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Comparative analyses of health traits from regional projects for genetic improvement of dairy health

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Background

- increasing importance of functional traits in dairy: intense R&D activities particularly in the field of health (internationally, see ICAR survey 2012)
- comprehensive key for health data recording (Germany) → basis for standardized recording and analyses, but
  - no general concept of health monitoring,
  - considerable differences regarding start-up conditions of health monitoring,
  - no uniform rules for continuous health monitoring (recording practices, efforts to address data quality issues)

Study approach

- sources of health data
  - veterinarians (selected spectrum of exact diagnoses)
  - expert groups like claw trimmers or feed consultants (small spectrum of specific diagnoses: claws, nutrition)
  - owners (indirect involvement of vet. and non-vet. experts; broad spectrum of diagnoses and further health-related data)
- different on-farm conditions
  - traditional farming (relatively small herd sizes, limited routine documentation on paper, blackboard, ...)
  - technically supported farming (relatively large herd sizes, extensive use of herd management software)

Do we arrive at the same conclusions regarding selection decisions for improved health?

Basis of comparative analyses

- same comprehensive key for health data recording in different herd management software (HMS)
  - hierarchical structure → user-defined recording specificity
  - from very general (e.g. Mastitis) to very specified (e.g. Chronic catarrhal mastitis)

  ⇒ user-acceptance
  + suitability for central analyses on various specificity levels
- regional cooperation partners and use of existing infrastructure

  → documentation of health events by farmers via HMS

  → transfer to central health data base (vit)

Outline of regional projects

Key figure	GKuh	THU
Region in Germany	Northwest (Osnabrück)	Mideast (Thuringia)
Starting point	No existing health-recording system → installation with intense on-farm support	Long-term experience in electronic documentation (incl. health data) → some adjustments
Number of farms	51	19
Farm size (average no. of cows per farm 2010/2011)	96 (max. 546)	802 (max. 1.709)
Time horizont	01.01.2010 - 30.06.2012	01.01.2009 - 30.06.2012
Total no. of females (all farms, whole period)	**16,179 incl. 9,278 cows**	**50,277 incl. 29,763 cows**
Total no. of diagnoses → health events / diseases	21,778 → 20,491	436,769 → 197.081
No. of animal with ≥ 1 diagnosis record	7,127	34,596

documentation of first diagnoses (GKuh) vs. first diagnoses + further treatments (THU)

Definition of health traits

- available health information:
  diagnosis + date + location (if applicable: quarter of the udder, limb)
- diseases with period of risk within each lactation
  → observation unit: animal X lactation
- lactation incidence rates (LIR) as measures for the quantitative importance of diagnoses
  - affected = at least one diagnosis record
  - unaffected = at risk without diagnosis

$$LIR = \frac{\text{affected lactations}}{\text{affected+unaffected lactations}}$$

- quasi-continuous coding
  number of health events in a given lactation (accounting for repeated occurrence of disease and multiple affections)
  → diseases with longer periods of risk and/or multiple locations

Lactation incidence rates (LIR)

	GKuh		THU	
Trait	**n**	**LIR (%)**	**n**	**LIR (%)**
Early Mastitis (-10 to 50 DIM)	**11,555**	**13.6**	**41,118**	**24.4**
Early Mastitis (L2ff)	7,218	13.5	26,300	24.8
Late Mastitis (51 to 305 DIM)	**8,833**	**22.1**	**34,015**	**35.8**
Late Mastitis (L2ff)	6,000	26.0	22,068	42.3
Retained placenta	**12,111**	**7.9**	**43,132**	**11.9**
Ovary cycle disturbances	**8,553**	**9.9**	**34,239**	**41.4**
Ketosis	**11,446**	**4.8**	**40,245**	**3.3**
Milk fever	**12,198**	**6.5**	**44,335**	**3.7**
Abomasal displacement to the left	**10,261**	**4.5**	**37,192**	**2.9**
Non-purulent claw diseases	**8,362**	**9.9**	**33,161**	**28.9**
Interdigital hyperplasia / Corns	8,259	4.6	29,440	10.5
Purulent claw diseases	**8,982**	**28.9**	**35,303**	**46.1**
Ulcers	8,402	11.0	30,104	16.3
Digital dermatitis / Mortellaro	8,501	14.0	30,202	18.3
Digital phlegmon / Panaritium	8,356	7.6	29,967	17.0

