Breeding for Durable Riding Horses using Competition Statistics

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Abstract

The breeding objectives for Swedish Warmblood horses are aiming for producing horses that have a good conformation and are internationally competitive in dressage and show jumping. It also states that the horses should be durable. The aim of this thesis was to investigate whether it is possible to use existing competition statistics for genetic evaluation of durability and, if so, how this should be done.

Number of years in competition (NYC) was used as a measure of durability. Genetic analyses were performed using linear animal models where heritabilities, genetic correlations, and breeding values (EBV) were estimated. It was concluded that birth year and age at first placing should be included as fixed effects in the model. Age at first placing is, to a great extent, reflecting the talent of the horse and since information about durability is desired, the suggestion is to adjust for the age effect in the analyses of NYC.

Three different datasets were tested when heritabilities and EBVs were estimated. The datasets varied based on sex and birth year of the included horses. Heritabilities for NYC were in the same range for all three datasets (total 0.06-0.07; show jumping 0.08-0.12; dressage 0.07-0.08; eventing 0.04-0.08) and there were high correlations between EBVs within the same discipline for the different datasets. The genetic correlations between total NYC and performance traits from competition and Riding Horse Quality Test (RHQT) were higher for jumping traits (0.65-0.69) than for dressage (0.27-0.40) indicating that there are connections between level of performance and NYC. The conclusions of the results were that it is recommended to estimate EBVs for NYC for stallions with a linear animal model and that they should be published for each discipline separately.

Besides the genetic analyses, the study showed that horses with successful results from more than one discipline at an early age had significantly more years in competition compared to the other horses. This indicates that an all-round training of young horses has a positive effect on the durability of the horse.

Keywords: Riding horses, Durability, Breeding value, Heritability, Animal model

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List of publications

This thesis is based on work contained in the following papers, referred to with Roman numerals throughout the text:

I Braam, Å., Näsholm, A., Roepstorff, L. and Philipsson, J. (2011a). Genetic variation in durability of Swedish Warmblood horses using competition results. Submitted for publication in Livestock Science.

II Braam, Å., Näsholm, A., Roepstorff, L. and Philipsson, J. (2011b). Breeding values for durability of Swedish Warmblood horses. To be submitted for publication.

Abbrevations

BLUP	Best Linear Unbiased Prediction
EBV	Estimated breeding value
NYC	Number of years in competition
RHQT	Riding horse quality test
SWB	Swedish Warmblood horse breed

Introduction

Swedish Warmblood (SWB) is a horse breed used mainly for riding in the disciplines of show jumping, dressage and eventing. The breeding organisation has a breeding objective saying that they should produce horses that are internationally competitive in the previously mentioned disciplines and that have a good conformation. It also mentions that the horses should have good temperament and be durable (ASVH, 2011). For performance traits and conformation, estimated breeding values (EBV) using Best Linear Unbiased Prediction (BLUP) have been published since 1986 (Àrnason, 1987). So far, no EBVs are available for durability (Viklund, 2010). Sweden is not the only country in Europe that includes durability or health in the breeding objective or considers these traits to be of importance for their breeds. In a survey, where questionnaires were given to all breeding organisations for riding horses in Europe, 14 out of 19 replied that health, including durability and soundness, was important (Koenen *et al.*, 2004). However, so far none of the breeding organisations estimate EBVs for durability, but most of them estimate BLUP breeding values for performance traits. Today, health is considered in the breeding of SWB with a health- and orthopaedic examination of stallions entering breeding. Also, breeding of animals with heritable disorders that lead to suffering of the animals is not allowed. In a questionnaire to breeding organisations in Europe, 9 of 11 answered that recording of disorders was done for stallions, but only 5 answered that they recorded disorders in mares (Nicolic *et al.,* 2009).

Durability should be an important trait to consider in the breeding of horses, as it is a prerequisite for the use of horses. Durability and health are crucial for the welfare of the horses, but it is also important from an economic point of view. Horses have the potential of a long productive life, provided they

stay healthy, and large investments are made in producing and training the animals to reach their top performance (Wallin *el al.*, 2001).

From both a breeding and a training point of view, it is important to find a trait that can be recorded and used as a measure of durability. In this thesis the number of active years in competition (NYC) is used. The trait was chosen because competition results have been recorded on a regular basis since the beginning of the 1970's and NYC can be calculated for many horses for a long time period. Ricard and Fournet-Hanocq (1997) suggested, besides NYC, other measures for length of competitive life, such as the difference in years between the first and last year in competition, and number of starts. In their study they chose to use NYC, but with a different statistical model compared with the models used in this thesis. Number of races is used in the BLUP evaluation of Swedish Standardbred trotters as a measure of durability. For this trait, both superior and inferior horses tend to have fewer races than the rest of the horses (Árnason, 1999).

