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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



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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 was 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 ($IBC=0.00$; $0 < IBC \leq 0.01$; $0.01 < IBC \leq 0.02$; $0.02 < IBC \leq 0.05$; $0.05 < IBC$). 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 $\pm 1\%$ of the variance in the models. The models were simultaneously adjusted for the bias of the confounding factor of sex which also accounted for $\pm 1\%$ of the variance. The majority of variance in iEBV is due to the year cohort effect which accounts for $\pm 95\%$. The low level of inbreeding ($\pm 1.5\%$) and lack of biological effect on iEBV indicate that inbreeding is not a problem in the Hanoverian horse.

Acknowledgements

I would like to sincerely thank everyone who made this thesis possible.

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.

Immeasurable thanks to the Hannoveraner Verband for permission to access their data.

To Dr. Kathrin Friederike Stock of the Vereinigte Informationssysteme Tierhaltung w.V., without which we would not have a dataset. I could not have hoped for a more knowledgeable and patient comrade and “unofficial” supervisor for this project.

Next to Dr Antje Higo who tirelessly meet with me for various discussions of data and methodology. It was indispensable having someone on the same continent to bounce ideas off.

Thanks to Dr Ludwig Christmann for his support and indispensable feedback on initial structure of the project.

To Dr Birthe Niemann whose support and availability for coffee and discussion provided unknown encouragement.

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.

Table of Contents

Abstract	2
Acknowledgements	3
Table of Contents	4
List of abbreviations and terms	6
List of Figures	10
List of Tables	11
List of Equations	13
List of Models	14
Chapter 1: INTRODUCTION	15
Chapter 2: LITERATURE REVIEW	16
2.1 Measurement of performance in horses	16
2.2 Indirect, Direct and combined selection	17
2.2.1 Indirect.....	17
2.2.2 Direct.....	18
2.2.3 Combination.....	19
2.3 Young Horse competitions and progeny testing	20
2.4 Integrated Estimated Breed Value (iEBV)	21
2.4.1 BLUP (Best Linear Unbiased Prediction)	21
2.5 Artificial insemination	21
2.6 The structure of studbooks - Breed vs Breed Type.	22
2.7 Genetic gain – The generation interval and it’s influence.	23
2.8 Heritability	24
2.8.1 Heritability of station performance test.....	25
2.8.2 Heritability of competition performance.....	25
2.9 Genetic correlation	26
2.10 Inbreeding: Advantages and disadvantages	26
2.10.1 Inbreeding in relevant horse populations	27
2.10.2 A relevant threshold of inbreeding.....	31
2.10.3 Calculating Inbreeding.....	31
2.11 Inbreeding and performance.	33
Chapter 3 Literature Summary	35
Chapter 4 The hypothesis	37
Chapter 5 Materials and method	38
5.1 Dataset and Range	38
5.2 Pedigree completeness	38
5.3 Inbreeding	40
5.4 Performance	40
5.6 Dressage vs Jumping in the iEBV	42

5.7 Performance Publication	42
5.8 Analysis.....	42
5.8.1 BLUP Analysis.....	42
5.8.2 Combination of traits and weighting for the iEBV calculation.....	43
5.8.3 Statistical methods describing the relationship between inbreeding (IBC) and genetic performance potential (iEBV)	44
Chapter 6 Results	46
6.1 Inbreeding.....	46
6.2 Relationship between Inbreeding and Performance (as measured by genetic performance potential)	48
6.2.1 Model 1.....	48
6.2.2 Model 2.....	54
6.2.3 Both Models	59
6.3 Comparing the influence of inbreeding to year effect and sex	61
6.3.1 Year cohort	63
Chapter 7 Discussion.....	66
7.1 The historic use of inbreeding	66
7.2 Data	66
7.3 Data evaluation.....	67
7.4 The Measure of performance.....	67
7.5 Inbreeding.....	69
7.6 The measure of inbreeding	70
7.7 Inbreeding – a critical level	70
7.8 Inbreeding classes	71
7.9 Inbreeding and performance.....	71
7.9.1 The Inbreeding effect in relationship to the standard deviation of iEBV	71
7.9.2 Jumping and dressage compared	73
7.9.3 Contribution of IBC to iEBV	73
7.9.4 Year cohort – a significant effect	74
7.9.5 contribution of sex to iEBV	74
7.9.6 The relative increase in iEBV	74
7.9.7 A constant IBC.....	75
Chapter 8 Limitations	76
Chapter 9 Future Research	79
Chapter 10 Conclusion	80
Chapter 11 References	81
Chapter 12 Appendices and Annova – see CD attached.....	95

