vit IT-Solutions for Animal Production

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Strategies for introducing new traits in routine genetic evaluations for dairy cattle in Germany: Health traits in the focus of R&D

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Overview

I. General framework

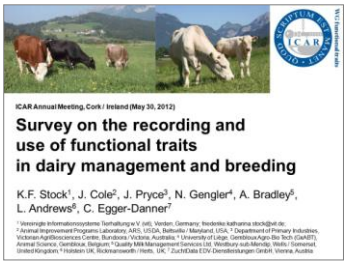
- functional traits in international dairy breeding
- health - longevity - sustainability

II. Health monitoring in dairy cattle in Germany

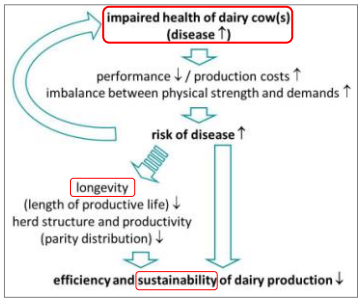
- development
- available applications
- perspectives

International dairy breeding

- substantial genetic progress in <u>production traits</u> of dairy cattle
  - routine performance testing
    (quantity and quality of phenotype data)
  - conventional and genomic breeding programs
- increasing importance of <u>functional traits</u>
  - integral parts of dairy breeding programs
  - increasing weights in selection indices
    ⇔ relevance of **sustainability** aspects ↑
  - in the focus of R&D activities worldwide:
    health (direct health traits)
    >> **longevity / survival** > efficiency



Sustainability improvement



- new goal-setting with shift
  from short-term and individual
  to long-term and global benefits
- <u>challenges of target definition</u>
  - identification of suitable indicators
    complex interplay of multiple factors on various levels
  - reliable and sufficiently broad information basis
    data sources (documentation routines or automated measurement vs. new recording),
    data accessibility (increase of on-farm data collection ≠ data transfer for routine analyses)
- approaches
  - global measure → **longevity**
  - major determinants → **health**

PRO easy to measure, established population-wide data collection (data quantity)
CON heterogeneous causes / influences

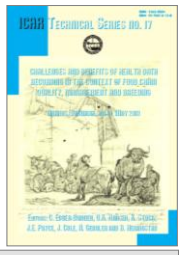
PRO specificity (data quality)
CON difficult and expensive to measure, often insufficient population-coverage

HEALTH in the focus (I)

- international trend in dairy breeding: replacing indirect by **direct selection for improved health**

✓ ■ framework across countries

- <u>increased legal requirements</u> regarding animal health issues
  heterogeneity of regulations ↓, pressure on livestock sector ↑
- <u>increased awareness</u> of the need for targeted health improvement
  new phenotypes in the context of methodological progress ('better' traits, specific rather than global trait definitions)



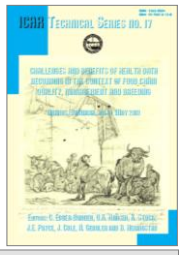
HEALTH in the focus (II)

- international trend in dairy breeding: replacing indirect by **direct selection for improved health**

✓ ■ framework across countries

✓ ■ <u>motivations</u> for using health traits in breeding

- societal demands:
  responsible modern livestock production
  (animal health and welfare; public reputation of agriculture, politics)
- dairy sector demands:
  optimized production conditions
  (productivity, production efficiency, profitability; economics)
- consumer demands:
  transparency and reliability
  (food safety, product quality)



HEALTH in the focus (III)

- international trend in dairy breeding: replacing indirect by **direct selection for improved health**
- ✓ framework across countries
- ✓ <u>motivations</u> for using health traits in breeding
- X <u>challenges</u> related to working with health data
  - legislation, information / transparency, data sensitivity, data security
  - data recording and logistics
  - data quality, validation, data processing and analysis, interpretation

HEALTH in the focus: German situation

Health traits in dairy breeding

Current status → prospects

unsatisfactory situation with few settled routines for direct health traits, but quite a lot underway!

Tab.: Genetic evaluations (GE=routine, R&D=prospected) for direct health traits.

