Source of Variation of Linear Type Traits Evaluated on Italian Heavy Draught Horse Breed

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Summary

The aim of this study was to analyze the non-genetic fixed effects affecting 14 linear type traits and an overall score recorded on 4,385 Italian Heavy Draught Horse adults (IHDH; 3,772 females and 613 males) scored by 29 classifiers in 20 years of evaluation (i.e. 1992-2011). Animals were scored with a 9 point scale system (1-5 including half points) at about 3 years of age. Data were analyzed by ANOVA to evaluate the magnitude of three non-genetic fixed effects: stud-year of evaluation-classifier (SYC; 1,325 levels), sex (2 levels), age at evaluation (AC; 5 classes, i.e., ≤27, 28, 29-32, 33-47, and ≥48 months of age). The R-square of model for all analyzed traits ranged from 0.38 to 0.57, with lower values for fore feet and greater values for frame size. The SYC resulted the effect of greater magnitude and in all traits adsorbed a significant amount of variation. Sex differentiated mainly frame size, fleshiness, bone incidence, fore diameters and upper line direction, indicating a significant aspects between males and females as regard the meat production characteristics of the breed. The AC influenced significantly frame size, fleshiness, thorax depth, fore diameters, rear diameters and the overall score. It is concluded that all potential source of variation need to be taken into account in the analysis of data from linear type evaluation of adult IHDH.

Key words

Italian heavy draught horse, linear type traits, source or variation, ANOVA

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Aim

The Italian Heavy Drought Horse (IHDH) represents today the only autochthonous Italian coldblood breed in the large group of coldblood horses widespread in Europe (Mantovani et al., 2005). This breed, initially developed for agricultural and draught uses, as well for artillery transport by the Italian army, is nowadays selected for meat production and heavy draught for works and leisure. Selection has been carried out for this breed accounting on linear type evaluation of young foals aged about six months. In such system, almost all newborn young foals are scored linearly every year and field data are used to estimate breeding values (EBV) via animal model. EVBs obtained are used for mares and stallions selection on the basis of a total merit index obtained from the EBVs of 5 linear traits, i.e., head size, temperament, fleshiness, fore and rear diameters (Mantovani et al., 2010). At present, the actual number of registered animals in the IHDH population is about 6,300 (3,300 of which are mares and 500 are stallions) in 1,000 registered stud-farms (Mantovani et al., 2013). Registered stud farms are distributed in almost all the country territory, although the most important diffusion areas are the north-east (Veneto and Emilia-Romagna regions), and the central regions of Lazio, Umbria and Abruzzo (ANACAITPR, 2013). Studbook data indicate that the mean stud size is about 3 mares, although in the north part of the country the number can be always lower, and in the centre and south of Italy much greater than the mean size (Mantovani et al., 2013). In this situation the within stud-farms contemporary comparison, i.e., the basis of animals' genetic evaluation, is difficult because of the small stud size and the large use of natural mating, that reduce data connection. Indeed, the main environmental effect in foals' dataset is characterized by only 25% of observations that belongs to at least 2 foals sons of different stallions scored by the same classifier in a given stud-farm and year of evaluation. Therefore, most of data could be lost following the principle of a good contemporary comparison and data connection in order to get reliable EBVs. However, as already done for the Italian Haflinger population (Samoré et al., 1997), some criteria have been adopted over years in order to increase the number of animals to be taken into account by the genetic evaluation. Particularly, stud farms are grouped on the basis of geographical areas (3 regions, north, center and south) and breeding management (stable, semi-feral, and feral conditions). The 7 combinations (i.e., north-stable, north-semi-feral, centre-stable, centre-semi-feral, centre-feral, south-semi-feral, and south-feral) are further grouped considering also the selection goal of the stud-farm (i.e., breeding, meat production or heavy draught), the prophylactic vaccination on foals (i.e., adopted or not), and the class (on a scale of 1 to 5) of the mean body condition of mares belonging to the same stud-farm over years and scored at the time of foals evaluation. In this way, 210 groups involving all stud-farms officially registered at the studbook could be potentially considered for grouping, although the mean number of have been about 120 during last decade, involving about 75% of type scores obtained on foals. This approach to data analysis has never been taken into account considering animal evaluation at about 3 years of age, i.e., the second time in which animals belonging to the IHDH breed are scored. Indeed, at about 3 years of age, males and females of the IHDH breed are officially registered to the studbook if they have a positive total merit index obtained from foals evaluation and a minimum overall morphological score obtained from scoring 14 linear type traits. In spite of reduced number of animals evaluated at about 3 years as compared to foal's evaluation, due to the fact that a large number of subjects are sent to slaughter between 12 and 18 months of age, it has become attractive in recent year the use of morphological evaluation at 3 years of age. This in order to reduce the selections' costs due to the evaluation of both foals and adults. Therefore, the aim of this study was the analysis of non-genetic factors affecting the type trait evaluation obtained at about 3 years of age in the IHDH breed.

