Genetics of Temperament and Productive Traits in the Italian Heavy Draught Horse breed

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Introduction

The Italian Heavy Draught Horse (IHDH) represents today the only autochthon Italian coldblood breed in the large group of coldbood horses widespread in Europe (Mantovani et al. (2005)). This breed was established in the middle XIX century by the Italian government and originated mainly from crosses of Norfolk-Breton stallions with local mares diffused in the north-east of the country. Even subsequently, the French Breton has been widely used to improve the IHDH, particularly for the heavy draught purpose (Mantovani et al. (2005)). Today, the IHDH counts in Italy about 6000 registered animals, half of which are mares distributed in about 900 stud farms. The breed, initially developed for agricultural and draught uses, as well for artillery transport by the Italian army, is nowadays mainly selected for heavy draught works and meat production. Within the selection scheme of IHDH, the genetic evaluation for linear type traits obtained on young foals (aged about 6 months) is a key moment in the genetic improvement process. Among the 11 traits linearly scored, the temperament (also called "blood"), the fleshiness, and the fore and rear diameters play an important role in animal breeding, because they represent 75% of the total merit index used for selection. This because both temperament and muscularity traits have been always considered important traits by breeders for their strict relation with the heavy draught work ability. The aim of this study is to analyse heritability and genetic correlations between the temperament and the other productive traits that are used for breeding purposes in the IHDH population.

Material and methods

Data were obtained from the national studbook and involved, after editing, 7004 young foals aged between 1 to 11 months. Animals were scored linearly for 11 traits with a 9 point scale system (from 1 to 5 including half points) by 21 classifiers in 10 subsequent years of evaluation (i.e., from 2000 to 2009). Data were classified accordingly to the sex of the foal, age of the foal at score (in month) and, in absence of a precise value for the number of foaling, the age of the mare at foal's scoring (in years). As regard the stud-year of evaluation effect accounted in the model, due to the small size of many studs and to the reduced incidence of AI (i.e., use of a single stallions in many studs), only about 25% of stud-year classes were actual studs within a given year of evaluation. Therefore, to get connection between stud-year effects as done in the genetic evaluation of the Italian Haflinger breed

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(Samorè et al. (1997)), most of studs were grouped. Studs' grouping was carried out on the basis of geographical position and management (stable, pasture-and-stable or outdoor), the farm's production goal (production of foals for heavy draught or fattening), the general prophylaxis on foals (vaccination or not) and the mean value of mares' body condition registered at foals' evaluation. In this way, groups could be created for neighbouring studs with similar nutrition and management. Estimates of (co)variance components using 4 of the 11 traits scored (temperament, TM; fleshiness, FL; fore FD and rear diameters RD) were obtained implementing a multiple trait REML animal model (Misztal (2008)) as follows:

$$y_{ijklm}=\mu+SY_i+SEX_j+FA_k+MA_l+a_m+e_{ijklm}$$

where y_{ijklm} is one of the four traits (TM, FL, FD or RD) recorded on a single animal, μ is the overall mean, SY_i the effect of stud-year i (i=1,…,1363), SEX_j the effect of foal's sex (j=1, 2), FA_k the age of foal at scoring (k=1,…, 11 months of age), MA_l the age of mare at foal's evaluation (l=2,…,≥17 years at foaling), a_m the random additive genetic effect (12847 levels, as animals in pedigree), and e_{ijklm} the random residual term ($\sim N(0, \mathbf{I}\,\sigma^2_e)$). Alternatively, the stud-year effect was considered as fixed or random effect and the models comparison was carried out evaluating the goodness of fitting through the Akaike Information criterion (AIC, Akaike (1974)). The assumptions about the structure of (co)variance in the most complete model, i.e. including stud-year as random effect, were as follows:

$$\mathrm{Var}\begin{bmatrix}\mathbf{s}\\ \mathbf{a}\\ \mathbf{e}\end{bmatrix}=\begin{bmatrix}\mathbf{I}\otimes\sigma^2_s & \mathbf{0} & \mathbf{0}\\ \mathbf{0} & \mathbf{A}\otimes\sigma^2_a & \mathbf{0}\\ \mathbf{0} & \mathbf{0} & \mathbf{I}\otimes\sigma^2_e\end{bmatrix}$$

Where σ^2_s is the stud-year variance, σ^2_a is the additive genetic variance, σ^2_e is the random residual variance, **A** is the numerator relationship matrix, **I** is an identity matrix, and $\otimes$ is the Kronecker product operator. Standard errors of both heritability estimates and genetic correlations were approximated from the formulas of Falconer (1989).

