H17-11

Multiple trait selection for radiographic health of the limbs, conformation and performance in Warmblood riding horses

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Background

- **classical selection criteria in the Warmblood horse:**
  - **conformation**
  - **performance (riding sport)**
- **orthopedic diseases as the main reason for losses and premature retirement of sport horses**
  → much importance attached to radiographic health of the limbs

Objectives

- **estimation of genetic correlations between**
  - **radiographic findings and conformation traits and**
  - **radiographic findings and performance traits**
- **prediction of breeding values for radiographic findings, conformation and performance traits**
- **evaluation of the opportunities for simultaneous selection for radiographic health of the limbs, conformation and performance**

Data

- **data sources:**
  - **(1) radiographic data from riding horse auctions**
  - **(2) conformation data from studbook inspections**
  - **(3) performance data from mare performance tests and auction horse inspections**
  - **$\rightarrow$ horses from birth years 1992-2001**
  - **$\Rightarrow$ 26434 German Warmblood horses**
- **pedigree data (unified animal ownership database)**

Traits

- radiographic findings
  - osseous fragments in fetlock joints (OFF)
  - osseous fragments in hock joints (OFH)
  - deforming arthropathy in hock joints (DAH)
  - pathologic changes in the navicular bones (PCN)
- conformation
  - front limbs
  - hind limbs
  - withers height
- performance
  - walk
  - trot
  - canter
  - rideability
  - free jumping

Radiographic data

- radiographic information on 5155 horses
- mostly 3 or 4 years old (mean age 4.14 years)
- riding horse auctions 1997-2004

Radiographic finding	Prevalence
Osseous fragments in fetlock joints (OFF)	27.78%
Osseous fragments in hock joints (OFH)	9.18%
Deforming arthropathy in hock joints (DAH)	7.70%
Pathologic changes in the navicular bones (PCN)	20.10%

Conformation data

- **conformation scores (scale 1-10) and height measurements for 20603 mares**
- **mostly 3 or 4 years old**
- **studbook inspections 1995-2004**

Conformation trait	Mean
Front limbs	6.62
Hind limbs	6.34
Withers height	165.43 cm

Performance data

- **performance scores (scale 1-10) for 16098 horses**
- **mostly 3 or 4 years old**
- **mare performance tests and auction horse inspections 1995-2004**

Performance trait	Mean
Walk	6.82
Trot	6.76
Canter	6.95
Rideability	7.14
Free jumping	6.66

Distribution of horses

12266 horses with information on only 1 group of traits

- radiographic data only (n = 2169)
- conformation data only (n = 7997)
- performance data only (n = 2100)

12914 horses with information on 2 groups of traits

- radiographic and conformation data (n = 170)
- radiographic and performance data (n = 1562)
- conformation and performance data (n = 11182)

1254 horses with information on all 3 groups of traits, i.e. radiographic, conformation and performance data

in total 26434 horses with radiographic data and/or conformation data and/or performance data

Estimation of genetic parameters

- **variance component estimation with REML (VCE)**
- **linear animal model**
  ($\rightarrow$ binary traits: transformation on the liability scale)
- **multiple bivariate analyses (4x3 + 4x5 = 32)**

Radiographic findings

$y_{ipq} = \mu + AUCT_i + a_p + e_{ipq}$ **(OFF)**

$y_{ijkpq} = \mu + AUCT_i + AUCTAGE\_SEX_j + SEAS_k + a_p + e_{ipq}$ **(OFH, DAH, PCN)**

Conformation

$y_{lmpq} = \mu + CONFAGE_l + confplace\_confyear_m + a_p + e_{ipq}$ **(Front limbs, Hind limbs, Withers height)**

Performance

$y_{nopq} = \mu + PERFAGE_n + perfplace\_perfyear_o + a_p + e_{ipq}$ **(Walk, Trot, Canter, Rideability, Free jumping)**

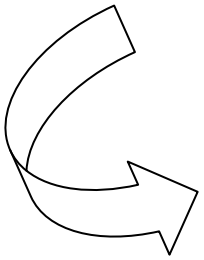
Additive genetic correlations

Trait	OFF	OFH	DAH	PCN
Front limbs	-0.282 ± 0.098	-0.051 ± 0.092	-0.278 ± 0.111	-0.006 ± 0.093
Hind limbs	-0.278 ± 0.099	0.012 ± 0.098	-0.511 ± 0.121	-0.161 ± 0.096
Withers height	0.384 ± 0.103	0.550 ± 0.075	-0.198 ± 0.084	-0.116 ± 0.097
Walk	-0.004 ± 0.079	-0.088 ± 0.070	-0.084 ± 0.090	-0.030 ± 0.071
Trot	-0.040 ± 0.079	-0.062 ± 0.072	-0.101 ± 0.094	0.012 ± 0.071
Canter	0.087 ± 0.085	-0.062 ± 0.078	-0.251 ± 0.104	-0.050 ± 0.078
Rideability	0.038 ± 0.082	0.008 ± 0.076	-0.166 ± 0.102	0.053 ± 0.080
Free jumping	-0.097 ± 0.059	-0.002 ± 0.055	-0.210 ± 0.065	0.037 ± 0.056

