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Use of competition results for genetic evaluation of longevity in Swedish warmblood horses

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Abstract

The aim of the present study was to investigate the possibilities to use "number of competition years" as a measure of longevity in the genetic evaluation of the Swedish warmblood horses. Male horses not used in breeding born between 1967 and 1991 were included in the study. Competition results recorded 1971-2006 in the disciplines dressage, show jumping and eventing were used to estimate genetic parameters for *number of competition years*. The study revealed that horses with placings in more than one discipline at an early age had a longer competition career. This result suggests that these horses are talented for sports and possibly also that there is a positive effect of all-round training of young horses on their longevity. For estimation of genetic parameters for *number of competition years* different linear mixed animal models were tested. Depending on the model the heritability for number of years in competition varied between 0.08 and 0.21. The lower values were obtained when adjustments were made for age at first results in competition. Positive genetic correlations were estimated between total number of years in competition and competition results as young horses (4 and 5 years old). These results indicate that *number of competition years* represents both the longevity of the horses and their talents for performance. It is suggested that *number of competition years* could be used for genetic evaluation of longevity and that the model must account for age at first successful competition.

Introduction

The breeding objective for Swedish Warmblood horses includes performance and conformation together with durability. Today breeding values are estimated with a BLUP animal model for performance traits and conformation. Longevity, or synonyms hereof (e.g. durability, stayability), are not only mentioned in the breeding objective for Swedish Warmblood horses but are included (together with health and soundness) in the objectives for 14 out of 19 breeding organizations in Europe (Koenen et al, 2004). The problem is how to measure longevity or durability in a useful way for genetic evaluation and selection. Veterinary examinations of potential breeding stallions are a common practice in most countries, but the issue is how predictive such examinations are for longevity.

In this paper focus is put on the opportunity to make use of existing competition statistics to get measures of longevity and that can be used for genetic evaluations. A possible trait to be used is the number of years in competition. However, this trait depends on different factors. The reason for a horse not longer to be in competition can be either voluntary or involuntary. Voluntary reasons may be that the horse does not perform at desired level, and involuntary reasons may be injuries, which lead to inability to compete at all (Ricard & Fournet-Hanocq, 1997). Similar definitions are also used in for example dairy cows, where true vs. functional stayability are mentioned. The definition of true stayability is the overall possibility to delay culling, whereas functional stayability means the ability to delay involuntary culling, i.e. independent of production level. Both traits are used internationally in dairy cattle breeding (Interbull, 2009). Although functional stayability may be a desirable measure of true longevity it may be difficult to use since voluntary reasons for culling always will be used for animals with bad production or performance (Ducrocq et al., 1988).

In a previous study in France, the heritability for length in overall competition life in show jumping was estimated to 0.18 (Ricard & Fournet-Hanocq, 1997). In a Swedish study made by Árnason (2006) the heritability for the overall length in competition life in standardbred trotters was slightly lower.

The aim of this study is to investigate the opportunity to use the number of years a horse is active in competition as a measure of longevity in genetic evaluation and breeding of Swedish Warmblood horses.

Materials

In the present study *number of competition years* will be used as a measure of longevity. Different linear mixed animal models will be tested to study the genetic variation in this measure and for assessing their suitability for a possible genetic evaluation of Swedish Warmblood horses. Correlations between longevity and performance, both at young age and in lifetime, will also be estimated.

Years in competition

Results from competitions in dressage, show jumping and eventing were used to study length in competition life. The trait *number of competition years* was recorded during the years 1971-2006 for male horses not used in breeding, and which were born between 1967 and 1991. These limitations were made because mares and breeding stallions may have an alternative use that can affect the amount of active years in competition. In total, results from 17892 horses were available of which 13159 horses had competition results in show jumping, 8271 in dressage and 1965 in eventing. The *number of competition years* does not follow a normal distribution and therefore needs to be transformed before the genetic analyses. The best fit was achieved by a 10-logarithm transformation of the records.

Performance

Results from field tests for young horses (Riding Horse Quality Test, RHQT) and competition results up to five years of age as well as accumulated for all years (lifetime results) were used for performance traits when estimating genetic correlations between longevity and performance, or when adjusting *number of competition year*s for performance in different models. RHQT data included 18240 horses and the results were collected from 1973 to 2007. The traits included in this study were temperament and general impression scored at the dressage and jumping tests respectively.