Country	UDDER HEALTH		FEMALE REPRODUCTION		METABOLIC HEALTH		HEALTH OF FEET & LEGS	
	GE	R&D	GE	R&D	GE	R&D	GE	R&D
Austria *	U1		R1,R3	R4	M1	M4		F2,F3
Canada	U1			R3,R4,R5		M1,M2,M3		F3
Denmark, Finland, Sweden	U2		R1,R2		M1,M2		F2	F1
Germany		U3,U4		R3, R4, R5, R6		M1,M2,M3		F1
France	U1							F1
Norway	U1		R4	R7	M1,M2			F1
Switzerland		U1		R7		M4		F2
The Netherlands							F1	
USA		U1		R3,R4,R5		M2,M3		F3

U1 mastitis, U2 clinical mastitis, U3 early mastitis, U4 late mastitis; R1 early reproduction disorders, R2 late reproduction disorders, R3 cystic ovaries, R4 retained placenta, R5 metritis, R6 ovary cycle disturbances, R7 fertility-related disorders / reproduction disorders; M1 milk fever, M2 ketosis, M3 displaced abomasum, M4 metabolic disorders; F1 individual claw diseases (e.g. digital dermatitis, sole ulcer), F2 feet and leg diseases, F3 lameness
* joint GE for Austrian German Fleckvieh and Brown Swiss

Federal state	Health project / program	Data recording
BaW	"Gesundheitsmonitoring Rind BW"	VET+HM, from 2010
Bay	"ProGesund"	VET+HM, from 2012
Brb	RBB contract herds	HM, from 2009
Hes	"HVL-Gesundheit"	HM, from 2013/2014
MV	RMV contract herds "ProFit"	HM, from 2005
Nds	"GKuh"* and other herds (not project-related)	HM, from 2010
RPf	"Gesundheitsmonitoring Rind RLP"	HM, from 2013
Sac	"Fitnessmonitoring Sachsen"	HM, from 2000
	"Zukunftsforum Veredlungsland Sachsen 2020"	HM, from 2011
SaA	"BHNP"* and other herds (not project-related)	HM, from 2010
	"YHealth"**	HM, from 2015
SH	"KuhVital"	VET+HM, from 2014
Thu	selected farms	HM, from 2007
	"BHNP"* and other herds (not project-related)	HM, from 2009

VET = veterinarian (compulsory treatment documentation a.o.), HM = herd management / on-farm documentation of health events (veterinary diagnoses a.o.), * Innovation project funded by the Federal Office for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung, BLE), ** project funded in the Innovation program of the Landwirtschaftliche Rentenbank (LR)

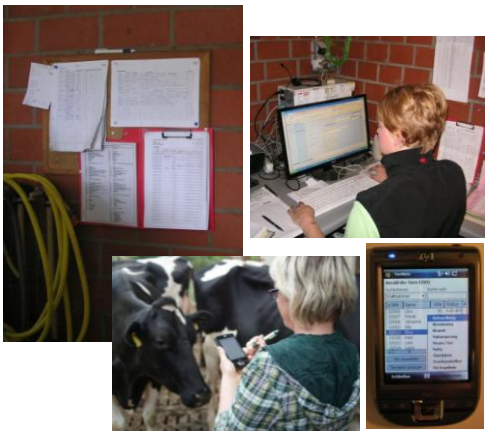
- **worldwide still few GE routines for direct health traits**
  - in Germany none for Holsteins
- **multiple and diverse R&D projects**
  - in Germany several strong initiatives with vit involvement

Development of health data recording

- standardization and harmonization of phenotype data collection as basis of reliable genetic and genomic evaluations
- early engagement in the German dairy sector (incl. vit / VIT-PCS) for systematic recording and use of health data
  - central health key (Staufenbiel 2003)
  - guidelines and standard for health data recording (ADR 2005)
  - practice-oriented development with scientific input (veterinary medicine, animal breeding; since 2005/2007)
  - national reference as model for international reference: ICAR guidelines for Recording, Evaluation and Genetic Improvement of Health Traits with ICAR Central health key (ICAR 2012)

➢ **FAVORABLE STARTING POINT**

Health data recording in practice (I)



