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The correlation between inbreeding and performance in the Hanoverian Sport Horse.

A thesis presented for the Degree

Master of Science

in

Animal Science

at

Massey University

Stafford William Robinson

2015
Abstract

The aim of this thesis was to examine the relationship between inbreeding and performance in the Hanoverian Sport Horse.

A total of 84,724 hanoverian horses born between the years 1990 and 2009 were used for the study, of which 78,907 had their own performance records. Pedigree records were traced back as far as possible, with a maximum of 37 generations used. There was 100% completeness of pedigree up to the grandparent generation for all horses. The majority of horses (80%) had completeness of pedigree past the sixth generation.

Inbreeding were calculated using two methods; the Meuwissen method and the van Raden Method. Both methods gave identical results (100% fit). As a quantitative measure of performance, the Integrated Estimated Breeding Value (iEBV), using both breed and competition results was used. The Evaluation was carried out using the BLUP (Best Linear Unbiased Prediction) Multitrait Repeatability Animal Model. Two different GLM were run with the inbreeding coefficient (IBC) modelled as either a continuous variable or as a fixed class of five differing levels of inbreeding (IBC=0.00; 0<IBC≤0.01; 0.01<IBC≤0.02; 0.02<IBC≤0.05; 0.05<IBC). Age and Sex were included as fixed effects within the model.

All subgroups in both dressage and jumping data, with either fixed effect or linear covariate for the IBC, generated a similar result. Due to the large sample size there was a significant (p<0.001) relationship between inbreeding (IBC) and performance (iEBV). In dressage horses there was a significant positive relationship in all categories while in jumping horses there was a significant negative relationship in all categories. However, the effect of inbreeding on iEBV explained only ±1% of the variance in the models. The models were simultaneously adjusted for the bias of the confounding factor of sex which also accounted for ±1% of the variance. The majority of variance in iEBV is due to the year cohort effect which accounts for ±95%. The low level of inbreeding (±1.5%) and lack of biological effect on iEBV indicate that inbreeding is not a problem in the Hannoverian horse.
Acknowledgements

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Firstly, my supervisors Dr Chris Rogers and Dr Rebecca Hickson whose structure and feedback was indispensable. It is not an easy job having a student in a foreign country half way round the world.

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To Rebecca Jeal of Onderstepoort Veterinary Facility, South Africa whose ongoing support, encouragement and discussions on statistical process kept me sane.

And of course to my wife Bathoni for her patience and support through the years of late nights analysing, understanding data and screaming at walls.
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List of abbreviations and terms

APB (Aufbauprüfung) Sport events – show jumping and dressage of Young Horses’ competitions,

ATSE Accumulated, transformed and standardized earnings

BLUP Best Linear Unbiased Predictor Multi-trait–Repeatability–Animal Model


CPT Central performance tests

DF Degrees of freedom

DKB-Bundeschampionate The German Championships of Young German Horses and Ponies

Dressage horses Refers to the dressage data of the relevant horse subgroup

DWB Dutch Warmblood horse

eijkl Random residual

F Coefficient of inbreeding as defined by Sewall Wright

F_A Inbreeding Coefficient of the common ancestor

F_s Inbreeding Coefficient of individual horse

FE Fixed effect

FEI Federation Equestre Internationale

FN Fédération Equestre Nationale (Germany)

GLM General Linear Model

H^2 Heritability

HLP (Hengstleistungsprüfung) Stallion performance test.

i Intensity of selection of genetic gain
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBC</td>
<td>Inbreeding coefficient</td>
</tr>
<tr>
<td>IBCi</td>
<td>Inbreeding coefficient of horse (_i)</td>
</tr>
<tr>
<td>IBCC (_i)</td>
<td>Fixed effect of inbreeding coefficient class ((i=1-5); IBC=0.00, 0.00 &lt; IBC (\leq) 0.01, 0.01 &lt; IBC (\leq) 0.02, 0.02 &lt; IBC (\leq) 0.05, IBC &gt; 0.05)</td>
</tr>
<tr>
<td>iEBV</td>
<td>Integrated Estimated Breeding Value</td>
</tr>
<tr>
<td>IGE</td>
<td>Integrated Genetic Evaluation</td>
</tr>
<tr>
<td>IHB</td>
<td>Irish Horse Board</td>
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</tbody>
</table>

**Jumping Horses**  
Refers to the jumping data of the relevant horse subgroup

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWPN</td>
<td>Royal Dutch Sport Horse</td>
</tr>
<tr>
<td>LC</td>
<td>linear covariate</td>
</tr>
</tbody>
</table>

