Development Of A Breeding Value Estimation System For The Saxon-Thuringian Heavy Warmblood

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Introduction

In the breeding of large animal species the breeding value estimation as a breeder's work equipment belongs already since a longer time to the daily routine.
The breed of Saxon-Thuringian Heavy Warmblood is originally a breed of Oldenburger and East Frisian Horses, which where mainly used as carriage horses. Through the process of breeding towards riding horses, was almost no need to produce the horses for the originally purpose anymore, the breed almost died out in the provenance region. But, in the last 25 years the Heavy Warmblood could get an impressive reactivation and at the same time an emergent development, especially in use for horse driving competitions, which leads to a breeding population in Saxonia and Thuringia of about 1.200 broodmares and 60 stallions nowadays. On the basis of a broad consistent aligned breeding basis, a modernized breeding program and a harmonized performance test, including the growing use for horse driving tournaments an intensive and at the breeding progress orientated breeding work became possible. In 2005 two horse breeding associations merged, which also kept the studbook of origin. Structural changes and new requirements were built to implement modern work equipment of animal breeding, such as an independent organisation internal Breeding Value Estimation for this upcoming horse race. With this new breeding resource a tool for breeding practice is provided which can realize the breeding progress more efficiently.

Material and Methods

Breeding value estimation. The breeding values were estimated using a BLUP ("Best Linear Unbiased Prediction") multitrait animal model.
The model served for estimation of breeding values in three different complexes:
1. Traits of foal classification using the herdbook data of foal inspections
2. Traits of exterior classification using data of studbook inspections and stallion licensing
3. Traits of body measures using again data of studbook inspections and stallion licensing.

For foal classification the included fixed effects are consisting of gender (m, f), age (up to 30d, 31-180d, above 180d), and year as well as place (Saxony and Thuringia) of classification. For the exterior classification the same criteria for fixed effects were applied, but the differentiation for age was used as follows (in years): below 3, 3, 4, 5, above 5. For the complex of body measures the vector of fixed effects and the covariable, which is in this

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case consisting of gender (m, f) as well as the covariable age as linear regression. For the repeated measures an effect of permanent environment is included as well.
The evaluation of genetic parameters was done by the use of PEST/ VCE (Groeneveld et al. (1990), Neumaier and Groeneveld (1998)). For the complex of exterior traits there were always two-traits-animal models used and then the joined matrix would be transformed to get positive definite by a bending algorithm implemented by Mielenz et al. (1992).
Single traits for foal classification are Type, Exterior and Movements, which are weighted for estimation of total breeding value 1:1:1. Single traits for the complex of body measures are Height at withers and Cannon's circumference, which will not be combined.
For the complex of exterior classification ten different traits were included in the estimation. Due to several changes in regulations of studbook observations and stallion licensing over the years, supporting traits were included with the purpose to integrate also older herd book data. That indicate that marks of former regulation traits (supporting trait) such as breed type were allocated to the current regulation traits (final trait), in this case Breed- and gender type. Final and corresponding supporting traits as well as the weighting factors of estimation of exterior classification are shown in table 1.

Table 1: Final and supporting traits and weighting factors for the breeding value estimation of exterior classification

Final trait	Supporting traits	Weighting factor
Breed- and gender type (Bgt)	Breed type	**1**
Head		**1**
Neck		**1**
Shoulder- and saddle bearing area (Ssa)	Forehand	**1**
Fundament (Fund)	Fore legs Hind legs	**1**
Correctness of gaits (Cg)		**1**
Back and croup (Bc)	Barrel Haunches	**1**
Walk		**1**
Canter		**1**
Trot	Ground cover and push Cadence and flexibility Momentum and flexibility Action of movements	**1**

Results and discussion

Estimates of phenotypic and genetic correlations of foal classification are shown in table 2. Overall about 5.100 scores for a single trait were included in the estimation. The heritability values ranged between 0.22 in exterior and 0.38 for movements. The genetic correlation is highest between the traits exterior and movements. Hascher et al. (1998) found higher heritabilities (up to 0.58) for foals in type and movements.

Table 2: Genetic and phenotypic parameters of breeding value estimation for foal classification $^{\alpha}$

Trait	Type	Exterior	Movements
Type	**0.34**	0.21	0.20
Exterior	0.08	**0.22**	0.32
Movements	0.08	0.09	**0.38**

$^{\alpha}$ Heritabilities on the diagonal, phenotypic and genetic correlations below and above the diagonal, respectively.