Number of years in competition is not only a trait that reflects horses' ability to avoid injuries and stay healthy. How long a horse stays in competition might also depend on factors such as talent for the sport, performance level, conformation, and temperament and spirit in competition. The skill of the rider, and the training and matching the horse for competitions are also of importance. It has been shown that horses with good conformation at the age of 4 years had a significantly lower risk of being culled than horses with lower scores for conformation traits. Correctness of legs showed an especially significant effect on the risk of being culled. When it comes to talent of jumping both high- and low-scoring horses had a significantly higher risk of being culled. For high-scoring horses this risk was associated with more extensive use of the best horses in competition (Wallin *et al.,* 2001).

In the current genetic evaluation of SWB for performance in competition the traits used are accumulated upgrading points over the lifetime in dressage and show jumping. These upgrading points are given to horses placed in competition. The more placings a horse receives, the more points it will get. Therefore, the upgrading points, to some extent, also measure the durability of the horse. The upgrading points are, however, also based on the level of competition, and placings in high-level competitions will result in more upgrading points.

In conclusion, there is a need to investigate the opportunities of using Swedish competition statistics for genetic analyses and estimation of breeding values for durability of Swedish Warmblood horses.

Aims of the thesis

The overall aim of the thesis was to investigate the possibilities of using number of years in competition (NYC) as a measure of durability in a genetic evaluation of Swedish Warmblood horses used for show jumping, dressage, and/or eventing. The intention was also to study the importance of using information from young horses still in competition for linear analysis of NYC. The more specific aims were to:

- investigate the influence of non-genetic factors on NYC
- estimate heritabilities for NYC in the three competition disciplines show jumping, dressage and eventing
- estimate genetic correlations between NYC and performance
- study the effect of information from young horses on genetic parameters and reliabilities of EBVs for NYC
- compare genetic parameters for NYC and reliabilities of EBVs for NYC when using competition results from only male horses not used in breeding and when also using results from mares and breeding stallions

The hypothesis was that NYC could be a useful measure of durability that should be applied in the future selection program of SWB.

Summary of investigations

Materials

Years in competition

Competition statistics were provided by the Swedish Equestrian Federation and the Swedish Horse Board. In paper I, competition statistics from 1971 to 2008 were restricted to male horses not used in breeding that were born between 1967 and 1991 (17,962 horses). Mares and breeding stallions were not included in the data for paper I, as they can be selected for use in breeding and therefore their NYC can be shortened unrelated to durability. Birth year was restricted to assure that data included observations only for horses with completed or nearly completed competition careers. In this dataset, 99.5% of the horses had no results from competition the year after data registration and were thereby assumed to have completed their competition careers. In paper II, competition statistics from 1971 to 2009 were used. In this paper, results using data from male horses not used in breeding and with no upper limit in birth year (25,312 horses) were compared to results using data including mares and breeding stallions as well (43,069 horses). This was done in order to investigate the opportunities for maximum use of the competition statistics for genetic evaluation. For both datasets used in paper II, 16% of the horses still competed the last year, giving the maximum level of censored data in this study. Total NYC and NYC for each of the disciplines show jumping, dressage, and eventing were analysed in both papers.

Performance

In paper I, genetic correlations between total NYC and performance traits were estimated, mainly for young horses. The performance traits used were results from the Riding Horse Quality Test (RHQT) provided by the Swedish Warmblood Association and competition results. RHQT is a field test mostly for 4-year-old horses of both sexes, but 5-year-old mares are allowed to participate if they had a foal the previous year. Results from 19,305 horses tested between 1973 and 2009 were included in the study, and the scores for "temperament and general impression" from the evaluations of dressage and jumping were used for the analyses.

For competition, accumulated upgrading points were included. Two different traits were used; number of upgrading points for 4- to 5-year-old horses (10,269 horses) and upgrading points throughout the horses' lifetime (40,360 horses). Competition results included in the study were from 1971 to 2008. The competition results from young horses, together with the results from RHQT were used as measures of the sports talents of the horses.

Methods

Statistical handling of data

The distribution of NYC for the horses was in the range of 1 to 18 years. Most of the horses had competition results only from one or two years and the mean was 3.7 years for male horses with complete competition careers and when young horses were included as well, the means decreased to 3.2 and 3.1 years for male horses and all horses, respectively. This resulted in a distribution deviating from the normal distribution. The genetic analyses were therefore performed using both original values and transformed values. Values were transformed with the logarithm to base 10 and to their fourth root. The transformation most suitable for the data, according to skewness and kurtosis were values transformed to its fourth root and analyses were performed using that transformation.

