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Towards preventive health management in native dual-purpose cattle via novel breeding strategies

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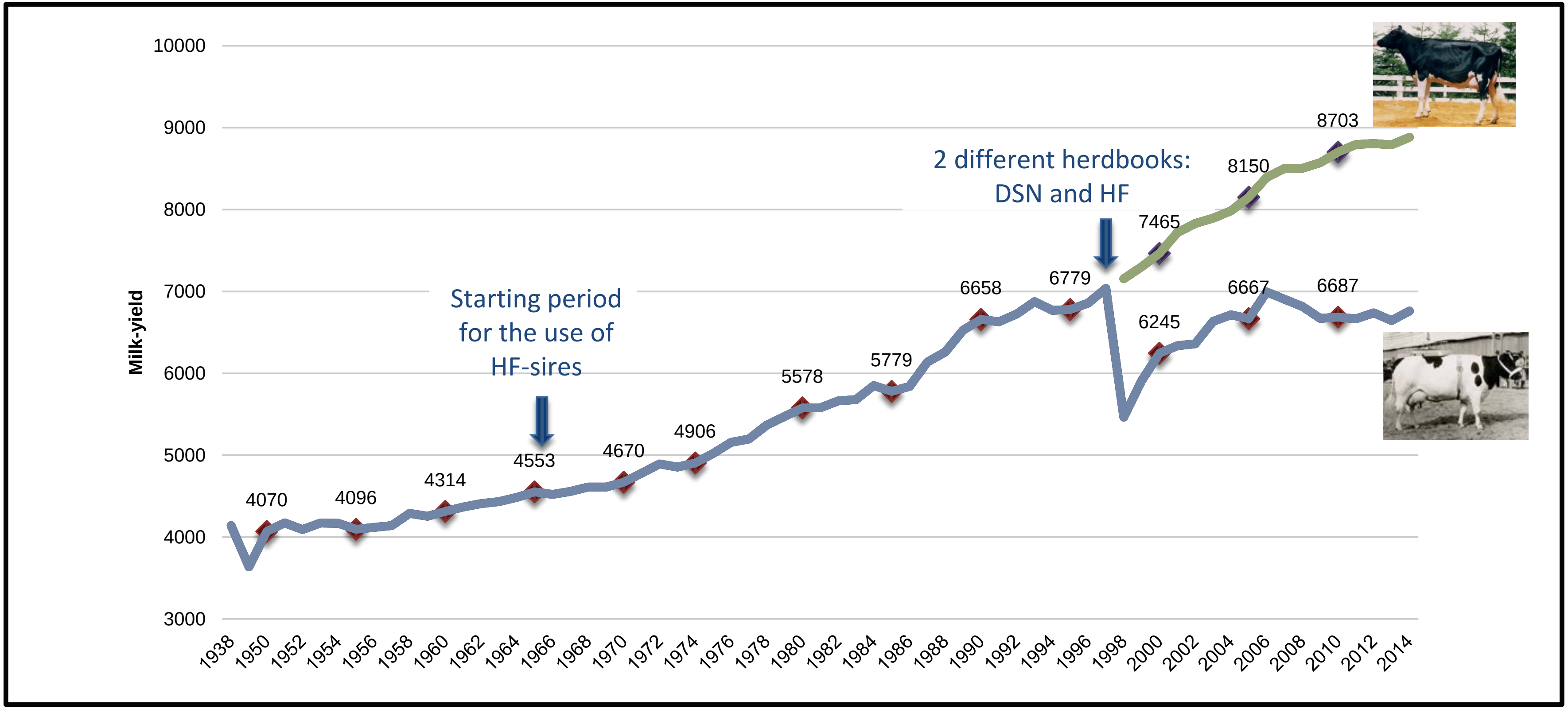
Breeding history

1965	2005
	
DSN cow Paula“ Sire „Troll“	HF-cow „Pretty“ Sire „Aerostar“

„The development from the dual-purpose DSN breed towards the modern HF cow is the most impressive breeding event in the past 50 years”
Dr. P. O. Grothe, former president of the German Holstein Association, 1994

Breed comparison for „conventional“ traits



Breed comparison for novel functional traits

Hypothesis:

Dual-purpose cows are more robust than modern dairy cattle breeds, and they are more suitable for harsh organic grassland systems regarding to constitution, physiology, health, milk quality and greenhouse gas emissions

DSN cows in grasland systems from the EU-project: 2-Org-Cows

Simmental cows in grasland systems from the EU-project: 2-Org-Cows

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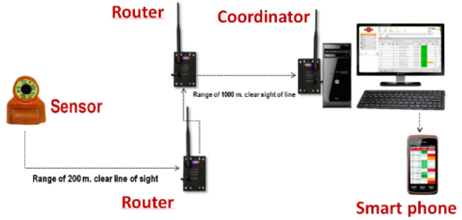
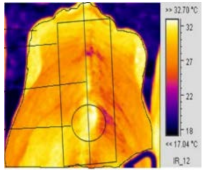
Verification of the hypothesis implies recording of novel functional traits!!!



