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Genetic parameters for longevity and informative value of early indicator traits in Danish show jumping horses

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ABSTRACT

The study aim was to investigate the usefulness of different longevity measures in Danish show jumping horses as well as potential early indicator traits for longevity in jumping. The analyses comprised jumping competition data from 9592 horses born during 1981 to 1994, 30,435 young horse records, and their pedigree. Genetic parameters and breeding values were estimated using AI-REML and mixed models including fixed effects of birth year, age at first placing, sex and number of offspring. Four longevity traits were investigated: no. years in competition from first to last entry (NYC), no. active years in competition i.e. only years with a registered start/placing (NAY), NAY plus no. foals carried to term by mares (NAYF), and accumulated lifetime points (LDP) combining longevity and competition success. Longevity defined as NAY was found most useful for the Danish Warmblood. The heritability of NAY was 0.11. Young horse jumping traits had moderate to high genetic correlation with longevity (r_g: 0.51–0.74) and highest value as indicator trait among young horse traits ($r_g \times r_{IA}$: 0.23–0.44). Conformation had lower informative value for longevity (highest $|r_g \times r_{IA}|$ was 0.10). Including information of young horse capacity and rideability during jumping in a multivariate analysis increased the accuracy of NAY breeding values of younger horses from 0.32 to 0.49 and increased model predictive ability compared to a univariate longevity evaluation.

1. Introduction

Longevity of domestic animals refers to the length of the animal's service or productive life. For example, longevity in dairy cows can refer to the duration of which the cow produces milk (e.g. Pritchard et al., 2013), and longevity in sport horses to the time in competition (e.g. Jönsson et al., 2014b). Longevity in horses is important because it increases the time they can be used for their primary purpose, competitions, relative to the investments associated with rearing and training them. Thus, longevity is considered one of the most important traits of a horse according to potential horse buyers on the market (Hennessy et al., 2008). Furthermore, longevity may be favourably associated with animal welfare traits such as orthopaedic health. It is difficult to measure longevity in horses, due to the risk of indirectly measuring talent and/or other factors. Furthermore, it is typically impossible to distinguish between voluntary and involuntary termination of the sport career in practice as the cause of it is not routinely recorded.

Ricard and Blouin (2011) proposed the use of number of years from the first entry to the last entry in competition as a measure of longevity, defined as NYC in the present study. The heritability of NYC was estimated at 0.10 in a French riding horse population by Ricard and Blouin (2011), and at 0.17 for Hungarian jumping horses (Posta et al., 2014). In the study by Braam et al. (2011) only years in which the horse had placings, were accounted for, i.e. number of active years in competition (presently defined as NAY). Braam et al. (2011) found that NAY in show jumping was on average 3.3 years, the heritability was found to range between 0.07 and 0.17 depending on model. The lowest heritability was found when age at first placing was taken into consideration. Jönsson et al. (2014b) likewise used NAY and estimated the heritability to be 0.20. The differences in heritability from Braam et al. (2011) could be due to differences between the populations considered as Braam et al. (2011) studied competing Swedish Warmblood (SWB) males born 1967 to 1991, while Jönsson et al. (2014b) studied all SWB horses participating in young horse performance tests (both gaits and jumping) from 1983–2005 (except 1985–87). In addition to NAY, Jönsson et al. (2014b) considered another trait where points were given upon lifetime results, i.e. number of accumulated lifetime points (defined as LDP in the present study). The highest points were given upon better placing's in the higher level

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of competition. The top 25% horses in a competition are given placings. Lifetime performance is therefore a mixture of ability to perform well in a single competition (preferably at high level) and ability to have a long competition career. The heritability for lifetime performance in competition was found to be 0.24 (Jönsson et al., 2014b). Furthermore, number of starts has been used as a longevity measurement (Arnason et al., 1982) for trotters, with an estimated heritability of 0.10. For race longevity and race persistence heritabilities have been estimated at 0.10 and 0.12, respectively, in similar records of Thoroughbred race horses (Velie et al., 2015). Only few of the European breeding associations have breeding goals directly focusing on longevity or health of horses. Most of the breeding associations instead put emphasis on soundness and/or conformation (Koenen et al., 2004), which in some cases may be indirect measures of longevity (Jönsson et al., 2014b). It is, however, beneficial to consider the breeding goal trait directly in genetic evaluations while also including correlated information from early indicator traits via a multivariate analysis rather than only evaluating the indicator traits. Early selection reduces the generation interval and improves genetic progress provided use of accurate selection criteria. But uncensored longevity records are not available until after the horse's sports career, which makes it challenging to improve longevity of sport horses through breeding unless genomics or informative early indicator traits are used. In addition to being available earlier in the life of a horse, potential early indicator traits such as young horse performance and conformation records are also expected to be less influenced by training, rider and random events compared to competition results later in life which is expected to result in higher heritabilities for the former traits.