_Meuw.f_  
The Meuwissen method for computation of inbreeding coefficients

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPT</td>
<td>iEBV for mare performance test</td>
</tr>
<tr>
<td>MPTD</td>
<td>iEBV for dressage in mare performance test</td>
</tr>
<tr>
<td>MPTJ</td>
<td>iEBV for jumping in mare performance test</td>
</tr>
<tr>
<td>N</td>
<td>Number of horses in relevant subgroup</td>
</tr>
<tr>
<td>(n_1)</td>
<td>Number of generations from the sire to the common ancestor</td>
</tr>
<tr>
<td>(n_2)</td>
<td>Number of generations from the dam to the common ancestor</td>
</tr>
<tr>
<td>p</td>
<td>P-value</td>
</tr>
<tr>
<td>Pr</td>
<td>“The probability of”</td>
</tr>
<tr>
<td>PEDIG</td>
<td>Fortran 77 software package used for computation of inbreeding coefficients</td>
</tr>
<tr>
<td>r</td>
<td>Accuracy of selection of genetic gain</td>
</tr>
<tr>
<td>R(^2)</td>
<td>R-squared</td>
</tr>
<tr>
<td>RF</td>
<td>Rasmussen Factor</td>
</tr>
<tr>
<td>rg</td>
<td>Genetic Correlation</td>
</tr>
<tr>
<td>SEX(_j)</td>
<td>Fixed effect of sex</td>
</tr>
</tbody>
</table>
S.D. Standard Deviation
SF Selle Français horse
SPT iEBV for stallion performance test.
SPTD iEBV for dressage in stallion performance test.
SPTJ iEBV for jumping in stallion performance test.
SS Sum of Squares
SWB Swedish Warmblood horse
T Generation interval
TC iEBV for Tournament competitions
TCD iEBV for tournament competitions dressage
TCJ iEBV for Tournament competitions jumping
TI Total Index
TID Total Index Dressage
TIJ Total Index Jumping
TIMEFORM Relates to Timeform Publications and is a publishing company in Halifax, West Yorkshire, England as used by the racing industry to produce information and statistics on individual racehorses.
TORIS Turnier ORganisations und Informations System
TSP (Turniersportprüfung) Sport events - show jumping and dressage competitions.
$V_P$ Phenotypic variation
$V_G$ Variation in genetic values
VA (Veranlagungsprüfung) ability test of young stallions,
$vanrad.f$ The van Raden method for the computation of inbreeding coefficients
YC iEBV for Young Horse competitions
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>YCD</td>
<td>iEBV for Young Horse competitions dressage</td>
</tr>
<tr>
<td>YCJ</td>
<td>iEBV for Young Horse competitions jumping</td>
</tr>
<tr>
<td>yijkl</td>
<td>Breeding value (iEBV)</td>
</tr>
<tr>
<td>ZSP</td>
<td>(Zuchtstutenprüfung) Own performance test of mares,</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Model constant</td>
</tr>
</tbody>
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**Equation 1:**

Heritability

\[ H^2 = \frac{V_G}{V_P} \]

\( H = \) Heritability

\( V_P = \) phenotypic variation

\( V_G = \) genotypic variation

**Equation 2:**

coefficient of inbreeding (F) defined by Sewall Wright in the early 1920s

\[ F_X = \sum \left[ \left( \frac{1}{2} \right)^{n_1 + n_2 + 1} \right] \left[ 1 + F_A \right] \]

\( F_X = \) Inbreeding Coefficient of individual horse

\( F_A = \) Inbreeding Coefficient of the common ancestor

\( n_1 = \) Number of generations from the sire to the common ancestor

\( n_2 = \) Number of generations from the dam to the common ancestor
List of Models

Model 1:

\[ y_{ijkl} = \mu + b IBC_i + SEX_j + BYEAR_k + e_{ijkl} \]

- \( y_{ijkl} = \) breeding value (iEBV)
- \( \mu = \) model constant
- \( IBC_i = \) inbreeding coefficient of horse, \( i \)
- \( SEX_j = \) fixed effect of sex
- \( e_{ijkl} = \) random residual

Model 2:

\[ y_{ijkl} = \mu + IBCC_i + SEX_j + BYEAR_k + e_{ijkl} \]

- \( y_{ijkl} = \) breeding value (iEBV)
- \( \mu = \) model constant
- \( IBCC_i = \) fixed effect of inbreeding coefficient class (i=1-5; IBC=0.00, 0.00 < IBC \leq 0.01, 0.01 < IBC \leq 0.02, 0.02 < IBC \leq 0.05, IBC > 0.05)
- \( SEX_j = \) fixed effect of sex (j=1-2; stallions, mares)
- \( e_{ijkl} = \) random residual