0.34_{0.02}$		
Gallop/Canter	$0.36_{0.02}$		
Spirit	$0.37_{0.02}$		
General impression	$0.31_{0.02}$		

Genetic correlations between the traits; height of withers; head; neck, withers and shoulders; back and hindquarters; and proportions correlated moderately strongly (Table 2). These conformation traits often showed moderately strong genetic correlations with the following riding ability traits: slow tölt, tölt, gallop, spirit and general impression. Genetic correlations among the majority of the riding ability traits were strong. The traits walk and pace showed the only exceptions to this pattern.

Table 2. Genetic correlations between breeding field-test traits from bivariate analyses

Trait	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Height of withers																
2. Mane and tail	0.04															
3. Head	-0.07	0.26														
4. Neck, w, shoulders	0.39	0.12	0.42													
5. Back, hindquarters	-0.01	0.09	0.22	0.35												
6. Proportions	0.44	0.12	0.30	0.69	0.39											
7. Leg quality	0.08	0.22	0.04	0.12	0.02	0.04										
8. Leg stance	0.02	-0.06	0.02	0.07	0.11	0.05	0.02									
9. Hooves	0.26	0.00	0.02	0.20	0.17	0.16	0.16	0.09								
10. Slow tölt	0.05	0.00	0.18	0.28	0.21	0.24	0.09	0.00	0.31							
11. Walk	0.08	-0.02	0.00	0.00	-0.03	0.06	0.26	-0.21	0.12	0.11						
12. Tölt	0.10	-0.05	0.10	0.32	0.24	0.22	0.02	0.01	0.25	0.92	0.18					
13. Trot	0.03	-0.02	0.07	0.17	0.20	0.12	0.04	0.00	0.20	0.65	0.29	0.74				
14. Pace (rec ≥ 5.5)	0.03	0.04	0.09	0.10	0.19	0.08	0.04	0.06	0.24	0.21	-0.22	0.38	0.11			
15. Gallop	0.14	0.00	0.16	0.44	0.26	0.32	0.12	0.07	0.27	0.72	0.11	0.80	0.62	0.31		
16. Spirit	0.17	0.01	0.25	0.54	0.30	0.38	0.08	0.05	0.26	0.87	0.04	0.88	0.64	0.33	0.82	
17. Gen. impression	-0.05	0.01	0.20	0.27	0.24	0.20	-0.01	0.06	0.27	0.61	-0.07	0.80	0.58	0.61	0.76	0.80

Standard errors on genetic correlations were between 0.02 and 0.09.

Heritabilities and genetic correlations among competition traits

Estimated heritabilities for the competition traits (Table 1) from univariate and bivariate analyses were very similar, ranging between 0.18 and 0.23 for sport competition traits; between 0.33 and 0.35 for gæðinga competition traits; and between 0.19 and 0.22 for the combined traits. Standard errors for estimated heritabilities of competition traits ranged between 0.05 and 0.23 where the highest values were observed for the gæðinga competition traits and the lowest values for the combined traits. Estimated repeatbilities for the competition traits were around 60%.

Estimated heritabilities for the competition traits changed considerably and became higher when highly correlated breeding field-test trait and competition trait were analysed together in a bivariate analyses.

Genetic correlations (Table 3) within sport competition traits were generally strong; between the gæðinga competition traits 0.43; between comparable sport and gæðinga competition traits 0.93 – 1.00; and within the combined traits values ranged between 0.62 and 0.90 (Table 4). Standard errors for estimated genetic correlations among competition traits ranged between 0.05 – 0.51, where lower values were observed among the combined traits than among original traits. The only weak genetic relationship observed within competition traits were between PP1 and all original and combined competition traits expressing tölt and four-gait.

Table 3. Genetic correlations with S.E. as subscripts between original competition traits from bivariate analyses

	Competition traits					
Breeding field-test traits	T1	T2	V1	F1	PP1	B-Class
T2	0.71 $_{0.19}$					
V1	0.85 $_{0.07}$	0.74 $_{0.22}$				
F1	0.63 $_{0.18}$	0.96 $_{0.14}$	0.71 $_{0.19}$			
PP1	0.43 $_{0.24}$	0.10 $_{0.41}$	-0.03 $_{0.30}$	0.93 $_{0.17}$		
B-Class	0.93 $_{0.17}$	1.00 $_{0.34}$	0.93 $_{0.26}$	0.18 $_{0.43}$	-0.42 $_{0.42}$	
A-Class	0.84 $_{0.33}$	0.50 $_{0.54}$	0.50 $_{0.35}$	0.94 $_{0.25}$	0.97 $_{0.49}$	0.43 $_{0.51}$

Table 4. Genetic correlations with S.E. as subscripts between combined competition traits and one original competition trait

	Competition traits		
Breeding field-test traits	Tölt(comp)	4-gait	5-gait
4-gait	0.90 $_{0.05}$		
5-gait	0.74 $_{0.14}$	0.62 $_{0.18}$	
PP1	0.38 $_{0.24}$	-0.12 $_{0.28}$	1.00 $_{0.13}$

Genetic correlations between breeding field-test traits and competition traits

Moderately strong genetic correlations were generally estimated between the competition traits and the following breeding field-test conformation-traits: neck, withers and shoulders; back and hindquarters; proportions; and hooves (Table 5). The combined traits showed high positive genetic correlations with the breeding field-test riding ability-traits: slow tölt, tölt, trot, gallop, spirit and general impression. 4-gait and 5-gait correlated strongly with walk and 5-gait showed strong genetic correlation with pace recorded in breeding field-tests. PP1

correlated moderately strongly with tölt, pace, spirit and general impression recorded in breeding field-tests.