The aim of this study was therefore to investigate the usefulness of different longevity measures in Danish show jumping horses as well as potential early indicator traits that can be used to improve the accuracy and predictive ability of genetic evaluations for longevity.

2. Materials and methods

2.1. Material

Longevity was studied, based on available information supplied by SEGES, Danish Warmblood (DWB) and the Danish Riding Association (DRF), as no. years in competition from first to last entry (NYC), no. active years in competition i.e. only years with a registered start/placing (NAY), NAY plus no. foals carried to term by mares (NAYF), and accumulated lifetime points (LDP) combining longevity and competition success.

2.1.1. Competition data

The competition data was recorded by DRF and registered by the Danish national centre for animal databases and breeding evaluations (SEGES). The competition data included 728,311 repeated competition observations of 22,034 DWB horses with 9739 riders from show jumping competitions held in Denmark in the years from 1986 to 2013. From 1986 to 1997 only placings were registered, since 1998 all entries independent of success in the competition were included. Records of 184 horses (0.8%) were omitted due to unrealistic age (<5 or >28 years) and of 11 horses born before 1970 due to few horses (<10) per age group. Years in competition were described up until a maximum of 14 years as few horses had competed longer (0.2% for NAY and 0.6% for NYC). To avoid right censuring regarding years in competition, only horses expected to have finished their sports career were included in the dataset. Hence, horses born after 1994 were excluded from the dataset. In total, observations on 10,631 horses were removed, leaving 11,208 horses born from 1970 to 1994. To avoid left censuring horses born before 1981 were omitted as competition records included data from 1986 and later, and horses can start competing in classes registered in DRF from the age of five. Thus, 9592 horses remained in the final competition dataset (3643 mares and 5949 males). Number of horses per birth year ranged from 409 (1981) to 1044 (1994) horses (Fig. 1). Geldings and stallions were categorised together as males, because information was missing about whether or when stallions had been castrated, and 30 geldings had registered offspring. NAYF was studied as the sum of NAY and number of foals carried to term as a mare (i.e. only mares were credited for foals) irrespective of whether the mare competed before or/and after parturition. The data did not include information of twin births. In total, 2252 mares had registered offspring. Horses had on average 3.56 NYC, 3.12 NAY, 250 LDP and 3.61 NAYF (Table 1). Mares had on average slightly lower longevity

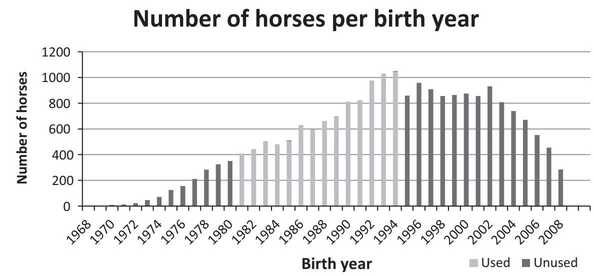

Fig. 1. Number of horses per birth year in the original competition data set; data from years marked with dark colour were discarded to avoid left and right censoring.

Table 1
Data description including phenotypic standard deviation (σ_P) of untransformed edited longevity data.

Trait	No. records	Mean	Median	75% quantile	σ_p [f]	Kurtosis	Skewness
NAY[a]	9592	3.12	2.00	4.00	2.58	5.56	1.61
NYC[b]	9592	3.56	2.00	5.00	3.05	4.33	1.37
LDP[c]	7836	250	31.0	131	952	236	12.3
NAYF[d]	9592	3.61	3.00	5.00	2.96	4.71	1.42
AJR[e]	9592	7.79	8.06	8.81	1.31	3.77	−0.87

[a] NAY – Number of active years in competition;
[b] NYC – Number of years in competition;
[c] LDP – Accumulated lifetime points;
[d] NAYF – Number of active years in competition plus number of foals;
[e] AJR-Average jumping results;
[f] σ_p – Phenotypic standard deviation.

Table 2
Estimated heritabilities (h^2) and additive genetic standard deviation (σ_A) of longevity traits, as well as their genetic correlations with average jumping results ($r_{g(\mathrm{AJR})}$) for different traits and models (SE is the asymptotic standard error from AI-REML of the given parameter).

Trait[a]	h^2	SE(h^2)	σ_A	$r_{g(\mathrm{AJR}^f)}$	SE($r_{g(\mathrm{AJR})}$)
NYC[b]	0.099	0.020	0.246	0.068	0.138
NAY[c]	0.114	0.021	0.241	0.086	0.130
NAYF[d]	0.233	0.027	0.370	0.526	0.094
LDP[e]	0.311	0.034	1.054	0.432	0.091
AJR[f]	0.190	0.032	0.441	–	–

[a] All traits are transformed by natural logarithm, to ensure best possible normal distribution.
[b] NYC – Number of years in competition;
[c] NAY – Number of active years in competition;
[d] NAYF – Number of active years in competition plus number of foals;
[e] LDP – Accumulated lifetime points;
[f] AJR = Average jumping results.