



Martin Luther University Halle-Wittenberg
Institute of Agricultural and Nutritional Sciences (IANS)
Animal Breeding



70th EAAP Annual Meeting, 26 - 30 Aug 2019, Ghent, Belgium

Session 44 "Free communications in animal genetics" , Aug 28th, 2019



Heritabilities and genetic correlations of differently categorized fertility traits, udder and hoof diseases

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Introduction

- Improving welfare of livestock, i.e. health and longevity, ever increase in importance
- Detailed (genomic) EBV for health traits are now established for the Holstein breed in Germany
- Current definition of traits is 'No. of new cases per lactation'
- **Objective**
 - Descriptive statistics for years covered and no. of farms and herds
 - evaluation of on farm recorded health data, definition of traits for fertility disorders, and comparison with other health traits
- **Genetic - statistical analysis**
 - estimate variance components and breeding values (single trait AM)
 - estimate phenotypic and genetic correlations between differently categorized traits in multi-trait AM

Data collection

- **raw data**
 - 1,391,767 diagnoses from 01/01/2013 to 22/05/2017
 - 139,104 animals in 313 farms
- **edited data**
 - 66,112 lactations (46,772 animals)
 - 30,130 cows (one lact.), 13,944 (two lact.), and 2,698 cows (three lact.)
 - 25,720 heifers, 24,165 cows in 2nd and 16,227 cows in 3rd lactation
 - average of 1,407 lactations per herd (47 herds)
 - calving in 14 seasons (01/2013-02/2016)
 - 1,236 sires
- **Production means**
 - milk 9,592 kg fat 376 kg protein 322 kg

Trait definitions

categorized fertility disorders

- fertility disorders (all)
 - sterility disorders (all)
 - uterine sterility
 - ovarian sterility
 - post-partum disorders (all)
 - retained placenta
 - puerperal disorders

udder disease = Mastitis

hoof disorders (all)

Number of news cases and Incidences (per lactation)

▪ Different trait categories and individual traits (N=66,112 lactations)

Trait	No of new cases (nonc) / Frequency	Incidences (inc %)
Fertility disorders (all)	22,603	34.19
Sterility disorders (all)	18,331	27.73
Uterine sterility	8,523	12.89
Ovarian sterility	12,733	19.28
Post-partum disorders (all)	8,181	12.37
Retained placenta	4,806	7.27
Puerperal disorders	3,601	5.45
Udder disease / Mastitis	14,414	21.80
Hoof disorders (all)	16,187	24.48

Incidences per lactation

- **Different trait categories and individual traits** (N=66,112 lactations)

Trait	Mean (inc %)	1. Lac (inc %)	2. Lac (inc %)	3.Lac (inc %)
Fertility disorders (all)	34.19	35.24	33.39	33.71
Sterility disorders (all)	27.73	28.34	27.33	27.35
Uterine sterility	12.89	13.69	12.22	12.63
Ovarian sterility	19.28	19.46	19.21	19.01
Post-partum disorders (all)	12.37	13.25	11.45	12.36
Retained placenta	7.27	6.52	7.19	8.57
Puerperal disorders	5.45	6.87	4.61	4.42
Udder disease / Mastitis	21.80	17.59	23.33	26.20
Hoof disorders (all)	24.48	21.56	24.73	28.75

Statistical models

Mixed linear and threshold models (uni- and multivariate)

$$\text{BIN}(y_{abcd}=1) = \theta(\mu + \text{LNo}_a + \text{HYS}_{bcd})$$

$$\text{LIN}(y_{abcde}) = \mu + \text{LNo}_a + \text{HYS}_{bcd} + \text{lin}(\text{DIM}_e) \quad \leftarrow \text{DIM only with linear trait definitions}$$

with

y_{abcd}, y_{abcde} = Health trait per lactation

y_{abcd} (0 = no disease record; 1= at least 1 disease record)

y_{abcde} (0 = healthy; 1,..., no of new cases)

θ = Inverse of probit-Linkfunction

μ = mean

LNo_a = fix effect of Lactation (1.-3.)

HYS_{bcd} = fix effect of herd-year-saison

$\text{lin}(\text{DIM})_e$ = fix effect of linear regression of DIM per lactation

Results

Estimates of heritabilities for **binary** and linear fertility traits

(inc = incidence, threshold model / nonc = number of new cases, linear model)

(N=66,112)

Fertility disorders (all)		Sterility (all)		Post-partum disorders (all)	
inc	nonc	inc	nonc	inc	nonc
0.131 (0.008)	0.050 (0.006)	0.123 (0.009)	0.039 (0.005)	0.111 (0.011)	0.033 (0.005)

Results

Estimates of heritabilities for **binary** and linear traits

(inc = incidence, threshold model / nonc = number of new cases, linear model)

(N=66,112)

Mastitis		Hoof disorders (all)	
inc	nonc	inc	nonc
0.131 (0.008)	0.057 (0.006)	0.188 (0.009)	0.108 (0.009)

Results

Estimates of heritabilities for linear fertility traits

(number of new cases = nonc)