In paper I, restrictions on birth year were used to avoid censored data. In an analysis including also a later year of competition showed that 99.5% of the horses had completed their careers. In paper II, on the other hand, these restrictions on birth year were not imposed on the data providing the opportunity to compare results with almost no censored records to results with more frequently censored records.

It was chosen to perform genetic analyses using animal linear models. It might also have been possible to use survival analysis, which is created to handle censored records. Sire models are usually used in survival analyses but, according to the breeding structure of SWB, animal models are preferable. A high level of assortative matings occurs in SWB, where the best stallions in show jumping cover the best mares in that discipline, and the same goes for dressage. Compared to other species, e.g. dairy cattle, many stallions are not so widely used. Thus, the groups of half-sibs are quite small and an animal model better handles the available information.

Genetic analyses

For the genetic analyses in papers I and II, (co)variances and EBVs were estimated using the DMU package (Madsen and Jensen, 2000). Restricted maximum likelihood (REML) mixed animal models using the average information algorithm were used. Heritabilities were estimated in single-trait analyses whereas genetic correlations between NYC and performance traits were estimated in bi-variate analyses. In paper I, two different models were tested for NYC. The first model included birth year as a fixed effect, and the second model included the fixed effect of age at first placing in competition in addition to birth year. Both models included the random effect of animal and a random residual effect. The second model was also used in paper II. When mares and breeding stallions were included in the analyses, the model was completed with the fixed effect of sex. The animal model used for performance traits in RHQT included the fixed effects of event, sex, and age according to Viklund *et al.* (2008). For performance traits in competition, the fixed effects of birth year and sex were included in the analyses (Viklund *et al.,* 2010).

Main findings

Effect of disciplines on number of years in competition

It was shown that horses, which competed in more than one discipline, had on average, longer competition careers than horses with results from only one of the disciplines show jumping, dressage or eventing. The results also showed that horses with successful competition results from more than one discipline at a young age had almost two more active years in competition than all other horses.

Heritabilities

Heritability estimates based on the original values (Table 1) for total NYC were 0.06-0.07 when adjustments for both birth year and age at first placing were done. Analyses with transformed data gave similar results when applied on both datasets. Among the specific disciplines, heritabilities for show jumping were highest (0.08-0.12) compared to dressage (0.07-0.08) and eventing (0.04-0.08). For NYC in show jumping a slightly higher heritability was found in the dataset with only male horses with complete competition careers compared to datasets comprising all male horses, including also young horses. When age at first placing was not included as a fixed effect, heritabilities were considerably higher indicating that age at first placing has a clear genetic background.

Genetic correlations

Genetic correlations were estimated between total NYC and performance traits in competition and judged at RHQT (paper I). Highest correlations were found between jumping traits and NYC (0.65-0.69), while genetic correlations between dressage traits and NYC were in the range of 0.27 to 0.40.

Estimation of Breeding Values

Within the same discipline there were high correlations between EBVs for stallions irrespective of which dataset was used. Correlations between EBVs from paper I, with only horses that had completed their competition careers, and paper II, with young horses also included, were in the range of 0.77 (eventing) and 0.91 (show jumping). In paper II, EBVs based on results only from male horses compared to EBVs based on all horses had correlations of 0.90 to 0.94 within each discipline.

Table 1. *Heritabilities (h^2) and additive genetic (σ^2_a) and residual variances (σ^2_e) with standard errors as subscripts for number of years in competition (NYC) estimated for different disciplines, with different data, and with different fixed effects in the model*

	σ^2_a	σ^2_e	h^2
Dataset with male horses not used in breeding and with completed competition careers			
Fixed effect of birth year included in the model			
Total	$1.06_{.12}$	$6.65_{.12}$	$0.14_{.02}$
Show jumping	$1.11_{.14}$	$5.55_{.13}$	$0.17_{.02}$
Dressage	$0.58_{.11}$	$5.50_{.13}$	$0.10_{.02}$
Eventing	$0.22_{.21}$	$4.78_{.26}$	$0.02_{.04}$
Fixed effect of birth year and age at first placing included in the model			
Total	$0.49_{.08}$	$6.29_{.09}$	$0.07_{.01}$
Show jumping	$0.72_{.11}$	$5.36_{.11}$	$0.12_{.02}$
Dressage	$0.45_{.10}$	$5.34_{.12}$	$0.08_{.02}$
Eventing	$0.20_{.19}$	$4.61_{.23}$	$0.04_{.04}$
Dataset with all male horses not used in breeding[1]			
Total	$0.29_{.04}$	$4.83_{.06}$	$0.06_{.01}$
Show jumping	$0.40_{.06}$	$4.46_{.07}$	$0.08_{.01}$
Dressage	$0.31_{.07}$	$4.31_{.09}$	$0.07_{.02}$
Eventing	$0.22_{.19}$	$3.54_{.22}$	$0.06_{.05}$
Dataset with all horses[1]			
Total	$0.26_{.03}$	$4.34_{.04}$	$0.06_{.01}$
Show jumping	$0.38_{.04}$	$4.04_{.05}$	$0.09_{.01}$
Dressage	$0.29_{.05}$	$3.96_{.06}$	$0.07_{.01}$
Eventing	$0.25_{.12}$	$2.98_{.15}$	$0.08_{.04}$