Installation of Sensor-technology
(Longitudinal data for health, rumination, movements,….)

Measurements for methane emissions on an individual basis

Milk fatty acid profiles based on spectral data



Heat stress indicators: Infrared pictures, respiration rate, body temperature, pulse,…

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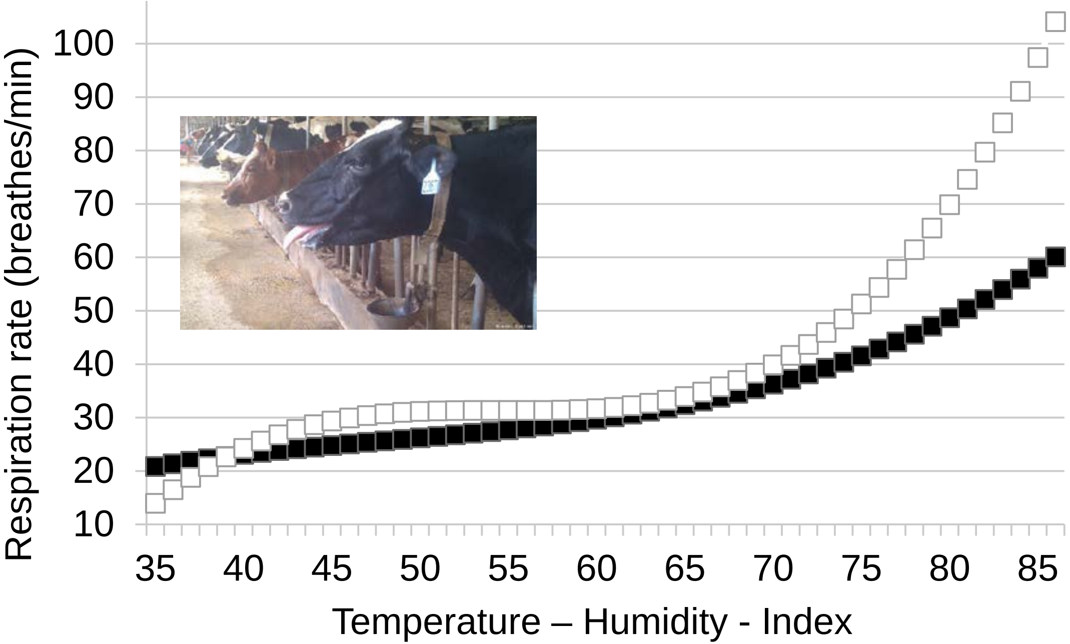
Breed comparison: Least-Square-Means for respiration rate

- 83 HF und 155 DSN cows
- Data recording from 2012 - 2014 in 2 herds (cross-classified research design)



(Al-Kanaan et al., 2015)

Second objective: Optimization of within-breed breeding strategies

……a challenge for endangered breeds because of:

SMALL POPULATION SIZE

$$\Delta G = \frac{i * r_{TI} * \sigma_A}{L}$$

The conventional progeny testing (PT)

Beurteilungskriterium	Zuchtfortschritt 100 000	Zuchtfortschritt 400 000	Zuchtfortschritt 1 600 000	Züchtungsgewinn 100 000	Züchtungsgewinn 400 000	Züchtungsgewinn 1 60[illegible]
Zuchtfortschritt je Kuh und Jahr in DM	11,15	12,77	14,06	10,62	11,97	13,[illegible]
Züchtungsgewinn je Kuh in DM	31,73	42,35	47,51	37,18	47,75	54,[illegible]
Zuchtaufwand je Kuh in DM bezogen auf die Gesamtpopulation	26,10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pay-Off-Periode in Jahren	17,6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Interne Verzinsung in %	9,4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Prozentanteil der Milchleistung am Zuchtfortschritt	83,3	80,0	81,7	74,5	76,1	78,[illegible]

Fewson and Niebel, 198[illegible]

Tabelle 2. Zuchtfortschritt und Züchtungsgewinn in Abhängigkeit von der Populationsgröße und dem Anteil des aktiven Zuchtmaterials

Genetic gain and profit depending on population size and the proportion of the active population

–	Anteil des aktiven Zuchtmaterials (%) 10	15	20	25	30	35	40
	Zuchtfortschritt je Kuh/Jahr (DM)						
100 000	8,54	9,10	9,45	9,69	9,88	10,03	10,15
200 000	9,77	10,41	10,80	11,08	11,28	11,44	11,55
400 000	10,83	11,53	11,95	12,16	12,30	12,39	12,45
800 000	11,75	12,39	12,72	12,91	13,04	13,12	13,17
1 600 000	12,42	13,03	[illegible]	[illegible]	[illegible]	[illegible]	13,79
3 200 000	12,95	13,57	[illegible]	[illegible]	[illegible]	[illegible]	14,34
	Züchtungsgewi[illegible]						
100 000	31,10	32,17	32,45	32,35	32,02	31,55	30,98
200 000	37,57	39,05	39,60	39,69	39,53	39,19	38,58
400 000	42,56	44,39	45,08	44,85	44,26	43,46	42,53
800 000	46,53	48,03	48,20	47,81	47,12	46,25	45,28
1 600 000	48,94	50,20	50,27	49,83	49,11	48,23	47,25
3 200 000	50,25	51,44	51,49	51,04	50,32	49,45	48,48

