A TOTAL MERIT INDEX FOR THE ITALIAN HAFLINGER HORSE USING BREEDING VALUES PREDICTED BY A MULTI-TRAITS ANIMAL MODEL

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SUMMARY

A total of 4582 records of height at withers, breed type, general harmony and gait from the Italian Haflinger horses were analysed. Variance components of the four traits were estimated by REML algorithm, using a multiple-trait animal model including herd group, classifier and year of scoring as fixed effects. The complete pedigree file, tracing back relationships to ancestors born at the beginning of the century, contained 21655 animals. Heritabilities were .79, .30, .36 and .26 for height at withers, breed type, general harmony and gait, respectively. Genetic correlations ranged from .72 to .93. Breeding values for the four traits were predicted with a multiple-trait animal model using the estimated variance components. A total merit index was developed multiplying each estimated breeding value by an index weight provided by the breed association. The total merit index has been already adopted by the Italian Haflinger Association as a selection criteria in the breeding scheme.

Keywords: horse, Haflinger, conformation, selection index

INTRODUCTION

The Italian Haflinger population is a horse breed widely spread throughout the country. Originally used as a draft horse by the Austrian Army, the breed has been exploited as a horse of burden until the ‘80s. However, in the last decade, breeders have oriented the selection process toward animals more suitable for horse riding. For six years selection was therefore based on independent culling approach using a single trait animal model evaluation for height at withers (Pagnacco \textit{et al.} 1991) and a traditional final conformation score. In the mean time a linear evaluation for 26 type traits was developed and data collected (Samoré \textit{et al.} 1997). Each record included a final conformation score for 4 general traits: body development, breed type (overall breed appearance: colour of coat and hair, expressiveness of head), general harmony (proportion of body regions) and gait. Objective of this study was to estimate variance components and breeding values for general conformation, and to develop an aggregate selection index that included height at withers and general conformation.

MATERIALS AND METHODS

Data for the study, collected on 4647 Italian Haflingers, were provided by the Italian Haflinger Association (ANACRA) and included information on three conformation traits (breed type, general harmony and gait) and one body measurement (height at withers). After
edits 4582 records were used for the analysis. Height at withers was measured in centimetres with mean of 138.9 cm and standard deviation of 3.41 cm. The three conformation traits were scored on a linear scale from 1 to 6: insufficient, sufficient, mediocre, good, very good, and excellent. Before the analysis, scores from 0 to 100 were assigned to the 6 categories using the scaling procedure of Snell (1964) for ordered categorical data (Table 1). All conformation scoring and measurements were conducted by 9 classifiers from April 1990 to October 1996 throughout Italy.

Table 1. Distribution of conformation traits and relative Snell scores

<table>
<thead>
<tr>
<th>Breed type</th>
<th>General harmony</th>
<th>Gait</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Snell score</td>
</tr>
<tr>
<td>Insufficient</td>
<td>276</td>
<td>0.00</td>
</tr>
<tr>
<td>Sufficient</td>
<td>468</td>
<td>15.86</td>
</tr>
<tr>
<td>Mediocre</td>
<td>1468</td>
<td>29.27</td>
</tr>
<tr>
<td>Good</td>
<td>1797</td>
<td>47.2</td>
</tr>
<tr>
<td>Very good</td>
<td>549</td>
<td>73.62</td>
</tr>
<tr>
<td>Excellent</td>
<td>24</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Variance components and breeding values. Genetic and residual variance components were estimated using REML. The following multiple trait animal model was applied, using canonical transformation (Meyer, 1985) and specific techniques developed by Mistzal et al. (1992):

\[
Y_{ijk} = H Y_{bi} + C Y_{sj} + A_k + e_{ijk}
\]

where: \(Y_{ijk}\) = observation on the \(k\)th horse, \(H Y_{bi}\) = fixed effect of \(i\)th herd group-year of birth (257 levels), \(C Y_{sj}\) = fixed effect of the \(j\)th classifier-year of scoring (57 levels), \(A_k\) = random additive genetic effect of the \(k\)th horse, \(e_{ijk}\) = random residual effect. A pedigree file of 21655 animals was included; unknown parents were attributed to six phantom groups. Due to small herd size, herds were grouped considering the effects of area and management. In a previous analysis effects of sex, season and age and their interactions were tested using PROC GLM of SAS\(^7\) (1985) and found to be non significant for the three conformation traits. However, age was significant for height at withers and therefore was pre-adjusted for age at measurement (Samoré and Pagnacco 1997). Breeding values were predicted with the same multiple trait animal model using the estimated variance components.