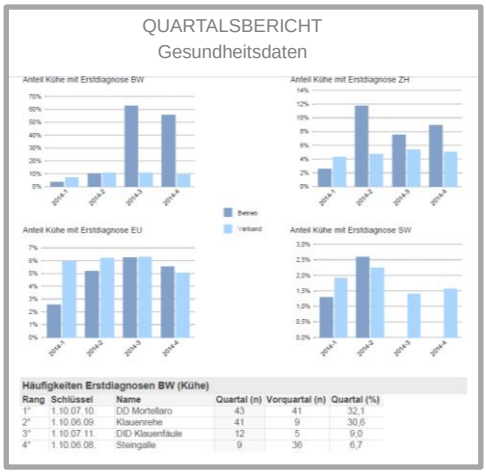
Knowledge and tools

- outcome of collaborative research:

- specific requirements in the field (dependent on herd size, resources, ...)
- on-farm documentation as valuable source of health data for management and breeding purposes (independent of herd size, resources, ...)
- **user-friendly and demand-oriented health monitoring tools** as determinants of compliance
- visible benefit as key to success: motivation (continuity, completeness), intrinsic data quality control

➢ **FAVORABLE STARTING POINT**

Health data recording in practice (II)



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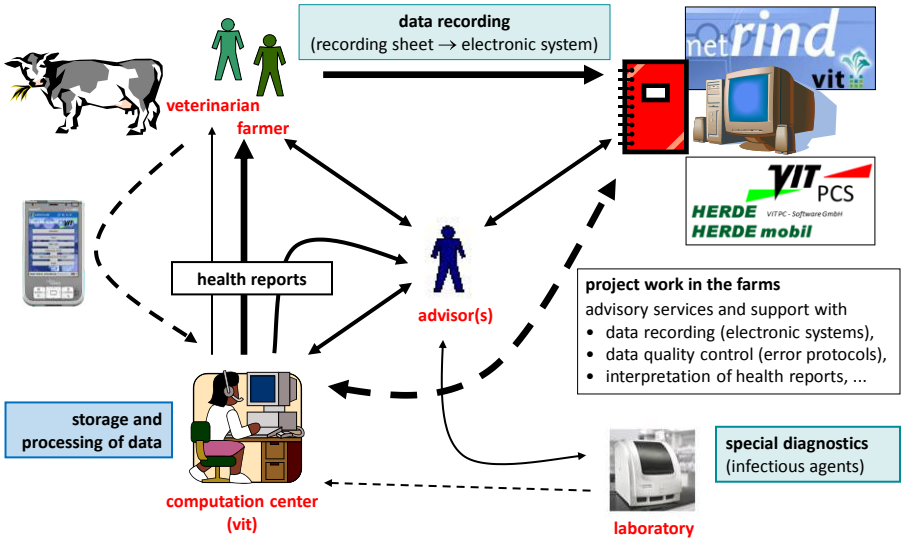
- **visible benefit** as key to success: motivation (continuity, completeness), intrinsic data quality control
  → **health reports**, EBV for health traits

Flow of health data



Crucial transition form R&D to routine

- acceptance of specialties of working with health data
  - challenging phenotyping (quality, quantity)
  - challenging analyses and interpretation of results
- shift from short-term to long-term planning
  - departure from (supported) project work with 'islands of data'
  - **arrival at self-carrying routines for health data**
  - needs for generating and visualizing benefits
    - tools for optimizing herd management and improved selection decisions
      (more farsighted, considering health and sustainability aspects)
    - direct health information as basis of new health-related phenotypes and of improved definitions / modelling of established functional traits
      (prerequisite for identification and calibration of biomarkers, validation variable)

➢ **TO DO: SETUP OF SUSTAINABLE CONCEPTS FOR HEALTH & SUSTAINABILITY IMPROVEMENT**

GKUHplus Project

- German innovation partnership
  - experienced project partners (successful regional health projects)
  - linking of knowledge and expertise (national initiative)
- comprehensive concept
  - interdisciplinary and integrative (on-farm records, veterinary data)
  - supra-regional coverage
  - linking of knowledge and expertise
- synergistic effects of collaboration
  - for project partners
  - for the whole German dairy sector

project period: 9 Jan 2014 to 31 Dec 2016
project coordination: vit (F. Reinhardt / K.F. Stock)