(N=66,112)

Uterine sterility	Ovarian sterility	Retained placenta	Puerperal disorders
nonc	nonc	nonc	nonc
0.017 (0.003)	0.033 (0.005)	0.021 (0.003)	0.013 (0.003)

Results

Estimates of heritabilities and correlations with milk yield

(N=66,112)

Trait 1 (nonc)	h^2 trait 1	h^2 milk yield	r_p trait1,milk	r_g trait1,milk
Fertility disorders (all)	0.051 (0.0131)	0.397 (0.0131)	0.050 (0.0046)	0.179 (0.0544)
Sterility disorders (all)	0.041 (0.0057)	0.397 (0.0134)	0.062 (0.0046)	0.163 (0.0588)
Uterine sterility	0.017 (0.0035)	0.397 (0.0131)	-0.007 (0.0044)	-0.002 (0.0800)
Ovarian sterility	0.034 (0.0510)	0.396 (0.0131)	0.075 (0.0045)	0.179 (0.0620)

Results

Estimates of heritabilities and correlations with milk yield

(N=66,112)

Trait 1 (nonc)	h^2 trait 1	h^2 milk yield	r_p trait1,MY	r_g trait1,MY
Post partum disorders (all)	0.033 (0.0050)	0.397 (0.0131)	-0.019 (0.0045)	0.245 (0.0625)
Retained placenta	0.021 (0.0036)	0.396 (0.0131)	-0.030 (0.0044)	0.302 (0.0722)
Puerperal disorders	0.013 (0.0034)	0.397 (0.0131)	-0.006 (0.0044)	0.082 (0.0898)
Mastitis	0.056 (0.0062)	0.396 (0.0131)	0.000 (0.0047)	0.355 (0.0513)
Hoof disorders (all)	0.108 (0.0091)	0.397 (0.0131)	0.002 (0.0050)	0.206 (0.0430)

Results

Estimates of heritabilities and correlations with mastitis

Mastitis (nonc) (N=66,112)

Trait 1 (nonc)	h^2 trait 1	h^2 Mastitis	r_p trait1,mastitis	r_g trait1,mastitis
Sterility disorders (all)	0.039 (0.005)	0.057 (0.006)	0.036 (0.004)	0.021 (0.091)
Uterine sterility	0.017 (0.003)	0.057 (0.006)	0.012 (0.004)	-0.038 (0.111)
Ovarian sterility	0.033 (0.005)	0.057 (0.006)	0.036 (0.004)	0.030 (0.948)
Post partum disorders (all)	0.034 (0.005)	0.057 (0.006)	0.039 (0.004)	0.405 (0.083)
Retained placenta	0.022 (0.003)	0.057 (0.006)	0.025 (0.004)	0.484 (0.086)
Puerperal disorders	0.013 (0.003)	0.057 (0.006)	0.027 (0.004)	0.166 (0.123)

Results

Estimates of heritabilities and correlations with hoof disorders

Hoof diseases (all) (nonc) (N=66,112)

Trait 1 (nonc)	h^2 trait 1	h^2 Hoof (all)	r_p trait1,hoof(all)	r_g trait1,hoof(all)
Sterility disorders (all)	0.040 (0.005)	0.108 (0.009)	0.088 (0.004)	0.430 (0.070)
Uterine sterility	0.017 (0.035)	0.108 (0.003)	0.042 (0.004)	0.201 (0.094)
Ovarian sterility	0.034 (0.005)	0.108 (0.009)	0.080 (0.004)	0.389 (0.076)
Post partum disorders (all)	0.030 (0.005)	0.111 (0.009)	0.045 (0.004)	0.409 (0.071)
Retained placenta	0.022 (0.003)	0.109 (0.009)	0.017 (0.004)	0.274 (0.088)
Puerperal disorders	0.015 (0.009)	0.110 (0.009)	0.049 (0.004)	0.487 (0.094)

Conclusions (1)

- Heritability estimates for fertility disorder traits appear to be low
- In general, estimates for fertility, udder, and hoof diseases (defined as $\text{nonc} = \text{no of new cases}$) are in the range of values found in the literature
- Break-down of all fertility disorders into sub-categories adds only little information (r_g varies)

Conclusions (2)

- All health traits analyzed exhibited a numerically positive genetic correlation with milk yield
 - ➔ this underlines the antagonism between production and health
- Non-zero genetic correlations of fertility disorder traits with other diseases do exist
 - Post partum disorders with mastitis
 - Sterility disorders and post partum disorders with hoof disorders
 - ➔ common genetic background could be metabolic stability

Acknowledgement

Project Partners

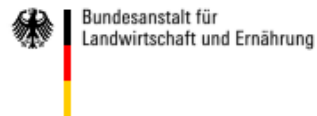
Breeding organisations

Farms & Health Management agencies

GKUH *plus*
GESUNDHEITSMONITORING



Deutsche Innovationspartnerschaft
dip Agrar



The project was supported by funds of the German Government's
Special Purpose Fund held at Landwirtschaftliche Rentenbank


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*...and Thank YOU
for Your Attention!*