[1)] Fixed effects of birth year and age at first placing included in the model

General discussion

This thesis considers durability of SWB, but how durability can be defined can vary. Similarities can be drawn to the terminology of stayability, which is commonly used in e.g. dairy cows. True stayability can be referred to when no consideration is done to the reason why the animal is culled or not used anymore. When animals are not used in production because of reasons such as injuries, diseases and fertility problems the term involuntary culling is used. Voluntary culling is defined as when healthy animals are culled because of low production or performance. Functional stayability is then the ability to avoid involuntary culling (Ducrocq *et al.,* 1988a). If parallels should be drawn to durability of riding horses, realised durability could be used to describe how long horses stay in competition and would then be equal to true stayability. Thus, realised durability includes horses' talent for sport, temperament and that they are manageable besides the ability to stay healthy and avoid injuries.

As mentioned earlier, durability is an important factor to take into account in the breeding of horses. When considering animal welfare, it is important that the horses we produce are healthy and sound. The economic values cannot be ignored either. Wallin *et al.* (2000) investigated the causes of culling of Swedish horses. For SWB the most common cause of death was diseases of the musculoskeletal system and especially diseases of the joints and skeleton. Thus, possible measures of durability could also include statistics from animal hospitals or orthopaedic measures such as radiographic screening or veterinary examinations. The use of such measures, if heritable, will lead to increased functional durability. In this thesis, focus is put on realised durability in competition. The trait used, NYC, can be compared to the trait length of productive life, which is commonly used in other species such as dairy cows and pigs.

Durability in competition

It was shown in paper I that horses with competition results from more than one discipline had longer competition careers than horses with results from one discipline only. Further, horses with official placings in competitions from more than one discipline at a young age, through 6 years, had almost two more active years in competition than the rest of the horses. Such results would be impossible to attain if not the horses were adequately trained for at least two disciplines. These results indicate the importance of an all-round training of young horses to be durable and able to compete longer.

Age at first placing in competition also had an effect on NYC and horses with early competition results stayed in competition longer. Whether this was due to the fact that these horses had more potential competition years ahead of them, or due to greater durability, is difficult to say. It is likely that horses starting earlier are the most talented. A talented sport horse would probably be used for a longer period in competition as well. For jumping horses in France, age at first start had a positive effect of continued competition after a given number of years in competition. However, when considering only horses of the same age, age at first start didn't seem to have the same effect on probability of continued competition (Ricard and Fournet-Hanocq, 1997). Age at first start also had a significant effect on the ability of Thoroughbred racing horses to have a long racing career (Sobczynska, 2007).

Genetics of years in competition

Heritabilities associated with traits such as durability, longevity, and health are in general low. However, the genetic variance may still be substantial, which makes it possible to successfully use the desired trait in a breeding programme (Ducrocq *et al.,* 1988b; Philipsson and Lindhé, 2003). The traits are also dependent on the distribution of data and on large environmental factors, which explains the low heritabilities. Heritabilities for NYC varied depending on which data, discipline, and model used. Higher heritabilities were estimated if no adjustment was made for age at first placing. Age at first placing depends to a great extent on the talent of the horse. In the present study it was desired to reduce the influence of talent on durability and it is therefore suggested that correction for age at first placing should be included in the model. Heritabilities for NYC in show jumping were higher (0.08-0.12) compared with dressage (0.07-0.08) and eventing (0.04-0.08). For