Material and methods

An amount of 7,133 records were obtained from the studbook database of IHDH breed and concerned the linear type scores routinely recorded up to 2011 by the National breeder association on animals aged about 3 years. The records of animals evaluated prior to 1992, as well as those with missing stud-farm or sire were previously discarded. Records that did not belong to a stud-farm or to a group of stud-farms with less than 2 observations in a given year of evaluation were also discarded. Within each year of evaluation, stud-farm*year or group*year were imposed to belong to the same classifier and to different stallions in order to get genetic connection. The edited dataset suitable for final analysis included single records of 4,385 subjects (3,772 females, and 613 males) scored for 14 linear traits using a 9 point scale system (from 1 to 5 including half points, Table 1) and carried out by 29 classifiers in 20 years of evaluation (i.e. from 1992 to 2011). An overall score (OS) reflecting the final judgement for each animal was also taken into account together with the 14 type traits. The linear traits were attributable to three main groups, i.e., general traits (head size/expression, HS; temperament/blood, Te; frame size, FS; fleshiness, Fl; and bone incidence, BI), traits of the trunk (thorax depth, TD; fore diameters, FD; rear diameters, RD; upper line length, UL; and upper line direction, UD), and traits of the limbs (rear legs side view, LS; fore feet, FF; rear feet, RF; and rear legs back view, LB). ANOVA (GLM procedure; SAS, 2009) was carried out to evaluate the magnitude of three non-genetic fixed factors as in the following linear model:

$$Y_{ijkl} = \mu + SYC_i + SEX_j + AC_k + e_{ijkl}$$

where y_{ijkl} is one of the 14 traits or the OS recorded on a single animal, μ is the overall mean, SYC_i is the fixed effect of i-th combination of stud-farm or stud-farm group by year of evaluation and classifier (1,325 levels), SEX_j is the effect of sex (2 levels), AC_k is the age class of animals at scoring (5 classes, i.e., ≤27, 28, 29-32, 33-47, and ≥48 months of age), and e_{ijkl} is the random residual term ~N (0, $I\sigma^2_e$). A preliminary analysis fitting SYC as random effect was also carried out (MIXED Procedure, SAS Institute 2009). The difference between residual variance estimates from the two models was 0.6% . Therefore, due to the slight difference in means and to the practice of considering the effect as fixed in IHDH genetic improvement (e.g., Mantovani et al., 2010), SYC was included in the model as fixed.

Results and discussion

Means and standard deviations, as well as minimum and maximum values for each trait are reported in Table 1. The means

Table 1. Descriptive statistics of 14 linear type traits and overall score in 4,385 IHDH horses scored at about 3 years of age using a 9 point scale (i.e., 1 to 5 with half points)

Trait	Value					Descriptor	
	Mean	SD	CV	Min	Max	Minimun	Maximum
Head size/Expression (HS)	3.03	0.64	0.21	1.0	5.0	Heavy	Light
Temperament/Blood (Te)	3.28	0.55	0.17	1.0	5.0	Lymphatic	Nevrile
Frame size (FS)	3.20	0.72	0.23	1.0	5.0	Little	Large
Fleshiness (Fl)	3.28	0.55	0.17	1.5	5.0	Poor	Excellent
Bone incidence (BI)	2.87	0.41	0.14	1.0	5.0	Fine boned	Heavy boned
Thorax depth (TD)	3.56	0.53	0.15	2.0	5.0	Little	Large
Fore diameters (FD)	2.92	0.65	0.22	1.0	5.0	Narrow	Broad
Rear diameters (RD)	3.38	0.55	0.16	2.0	5.0	Narrow	Broad
Upper line length (UL)	3.30	0.46	0.14	2.0	5.0	Short	Long
Upper line direction (UD)	2.83	0.38	0.13	1.0	4.0	Dipped	Arched
Rear legs side view (LS)	2.56	0.48	0.19	1.0	5.0	Sickle	Straight
Fore feet (FF)	3.22	0.52	0.16	1.0	5.0	Toed out	Toed in
Rear feet (RF)	3.01	0.42	0.14	1.0	5.0	Toed out	Toed in
Rear legs back view (LB)	2.90	0.33	0.11	2.0	4.0	Close	Wide
Overall score (OS)	2.04	0.80	0.39	1.0	5.0	Poor	Excellent

Table 2. Results of ANOVA carried out on 14 linear traits and overall score of 4,385 IHDH horses scored at about 3 years of age (*P < 0.05; **P < 0.01; ***P < 0.001; when absent not significant)