Estimates of phenotypic and genetic correlations of exterior classification are given in table 3. Approximately 4.700 scores per trait were used for the estimation. The heritability estimates for exterior classification ranged between 0.15 (Correctness of gaits) and 0.36 (Fundament and trot). The highest genetic correlation was estimated between Breed- and gender type and Head (0.61). High genetic correlations were also found between Shoulder- and saddle bearing area and the traits for movement (Walk - 0.49, Canter - 0.45 and Trot - 0.30). The heritability value for Breed- and gender type was 0.26, which is lower than literature values (0.28-0.42) (Stock et al. (2006)). The observed heritability value of 0.27 for Head is also lower compared to the results of Christmann (1996), who found for Hanoverian Warmblood mares a value of 0.42. In the same study he found heritability value of 0.25 for the trait Neck, which is comparable to our study. For correctness of gaits similar values for different warmblood breeds are published (Stock et al. (2006), Christmann (1996), Preisinger et al. (1991)).

Table 3: Genetic and phenotypic parameters of breeding value estimation for exterior classification $^{\alpha}$

Trait	Bgt	Head	Neck	Ssa	Fund	Cg	Bc	Walk	Canter	Trot
Bgt	**0.29**	0.61	0.36	0.01	0.07	0.01	0.01	0.03	0.00	0.02
Head	0.30	**0.27**	0.45	0.01	0.07	0.07	0.02	0.06	0.01	0.07
Neck	0.23	0.22	**0.25**	0.31	0.11	0.10	0.01	0.04	0.01	0.09
Ssa	0.13	0.06	0.18	**0.20**	0.13	0.04	0.11	0.49	0.45	0.30
Fund	-0.01	0.14	0.02	0.05	**0.36**	0.71	0.12	0.2	0.07	0.08
Cg	0.16	0.08	0.08	0.11	0.25	**0.15**	0.02	0.12	0.06	0.13
Bc	0.16	0.11	0.13	0.15	0.04	0.14	**0.21**	0.02	0.00	0.01
Walk	0.10	0.05	0.08	0.25	0.23	0.10	0.11	**0.26**	0.37	0.38
Canter	0.13	0.08	0.09	0.22	0.23	0.08	0.11	0.17	**0.27**	0.35
Trot	0.16	0.07	0.09	0.21	0.30	0.09	0.15	0.22	0.25	**0.36**

$^{\alpha}$ Heritabilities on the diagonal, phenotypic and genetic correlations below and above the diagonal. (Bgt-Breed- and gender type, Ssa-Shoulder- and saddle bearing area, Fund-Fundament, Cg-Correctness of gaits, Bc-Back and croup)

As mentioned above in case of exterior classification supporting traits were allocated to final traits of current regulation system. An example of the PEST run for the supporting trait Breed type (Bt) and the final trait Breed- and gender type (Bgt) is shown in table 4. For Bt 3.601 marks are registered in the database, whereas for Bgt, which is the final trait, only 1.182 marks are listed. These 3.601 marks of Bt would disappear in the breeding value estimation for exterior and the single final trait Bgt, if they would not be linked to each other. Genetic correlation between both strongly connected traits was 0.82 (data not shown).

Table 4: PEST analysis of final trait Bgt and corresponding supporting trait Bt [β]

Trait	Min	Max	n	Mean	std
Bgt	5.0	10.0	1182	7.750	0.744
Bt	5.0	10.0	3601	8.318	0.946

[β] Min-Minimum mark for this trait, Max-Maximum mark for this trait, n-Number of marks, Mean-mean of all marks, std-Standard deviation of all marks.

Estimates of phenotypic and genetic correlations of body measures are shown in table 5. For height at withers about 5.500 and for Cannon's circumference about 3.500 animal data were included in the estimation. We found high heritability values (0.74) for height at withers for the breed of Heavy Warmblood. Published literature values for different warmblood breeds were found to be much lower, which means 0.25-0.36 in studies of Christmann (1996) and Kaiser et al. (1991).

Table 5: Genetic and phenotypic parameters of estimation for body measures [α]

Trait	Height at withers	Cannon's circumference
Height at withers	**0.74**	0.45
Cannon's circumference	0.39	**0.54**

[α] Heritabilities on the diagonal, phenotypic and genetic correlations below and above the diagonal, respectively.

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