Total merit index. Techniques by Schneeberger et al. (1992) were used to develop the aggregate selection index using breeding values predicted by BLUP. The index weights \(b\) are equal to \(G_{11}^{-1} G_{12} v\) where \(G_{11}\) is the genetic variance-covariance matrix among the traits in the selection criteria, \(G_{12}\) is the genetic covariance matrix between the selection criteria and
the traits in the objective, and \(v\) is the vector of economic values in the objective. For Italian Haflingers the traits in the selection objective are the same as in the selection criteria. Following Dekkers (1995) \(b = G_{11}^{-1}G_{11}v\). Thus, \(b=lv\) where \(I\) is an identity matrix. The index weights are then equivalent to the economic weights: \(b=v\).

**RESULTS AND DISCUSSION**

**Variance components estimation.** Estimates of heritability and genetic and residual correlations are presented in Table 2. Heritability for height at withers was larger (.79) than the value (.71) found by Miglior et al. (1994) in the same population, but on a smaller data set. VanBergen and VanArendonk (1993) found an heritability of .89 for height at withers in Dutch Shetland ponies. Heritabilities for the conformation traits ranged from .26 to .36. All genetic correlations among the four traits were positive and very high, ranging from .72 to .93. Arnason (1984) found lower or negative genetic correlations between height and movements in the Icelandic Toelter horses. It is important to note that in the past the Haflinger was used for work and draft. Selection for a taller horse is then associated with a more harmonic and agile horse.

**Table 2. Heritabilities on diagonal, genetic correlations above diagonal and residual correlations below diagonal.**

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>Breed type</th>
<th>Harmony</th>
<th>Gait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0.79</td>
<td>0.72</td>
<td>0.81</td>
<td>0.76</td>
</tr>
<tr>
<td>Breed type</td>
<td>0.27</td>
<td>0.30</td>
<td>0.93</td>
<td>0.85</td>
</tr>
<tr>
<td>Harmony</td>
<td>0.20</td>
<td>0.49</td>
<td>0.36</td>
<td>0.92</td>
</tr>
<tr>
<td>Gait</td>
<td>0.18</td>
<td>0.29</td>
<td>0.32</td>
<td>0.26</td>
</tr>
</tbody>
</table>

**Genetic trends.** A genetic base was set using mares born between 1990 and 1994. Genetic trends observed are plotted in Figure 1. The evident positive trend for all traits in the last five years corresponds to selection on estimated breeding values computed with an animal model for height at withers that started in 1991 for the Italian Haflinger population (Pagnacco et al. 1991). Breed type, general harmony and gait increased as a consequence of the high genetic correlation with height at withers.

**Total merit index.** Index weights were provided by the Italian Haflinger technical committee and were based on the breed selection objectives: improving gait, then general harmony and breed type, with less emphasis placed on height at withers that has been given in the last five years. Fifty percent emphasis was given to gait, 20% each to breed type and general harmony, and 10% to height at withers. Index weights were divided by their relative phenotypic standard deviation before being multiplied by the respective estimated breeding values. The total merit index (IMT) is:

\[
IMT = .30*EBV_{\text{height}} + .11*EBV_{\text{breed type}} + .12*EBV_{\text{harmony}} + .34*EBV_{\text{gait}}
\]
An approximated accuracy of the total merit index has been calculated summing all the accuracies of each trait multiplied by the percent relative weight used for the index:

\[ \text{ACC}_{\text{MT}} = 0.35 \times \text{ACC}_{\text{height}} + 0.13 \times \text{ACC}_{\text{breed_type}} + 0.14 \times \text{ACC}_{\text{harmony}} + 0.39 \times \text{ACC}_{\text{gait}} \]

This new index has been approved by the Italian Haflinger Association and already put in place in the breed selection scheme. Every year only the top stallions for the total merit index can be used for reproduction.

Figure 1. Genetic trends of height at withers, breed type, general harmony and gait

REFERENCES
Snell, E.J. (1964) Biometrics 20:592-607