Table 5. Genetic correlations with S.E. as subscripts between competition traits and breeding field-test traits from bivariate analyses

	Competition traits			
Breeding field-test traits	Tölt(comp)	4-gait	5-gait	PP1
Height on withers	0.15 $_{0.09}$	0.15 $_{0.09}$	0.14 $_{0.10}$	0.38 $_{0.15}$
Mane and tail	0.08 $_{0.10}$	0.09 $_{0.09}$	0.22 $_{0.11}$	0.07 $_{0.15}$
Head	0.28 $_{0.09}$	0.23 $_{0.10}$	0.24 $_{0.11}$	-0.05 $_{0.15}$
Neck, withers and shoulders	0.52 $_{0.08}$	0.41 $_{0.08}$	-0.05 $_{0.18}$	0.29 $_{0.14}$
Back and hindquarters	0.41 $_{0.10}$	0.29 $_{0.10}$	0.54 $_{0.12}$	0.26 $_{0.15}$
Proportions	0.39 $_{0.09}$	0.32 $_{0.09}$	0.45 $_{0.11}$	0.17 $_{0.14}$
Leg quality	0.06 $_{0.09}$	0.15 $_{0.09}$	0.03 $_{0.10}$	0.01 $_{0.14}$
Leg stance	-0.03 $_{0.11}$	-0.07 $_{0.11}$	-0.24 $_{0.12}$	0.13 $_{0.17}$
Hooves	0.52 $_{0.09}$	0.45 $_{0.09}$	0.39 $_{0.11}$	0.41 $_{0.16}$
Slow tölt	0.93 $_{0.06}$	0.89 $_{0.55}$	0.73 $_{0.10}$	0.34 $_{0.18}$
Walk	0.23 $_{0.12}$	0.71 $_{0.08}$	0.51 $_{0.14}$	-0.10 $_{0.18}$
Tölt	0.96 $_{0.03}$	0.87 $_{0.04}$	0.84 $_{0.08}$	0.55 $_{0.15}$
Trot	0.91 $_{0.05}$	0.95 $_{0.04}$	0.79 $_{0.08}$	0.16 $_{0.16}$
Pace (all records)	-0.14 $_{0.07}$	-0.42 $_{0.07}$	0.83 $_{0.08}$	0.71 $_{0.17}$
Pace (records $\geq$ 5.5)	0.38 $_{0.11}$	0.12 $_{0.11}$	0.86 $_{0.08}$	0.83 $_{0.15}$
Gallop	0.93 $_{0.06}$	0.90 $_{0.05}$	0.65 $_{0.11}$	0.36 $_{0.17}$
Spirit	0.94 $_{0.04}$	0.87 $_{0.04}$	0.79 $_{0.09}$	0.43 $_{0.15}$
General impression	0.88 $_{0.05}$	0.75 $_{0.06}$	0.83 $_{0.08}$	0.68 $_{0.20}$

Discussion

Estimated genetic parameters on competition traits show that they are suitable to include in a genetic evaluation. The combined traits were the most stable in statistical analyses and the traits where the most precise estimates were obtained. The combined traits describe competition traits in simpler manner than the original traits, expressing different competing aptitudes of tölting, four-gaited and five-gaited horses. The combined traits could therefore be included in a genetic evaluation along with PP1, in order to express the pacing ability of competition horses.

Problems of biased genetic parameters due to selection in competition are known (Koenen et al., 2004). This study showed that when strongly related breeding field-test traits and competition traits are analysed together, the estimated heritabilities of the competition traits becomes higher. This is an indication that breeding field-test data, which is assumed to be less selected data compared with competition data, diminishes the effect of selection in reducing genetic variance in the competition data. Therefore, simultaneous genetic evaluation of both data-sets, breeding field-test data and competition data, is supported. Additionally, genetic evaluation based on records from both breeding field-tests and competitions reflect more appropriately the breeding goal of producing good riding horses.

Estimated genetic correlations between breeding field-test traits and competition traits confirm that comparable traits are evaluated similarly in field-tests and competitions. The conformation trait, hooves, was more strongly correlated with competition performance traits than with breeding field-test performance traits. This reflects the importance of having good quality hooves in durable competition horses. In general it can be concluded that both sets of

traits, breeding field-test traits and competition traits, are controlled to a great deal by the same genes.

Inclusion of competition data would entail utilization of a new information source with the inclusion of records relating to many new individuals, as a large number of competing horses are geldings that seldom participate in breeding field-tests. Increased reliability of the genetic evaluation is therefore expected as competition traits add information relating to the breeding goal. Hence, this inclusion could bring considerable economic benefits, because good competition horses are valuable and much sought-after by riders. However, if competition traits are to be integrated into the genetic evaluation, a sufficient quantity of competition data needs to be made available in the future, and the data collection should be standardized.

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