performance in competition of SWB, higher heritabilities are found for show jumping compared with dressage as well. Competition results in show jumping are more dependent on horses' talent and less on the rider compared with competition results in dressage. There is also more information available from competitions in show jumping due to more horses and more competition opportunities in that discipline (Viklund *et al.,* 2010). The higher heritabilities for NYC in show jumping can be explained by the same factors as for the performance traits. The positive genetic correlations between NYC and performance traits, estimated in this study, also indicate that there are clear relationships between the different traits. For longevity traits and length in competition life, heritabilities estimated in previous studies for racing horses and riding horses are in the same range or slightly higher (0.09-0.18) than heritabilities estimated in paper I and paper II (Ricard and Fournet-Hanocq, 1997; Árnason, 2006; Burns, 2006; Sobczynska, 2007). In the other studies survival analyses were used, whereas linear analyses were performed in this thesis. When comparisons have been made between heritabilities for longevity traits estimated using linear and survival analyses in pig production, it has been found that survival analyses gave slightly higher heritabilities (Serenius and Stalder, 2004; Engblom *et al.,* 2009). However, a higher heritability does not automatically mean that the model or method is better than in a case where the estimated heritability is lower. It is always most important that the model and method chosen for analysis is appropriate for the question raised. In our case the lower heritability is likely to be more true in reflecting durability, whereas the higher values to a larger extent reflects genetic variation in performance talent. Secondly, practically the same heritabilities were obtained for complete and censored data with linear animal model.

The genetic correlations between performance traits and NYC were estimated for total NYC. Because of more horses competing in show jumping compared with dressage, higher correlations were found for total NYC and jumping traits. The higher correlations are also explained by jumping horses often start their competitive life at an earlier age than for example dressage horses. This will automatically give them a longer potential time in competition before retiring. The average number of years in competition was also higher for show jumping. There are positive correlations between longevity traits and production in other species, too. For dairy cows, longevity is associated with milk production, and high producing cows live longer even though high milk production is not synonymous with high stayability (Ducrocq *et al.,* 1988b). In pig production

there are positive correlations between sow longevity and production, e.g. sows that live longer will also produce more piglets (Serenius and Stalder, 2006).

Breeding for durability

Choice of data and methods

How long a horse is active in competition can be affected by factors that have already been discussed. Other factors such as use of the horse in other areas, for example, in breeding, can also affect the trait. When it comes to NYC, the effect of breeding is more important for mares than for breeding stallions, even though it can influence the number of active years in competition for breeding stallions as well. To have the same prerequisite for all horses when NYC is analysed, one option is to use results only from male horses not used in breeding, as was done in paper I. Such restrictions were also made by Ricard and Fournet-Hanocq (1997). In paper I, restrictions were also made on birth year to enable horses to compete for at least 12 years, i.e. the youngest horses were 17 years old, and only 0.5% of the horses had not yet completed their careers. To include only horses with almost complete competition careers, however, is not practical in a genetic evaluation for NYC. Results would then come too late in life and the stallions will get too old before they have progenies old enough to be included in the genetic evaluation. In paper II, no restrictions on birth year were used, and results from young horses still active in sport were included in the analyses. The differences in the results when young horses were included were naturally lower average NYC, but only marginally lower heritabilities, than when they were excluded. The lower NYC depended on the fact that many of the younger horses would still compete for several years. The decreased estimates of heritabilities were explained by a decrease in both the genetic and residual variances due to the young horses' shorter time in competition. Since there were no large differences in the results when censored records were included or excluded, it seems that it should be possible to use a linear animal model when EBVs for NYC is estimated instead of using a more complicated survival analysis. However, the most important reason for choosing a linear animal model is that it is considered to better fit the mating structure of the breed.

To make the interpretation of the EBVs more understandable, EBVs should be estimated using original values instead of transformed values. The

differences of the results between the various scales were marginal and the pedagogic benefits of using the original scale are obvious when EBVs are explained as the deviation from the mean in terms of years in competition compared to the use of transformed data.

There were almost no differences in heritabilities when mares and breeding stallions were included in the analyses, but a small increase of the heritabilities for show jumping and eventing. The average reliabilities of EBVs for stallions with at least 10 competed progenies increased by 10-14% for show jumping, dressage and total NYC and by 40% for eventing when all horses were included in the analyses compared with the case when only male horses were included. The recommendation is to include all horses in the genetic evaluation. This is based on quite similar heritabilities and high correlations within disciplines between the datasets, but also on higher reliabilities when all horses were included.