Central health data base (vit)

Parameter	*Nds*	*RPf*	*Hes*	*Thu*	*SaA*	*Sac*
Data recording system (herd management software)	NETRIND a.o.			HERDE a.o.		
No. of herds	**86**	**49**	**70**	**26**	**5**	**5**
Start of health data recording	1 Jan 2010	1 Sep 2013	1 Dec 2013	1 Jan 2009	1 Jan 2010	1 Jan 2011
Herd size (average no. of cows per herd in 2014)	N_{herds}=57: 113 (32-621)	N_{herds}=47: 96 (5-277)	N_{herds}=61: 97 (24-314)	N_{herds}=23: 766 (204-1.692)	N_{herds}=5: 637 (316-738)	N_{herds}=5: 795 (317-1.842)
Health data in total	health records from 241 dairy farms in 6 federal states: **about 1.2 mio. diagnoses referring to 0.6 mio. disease events,** **> 260,000 health monitored animals (123,888 animals with diagnoses),** including about 175,000 females (~83,000 cows + 92,000 calves/heifers)					

Health data from 01/2009 - 12/2014 (vit, 12 Jan 2015)

strengthening of central analyses
= completing the complex picture
(health, performance, genetics, environment)

Parameter	*BaW*
Data recording system	RDV4M, RDV4Vet
No. of herds	**1,030 (155 veterinary practices)**
Start of health data recording	end of 2010
Health data in total	**>250,000 diagnoses, 60,000 dairy cows, 54,000 heifers**

(LKV BW, 11 Nov 2014)

Routine health data analyses (vit)

I. Management

- health reports
  - monthly, quarterly, yearly formats
  - prototype available since 2010 (pilot farms)
  - continuous optimization for and with the dairy farmers
- major motivation factor → factor of success
  - ✓ everyday support (farm personnel, advisory services)
  - ✓ proof of good investment in thorough data recording (added value; self-learning process: data quality, continuous data flow)
  - ✓ **short- to medium-term visibility of the benefits of health monitoring: improved animal health status** (and performance)
- improvement level: individual farm

Routine health data analyses (vit)

II. Breeding

- genetic evaluation for direct health traits
  - quarterly (test runs)
  - first EBV for direct health traits (regional estimation basis) in 2012
  - continuous development (traits, models, multiple regions)
- additional motivation factor → factor of consolidation
  - ✓ targeted support of selection decisions
  - ✓ future-oriented and competitive breeding programs
  - ✓ **long-term and sustainable improvement of animal health**
- improvement level: population

Genetic parameters

Health trait	N	LI [%]	h^2
Early mastitis (-10 to 50 DIM)	149,256	19.5	**0.04**
Late mastitis (51 to 305 DIM)	131,457	33.8	**0.10**
Retained placenta	151,930	12.1	**0.05**
Ovary cycle disturbances (sterility)	139,994	25.6	**0.03**
Ketosis	109,614	3.8	**0.02**
Milk fever	138,123	5.2	**0.03**
Abomasal displacement to the left	131,756	2.7	**0.03**
Non-purulent claw diseases	128,203	20.0	**0.08**
Interdigital hyperplasia / Corns	106,101	6.8	**0.15**
Laminitis	112,759	12.3	**0.06**
White line defect	104,191	5.1	**0.07**
Purulent claw diseases	136,985	38.1	**0.07**
Claw ulcers	98,641	16.9	**0.10**
Digital phlegmon / Panaritium	94,841	13.6	**0.08**
Digital dermatitis / Mortellaro	104,236	21.4	**0.06**

LI = no. of lactations with ≥1 diagnosis / total no. of lactations at risk; $SE_{h^2} < 0,01$

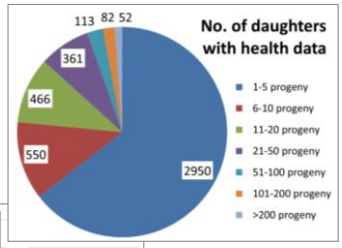
Outline of genetic analyses:

