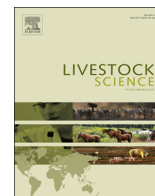




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Genetic parameters for harmony and gaits in Hispano-Arabe horses estimated by Bayesian methods and Restricted Maximum Likelihood



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ABSTRACT

Genetic parameters for harmony and gaits (walk, trot and canter) were estimated in the Hispano-Arabe horse breed. The data set included 12,957 records of 901 animals, collected from 2000 to 2014, and was analysed by Bayesian procedures (Gibbs Sampling) and Restricted Maximum Likelihood. The multivariate animal model with repeated records included management group, sex, combination of year and event of evaluation, season of evaluation as fixed effect, plus age at classification and proportion of Arabian genes as linear covariates and additive genetic, permanent environmental and judge as random effects. Bayesian heritability/repeatability estimates for harmony, walk, trot and canter were 0.18/0.35, 0.10/0.18, 0.13/0.27 and 0.13/0.20, respectively, with standard errors from 0.02 to 0.05. Estimates of additive genetic correlations among harmony and gaits traits ranged from 0.45 to 0.83, and were stronger between harmony and trot or canter than between walk and trot. Analyses by Restricted Maximum Likelihood yielded similar results, and correlations between breeding values estimated by both procedures ranged from 0.80 to 0.94.

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1. Introduction

The Hispano-Arabe horse (HA) is a breed formed during centuries by fixation after crossbreeding between purebred Arab and Spanish horses in the Andalusian region (Southern Spain). Presently, the HA is recognized to have a clearly functional utilization as a saddle-horse, with good sports aptitude in different competitions and sports disciplines (dressage, raid, jumping, etc.). Because of the reduced census of the breed and the small number of animals competing until now, the information available on sports events is limited, which has so far hindered routine genetic evaluation based on sports performance. However, given their relationship with performance in different sports disciplines, traits such as gaits and harmony can be used as indicator traits, which could support selection decisions. This relationship has been shown in Lusitano horses (Vicente et al., 2014a), but the information available so far in HA horses is still scarce to establish a clear relationship between harmony, gaits and sports performance.

Traditionally, HA broodmares and stallions have been scored by visual assessment, and selection is essentially based on

morphological aspects. In the last few years, recording in the current breeding program has been more systematic, and is based on visual scoring of different conformation and movement traits, which are thought to be related to functionality, in an attempt to assess the general abilities of the horse. The traits currently considered are the harmony (global score), reflecting the overall conformation of the horse, and gait scores (separate scores for walk, trot and canter), which represent its movement ability.

In recent years, Bayesian methods have emerged as an option for solving problems related to the estimation of genetic parameters and prediction of genetic merit in animal populations. In this framework, Markov Chain Monte Carlo (MCMC) methods, including Gibbs Sampling (GS), may be used as a tool for Bayesian inference. Gibbs Sampling is a stochastic integration procedure used to estimate joint and marginal distributions of all parameters in a model from their full conditional posterior distributions. This method has been suggested for use in animal breeding, particularly when data does not strictly fit a normal distribution (Sorensen et al., 1994; Van Tassel and Van Vleck, 1996; Faria et al., 2007), which is often the case for scores applied to horse conformation and gait traits.

Genetic parameters reported for conformation and gait traits in different horse breeds have revealed heritability estimates in the

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range of 0.20 (Christmann et al., 1995) to 0.30 (Albertsdóttir et al., 2008) for harmony, 0.08–0.43 for walk, 0.16–0.49 for trot and 0.17–0.37 for canter (Viklund et al., 2008; Schroderus and Ojala, 2010). Moreover, the genetic correlations between conformation and gaits are usually reported to be positive and moderate to high, in the range of 0.34–0.93 (Ducro et al., 2007a; Vicente et al., 2014a), indicating that both groups of traits can be selected simultaneously. On the other hand, inconsistent results have been reported in various horse breeds regarding the genetic relationship of conformation and gaits with functionality. (Koenen et al., 1995; Ducro et al., 2009). Briefly, this inconsistency could result from different ways of scoring conformation in various breeds, but also from the specific functional traits that are being favoured by the breeding program.

In summary, most estimates point towards a low to intermediate genetic correlation between morphological traits and functional ability in dressage events (Wallin et al., 2003), which tends to be higher when the correlation between gaits and dressage ability is considered (Wallin et al., 2003; Ducro et al., 2007b).