Disciplines

The most common competition discipline for horses in Sweden is show jumping followed by dressage and then eventing. Some horses had results from more than one discipline. This is especially true for horses with results in eventing, of which approximately 80 % had results from show jumping and/or dressage as well. The SWB is a multipurpose breed, even though most horses are only used in one discipline in competition and in breeding. For performance traits, breeding values are published separately for each discipline allowing breeders to choose where to focus. For EBVs of NYC, there were in many cases low correlations, both positive and negative, between disciplines. Breeding values for total NYC had highest correlations with NYC for show jumping (0.81-0.90). In the ranking of stallions according to their EBVs for NYC, it was shown that large differences exist between disciplines and that the ranking of total NYC largely agreed with NYC in show jumping. As more than 70% of the competing horses had results from show jumping, it is reasonable that EBVs for NYC in show jumping are close to EBVs for total NYC. The low correlations between disciplines were probably not due to different factors affecting durability, but more likely due to different talents for sport and characteristics of the sport disciplines. There are for example more competitions available in show jumping and the horses tend to start competing earlier in that discipline compared to dressage and eventing. Because of the differences between the disciplines it seems reasonable that EBVs for NYC should be published for each discipline instead of an index for total NYC. Thus, the initially

expressed hypothesis to recommend a genetic evaluation procedure for durability of Swedish Warmblood horses based on competition statistics can be accepted.

Trends and future developments

The trend for NYC in show jumping and dressage indicates an increase of EBVs for stallions born in the 1980s and later (Figure 1). This has occurred even though no specific selection for the trait has been done from the breeding organisation. The trend is to a certain extent probably due to the breeding progress for performance in competition (Viklund, 2010). The performance traits in competition used in the genetic evaluation of SWB are the same as were used in this study. These traits are related to durability since the more years a horse competes, the more points it will have the opportunity to receive.

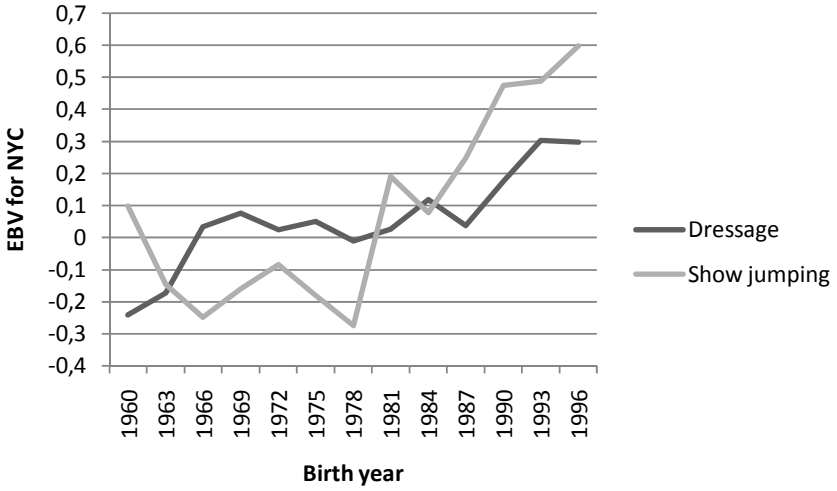

Figure 1. Trend in EBVs for NYC in dressage and show jumping for stallion with at least 10 competing progenies

For the future, it would be of great interest to learn more about factors that can affect the functional durability of horses. There are ongoing projects for SWB where results from conformation evaluations and veterinary examinations at RHQT are analysed. It would be specifically interesting to see what relationships these traits may have on length of competition life. A

possibility would also be to see how e.g. osteochondrosis based on radiographic findings or clinical examinations affect NYC.

Conclusions

Based on the results of the studies in this thesis it can be concluded that:

- Swedish Warmblood horses with competition results at an early age in more than one discipline have significantly more active years in competition compared to other competing horses, indicating that an all-round training of young horses has a positive effect on durability.
- there is a genetic variation of NYC which makes it possible to use NYC in a breeding programme despite low heritabilities.
- durability, measured as NYC, is positively correlated with sports talents in competitions and at RHQT, which shows that NYC is affected by the level of performance of the horses.
- EBVs for NYC are different for show jumping, dressage and eventing and the ranking among stallions differ between the disciplines. EBVs should therefore be published for each discipline separately.
- breeding values estimated with a linear animal model for number of years in competition as an indicator of durability for horses can be used as a complement to already existing breeding values for performance.
- only slight differences of heritabilities and EBVs suggest that results from young horses still active in sport should be included in the estimation of breeding values for NYC. It is also concluded that results from mares and breeding stallions should be included, leading to more reliable EBVs and the possibility of earlier published EBVs for stallions.

Avelsarbete för hållbara ridhästar med användande av tävlingsstatistik

I avelsmålet för den svenska varmblodiga hästen står det att man ska producera hästar med en bra exteriör och som kan vara internationellt konkurrenskraftiga som dressyr- eller hopphästar. Det står också nämnt att hästarna ska vara hållbara. Sedan 1986 har avelsvärden skattats med BLUP-metoden för prestations- och exteriöra egenskaper men än så länge skattas inga avelsvärden för hållbarhet. Att det bör bedrivas avelsarbete för hållbarhet kan vara viktigt ur flera aspekter, bland annat ur djurskyddssynpunkt då skador och sjukdomar leder till ett lidande för de drabbade hästarna. Men även ur ett ekonomiskt perspektiv, då stora investeringar ofta görs i hästarna och att eventuella veterinärkostnader kan bli stora. En förutsättning är dock att man har något lämpligt mått på hållbarhet som dessutom har en tydlig genetisk variation.