(Niebel and Fewson, 1978)

Tabelle 3. Zuchtfortschritt in Abhängigkeit von dem Testanteil und der Anzahl Bullenv[illegible] ter für 3 Populationsgrößen

Genetic gain depending on the proportion of cows inseminated with young bulls, th[illegible] number of bull sires and the population size

Populationsgröße (aktives Zuchtmaterial)	Testanteil (%)	Anzahl Bullenväter je Jahr 2	4	6	8	10
100 000 (25 000)	20	9,94	9,46	8,85	8,26	7,71
	30	10,23	9,69	9,06	8,46	7,90
	40	10,38	9,82	9,18	8,59	8,03
	50	10,47	9,89	9,26	8,68	8,15
	60	10,51	9,93	9,32	8,76	8,25
	70	10,50	9,94	9,36	8,83	8,34
	80	10,46	9,94	9,39	8,89	8,43
400 000 (100 000)	20	11,99	11,85	11,64	11,29	10,98
	30	12,32	12,16	11,88	11,52	11,19
	[illegible]	[illegible]	[illegible]	[illegible]	11,60	11,28
	[illegible]	[illegible]	[illegible]	[illegible]	11,62	11,30
	[illegible]	[illegible]	[illegible]	[illegible]	11,60	11,29
	[illegible]	[illegible]	12,25	11,88	11,55	11,25
	80	12,41	12,14	11,79	11,47	11,19
1 600 000 (400 000)	20	13,22	13,17	13,02	12,87	12,74
	30	13,60	13,54	13,38	13,22	13,08
	40	13,80	13,74	13,56	13,40	13,25
	50	13,91	13,84	13,66	13,49	13,34
	60	13,94	13,87	13,69	13,51	13,36
	70	13,92	13,85	13,66	13,48	13,30
	80	13,84	13,77	13,58	13,34	13,14

Fewson and Niebel, 1986)

Tabelle 4. Züchtungsgewinn in Abhängigkeit von dem Testanteil und der Anzahl Bullenväter für 3 Populationsgrößen

Profit depending on the proportion of cows inseminated with young bulls, the number of bull sires and the population size

Populationsgröße (aktives Zuchtmaterial)	Testanteil (%)	Anzahl Bullenväter je Jahr 2	4	6	8	10	12
100 000 (25 000)	20	32,62	31,15	28,28	25,33	22,40	19,45
	30	34,04	32,35	29,41	26,45	23,53	20,60
	40	34,85	33,06	30,17	27,38	24,45	21,62
	50	35,29	33,51	30,72	27,96	25,27	22,60
	60	35,46	33,76	31,14	28,55	26,04	23,56
	70	35,36	33,84	31,44	29,06	26,77	24,51
	80	34,98	33,76	31,63	29,50	27,46	25,46
400 000 (100 000)	20	42,59	43,20	42,86	41,44	40,04	38,72
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41,20	39,87
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41,75	40,43
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41,95	40,69
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41,94	40,74
	70	45,16	45,36	44,19	42,93	41,73	40,62
	80	44,31	44,60	43,58	42,44	41,36	40,35
1 600 000 (400 000)	20	46,46	48,90	49,33	49,33	49,20	49,03
	30	48,54	51,04	51,45	51,41	51,25	51,05
	40	49,74	52,31	52,71	52,65	52,46	52,24
	50	50,42	53,06	53,46	53,38	53,17	52,93
	60	50,69	53,41	53,80	53,71	53,48	53,21
	70	50,56	53,37	53,76	53,65	53,40	53,11
	80	49,99	52,89	53,28	53,16	52,89	52,58

Niebel and Fewson, 1978)

Genetic evaluations: An across-Europe approach

For example for the DSN-breed:
Inclusion of herds from Poland, The Netherlands, and Germany

Novel trait recording in the University research herds „Lozema“

Novel trait recording in the University research herd „Juchowo“

Novel trait recording in the University research herds „Frankenhausen“ and „Oberer Hardthof“