In most studies where genetic variability for morphology and gaits has been investigated in horses, the analyses have been performed using Restricted Maximum Likelihood (REML) methods. Nevertheless, these scores in horses usually do not have a normal distribution, which may raise questions regarding the suitability of the parameters estimated in some of those studies, as these often assume the normality of the distribution of records.

In this work, we estimated genetic parameters for harmony and gaits in the HA horse, as a first step to set up an organized breeding program in the HA. This research is essential to supply the genetic improvement program of the HA breed with accurate parameter estimates, but can also be of interest for other analyses where quasi-normal variables are evaluated, especially in horse scoring traits evaluated by qualified judges.

2. Material and methods

2.1. Data description

This work was carried out with data made available by the Hispano-Arabe Breeders Association, collected in the framework of its breeding program. Overall, the data set included pedigree records on 3540 animals, while the scoring data set included 12,957 records of 901 animals evaluated between 2000 and 2014. The scores were from horses evaluated in connection with the registration in the studbook or in morpho-functional competitions which take place 3–7 times per year throughout Spain. When they are evaluated, either in the farm of origin or in competitions, animals are presented in-hand, and in both cases they are scored by 1–3 official judges, who give them scores (scale 1–10) on traits of conformation and gaits.

The score given by each judge was considered as a distinct trait observation, and the total number of observations per trait and sex was as shown in Table 1. The data set analysed was characterized by a large number of studs with very few animals per stud (mostly 1–5 individuals), which could hinder the estimation of the stud source of variation. To overcome this difficulty, management groups ($n=17$) were defined according to the production level of studs, by clustering studs enclosed in ranges of the four traits combined mean performances. On the other hand, the breed history of the HA implies variation in the number and proximity of Arabian ancestors and accordingly different levels of heterosis. To account for that, the proportion of Arabian genes was considered in the analyses as a linear covariate.

Table 1

Number of animals (N) with one, two, three and more than four observations per trait in males (M) and females (F).

Trait	N	Sex	Number of records per animal				Total
			1	2	3	> 4	
Harmony	363	M	101	166	150	1003	1420
	538	F	186	238	294	1046	1764
Walk	363	M	94	162	153	1118	1527
	538	F	185	230	300	1115	1830
Trot	363	M	94	162	153	1117	1526
	538	F	185	230	300	1115	1830
Canter	349	M	92	168	159	967	1386
	513	F	182	218	303	971	1674
Total			1119	1574	1812	8452	12,957

2.2. Trait description

Harmony is a visual assessment of the body structure of the animal, and is often called “Overall impression”. An adequate proportionality among various body components results in a maximum score of 10 points, while serious disproportions compromising the horse capacities will lead to a minimum score of 1 point. At the time of registration, a minimum score of 6 is required for animals to be enrolled in the Studbook. Gaits scoring is attributed to three items, i.e., walk, trot and canter. Walk, is the relaxed movement when the horse starts its dynamic, and a balanced movement in this gait indicates good aptitude to interact with the rider and is awarded the maximum score, while progressive misbalancing produces a reduction in the scoring. Trot and Canter are stronger movements, such that the first is a smooth run related to the ability for dressage and other high school disciplines. Canter is an extreme run more related to sprint and resistance competitions, such as raid, jumps, among others. Both traits receive a maximum score when balanced movements are shown, while misbalancing progressively reduces the scoring. Animals are scored by qualified judges, who have homogeneous criteria demonstrated in periodical qualification courses, and training journeys.

2.3. Statistical and genetic analyses

Descriptive statistics and tests of normality were conducted using the Univariate procedure of software package SAS 9.2 (SAS, 2009). Data distribution was tested in order to check their fit to a normal distribution. As a consequence of this assessment, a slight deviation from normality was detected in most traits, which suggests that the use of Bayesian methods may yield better results than the conventional BLUP/REML, given the better performance of Bayesian methods when data are not normally distributed (Sorensen et al., 1994; Van Tassel and Van Vleck, 1996).

The analyses of variance were carried-out in PROC MIXED of the software package SAS 9.2 (SAS, 2009) to determine which potential effects significantly influence the traits and should be included in the mixed models. The fixed effects considered in the analyses of variance were management group, sex, combination of year and event (yearly horse concentrations), season of evaluation, plus the effect of age at qualification (considered as linear and quadratic covariate) and the proportion of Arabian genes (fitted as a linear covariate). The effect of the judge was included as a random source of variation in mixed model analyses, due to the high number of judges participating in the program.

The following multitrait animal model was used to estimate (co) variance components, and the corresponding heritability, repeatability and correlations for the traits under study.

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