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
BYEAR _k	fixed effect of birth year class (k=1-10; 1990-1991, 1992-1993, ..., 2008- 2009)
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 _x	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

IBC	Inbreeding coefficient
IBCi	Inbreeding coefficient of horse _i
IBCC _i	Fixed effect of inbreeding coefficient class (i=1-5; IBC=0.00, 0.00 < IBC ≤ 0.01, 0.01 < IBC ≤ 0.02, 0.02 < IBC ≤ 0.05, IBC > 0.05)
iEBV	Integrated Estimated Breeding Value
IGE	Integrated Genetic Evaluation
IHB	Irish Horse Board
Jumping Horses	Refers to the jumping data of the relevant horse subgroup
KWPN	Royal Dutch Sport Horse
LC	linear covariate
<i>Meuw.f</i>	The Meuwissen method for computation of inbreeding coefficients
MPT	iEBV for mare performance test
MPTD	iEBV for dressage in mare performance test
MPTJ	iEBV for jumping in mare performance test
N	Number of horses in relevant subgroup
n ₁	Number of generations from the sire to the common ancestor
n ₂	Number of generations from the dam to the common ancestor
p	P-value
Pr	“The probability of”
PEDIG	Fortran 77 software package used for computation of inbreeding coefficients
r	Accuracy of selection of genetic gain
R ²	R-squared
RF	Rasmussen Factor
r _g	Genetic Correlation
SEX _j	Fixed effect of sex

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,
<i>vanrad.f</i>	The van Raden method for the computation of inbreeding coefficients
YC	iEBV for Young Horse competitions

YCD	iEBV for Young Horse competitions dressage
YCJ	iEBV for Young Horse competitions jumping
yijkl	Breeding value (iEBV)
ZSP	(Zuchtstutenprüfung) Own performance test of mares,
μ	Model constant

List of Figures

- Figure 1:** **23**
- Estimated relationship between the birth year and the genetic standard deviation of jumping, eventing and dressage horses in the the Selle Francais (SF) horse population (1974- 2002)
- Figure 2.** **30**
- Bar graph with corresponding line regression illustrating the relationship between years in which horses were born and the percentage (%) of inbreeding and coefficient of inbreeding in Selle Francais Warmblood horse populations from the year 1974 to 2002.
- Figure 3.** **46**
- Graph of the the year of birth and the inbreeding coefficient (Least Square Mean) of All horses with own performance and the Hanoverian bred horses.
- Figure 4.** **47**
- Graph of IBC (inbreeding coefficient) and the birth years of male and female subgroups.
- Figure 5:** **59**
- Histogram illustrating the relationship between various IBC classes and iEBV for all dressage horses, dressage horses with own performance, all jumping horses and jumping horses with own performance
- Figure 6:** **65**
- A linear regression illustrating the Performance index (iEBV) in relation to the year of birth for TID-Male, TIJ, TID-Female and TIJ-