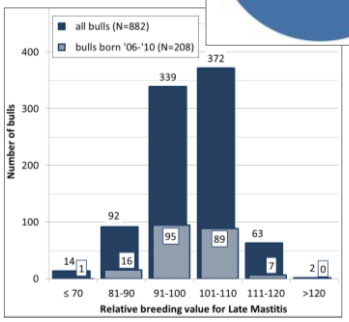
- major health issues of dairy cows
  (udder health / mastitis, claw diseases, reproduction disorders, metabolic disorders)
- diagnosis + localization,
  no. of disease events per parity
- single- and multiple-trait repeatability linear animal models
  $y_{ijkl} = \mu + PAR_i + hys_j + pe_k + a_k + e_{ijkl}$
- **usable genetic variation**
  with mostly h^2=0.05-0.10
  (claw, udder > reproduction, metabolism)

***Tab.: Heritabilities (h^2) for direct health traits** with total number of lactations (N) and lactation incidences (LI); health data 01/2009 - 12/2014 (variance component estimation REML/VCE6 1406)*

Breeding values

GE prototype / Holstein (GKUHplus test run 1406)





Genetic evaluation:

- in total 72,269 animal with health data considered
  (relationship matrix: 237,557 animals)
- average EBV reliabilities still low: 4,574 bulls with 15.8 daughters (range 1-1,853)
- **EBV reliability ≥ 0.5: about 240 Holstein bulls**

h^2	Number of progeny (n)						
	5	10	15	20	25	50	75
0.05	0.06	0.11	0.16	0.20	0.24	0.39	**0.49**
0.07	0.08	0.15	0.21	0.26	0.31	**0.47**	**0.57**
0.10	0.11	0.20	0.28	0.34	0.39	**0.56**	**0.66**
0.15	0.16	0.28	0.37	0.44	**0.49**	**0.66**	**0.75**

Tab.: *Reliabilities of estimated breeding values in dependence on heritability (h^2) and number of progeny (n); approximation as $r^2 = n / (n + k)$ with $k = (4 - h^2) / h^2$*

EBV correlations

GE prototype / Holstein (GKUHplus test run 1406)

Health trait	Health EBV (test run 1406)	EBV from routine GE 1412					
		RZG	RZM	RZN	RZS	RZE	RZR
Early mastitis (-10 to 50 DIM)	66 - 125	**+0.17**	**-0.14**	**+0.38**	**+0.5**4	+0.12	**+0.14**
Late mastitis (51 to 305 DIM)	67 - 123	**+0.15**	**-0.15**	**+0.38**	**+0.55**	+0.09	**+0.18**
Retained placenta	70 - 122	+0.12	-0.09	**+0.31**	+0.12	+0.11	**+0.23**
Ovary cycle disturbances (sterility)	63 - 125	**+0.14**	-0.11	**+0.42**	**+0.21**	+0.06	**+0.30**
Ketosis	77 - 119	+0.03	-0.06	**+0.19**	+0.09	**-0.17**	**+0.17**
Milk fever	78 - 122	**+0.20**	**+0.19**	+0.09	+0.07	-0.05	+0.05
Abomasal displacement to the left	66 - 117	**+0.17**	+0.09	**+0.24**	+0.03	**-0.13**	**+0.14**
Non-purulent claw diseases	63 - 138	**+0.36**	**+0.18**	**+0.35**	**+0.20**	+0.10	+0.06
Interdigital hyperplasia / Corns	52 - 131	**+0.23**	+0.10	**+0.26**	**+0.13**	+0.06	+0.01
Laminitis	68 - 145	**+0.33**	**+0.17**	**+0.32**	**+0.21**	+0.12	±0.00
White line defect	65 - 145	**+0.31**	**+0.17**	**+0.25**	**+0.18**	**+0.14**	+0.06
Purulent claw diseases	68 - 133	**+0.34**	**+0.16**	**+0.38**	**+0.21**	-0.02	+0.06
Claw ulcers	71 - 135	**+0.32**	**+0.15**	**+0.36**	**+0.22**	+0.01	+0.06
Digital phlegmon / Panaritium	72 - 128	**+0.28**	+0.09	**+0.37**	**+0.22**	+0.06	+0.03
Digital dermatitis / Mortellaro	54 - 142	**+0.20**	+0.12	**+0.23**	+0.12	-0.12	+0.02