For competition, the trait accumulated number of *upgrading points* was included. These upgrading points are given to horses that are placed in a competition and depend on what placing and the level of competition. Competition results from the period 1961 to 2006 were included and two traits were used; total number of upgrading points up to five years of age (9294 horses) and in lifetime (37718 horses). To get the traits as close to normal distribution as possible, they were transformed with a 10-logarithm.

Methods

Estimation of genetic parameters

For estimation of genetic parameters restricted maximum likelihood (REML) mixed animal models using the average information algorithm included in the DMU package was used (Madsen & Jensen, 2000). Heritabilities were estimated in univariate analyses and genetic correlations in bivariate analyses between the two correlated traits. The most important factor to adjust the records for was year of birth as it reflects the time trends in expansion and characters of the sport.

The following animal models were tested for the trait *number of competition years*:

$$y_{ij} = \text{birth year}_i + \text{animal}_j + e_{ij} \qquad \text{(Model I)}$$

where y_{ij} is number of years in competition transformed with 10-logarithm for *j*th horse. Birth year_i is the fixed effect of *i*th birth year. Animal_j is the random effect of the *j*th animal and e_{ij} is the random residual effect. Model II is the same as model I with the addition of the fixed effect of age at first recorded competition result. Adjustment for this factor is made because it determines the opportunities for number of competition years in the remaining life, and probably also reflects the talent for performance. Model III is the same as model II but instead of age at first competition it includes the fixed effect of lifetime upgrading points divided by number of placings in competition, which reflects the achieved capacity for sports. Finally, Model IV includes the effects of both age at first competition and points per placing.

For the covariance analyses with performance traits from RHQT the following animal model was used (Viklund *et al.*, 2008):

$$y_{ijkl} = \text{event}_i + \text{sex}_j + \text{age}_k + \text{animal}_l + e_{ijkl}$$

where y_{ijkl} is the score of each trait of the *l*th horse. The fixed effect of event, sex and age at test (4 or 5 years) were included. For analyses with competition records the following animal model was used:

$$y_{ijk} = \text{birth year}_i + \text{sex}_j + \text{animal}_k + e_{ijk}$$

where y_{ijk} is accumulated upgrading points, up to 5 and all years respectively, transformed with 10-logarithm for *k*th horse. Birth year and sex were included as fixed effects. For this bivariate analysis all competing horses during the period until 2006 were included to reflect the present genetic evaluation system as regards competition data.

Results

Descriptive statistics

In table 1 the average number of active years in competition and the mean upgrading points achieved are shown for seven groups of horses according to which discipline or combination of disciplines horses had competed. For the total data set the distribution of *number of competiton years* are shown in figure 1. On average the horses had 3.7 years active in sport, ranging from one to 18 years. The groups including horses with competition results from more than one discipline had on average a 1-1.5 years longer career than horses with results from only show jumping or dressage. Horses competing in only eventing had the shortest career. The average upgrading points of the horses in the different groups show that horses with results in only show jumping and dressage, with possibly one exception, had the highest number of upgrading points, despite their lower number of years in competition. This reflects that the most successful horses in these disciplines are not competing in more than one discipline. For eventing the result is opposite which indicates that the best eventing horses successfully compete also in show jumping and/or dressage. It should be noted that horses competing in all three disciplines had the longest career and as high accumulated number of upgrading points as those competing in a single discipline (except eventing).

One hypothesis for the longer career of multi-disciplined placed horses was that this could be a positive effect of an all-round training of young horses, but could also be an effect of trying out several disciplines. This was investigated further by comparing the group of horses that had successful results from more than one discipline up to the age of six years with the rest of competing horses. The results in table 2 show that horses with early competition results from two or three disciplines had almost two more active years in competition than the others. The upgrading points also show that these horses in average gained more points in their lifetime than the others.

Table 1. Total active years in competition and number of upgrading points for horses with results in different combinations of disciplines.