Disease focusses:
- **udder**
- **claws**
- **reproduction**
- **metabolism**

Heterogeneity:
- **extent of routine screenings (impact on diagnosis rates),**
- **documentation agreements, e.g. lameness-related vs. all claw diseases**

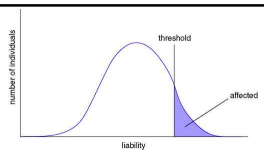
Genetic analyses

- separate by data origin (GKuh, THU)
- variance component estimation with REML (VCE6), genetic evaluation with BLUP (PEST)
- repeatability linear animal model
- correlation analyses based on univariately estimated breeding values (EBV) from GKuh and THU

$$y_{ijkl} = \mu + PAR_i + hys_j + pe_k + a_k + e_{ijkl}$$

with PAR_i = fixed effect of parity class,
hys_j = random effect of herd X year-season of calving,
pe_k = random permanent environmental effect of the animal,
a_k = random additive genetic effect of the animal,
e_{ijkl} = random residual

Heritabilities



Trait	GKuh h^2 ($h^2_{tr\ NV}$)	THU h^2 ($h^2_{tr\ NV}$)
Early Mastitis (-10 to 50 DIM)	**0.091**	**0.034**
Early Mastitis (L2ff)	0.110	0.038
Late Mastitis (51 to 305 DIM)	**0.089**	**0.078**
Late Mastitis (L2ff)	0.140	0.087
Retained placenta	**0.017** (0.055)	**0.048** (0.126)
Ovary cycle disturbances	**0.008**	**0.036**
Ketosis	**0.036** (0.163)	**0.034** (0.198)
Milk fever	**0.022** (0.080)	**0.024** (0.132)
Abomasal displacement to the left	**0.026** (0.124)	**0.030** (0.189)
Non-purulent claw diseases	**0.024**	**0.083**
Interdigital hyperplasia / Corns	0.036	0.133
Purulent claw diseases	**0.079**	**0.092**
Ulcers	0.067	0.077
Digital dermatitis / Mortellaro	0.004	0.099
Digital phlegmon / Panaritium	0.031	0.050
	SE_{h^2} ≤0.03	SE_{h^2} ≤0.01

Genetic determination of health traits: h^2 ~ 0.03-0.12

Heterogeneity:
- **extent of routine screenings (impact on diagnosis rates),**
- **documentation agreements, e.g. lameness-related vs. all claw diseases**

some impact on variance components

Estimated breeding values (EBV)

- many bulls with mostly few daughters in each of the projects
  → few bulls with reliable EBV for health traits
- small basis of analyses across projects (EBV correlations):
  - few bulls (N=249) with daughters in both projects
  - very few bulls (N=53) with ≥ 10 daughters in each of the projects

Key figure	GKuh	THU
No. of bulls	820	1,437
→ No. of daughters	10.3 (1 - 1,242)	19.7 (1 - 1,012)
No. (%) of bulls with ≥10 daughters	149 (18%)	570 (40%)
→ No. of daughters	44.8	44.3
No. (%) of bulls with ≥10 daughters each	53 (6% | 4%)	
→ No. of daughters	78.4 | 63.9	

No. of progeny (n)	EBV reliability *			
	h^2=0.05	h^2=0.07	h^2=0.10	h^2=0.15
5	0.06	0.08	0.11	0.16
10	0.11	0.15	0.20	0.28
15	0.16	0.21	0.28	0.37
20	0.20	0.26	0.34	0.44
25	0.24	0.31	0.39	**0.49**
50	0.39	**0.47**	**0.56**	**0.66**
75	**0.49**	**0.57**	**0.66**	**0.75**