Results and discussion

The comparison of different models, i.e., accounting or not for the stud-year (SY) as fixed or random effect, indicated a better fitting when SY was accounted as random factor. Actually, the AIC (Akaike (1974)), resulted more favorable, i.e. lower, in this model situation (24.178.9 vs. 23071.1 for SY fixed and random, respectively). Despite these results, the variance component estimates (Table 1) presented not a lot of differences between models. The amount of environmental variance absorbed by SY when considered random was not very great, influencing only in minimal part the shift of variance to other components, that remained mainly unchanged. This reflected only moderate changes of the heritability estimates. The only exception was for fleshiness (FL) and fore diameter (FD) traits. Particularly, for the first trait the reduction of h^2 estimate had a magnitude of 8%, which was reduced to a 4% for the FD trait (Table 1). These differences are mainly due to the shift of the additive genetic variance toward the SY and residual in the case of FL (Table 1). However, heritability estimates remained on moderate-low level for temperament and on medium-high magnitude for all the other productive traits connected to muscularity. Indeed, the TM exhibited a mean h^2 of about 0.26, independently from the model considered, while muscularity traits ranged between 0.35 and 0.44. Among these latter traits, greatest h^2 were always detected for FL and FD, particularly in the model with lower fitting performance, i.e. considering SY as fixed, where both these traits showed a h^2 greater than 0.4. For all estimates, the approximate standard errors obtained were always low, ranging from 0.032 to 0.040. As regard the TM, the heritability estimate obtained din this study results greater than estimates obtained for a similar trait in Andalusian horses by Molina et al. (1999) or in Italian Haflinger breed by Samorè et al. (1997). Indeed, in both these studies h^2 ranged between 0.02 and 0.08. On the other hand, results similar to the present study have been reported by Von Butler (1987) in the Bavarian Heavy Horse, for which an h^2 value of 0.25 was estimated. Also in Thoroughbred (Oki et al. (2007)), heritability of TM was similar to our results (i.e., 0.23), although expressed on a liability scale in this case. Differences in estimates could be due to different factors. First of all, the age at which the trait is measured, that in the case of IHDH is very early in comparison to other breeds; second, the different meaning that the trait assumes in different situations. Actually, Seamana et al. (2002), have pointed out that the assessment of TM could be a questionable matter, because of this trait can assume different meanings. As regard to the other traits related to muscular development, the estimates obtained in this study are difficult to compare within horse breeds, due to the lack of similar studies. On the other hand, comparisons can be made with cattle hypertrophic breeds. Looking at literature on this topic, heritability estimates reported by Albera et al. (2001) on fleshiness in Piemontese young bulls ranged from 0.26 to 0.55. Also Hanset et al. (1997), estimated heritability between 0.36 and 0.41 for muscularity in Belgian Blue cows. Therefore, the medium-high estimated heritability seems to fit with results reported in literature on similar traits, although in different species.

Table1: Genetic parameters using different models for the stud-year effect on temperament and other productive traits scored linearly

	Stud-Year		Variance components$^{\alpha}$				
Traits	Fixed	Random	σ^2_s	σ^2_a	σ^2_e	h^2	s.e. h^2
Temperament	√	-	-	0.0633	0.1663	0.276	0.032
	-	√	0.0386	0.0690	0.1653	0.253	0.033
Fleshiness	√	-	-	0.1104	0.1384	0.444	0.037
	-	√	0.0231	0.0960	0.1440	0.365	0.040
Fore Diameter	√	-	-	0.1226	0.1676	0.423	0.038
	-	√	0.0496	0.1276	0.1579	0.381	0.039
Rear Diameter	√	-	-	0.0914	0.1662	0.355	0.037
	-	√	0.0329	0.1055	0.1594	0.354	0.037

$^{\alpha}\sigma^2_s$ = stud-year variance, σ^2_a = additive genetic variance, σ^2_e = random residual variance.

Correlations among traits analyzed (Table 2) were consistent across different models, although some exceptions were found comparing TM with RD (range from 0.001 to 0.068), or, particularly, comparing FL and RD (range from 0.539 to 0.882). In general, TM was positively correlated with all the other traits, although the genetic correlation was on average low (0.12). No easy comparison with literature could be made for such correlation. Moreover, in horses calm temperament could be considered negative, but in cattle it seems positively correlated with performances, as indicated by Voisinet et al. (1997). Concerning the correlation between fleshiness traits, with only one exception, it resulted on average very high (0.74), i.e., in agreement with results of similar studies carried out on cattle (Albera et al. (2001); Hanset et al., (1997)).

Table 2: Genetic correlations among linearly scored traits (standard error in brackets) using different models as regard the stud-year effect

	Stud-Year		Traits		
Traits	Fixed	Random	Fleshiness	Fore Diameter	Rear Diameter
Temperament	√	-	0.101 (0.067)	0.185 (0.061)	0.001 (0.079)
	-	√	0.117 (0.071)	0.235 (0.061)	0.068 (0.076)
Fleshiness	√	-		0.721 (0.018)	0.539 (0.032)
	-	√		0.717(0.023)	0.882 (0.010)
Fore Diameter	√	-			0.811 (0.013)
	-	√			0.794 (0.017)

Conclusion

The results of this study indicate that both temperament and fleshiness are heritable traits in the Italian Heavy Draught Horse population, when measured early in life (i.e., on young foals). The traits analyzed are characterized by a generally positive genetic correlation, confirming the possible combination of these traits in the total merit index used for selection purposes. Last, the use of the stud-year as random effects produce better fitting and results, and it is therefore a recommended practice in estimates of breeding values for animals.

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