Trait	Factor Variance and significance[1]			Error Variance	R-square
	SYC	SEX	AC		
HS	0.59***	0.46	0.44	0.32	0.46
Te	0.48***	0.33	0.47	0.22	0.49
FS	0.85***	11.68***	1.24**	0.32	0.57
Fl	0.47***	2.51***	1.42***	0.21	0.51
BI	0.22***	1.99***	0.14	0.14	0.40
TD	0.48***	0.15	0.59*	0.19	0.52
FD	0.69***	11.43***	1.53***	0.27	0.56
RD	0.49***	0.75	2.34***	0.22	0.50
UL	0.31***	0.19	0.18	0.17	0.44
UD	0.24***	2.34***	0.05	0.10	0.53
LS	0.38***	0.33	0.16	0.16	0.52
FF	0.34***	0.21	0.35	0.24	0.38
RF	0.24***	0.38	0.12	0.15	0.42
LB	0.16***	0.01	0.07	0.09	0.44
OS	1.08***	1.73*	3.34***	0.41	0.55

[1] SYC is the herd-year-classifier effect (1,325 levels); SEX is the sex effect (male or female), AC is the class of animals at scoring (5 classes, i.e., ≤27, 28, 29-32, 33-47, and ≥48 months of age).

ranged from 2.04 to 3.56, although most traits had a mean close to 3 (i.e., the mean point of the linear scale). Traits with greater mean score were thorax depth (3.56), rear diameters (3.38), upper line direction (3.30), temperament (3.28) and fleshiness (3.28). On the other hand, the traits with the lower mean score were legs side view (2.56), upper line direction (2.83), bone incidence (2.87), and the overall score (2.04), that showed the lowest value. The standard deviation (SD) on raw data ranged from 0.33 to 0.80, with a mean of 0.53 SD. The higher SD were observed for OS (0.80), HS (0.64), FS (0.72), and FD (0.65), while the lower values of SD were obtained for LB (0.33), UD (0.38), BI (0.41), RF (0.42), LS (0.48) and RF (0.42). In comparison, Samorè et al. (1997) have reported greater standard deviation for all type traits evaluated on the Italian Haflinger. However, these authors have dealt with a system of scoring based on a different scale, i.e., 0-10 points for all type traits. Indeed, for many trait in common in the evaluation form of the two breeds, the coefficient of variability resulted lower in the IHDH (from 0.11 to 0.21) than in the Italian Haflinger (from 0.21 to 0.37). On the other hand, Vostrý et al. (2009) reported similar coefficient of variation for traits related to upper line length and direction or for rear legs scored in the Czech-Moravian Belgian horse. Gómez et al.(2009) reported a lower CV for traits related to upper line length, fore diameters and bone incidence obtained in Andalusian horses. Jakubec et al. (2007), reported a greater standard deviation for almost type traits evaluated on the Old Kladrub horse, although they used a wider scoring system (scale from 1 to 9), resulting in a greater CV for traits related to head size, upper line length, fore diameters, rear diameters, rear legs side view and rear legs back view than in the present study. The stud-classifier-year effect (Table 2) was the most important effect among those tested and resulted highly significant for all the traits analysed (P < 0.001). On the contrary, the age at scoring was significant (P < 0.001) only for 4 on 15 traits analysed, i.e., Fl, FD, RD, and OS. Other traits af-

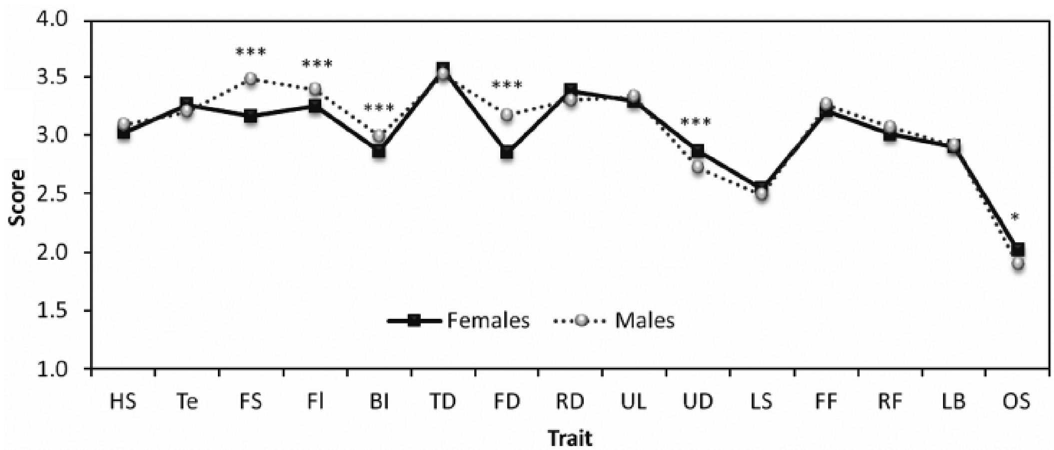

Figure 1. Least square means for sex effect (males; grey dotted line with circle; and females; black continuous line with squares) evaluated on 14 linear type traits and the overall score measured on 4,385 IHDH horses scored at the age of about 3 years using a 9 point scale (1 to 5 with half points)