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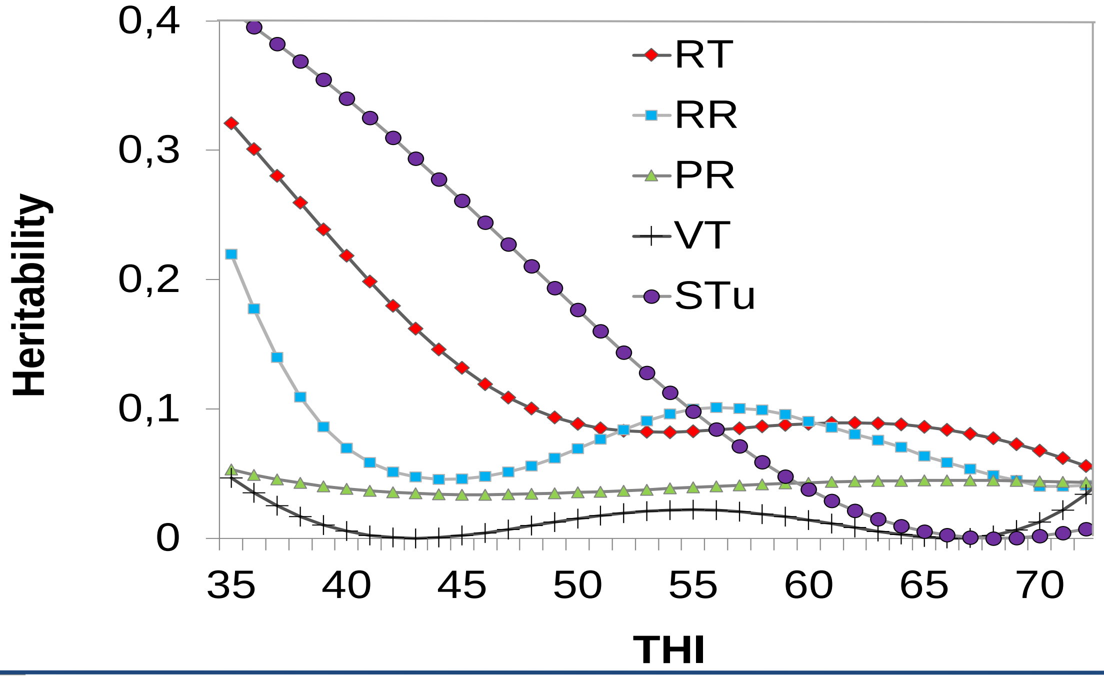
Genetic evalutions: Adaptation and evaluation of alternative methods

A: Genetic parameters in dependency of continuous environmental descriptors, e.g. temperature, humidity, grassland characteristics, etc.

➔ Application of random regression models with environmental dependent covariates



(Al-Kanaan et al., 2015)

Genetic evalutions: Adaptation and evaluation of alternative methods

B: “borderless clustering” approach

➔ Allocation of herds across country borders according to production system characteristics

Based on the idea by Weigel et al. (1999)
Utilisation of production systems for international genetic evaluations instead of country borders!

Weigel et al. (2001):

- **131.9 Mio.** test-day data from **16.4 Mio. Holstein cows** located in **17** countries

- grouping herds accross country borders into clusters
(7 clusters were defined)

Criteria for herd clustering (Weigel et al., 2001)

1. Herd size
2. Average calving interval
3. Milking frquency
4. Age at first calving
5. 305-d milk yield
6. Most frequent month of calving

Herd characteristics (Management)

7. Genetic value of sires
8. % Holstein genes of sires

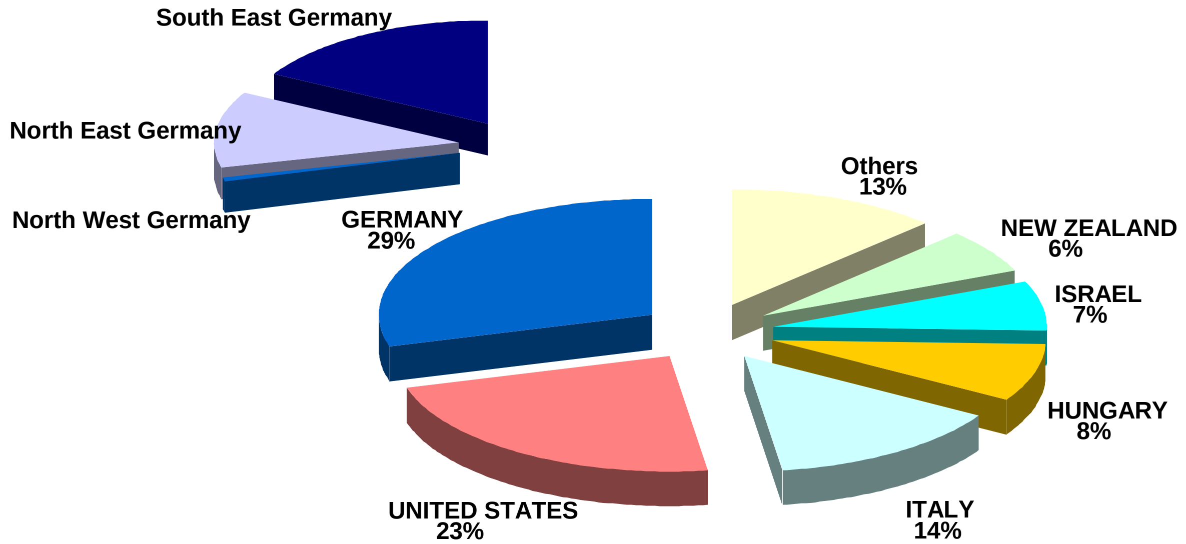
Herd characteristics (Genetics)

9. Degree of latitude
10. Sea level
11. Average temperature in July
12. Average rainfall in July
13. Percentage of pasture