Syftet med den här avhandlingen var att undersöka om den redan befintliga tävlingsstatistiken kan användas för att skatta avelsvärden för hållbarhet genom att studera antal aktiva år i tävling. Det gjordes genom att:

- studera olika faktorer som kan påverka hur många år hästar tävlar.
- utarbeta en lämplig genetisk modell som kan användas för att skatta arvbarheter och avelsvärden för hållbarhet samt att undersöka vilka hästars resultat som ska ingå i skattningarna.
- studera de genetiska sambanden mellan antal tävlingsår och prestationsresultat vid kvalitetsbedömning och tävling.

Låga arvbarheter – men hållbarheten möjlig att förbättra med avel

Resultaten visade att arvbarheterna för antal år i tävling var ganska låga (0,04-0,12), men det är vanligt förekommande för egenskaper som berör hållbarhet, hälsa och livslängd oavsett djurslag. Det beror på att dessa egenskaper till stor del beror på yttre faktorer och att de registreras som antingen-eller-egenskaper, till exempel sjuk-frisk. Trots de låga arvbarheterna fanns en betydande genetisk variation som möjliggör att egenskaperna kan användas i ett avelsprogram. De högsta arvbarheterna skattades för antal tävlingsår i hoppning.

Skillnader mellan disciplinerna

Mellan avelsvärdena för antal tävlingsår i hoppning, dressyr och fälttävlan fanns det endast svaga samband. Det behöver inte betyda att antal tävlingsår i de olika disciplinerna är helt skilda egenskaper utan det är mer troligt att de låga sambanden beror på att det i stor utsträckning inte är samma hästar som tävlar i de olika disciplinerna. Men det beror även på olika tävlingsstrukturer mellan disciplinerna. Hopphästar börjar till exempel ofta sin karriär tidigare än dressyrhästar som dessutom har färre tävlingstillfällen. Därför bör avelsvärden för antal år i tävling skattas för de enskilda disciplinerna var för sig.

När genetiska korrelationer skattades mellan totalt antal år i tävling och prestationsresultat från tävling och kvalitetsbedömning visade det sig att det var högre korrelationer mellan antal år i tävling och hoppegenskaperna (0,65-0,69) jämfört med dressyregenskaperna (0,27-0,40). Detta beror till viss del på att betydligt fler hästar tävlar i hoppning och därmed påverkar deras resultat totalt antal år i tävling mer än vad resultaten för dressyrhästarna gör. Korrelationerna visar dock att det finns ett tydligt samband mellan antal tävlingsår och talang och förmåga att lyckas väl i tävling.

Användning av alla hästar ger säkrare index

Analyserna gjordes för tre grupper av hästar med varierande restriktioner på kön och födelseår. Begränsningen på kön sattes för att ston och avelshingstar kan ha färre antal aktiva tävlingsår beroende på att de är verksamma i avel och inte på grund av deras tävlingsförmåga. I en av grupperna var födelseår begränsat så att de flesta hästarna skulle ha avslutat sin tävlingskarriär. Utifrån skattningarna av arvbarheter och avelsvärden drogs slutsatsen att alla hästar, oavsett kön och födelseår, kan ingå i analyserna. Detta baserades på likvärdig

storlek på arvbarheterna och att höga samband förelåg mellan avelsvärdena då alla hästar respektive bara valacker eller äldre hästar ingick i materialet. Dessutom blir avelsvärdernas högre när resultat från fler hästar ingår.

Allsidig träning är positivt för hållbarheten

Förutom de genetiska analyserna, har det visat sig att hästar med placeringar i fler discipliner även har fler aktiva år i tävling. Det visade sig även att hästar som till och med sex års ålder hade officiella placeringar i minst två discipliner i genomsnitt hade cirka två års längre tävlingskarriär än övriga hästar. Utifrån detta kan slutsatsen dras att en allsidig träning av unga hästar har en positiv effekt på hållbarheten i tävling senare i livet.