fected significantly by the age at score were the for FS ($P < 0.01$) and TD ($P < 0.05$). The sex affected significantly FS, Fl, BI, FD and UD ($P < 0.001$), but also for FF and FS ($P < 0.05$). The coefficient of determination ranged between 0.38 and 0.57, and was under 0.40 only one trait FF (0.38). The greatest values were found for frame size (0.57), fore diameters (0.56), overall score (0.55) and upper line direction (0.53). In Figure 1 are reported the least means square means for the sex effect. The main noticeable variations between sexes were for FS and FD traits, that differed of almost 0.3 point. Less marked, although significant variations between sexes were detected also for Fl, BI, UD, and OS. The mean superiority of males in such cases were of about 0.13 point for Fl and Bl, while females had greater score than males of about 0.13 points for UD and, particularly, for the overall score. Difference between males and females using body measurements was also found by Kashiwamura et al. (2001), for traits related to upper line length, fore diameters, and rear diameters. Also Kaproń et al. (2013) reported a different value between males and females for a trait related to bone incidence. Simčič et al. (2012), using body measurements, reported significance between males and females for traits related to bone incidence, fore diameters, and rear diameters, and for head size and rear limbs, considering type scores. Kashiwamura et al. (2001) reported that hip width, croup width and rump length of females were greater than those of males. It should be taken into consideration that the greater hind quarters on females could be related to reproduction aspects. Difference between sexes was also found by Jakubec et al. (2007), for traits related to head size, upper line direction, fore diameters, and rear diameters. Table 3 reports the least square means obtained for the different age classes considered in the model of analysis. Only some traits were affected by the class of ages of the IHDH subjects. For example, HS, Te, and RD were not affected by the age class, while among the traits included in the total merit index, only Fl and FD were affected by the age class of the animal. Particularly, both these scores increased with the age of the animal (i.e., from 3.2 at ≤27 months of age

Table 3. Least square means for age effect on 14 linear type traits and the overall score according to the 5 class of evaluation used (i.e., ≤27, 28, 29-32, 33-47, and ≥48 months of age)

Traits	Age class at evaluation				
	≤27 Months	28 Months	29-32 Months	33-47 Months	≥48 Months
HS	3.00	3.05	3.10	3.10	3.03
Te	3.24	3.24	3.28	3.23	3.17
FS	3.22^{b}	3.25^{b}	3.34^{ab}	3.36^{ab}	3.43^{a}
Fl	3.21^{b}	3.27^{ab}	3.38^{a}	3.35^{a}	3.39^{a}
BI	2.89	2.95	2.91	2.91	2.95
TD	3.48	3.49	3.56	3.57	3.61
FD	2.89^{b}	2.98^{b}	3.08^{a}	3.05^{ab}	3.05^{ab}
RD	3.18^{c}	3.27^{c}	3.36^{b}	3.41^{ab}	3.49^{a}
UL	3.26	3.31	3.31	3.32	3.36
UD	2.82	2.79	2.78	2.78	2.77
LS	2.55	2.50	2.53	2.49	2.50
FF	3.16	3.22	3.24	3.27	3.28
RF	3.04	3.05	3.03	3.01	3.07
LB	2.91	2.91	2.89	2.89	2.93
OS	1.82^{c}	1.91^{bc}	2.08^{a}	2.03^{ab}	1.97^{abc}

to about 3.4 at ≥48 months of age, and from 2.9 at ≤27 months of age to about 3.0 at ≥48 months of age, for Fl and FD, respectively). Also FS and OS were affected by age, but for the latter trait the score did not change linearly with the increased age at scoring, probably because of the non-linear distribution of this trait as compare to the other 14 traits.

Conclusions

The stud-year of evaluation effect-classifier has demonstrated to be the effect of greater magnitude within the linear type trait evaluation of IHDH subject at 3 years of age. The results of this study have also allowed to analyse differences between sexes of IHDH animals at 3 years of age, showing that males are usually greater in size, fleshiness, bone incidence and fore diameters than females. On the other hand, females have a less dipped upper line than males, showing in general a lower amount of this defect. Frame size, fleshiness, and fore diameters are also affected by the age at evaluation, being of greater score at an older age. However, the overall score, reflecting a final judgement for the animal do not follow a linear trend of score with the age.

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