Climate and geographie

Cluster 1

„large herds with high intra-herd SD, high production level“



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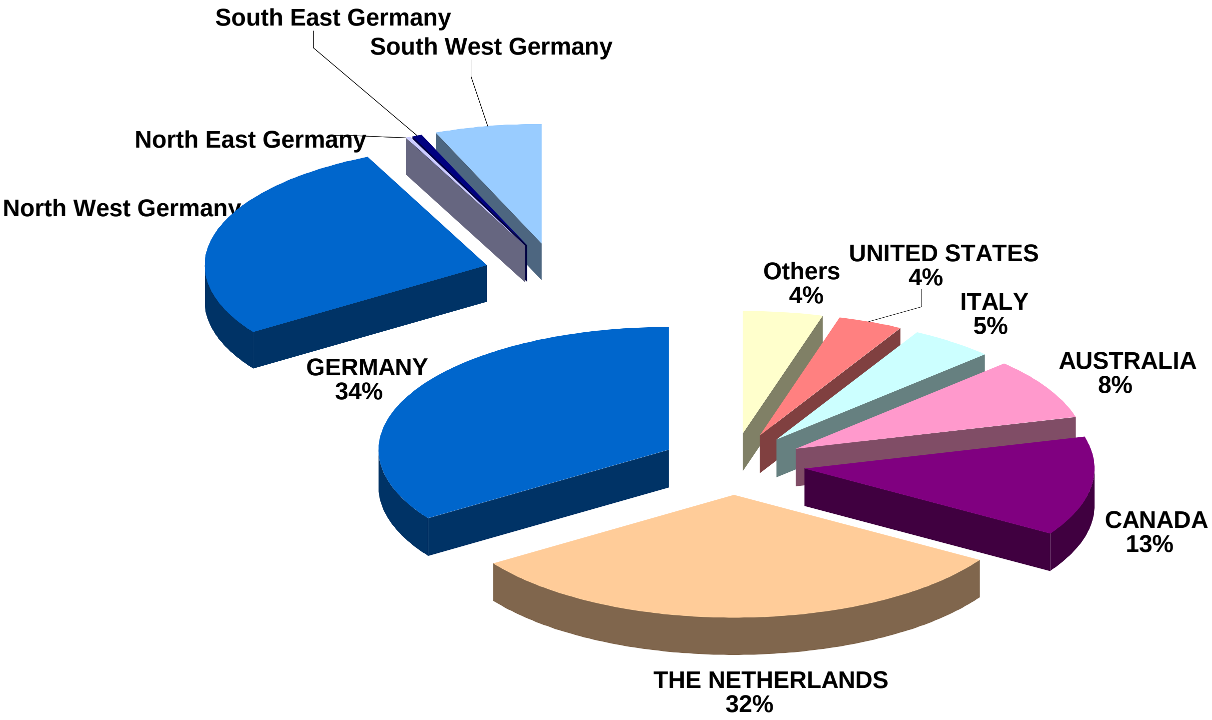
Cluster 2

„small herds with low intra-herd SD, high production level“



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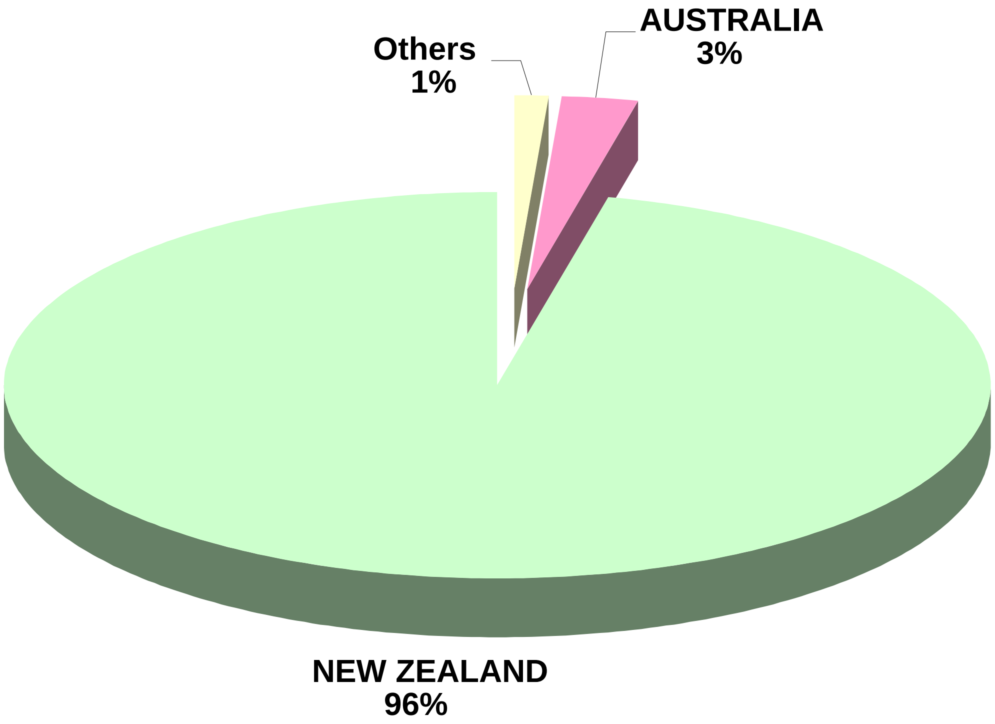
Cluster 5

„cluster for pasture based herds"



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What are the clusters for dual-purpose cattle?