For all traits: h^2 = 0.099-0.500 (SE_{h^2} = 0.008-0.056)

Prediction of breeding values

- **genetic evaluation via BLUP (PEST)**
- **multivariate linear animal model (binary traits: use of transformed (co-)variances)**
- **standardization of breeding values to 100 ± 20 (reference population: sires of horses with records) → relative breeding values (RBV)**



RBV-based selection

on sires with at least 5 informative offspring per trait group (radiographic findings, conformation and performance)

→ 207 sires with 1138 offspring

RBV-based selection

a) **‘single-trait selection’**
   - individual or all radiographic findings
   - limb conformation, medium or large withers height
   - gaits, rideability, free jumping, performance

b) **‘multiple-trait selection’**

   all radiographic findings
   - plus limb conformation
   - plus performance
   - plus limb conformation and performance
   - plus limb conformation, performance and medium withers height

Expected selection response
(‘single-trait selection’)

Trait	No sel.	Rad.	Limbs	Gaits	Rid.	Jump.
n_{sires} ($n_{offspring}$)	207 (1138)	103 (553)	105 (774)	109 (760)	121 (867)	107 (548)
OFF	28.65%	25.32%	28.68%	28.82%	29.41%	27.55%
OFH	7.56%	5.61%	7.88%	7.24%	7.96%	7.48%
DAH	6.41%	3.98%	4.91%	6.05%	6.46%	6.20%
PCN	16.43%	11.21%	16.54%	16.71%	16.26%	17.34%
Front limbs	6.80	6.80	6.86	6.83	6.82	6.74
Hind limbs	6.56	6.58	6.63	6.59	6.58	6.50
Withers height	165.93	165.68	165.92	165.93	165.95	165.89
Walk	7.12	7.16	7.24	7.31	7.21	6.81
Trot	7.18	7.17	7.34	7.39	7.29	6.86
Canter	7.31	7.32	7.40	7.42	7.37	7.17
Rideability	7.53	7.52	7.64	7.66	7.63	7.34
Free jumping	6.83	6.83	6.48	6.39	6.57	7.64

Expected selection response
(‘multiple-trait selection’)

Trait	No sel.	Rad. + limbs	Rad. + perf.	Rad. + limbs + perf.
n_{sires} ($n_{offspring}$)	207 (1138)	62 (439)	79 (512)	49 (378)
OFF	28.65%	26.20%	25.20%	26.19%
OFH	7.56%	6.15%	5.47%	6.35%
DAH	6.41%	4.10%	4.69%	4.23%
PCN	16.43%	11.85%	12.11%	11.90%
Front limbs	6.80	6.86	6.78	6.84
Hind limbs	6.56	6.64	6.57	6.63
Withers height	165.93	165.68	165.60	165.63
Walk	7.12	7.26	7.17	7.28
Trot	7.18	7.31	7.20	7.33
Canter	7.31	7.41	7.34	7.42
Rideability	7.53	7.63	7.55	7.65
Free jumping	6.83	6.57	6.86	6.59

Summary of results

relative decrease of prevalences of radiographic findings:

- **12-38% with ‘single-trait selection’**
  for radiographic health of the limbs
- **12-36% with ‘multiple-trait selection’**
  for radiographic health of the limbs, limb conformation and performance (gaits, rideability, jumping)

relative increase of conformation and performance scores:

- **up to 2.9% with ‘single-trait selection’**
  for limb conformation or performance (gaits, rideability)
- **up to 2.2% with ‘multiple-trait selection’**
  for radiographic health of the limbs, limb conformation and performance (gaits, rideability, jumping)

Conclusions

- **feasibility of simultaneous selection for conformation traits, performance traits and radiographic health of the limbs**
- **recommendation of multivariate genetic evaluation and ‘multiple-trait selection’ in order to account for additive genetic correlations and maximize the breeding progress for all traits with selection relevance in the Warmblood horse**


Thank you!
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