HERITABILITY ESTIMATES OF TROTTING PERFORMANCE TRAITS FOR EARLY CAREER AND ANNUAL RECORDS

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SUMMARY

Heritabilities of trotting performance traits for early career and annual records were estimated using the animal model REML. Obtained estimates were somewhat higher than those by the sire model and Henderson's method 3 in the literature. Heritability estimates for early career records were distinctly higher than estimates for annual records, but were probably overestimated.

INTRODUCTION

Some countries have moved over to use BLUP-method and animal model in evaluations of breeding values for trotting horses. Some countries are using early career records and some are using annual records of different age classes. However, most of the genetic parameters used in breeding value estimation have been obtained using the sire model and Henderson's method 3 in variance component estimation. Some of the assumptions made in the sire model, such as non-assortative mating, unrelated sires and unrelated dams, are strongly violated in trotter populations. In using more sophisticated variance component estimation methods, such as Restricted Maximum Likelihood (REML), the effect of selection can also be accounted for.

The objective of this study was to estimate heritabilities of some trotting performance traits for early career records, and heritabilities and repeatabilities for annual racing records using the animal model REML.

MATERIALS AND METHODS

Data

The data consisted of annually summarized racing records from the years 1979 to 1991 for Finnhorse trotters born between 1975 to 1984 and from the years 1984 to 1991 for Standardbred trotters born between 1981 to 1985. The early career of Finnhorse trotters consisted of racing records from 3 through 7 years of age. The total number of Finnhorse trotters having at least one record from the four different age classes ($\leq 4, 5, 6, 7$ years) was 6 934 and the total number of observations was 19 550. The early career of Standardbred trotters was based on annual records from 2 to 6 years of age. The total number of Standardbred trotters having at least one record from the four age classes ($\leq 3, 4, 5, 6$ years) was 5 298 and the total number of observations was 14 184. The data set for Standardbred trotters included both Finnish born and imported horses.

The studied traits were the best time in voltstart, fourth root transformation of earnings and earnings per start, number of starts, and logit transformation of first placings, first to third placings, disqualified races and races where a horse had broken stride. Logit transformation was performed according to Snedecor and Cochran (1967).

Statistical analysis

The following linear animal model was assumed to estimate the necessary variance components to calculate heritabilities of trotting performance traits for early career records of Finnhorse trotters:

$$y_{ijkl} = \mu + b_i + c_j + a_k + e_{ijkl}$$

y_{ijkl} = record of a horse
μ = overall mean
b_i = fixed effect of birth year$_{i, i=1-10}$
c_j = fixed effect of sex$_{j, j=1,2}$
a_k = random animal (additive genetic) effect
e_{ijkl} = random residual effect.

The model for estimating heritabilities of trotting performance traits for early career records of Standardbred trotters was the same as for Finnhorse trotters with the two exceptions that it included also the fixed effect of country of birth, with two classes: Finnish born and imported horses, and that the fixed effect of birth year had only five classes. The country of birth was included in the model to account for the effect of selection due to the Finnish import regulations. The distribution of **a** and **e** was assumed to be multivariate normal with zero means, and with var(**a**)=A σ_a^2, var(**e**)=I σ_e^2, and cov(**a**, **e**)=0, where A is a matrix of additive relationships among animals, I is a identity matrix, and σ_a^2 and σ_e^2 are variance components for additive genetic and residual effects, respectively.

Another linear animal model was assumed to estimate the necessary variance components to calculate heritabilities and repeatabilities from the data set where a horse could have a record in one through four age classes:

$$y_{ijklm} = \mu + b_i + c_j + d_k + a_l + pe_l + e_{ijklm}$$

y_{ijklm} = record of a horse
μ = overall mean
b_i = fixed effect of birth year$_{i, i=1-10}$
c_j = fixed effect of sex$_{j, j=1,2}$
d_k = fixed effect of age class$_{k, k=1-4}$
a_l = random animal (additive genetic) effect
pe_l = random permanent environmental effect
e_{ijklm} = random residual effect.

In analysing the data set for Standardbred trotters, the statistical model included the fixed effect of country of birth, and the fixed effect of birth year had five classes. The distribution of **a**, **pe** and **e** was assumed to be multivariate normal with zero means, and with var(**a**)=A σ_a^2, var(**pe**)=I σ_{pe}^2, var(**e**)=I σ_e^2, and cov(**a**, **pe**)=cov(**a**, **e**)=cov(**pe**, **e**)=0, where A is a matrix of additive relationships among animals, I is an identity matrix, and σ_a^2, σ_{pe}^2 and σ_e^2 are variance components for additive genetic, permanent environmental and residual effects, respectively.