Aim: Identification of relevant environmental and herd descriptors for dual-purpose cattle accross Europe, and clustering herds accordingly

First attempt: See presentation by Maria Jaeger in this session

Genetic improvements of novel health traits in dual-purpose cattle

- Impossible to setting up the infrastructure and logistics for a PT-program
- Alternative: Implementation of genomic selection using cow calibration groups

GEBVs for e.g.:
Paternal calving ease, paternal NR56
Longevity, SCS
+ health, product quality, behaviour,….

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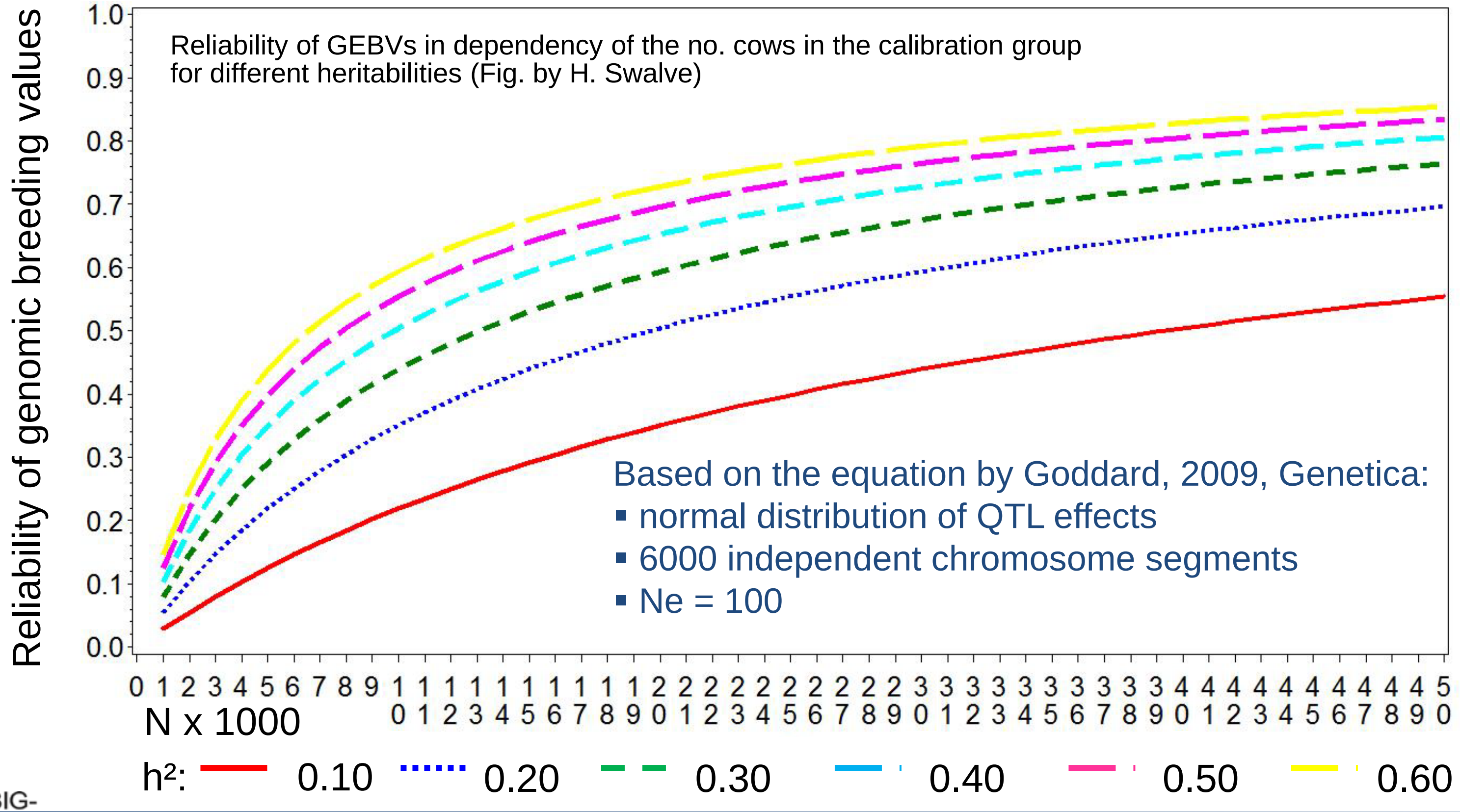
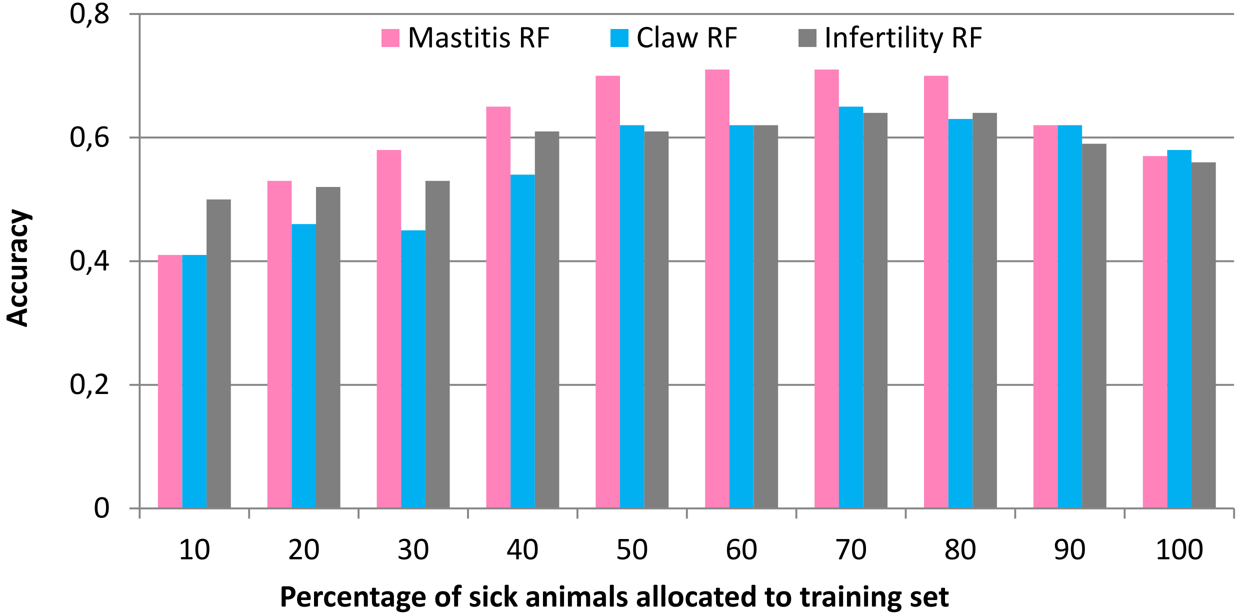
Cow calibration groups: How many cows should be included?



