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Estimates of genetic parameters for body measures and subjectively scored traits in the Finnhorse

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Abstract

The aim of this study was to estimate genetic parameters for body measures (height at withers, height at croup, circumference of girth, circumference of cannon bone, length of body) and subjectively scored traits (character, body conformation, leg stances, hooves, quality of legs, movements) in the Finnhorse. Genetic parameters were estimated in the Finnhorse trotter population from the studbook inspection data, which included observations from 6381 horses. Mixed models including sex, age and year of judging as fixed effects, and animal as a random effect, were applied. Data were analyzed also with a model combining year and sex effects into a year-sex subclass effect. The data were analyzed separately within the two sexes as well. Genetic parameters were estimated with REML-method using VCE-program.

Estimates of heritability for body measures were in range of 0.49 to 0.82 and for subjectively scored traits from 0.10 to 0.31. Genetic correlations among body measures were high and positive, varying from 0.72 to 0.99. Genetic correlations among subjectively scored traits varied from -0.33 to 0.58, most of them being positive. Genetic correlations between body measures and subjectively scored traits were low to moderate, from -0.40 to 0.10, most of them being negative.

Aim of the study

Studbook inspection is an evaluation of the phenotype of the Finnhorse trotter and the studbook inspection panel can approve a horse to breeding after judging. Before entering a studbook inspection show, a horse has to have a result from trotting races with a minimum time demand and a trotting result defines the overall breeding class of the Finnhorse trotter.

Studbook inspection and conformation evaluation has an important role in breeding program of the Finnhorse trotter. However, breeding values based on conformation results have not been calculated in breeding program of the Finnhorse. To have more information for the development of the Finnhorse trotter and the effects of the changes in breeding program as well as to outline possibilities for more effective use of studbook inspection results, it is necessary to study non-genetic effects on the traits and to estimate genetic parameters of studbook inspection traits.

The aim of this study was to build up a genetic model to describe the traits of the Finnhorse trotter in the studbook inspection and to estimate heritabilities and genetic correlations of them.

Material and methods

The Finnish horse breeding organization arranges annually several studbook inspection shows in the 16 different areas in the country. For mares, 80 inspection shows per year are being offered. Stallions are evaluated at stallion shows, which are arranged three times a year. The panel of mare judging committee consists of three judges and the chairperson in committee is the same in different areas in the country. The panel of stallion judging committee having four members is the same in all of the three shows. A horse may be judged in a studbook inspection show earliest at the age of four years. Before entering an inspection show, a horse has to have a result from trotting races with a minimum time demand.

In a studbook inspection show, a trotting horse is measured with six different body measures: height at withers, height at croup, circumference of girth, width of chest, circumference of cannon bone and length of body. Inspection panel judges a horse and gives points for each trait and judgement is a common decision. Scored traits are character, body conformation, leg stances, quality of legs, hooves and movements. Judges can give points from four to ten for each trait. Height at croup has been at inspection scheme since 1978 and width of chest, body conformation and quality of legs were included in judgement since 1987. Change in scale of judging occurred in 1987 and scoring was tightened with one point for each trait.

Data consisted of 6381 Finnhorse evaluated to studbook section of trotters during the years 1971-2004. The number of stallions in the data was 1417 and that of mares was 4964. The average number of offspring per sire was 5.7 and total number of sires was 856. The average age at judging was 6.6 years. The number of four-year-old horses was 1017, five-year-old 1582, six-year-old 1237, seven-year-old 915 and 8-year-old and older 1630 in data. The average number of horses judged per year was 187.7. The number of mares judged per year varied from 45 to 236 and that of stallions from 11 to 83.

The traits of body measures included into the analyses were height at withers (HW), height at croup (HC), circumference of girth (CG), circumference of cannon bone (CCB) and length of body (LB). Of the subjectively scored traits character (CH), body conformation (BO), leg stances (LGS), hooves (HO), quality of legs (QLG) and movements (MOV) were included in calculations.