List of Tables

Table 1.	31
Collates reported figures on IBC for specific breeds, and their authors.	
Table 2.	39
Pedigree completeness over the first 20 ancestral generations in a sample of N=84,724 Hanoverian Warmblood horses born 1990-2009.	
Table 3.	43
Traits correlating for both jumping and dressage horses correlated with heritability and genetic correlation.	
Table 4.	44
Traits of both jumping and dressage horses used in the breeding value (iEBV) and the weighted value for each trait.	
Table 5.	48
Breeding value for total dressage horses in relation to the R ² value and the linear regression coefficients for IBC (inbreeding coefficient) for TID, TCD,YCD,MPTD and SPTD.	
Table 6.	49
Breeding value for dressage horses with own performance in relation to the R ² value and the linear regression coefficients for IBC (inbreeding coefficient) for TID, TCD,YCD,MPTD and SPTD.	
Table 7.	50
Breeding value for total jumping horses in relation to the R ² value and the linear regression coefficients for IBC (inbreeding coefficient) for TIJ, TCJ,YCJ,MPTJ and SPTJ.	
Table 8.	51
Breeding value for jumping horses with own performance in relation to the R ² value and the linear regression coefficients for IBC (inbreeding coefficient)) for TIJ, TCJ,YCJ,MPTJ and SPTJ.	
Table 9.	53
Coefficient of IBC for dressage and jumping horses in relation to the average inbreeding level, the contribution of inbreeding to iEBV and the overall average iEBV for TID and TIJ.	

Table 10.	54
Illustrates the distribution of horses across the various classes of inbreeding coefficient.	
Table 11.	55
Breeding values for all dressage horses in relation to the R ² for each, over a variety of IBC classes for TID, TCD,YCD,MPTD and SPTD.	
Table 12.	56
Breeding values for horses with own performance in relation to the R ² for each, over a variety of IBC classes and the subsequent P-value for TID, TCD,YCD,MPTD and SPTD.	
Table 13.	57
Breeding values for all jumping horses in relation to the R ² for each, over a variety of IBC classes and the subsequent P-value for TIJ, TCJ,YCJ,MPTJ and SPTJ.	
Table 14.	58
Breeding values for jumping horse with own performances in relation to the R ² for each, over a variety of IBC classes and the subsequent P-value for TIJ, TCJ,YCJ,MPTJ and SPTJ.	
Table 15.	60
Dressage subgroups in relation to R ² value for all dressage and jumping horses (All horses and All horses with own performance) using Model 1 and Model 2. Total population sizes are N=84 724 and N=78 907.	
Table 16.	61
Independent variables in relation to source (model, IBC, Bsex and year), DF value, Sum of Squares, Mean Square value, F-value and Pr>F for iEBV Dressage (FE), iEBV Dressage (LC), iEBV Jumping (FE) and iEBV Jumping (LC).	
Table 17.	64
Sex (male and female) in relation to year, N, IBC, TID and TIJ.	

List of Equations

Equation 1:

24

Heritability

$$H^2 = V_G/V_P$$

H = Heritability

V_P = phenotypic variation

V_G = Genotypic variation

Equation 2:

32

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

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

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:

45

$$y_{ijkl} = \mu + b \text{IBC}_i + \text{SEX}_j + \text{BYEAR}_k + e_{ijkl}$$

y_{ijkl} = breeding value (iEBV)

μ = model constant

IBC_i = inbreeding coefficient of horse_i

SEX_j = fixed effect of sex

BYEAR_k = fixed effect of birth year class ($k=1-10$; 1990-1991, 1992-1993, ..., 2008-2009)

e_{ijkl} = random residual

Model 2:

45

$$y_{ijkl} = \mu + \text{IBCC}_i + \text{SEX}_j + \text{BYEAR}_k + e_{ijkl}$$

y_{ijkl} = breeding value (iEBV)

μ = model constant

IBCC_i = fixed effect of inbreeding coefficient class ($i=1-5$; $\text{IBC}=0.00$, $0.00 < \text{IBC} \leq 0.01$, $0.01 < \text{IBC} \leq 0.02$, $0.02 < \text{IBC} \leq 0.05$, $\text{IBC} > 0.05$)

SEX_j = fixed effect of sex ($j=1-2$; stallions, mares)

BYEAR_k = fixed effect of birth year class ($k=1-10$; 1990-1991, 1992-1993, ..., 2008-2009)

e_{ijkl} = random residual