The German cow calibration group project for health traits in HF cattle

- 20’000 genotyped Holstein cows and their imputed dams
- Health trait recording according to a central diagnosis key (956 single disease traits)

Accuracy of genomic predictions for laminitis, clinical mastitis and infertility (Naderi et al., 2016)



….but we do not have 20‘000 DSN cows with pheno- and genotypes

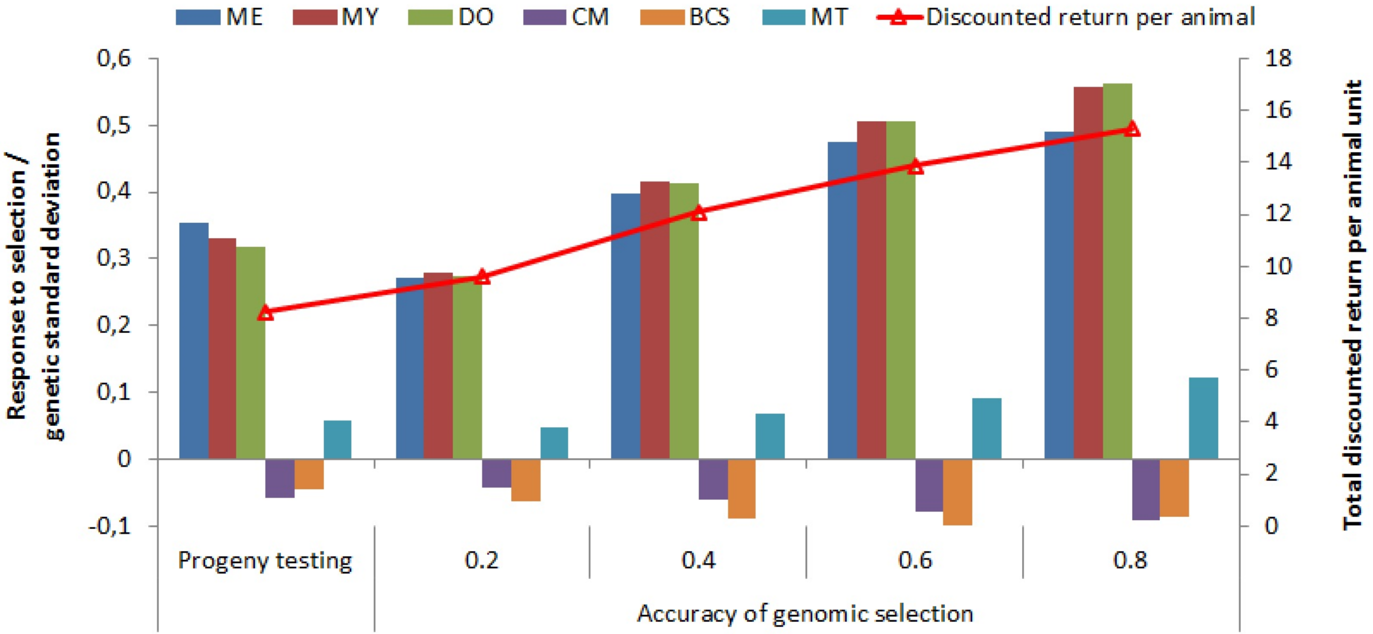
- Solution A: Using SNP-effects from HF-calibration groups for predictions in DSN
  ➔ usually this does not work
- Solution B: Mixing breeds in reference groups
  ➔ acceptable results for a similar no. of cows from both breeds