The effects of non-genetic factors and variance components were estimated by using various mixed models including univariate, bivariate and multivariate analyses. Different non-genetic effects including age at judging, sex, judging year and year-sex-subclass were analyzed from data. Data was analyzed separately within the two sexes as well, using bivariate model, excluding the effect of sex. Estimates of heritability and genetic correlations, in tables of this paper, are from multivariate analyses among body measures and among scored traits, and from bivariate analyses between body measures and scored traits.

The following model was used in final analyses.

Model 1: $y_{ijk=}$ μ+ $yearsex_i$+ age_j+$animal_k$+e_{ijk}

Where Y_{ijk} is the trait, μ is the mean of the population, $yearsex_{(i=1,...68)}$ is the year-sex subclass effect, $age_{(j=1,...5)}$ is the fixed effect of the age of the horse at judging, $animal_k$ is the random effect of the animal N(0, $\mathbf{A}\sigma^2_a$) and e_{ijk} is a residual effect N(0, $\mathbf{I}\sigma^2_e$).

In pedigree data, the total number of animals was 18798 and pedigree in four generations was taken into account.

The effects of non-genetic factors were estimated with PEST-program (Groeneveld 1990) and variance components were estimated of the random effects with REML-method using VCE-program (Groeneveld 1997).

Results and discussion

Means and standard deviations

The Finnhorse trotter is approximately 157 cm height at withers, and its body length is on average 9 cm larger than height at withers (Table 1). Mares are slightly bigger than stallions concerning all other body measures with the exception of cannon bone circumference, which is 19.9 cm for mares and 20.6 cm for stallions, respectively. Coefficients of variation were in range from 3% to 4% for all body measures.

The means for the subjectively scored traits ranged between 7.2 and 8.3 points (Table 1). The largest points are for character and the smallest for quality of legs. Coefficients of variation for all subjectively scored traits were within the range from 10% to 11%.

Table 1. Statistical description of the traits.

Trait[1]	n	mean	std dev	CV-%	min	max
HW	6381	156.9	4.0	3	141	173
HC	5098	156.2	3.9	3	142	170
CG	6380	183.7	6.6	4	147	218
CCB	6381	20.1	0.88	4	17	24
LB	6381	165.6	5.0	3	142	189
CH	6212	8.3	0.94	11	4	10
BO	2799	7.5	0.75	10	5	10
LGS	6336	7.5	0.79	11	4	10
HO	6332	7.8	0.85	11	5	10
QLG	2834	7.2	0.74	10	4	9
MOV	6332	7.7	0.84	11	4	10

[1]**HW** Height at withers, **HC** Height at croup, **CG** Circumference of girth, **CCB** Circumference of cannon bone, **LB** Length of body, **CH** Character, **BO** Body conformation, **LGS** Leg stances, **HO** Hooves, **QLG** Quality of legs, **MOV** Movements

Influence of non-genetic factors

Year of judging and year-sex subclass had a statistically significant influence ($p<0.0003$) on all body measures and subjectively scored traits as well. Year of judging showed differences between individual years but also a declining trend in all traits. Combined year-sex effect had a similar effect compared to the year and revealed clear differences between stallion and mare inspections but the declining trend in body measures was not observed with the exception of cannon bone circumference of mares.

In the analyses with separate year and sex effects, the effect of sex had a statistically significant ($p<0.02$) influence on all traits with the exception of the trait movements, which did not reveal any difference between mares and stallions. Mares had larger values than stallions, with the exception of cannon bone and character.

The effect of age had a statistically significant ($p<0.001$) influence on all traits with the exception of height at withers and points for body conformation. There was a trend to older horses being larger than the younger ones. The older horses received also smaller points for the subjectively scored traits compared to younger horses.

Estimates of heritabilities and genetic correlations

Estimates of heritabilities and genetic correlations were quite similar in spite of the model used. Estimates of heritabilities and genetic correlations for the traits with model 1 are given in table 2, 3 and 4.

The heritabilities for body measures were high, ranging between 0.49 and 0.82. Thus, the additive genetic effects determine the body size of the Finnhorse trotter for a great deal. Estimates of genetic correlations among body measures were positive and high, varying between 0.72 and 0.99. High to moderate estimates for heritability and genetic correlations of body size have been found also in other breeds (e.g. Arnason 1984, Dolvik et al 1999). However, lower values for heritabilities of body measures have been reported in the Finnhorse in previous studies (Varo 1965).