All traits were analysed univariately. The variance components were estimated using the method of Restricted Maximum Likelihood (REML) (Patterson and Thompson, 1971) by variance component estimation program based on derivate free approach (Groeneveld, 1993) attached to PEST (Groeneveld, 1990).

RESULTS

Heritability estimates for annually summarized records were distinctly lower than for early career records. In fact, some of the heritability estimates for early career records were even higher than the respective repeatabilities (tables 1 and 2). Only the heritability estimate of best time in Standardbred trotters was higher for annually summarized records than for early career results.

The highest heritability estimates were obtained for best time, earnings, earnings per start and first to third placings from both early career and annual records in the two breeds. Heritability estimates were lowest for number of starts. The repeatability estimates for best time were distinctly higher than those for other traits.

Table 1: Estimates of variance components (σ_a^2, σ_{pe}^2 and σ_e^2), heritability (h^2) and repeatability (r) of trotting performance traits for early career and annual records in Finnhorse trotters

trait	early career records			annual records				
	σ_a^2	σ_e^2	h^2	σ_a^2	σ_{pe}^2	σ_e^2	h^2	r
best time	29.292	40.600	0.42	21.079	24.678	14.002	0.35	0.77
$(\text{earnings})^{1/4}$	7.444	15.738	0.32	3.159	3.958	8.239	0.21	0.46
$(\text{earnings per start})^{1/4}$	0.867	1.437	0.38	0.723	0.701	1.630	0.24	0.47
number of starts	138.561	641.195	0.18	8.081	21.170	51.747	0.10	0.36
logit (first placings)	0.256	0.779	0.25	0.112	0.143	0.627	0.13	0.29
logit (first to third placings)	0.360	0.591	0.38	0.231	0.141	0.684	0.22	0.35
logit (disqualifications)	0.252	0.954	0.21	0.165	0.327	0.875	0.12	0.36
logit (breaking stride)	0.148	0.561	0.21	0.136	0.182	0.664	0.14	0.32

Table 2: Estimates of variance components (σ_a^2, σ_{pe}^2 and σ_e^2), heritability (h^2) and repeatability (r) of trotting performance traits for early career and annual records in Standardbred trotters

trait	early career records			annual records				
	σ_a^2	σ_e^2	h^2	σ_a^2	σ_{pe}^2	σ_e^2	h^2	r
best time	2.689	6.743	0.29	3.689	2.728	4.044	0.35	0.61
$(\text{earnings})^{1/4}$	8.063	16.674	0.33	4.345	3.405	10.529	0.24	0.42
$(\text{earnings per start})^{1/4}$	1.148	1.443	0.44	1.090	0.520	2.069	0.30	0.44
number of starts	72.308	608.182	0.11	6.704	19.575	56.661	0.08	0.32
logit (first placings)	0.249	0.736	0.25	0.102	0.138	0.625	0.12	0.28
logit (first to third placings)	0.272	0.590	0.32	0.192	0.120	0.697	0.19	0.31
logit (disqualifications)	0.246	1.100	0.18	0.161	0.397	0.882	0.11	0.39
logit (breaking stride)	0.191	0.658	0.23	0.160	0.249	0.730	0.14	0.36

DISCUSSION

Heritability estimates for early career records in this study were slightly higher than the estimates in the studies of Arnason et al. (1989) and Saastamoinen and Ojala (1991), where variance components were obtained using the sire model and Henderson's method 3, and in Klemetsdal (1989), where genetic parameters were estimated with REML and the sire model. In all these studies early career of a horse was defined as one year shorter than in this study. In Arnason et al. (1989) heritability estimates for full career records were distinctly lower than those for early career records in the same study.

Saastamoinen and Ojala (1991) reported rather similar estimates of heritability for annual records of the three first age classes in Finnish Standardbred trotters to those in this study, but considerably lower in Finnish trotters. Tavernier (1989) reported heritability of 0.26 for logarithmic transformation of earnings per start estimated from five age classes from two to ten years of age.

Higher heritability estimates suggest that breeding values for trotters should be estimated on the basis of early career records rather than using annual records from several age groups. However, the heritability estimates calculated from early career records are likely to be overestimated for at least two reasons. First, the variation between the animals is bound to be large due to selection after one or two years of racing. The poorest performers are culled and only the better performers have an opportunity to race long enough to have 'a career'. Second, incomplete career results, i. e. careers of the horses that do not have a record in every age class, are formed of annually summarized racing records done at different ages. Thus, the variation caused by age and race year is confounded with the animal effect when using career records. In breeding evaluation, the repeatability model would be more fair to horses that for some reason (accidents or injuries) have not been able to race during several years. Also when using annually summarized racing records the effects of age and race year could also be accounted for.

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