		Competition years		Upgrading points	
Combination of disciplines	**Number of horses**	**Mean**	**s.e.**	**Mean**	**s.e**
Show jumping (only)	8494	3.31	0.03	83.8	3.0
Dressage (only)	4354	3.08	0.04	88.0	4.3
Eventing (only)	279	1.76	0.07	3.7	0.7
Show jumping + Dressage	3079	4.77	0.05	76.9	3.7
Show jumping + Eventing	848	4.76	0.09	51.1	3.6
Dressage + Eventing	100	4.47	0.24	63.3	16.0
Show jumping+Dressage+Eventing	738	6.41	0.11	84.8	5.3
Total	17892	3.69	0.02	80.8	1.9

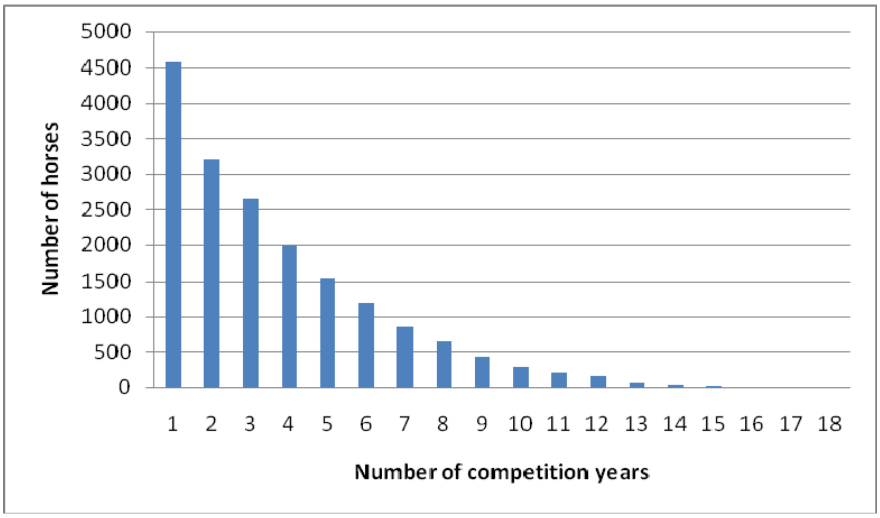

Figure 1. Distribution of number of competition years in the total data set

Table 2. Total active years in competition and number of upgrading points for horses with results from more than one discipline up to six years of age compared to the rest of competing horses.

	Number of horses	Competition years		Upgrading points	
		Mean	**s.e.**	**Mean**	**s.e.**
Results from more than one discipline before seven years	1058	5.39	0.10	99.3	6.2
Other horses	16834	3.58	0.02	79.6	2.0

Estimation of heritabilities and genetic correlations

Heritabilities, genetic and residual variances are given in table 3. The results show that models with the fixed effect of age at first placing give lower heritabilities, 0.08-0.09, compared to 0.17 for model I, which reflects the overall longevity. The genetic variances decreased by approximately half in these cases whereas the residual variances stayed almost unchanged. The model including points per placing did decrease both variances and increased the heritability slightly.

Table 3. Heritabilities (h^2), additive genetic variances (σ^2_a) and residual variances (σ^2_e) with standard errors as subscripts for number of years in competition estimated in different models.

Model used	σ^2_a	σ^2_e	h^2
I (BY)	$0.0183_{.002}$	$0.0889_{.002}$	$0.17_{.02}$
II (BY+Age)	$0.0077_{.001}$	$0.0844_{.001}$	$0.08_{.01}$
III (BY+Points/Placing)	$0.0168_{.002}$	$0.0636_{.002}$	$0.21_{.02}$
IV (BY+Points/Placing+Age)	$0.0061_{.001}$	$0.0649_{.001}$	$0.09_{.01}$

Genetic correlations between number of years in competition and performance traits from different statistical models are shown in table 4.

Table 4. Genetic correlations with standard errors as subscripts between total number of years in competition, with different model tested, and performance traits. Competition results are accumulated to 5 years of age and for lifetime respectively.