Slutsatser i korthet

- Hållbarhet, mätt som antal år i tävling, är ett uttryck för både talang för tävling och ”verklig” hållbarhet.
- Trots ganska låga arvbarheter för antal år i tävling är det möjligt att skatta avelsvärden och bedriva en selektion ökad hållbarhet.
- Avelsvärden för antal år i tävling bör skattas separat för hoppning, dressyr och fälttävlan.
- Alla tävlande hästar bör ingå i analyserna då hästarna hela tiden jämförs inom kön och födelseårgång.
- Hästar med placeringar från mer än en disciplin vid ung ålder hade i genomsnitt längre tävlingskarriär än övriga hästar, vilket tyder på att en allsidig träning av unga hästar har en positiv effekt på hållbarheten.

References

Árnason, T. (1987). Contribution of Various Factors to Genetic Evaluations of Stallions. *Livestock Production Science 16*, 407-419.

Árnason, T. (1999). Genetic evaluation of Swedish standard-bred trotters for racing performance traits and racing status. *Journal of Animal Breeding and Genetics 116*, 387-398.

Árnason, T. (2006). Survival analysis of the length of competition life of Standardbred trotters in Sweden. 57th *Annual Meeting of the European Association of Animal Production, Antalya,* p350.

ASVH (Avelsföreningen för svenska varmblodiga hästen). (2011). Available from: http://www.asvh.se/avel/avelsmal [Accessed 17 March 2011]

Burns, E.M., Enns, R.M. and Garrick, D.J. (2006). The effect of simulated censored data on estimates of heritability of longevity in the Thoroughbred racing industry. *Genetics and Molecular Research 5* (1):7-15.

Ducrocq, V., Quaas, R.L. and Pollak, E.J. (1988a). Length of Productive Life of Dairy Cows. 1. Justification of a Weibull Model. *Journal of Dairy Sciences 71*, 3061-3070.

Ducrocq, V., Quaas, R.L. and Pollak, E.J. (1988b). Length of Productive Life of Dairy Cows. 2. Variance Component Estimation and Sire Evaluation. *Journal of Dairy Sciences 71*, 3071-3079.

Engblom, L., Lundeheim, N., Schneider, M.del P., Dalin, A.-M. and Andersson, K. (2009). Genetics of crossbred sow longevity. *Animal 6*, 783-790.

Madsen, P. and Jensen, J. (2000). A user's guide to DMU.A package for analyzing multivariate mixed model. Danish Institute of Agricultural Sciences, Tjele, Denmark.

Koenen, E., Aldridge, L.I. and Philipsson, J. (2004). An overview of breeding objectives for warmblood sport horses. *Livestock Production Science 88*, 77-84.

Nicolic, D., Jönsson, L., Lindberg, L., Ducro, B. and Philipsson, J. (2009). Inherited disorders and their management in European warmblood sport horse breeds. *60th Annual Meeting of the European Association of Animal Production, Barcelona, Spain*, 24-27 August. 8 pp.

Philipsson, J. and Lindhé, B. (2003). Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programmes. *Livestock Production Science 83*, 99-112.

Ricard, A. And Fournet-Hanocq, F. (1997). Analysis of factors affecting length of competitive life of jumping horses. *Genetics Selection Evolution 29*, 251-267.

Serenius, T. And Stalder, K.J. (2004). Genetics of length of productive life and lifetime prolificacy in the Finnish Landrace and Large White pig populations. *Journal of Animal Science 82*, 3111-3117.

Serenius, T. And Stalder, K.J. (2006). Selection for sow longevity. *Journal of Animal Science 84,* E166-E171.

Sobczynska, M. (2007). The effect of selected factors on length of racing carrer in Thoroughbred racehorses in Poland. *Animal Science Papers and Reports 25*, 131-141.

Viklund, Å., Thorén Hellsten, E., Näsholm, A., Strandberg, E. and Philipsson, J. (2008). Genetic parameters for traits evaluated at field tests of 3- and 4-year-old Swedish Warmblood horses. *Animal 12*, 1832-1841.

Viklund, Å., Braam, Å., Näsholm, A., Strandberg, E. and Philipsson, J. (2010). Genetic variation in competition traits at different ages and time periods and correlations with traits at field tests of 4-year-old Swedish Warmblood horses. *Animal 5*, 682-691.

Viklund, Å. (2010). Genetic evaluation of Swedish Warmblood horses. *Doctoral Thesis no 2010:48. Swedish University of Agricultural Sciences*. ISBN 978-91-576-7461-6.

Wallin, L., Strandberg, E., Philipsson, J. and Dalin, G. (2000). Estimates of longevity and causes of culling and death in Swedish warmblood and coldblood horses. *Livestock Production Science 63*, 275-289.

Wallin, L., Strandberg, E. and Philipsson, J. (2001). Phenotypic relationship between test results of Swedish Warmblood horses as 4-year-olds and longevity. *Livestock Production Science 68*, 97-105.

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