* approximation: $r^2 = n / (n + k)$ with $k = (4 - h^2) / h^2$

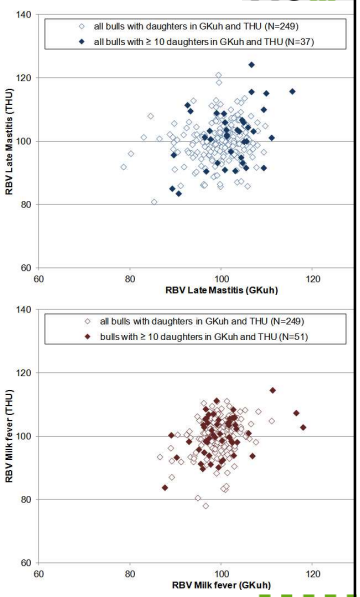
EBV correlations (I)

correlations between EBV for corresponding health traits from GKuh and THU

	B10_2		B_rel15	
Trait	**N**	**r**	**N**	**r**
Early Mastitis (-10 to 50 DIM)	50	0.28	36	0.36
Early Mastitis (L2ff)	29	0.29	26	0.23
Late Mastitis (51 to 305 DIM)	37	0.40	45	0.40
Late Mastitis (L2ff)	26	0.45	42	0.30
Retained placenta	51	0.25	15	0.27
Ovary cycle disturbances	35	0.33	5	0.19
Ketosis	50	0.42	23	0.42
Milk fever	51	0.39	11	0.50
Abomasal displacement to the left	41	0.43	14	0.59
Purulent claw diseases	37	0.55	42	0.50

B10_2 = bulls with ≥ 10 daughters in each of the projects,
B_rel15 = bulls with EBV reliabilities ≥ 15% in each of the projects

significantly positive correlations between EBV for analogous health traits



EBV correlations (II)

correlations between EBV for health traits and selected EBV from routine genetic evaluation (bulls with ≥ 10 daughters within project):

	GKuh					THU				
Trait	**N**	**EBV$_{health}$**	**Routine EBV (1208)**			**N**	**EBV$_{health}$**	**Routine EBV (1208)**		
			RZM	**RZN**	**#RZS / *RZR**			**RZM**	**RZN**	**#RZS / *RZR**
Early Mastitis (-10 to 50 DIM)	130	75 - 115	+0.03	+0.19	+0.30 #	504	75 - 122	-0.10	+0.33	+0.43 #
Early Mastitis (L2ff)	64	73 - 114	+0.06	+0.21	+0.33 #	355	77 - 120	-0.01	+0.39	+0.47 #
Late Mastitis (51 to 305 DIM)	88	88 - 116	-0.15	+0.30	+0.24 #	434	79 - 124	-0.12	+0.32	+0.45 #
Late Mastitis (L2ff)	54	85 - 114	-0.27	+0.18	+0.22 #	307	78 - 122	-0.16	+0.30	+0.46 #
Retained placenta	137	88 - 114	-0.17	+0.24	+0.24 +	520	77 - 117	-0.09	+0.08	+0.10 +
Ovary cycle disturbances	84	86 - 112	-0.08	+0.29	+0.21 +	449	68 - 124	-0.10	+0.29	+0.32 +
Ketosis	126	85 - 115	+0.06	+0.20		502	77 - 119	-0.02	+0.10	
Milk fever	137	86 - 123	-0.02	+0.05		524	68 - 116	-0.01	+0.13	
Abomasal displ. to the left	104	82 - 112	-0.22	+0.37		469	74 - 118	+0.20	+0.15	
Purulent claw diseases	94	86 - 115	+0.01	+0,21		444	76 - 128	+0.19	+0.23	

RZM = EBV for milk yield, RZN = EBV for functional herd life (longevity), RZS = EBV for somatic cell score, RZR = EBV for reproduction

Conclusions

- owner-recorded health data from distinct projects as valuable sources of information for genetic analyses
- impact of health monitoring systems
  - trait-dependent (diseases with high rates of subclinical cases)
  - trait distributions (LIR) > genetic parameters
    → some re-ranking among the quantitatively important health traits, but similar heritabilities of mostly 0.03-0.12
- promising results of comparative analyses based on EBV for health traits (similar selection decisions)
  ↔ limited data within project + regional use of bulls

Implications

- different challenges within projects (start-up / implementation of health monitoring vs. adjustments of routine on-farm documentations)
- high quality of owner-recorded health data requiring intense expert support and continuous communication between all cooperation partners
- informative and helpful health reports as immediate rewards for the owners ensuring continuous data flow
- use of experiences from distinct projects for extending collection & combining analyses of health data
  → sound basis for genetic evaluation for health traits to allow selection for improved health and longevity

owners of participating farms

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