Estimates of heritability for subjectively scored traits varied from low to moderate, being within the range of 0.10 to 0.31. Estimates of heritability for subjectively scored traits are in general low or moderate (e.g. Arnason 1984). We found few negative genetic correlations between the subjectively scored traits: quality of legs with character, movements and body conformation. However, genetic correlations between the subjectively scored traits ranged from -0.33 to 0.58.

Genetic correlations between body measures and subjectively scored traits were mainly negative and varied from low to moderate, in range of -0.40 to 0.10

Remarkable differences did not exist in estimates between the various models, but standard errors decreased with combined data and multivariate models. Reliability of the estimates of heritabilities and genetic correlations improved considerably in the analyses with combined data and multivariate models, standard errors were within the range of 0.001 to 0.11.

Table 2. Estimates of heritability for (on diagonal) and genetic correlations among body measures from multivariate analysis.

Trait [1]	HW	HC	CG	CCB	LB
HW	**0.78±0.01**				
HC	0.98±0.001	**0.76±0.01**			
CG	0.83±0.01	0.83±0.01	**0.53±0.01**		
CCB	0.77±0.01	0.79±0.01	0.75±0.01	**0.68±0.01**	
LB	0.84±0.01	0.85±0.01	0.78±0.01	0.81±0.01	**0.69±0.01**

[1]**HW** Height at withers, **HC** Height at croup, **CG** Circumference of girth, **CCB** Circumference of cannon bone, **LB** Length of body

Table 3. Estimates of heritability for (on diagonal) and genetic correlations among subjectively scored traits from multivariate analysis.

Trait[1]	CH	BO	LGS	HO	QLG	MOV
CH	**0.13±0.01**					
BO	0.43±0.11	**0.10±0.02**				
LGS	0.25±0.04	0.42±0.04	**0.13±0.01**			
HO	0.24±0.04	0.26±0.04	0.31±0.03	**0.17±0.01**		
QLG	-0.16±0.03	-0.20±0.05	0.19±0.03	0.29±0.03	**0.19±0.02**	
MOV	0.51±0.04	0.20±0.07	0.28±0.05	0.39±0.04	-0.14±0.03	**0.17±0.01**

[1]**CH** Character, **BO** Body conformation, **LGS** Leg stances, **HO** Hooves, **QLG** Quality of legs, **MOV** Movements

Table 4. Estimates of genetic correlations between body measures and subjectively scored traits from bivariate analyses.

Trait[1]	HW	HC	CG	CCB	LB
CH	-0.28±0.05	-0.31±0.06	-0.32±0.06	-0.38±0.06	-0.34±0.05
BO	-0.28±0.10	-0.29±0.09	-0.07±0.09	-0.07±0.09	-0.15±0.10
LGS	-0.20±0.05	-0.17±0.05	-0.06±0.06	-0.04±0.05	-0.20±0.05
HO	0.03±0.05	0.04±0.03	-0.07±0.05	-0.01±0.05	0.09±0.05
QLG	-0.23±0.06	-0.21±0.07	-0.24±0.07	-0.20±0.06	-0.22±0.06
MOV	-0.26±0.04	-0.25±0.05	-0.12±0.05	-0.22±0.04	-0.33±0.04

[1]**HW** Height at withers, **HC** Height at croup, **CG** Circumference of girth, **CCB** Circumference of cannon bone, **LB** Length of body, **CH** Character, **BO** Body conformation, **LGS** Leg stances, **HO** Hooves, **QLG** Quality of legs, **MOV** Movements

Conclusions

Estimates of heritability and genetic correlations differed only slightly between the different models and data sets used, but the reliability of the estimates improved remarkably with multivariate models and combined data. To develop breeding values, results from young horse shows have to be studied with studbook inspection results.

Estimates of heritability for body measures were high and for subjectively scored traits from low to moderate. Genetic correlations among body measures were high and positive. Genetic correlations among subjectively scored traits varied from low to moderate and most of them being positive. Mainly negative genetic correlations were found between body measures and subjectively scored traits, varying from low to moderate.

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