- Due to shared founder animals, genetic relationships between DSN- and HF-populations do exist (< 1%).
  ➔ further increase of reliabilities of genomic breeding values for DSN cows is expected

- All project partners intend to genotype a fraction of dual-purpose cattle
  ➔ cow calibration group across country borders!

- Studie von Van Eijndhoven et al. (2015), J. Dairy Sci. 98, 6510-6521
  High correlations between SNP effects contributing to milk quality traits when using DSN- and HF-cows

Definition of breeding goals / evaluation of breeding strategies

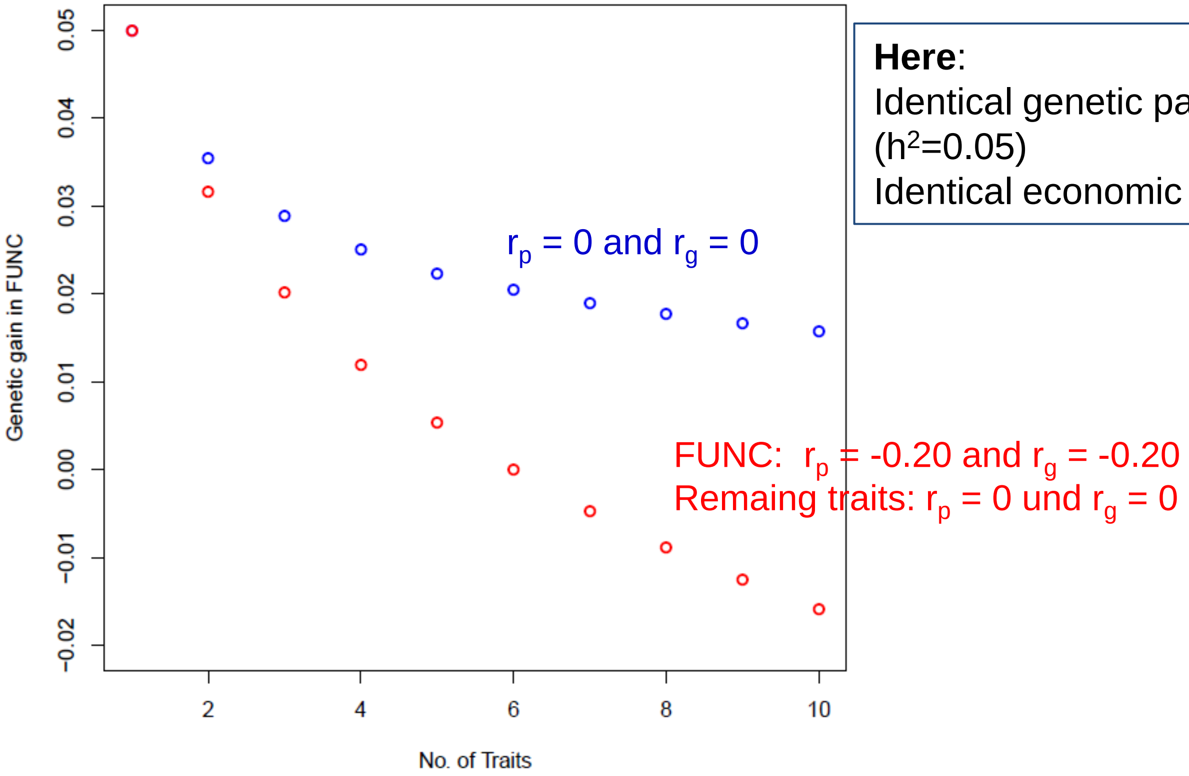


Proeny testing and genomic breeding program with different accuracy

(Yin et al., 2015)

The breeding challenge

An increase of traits in the breeding goal reduces genetic gain in single traits!!



Here:
Identical genetic parameters for all traits (h^2=0.05)
Identical economic weights for all traits

Conclusions: Steps for preventive health management via breeding in dual purpose cattle kept in „harsh environments“ (grassland systems)

1. Recording of novel functional traits (traits of interest and indicator traits)

2. Developing and evaluating alternative models for genetic evaluations (Consideration of GxE-interactions, e.g. RRM or “borderless clustering”

3. Setting up cow calibration groups on a European scale

4. Defining overall breeding goals and evaluating alternative breeding strategies

Thanks in advance to all project partners for their scientific contributions in order to realize those challenging breeding tasks!

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Beat Bapst **Florian Grandl**	Qualitas AG
Vedat Karakaş	International Center for Livestock Research and Training