RZG = total, RZM = milk production, RZN = longevity (functional herd life), RZS = somatic cell score, RZE = conformation, RZR = reproduction

Tab.: Pearson correlation coefficients between estimated breeding values (EBV) *for direct health traits and composite breeding values from routine genetic evaluation for 234 German Holstein bulls with EBV reliability ≥ 50% for at least one of the direct health traits (health data 01/2009 - 03/2014)*

New health phenotypes

- dairy cow as main target of
  systematic recording and use of health data (health monitoring)
- currently too little emphasis on the juvenile health status
  (**<u>Young</u> Health**) of dairy cattle
  - losses in the rearing period
    ('longevity' → 'survival')
  - long-term impact of diseases
    in the growth period
    (development, performance,
    general disease susceptibility)

YHealth

The project is supported by funds of the Landwirtschaftlichen Rentenbank.

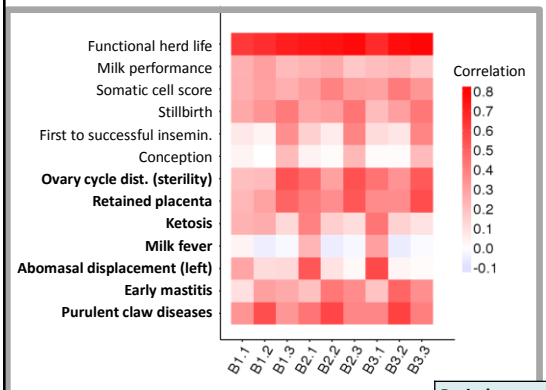
rentenbank

Bundesanstalt für Landwirtschaft und Ernährung

project period: 1 Oct 2014 to 30 Sep 2017
project coordination: vit (F. Reinhardt / S. Jansen)

→ (further) extension of the phenotypic data basis for exploiting the potential of genomic applications for health traits

New traits & routine applications



<u>R&D on longevity:</u>

- differentiated genetic determination of survival in different time periods
  (N=3 distinct periods in lactations 1-3)
- multiple-trait linear sire model
- correlation analyses using EBV from routine GE and R&D on **health traits (→ validation)**
  plausible patterns, support of the new trait definitions ('partitioning concept')

Period within lactation (L)	L1 abbr.	L1 h2	L2 abbr.	L2 h2	L3 abbr.	L3 h2
0 - 49 DIM	B1.1	0.085	B2.1	0.082	B3.1	0.103
50 - 249 DIM	B1.2	0.080	B2.2	0.091	B3.2	0.087
250 - next calving	B1.3	0.062	B2.3	0.064	B3.3	0.066

Tab.: Transformed heritabilities (h^2) of the new longevity traits

Förderverein Biotechnologieforschung e.V.

Conclusions (I)

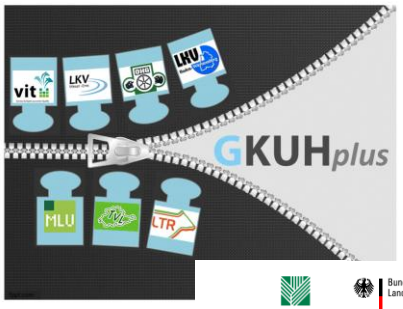
- important role of **health traits** in current R&D in dairy cattle
  - multi-dimensional motivation
    to working with direct health traits
  - multiple and special challenges
    requiring integrative and interdisciplinary approaches with close collaboration across the whole dairy sector

Conclusions (II)

- important role of **health traits** in current R&D in dairy cattle
- important role of **vit** in R&D projects on new traits
  - link between science and practice
    → coordination function, demand- and routine-oriented R&D
  - strong infrastructure, established logistics
    → utilization of favorable starting position (health monitoring)
  - optimum opportunities for immediate and broad innovation transfer
    → support of the crucial transition to broad practice application

➢ **GOOD PROSPECTS FOR FUTURE ROUTINE GENETIC & GENOMIC APPLICATIONS FOR DIRECT HEALTH TRAITS IN GERMAN HOLSTEIN ALLOWING MORE TARGETED IMPROVEMENT OF HEALTH, LONGEVITY AND SUSTAINABILITY**

THANK YOU!



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