Model	**Temp. jumping (RHQT)**	**Temp. gaits (RHQT)**	**Competition results (up to 5)**	**Competition results (lifetime)**
I (BY)	$0.64_{.07}$	$0.31_{.08}$	$0.44_{.1}$	$0.62_{.04}$
II (BY+Age)	$0.71_{.07}$	$0.30_{.09}$	$0.63_{.1}$	$0.78_{.04}$
III (BY+Points/Placing)			$0.26_{.1}$	$0.79_{.03}$
IV (BY+Points/Placing+Age)			$0.41_{.1}$	$0.87_{.02}$

Discussion

Data to be used

In this study some restrictions were applied concerning data used for calculation of *number of competition years* in order to avoid horses with an alternative use in breeding. A similar restriction was also made by Ricard & Fournet-Hanocq (1997) in their study. Swedish competition results are available from the beginning of 1970-ies. To prevent left censored data, horses born before 1967 were excluded from the material since it was possible for them to have competition results before the recording period. The youngest horses were also excluded from the study to make sure that all included horses should have had the possibility to compete for at least 10 years to get reasonably reliable results on longevity. This period is equal to or exceeds the average age of sport horses at culling of Swedish Warmblood horses as shown by Wallin et al. (2000). However, since birth year is included in the models used for estimation of genetic parameters and breeding values it might be possible to expand the material by including younger horses as well. A survival analysis should then be applied. The effects of doing so need to be further investigated.

Factors affecting durability

As mentioned earlier, results from this study show that horses with competition results from more than one discipline had longer competition career than horses with results from one discipline only. The results also show that horses with results from two or three disciplines up to six years of age had significantly more years than all other competing horses (table 2). One reason for that might be a positive effect of an all-round training of young horses. Performance results also showed that horses with early results achieved more upgrading points than the other horses. However, when discipline groups were created not depending on early results, most upgrading points were found in the groups of horses that only had competed in dressage or show jumping.

Age at first successful result clearly influenced *number of competition years.* The earlier a horse started, within the accepted range from four years and up, the longer he would stay in competition. Whether this was due to the fact that if a horse starts to compete at an early age have more potential years in competition than a horse that starts its competition career later in life rather than other aspects is difficult to decide. Early starting horses may as well be the most talented for sports, and apparently age at first competition shows a considerable genetic variation. Árnason (personal communication) has also found that standardbred trotters that start their racing career at the age of two years have significantly more racing years than horses that start to race at a later stage of life.

Heritabilities and genetic variance

Estimated heritabilities varied between 0.08 and 0.21 depending on which model was used. If adjustment was made for age at first start the genetic variance was about halved (table 3) which also led to a corresponding decrease of the heritability. When back-transforming the additive genetic variance to the observed scale one may conclude that that there is a considerable genetic variation despite the relatively low heritability. The range in EBVs among stallions evaluated by Model II on at least 10 progeny amounts to 14 months, which corresponds to 30 % of the mean competition period.

The range of heritabilities in this study was comparable with similar studies made on horses (Ricard & Fournet-Hanocq, 1997; Árnason, 2006). In both of these studies heritabilities were estimated with a survival analysis. Low heritabilities for different longevity traits have been reported for other animal species as well, for example in dairy cows and pigs (Ducrocq et al., 1988; Engblom, 2008). It is also shown for a number of health and functional traits in dairy cattle that large genetic variation exists despite relatively low heritabilities (Philipsson & Lindhé, 2003).

Genetic correlations

Because longevity for production and performance traits depends on the animal's ability for production and performance there should be positive correlations between the two different traits, as is also found in this study. Correlations were lower between the talent measures in dressage (0.3) and jumping (0.7) than with competition results, especially those reflecting lifetime performance (0.6-0.9). It seems, however, that age at first competition result does not have the same influence on the genetic correlations between years in competition and performance as on the heritabilities.

Models and definition of longevity trait

Several models were tested in an attempt to find out which might be most suitable to use in a possible genetic evaluation. It is obvious that there is a considerable genetic variation in *number of competition years,* but that the variation to a large extent is dependent on the age at first results in competition. As the age at first start is clearly dependent on the management and training of the horse it seems quite important to adjust for this factor in the genetic analyses. It will at the same time adjust for some of the genetic variation in talent for sport. Yet the genetic correlations between longevity defined in this manner and performances of young horses are 0.3-0.7 and 0.8 with lifetime competition results. An alternative is to also fully adjust for the genetic talents for sport as done in Model III to obtain just functional longevity, although the measure used here was not very effective. As the competitive life of a horse is a function of both durability and its sports talent it is proposed to use a model that, beside birth year, just corrects for age at first competition results. Further studies should focus on the use of data on also younger horses, whereby survival analysis should be compared with linear models for genetic analysis and prediction of breeding values.

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