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RZFeedEfficiency

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Breeding for feed efficiency in German Holsteins: the new RZFeedEfficiency

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What is feed efficiency ?

- The ratio of input and output
- More precisely: The ratio of feed intake (input) to income-relevant performance (output)
- Ratios not easy to handle in context of breeding values

- Feed efficiency should refer to the cow's entire life
- Since this is very complex: currently feed efficiency is assessed only for time of productive life

ECM	energy-corrected milk
DMI	dry matter intake
BW	body weight
BWC	body weight change

Feed efficiency: feed saved concept

- schematic example: two animals with same input but different output

additional output from same input = + Feed-Saved

- Computation of expected DMI needed for
  - ECM
  - BWC
- … and comparison to actually measured DMI
- **the difference of expected and measured DMI is „feed saved“**

➢ Animal 1 is more feed efficient than animal 2

Data

Common data pool of the countries in the RDGP project

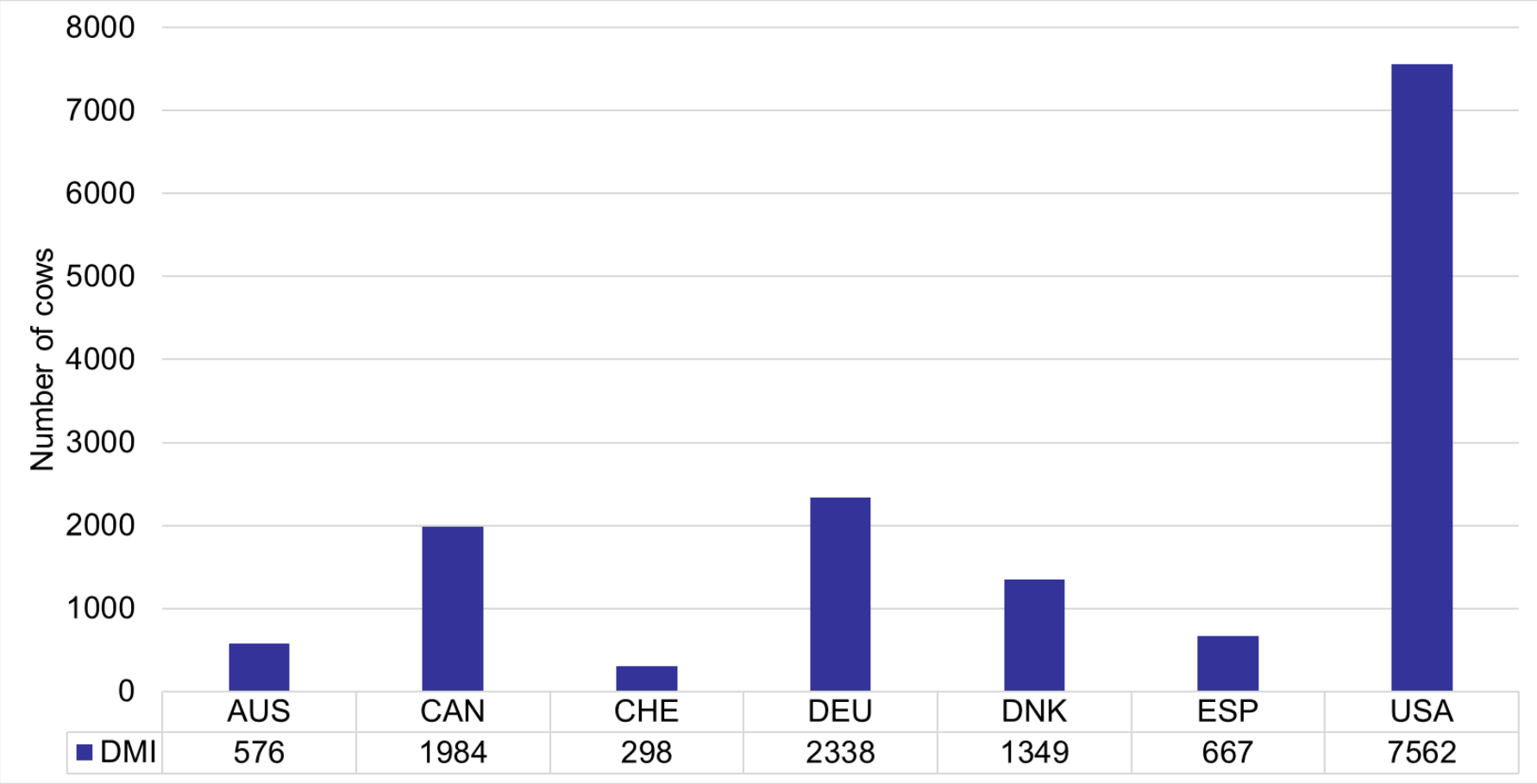
- Data for individual feed intake records
  - At least on a weekly basis (partly daily records)
  - Additional data for ECM and body weight
  - Animals are genotyped

THE Resilient Dairy GENOME PROJECT

(RDGP)

Data from international data exchange project RDGP

- Number of cows with feed intake records per country



In total
14,774 cows
(Oct. 2023)

Phenotypic performance of cows with feed intake records

- Common data pool of 7 countries in the RDGP project
- About 14’000 cows with dry matter intake from 6 countries (excluding Australia)

	N cows	Ø DMI 305	Ø ECM 305	Ø BW 305	Ø DMI /day
1. La	8,718	6,291	9,762	619	20.6
2. La	5,911	7,207	11,538	684	23.6
3. La	3,173	7,432	11,902	721	24.4
4. La	1,255	7,454	12,187	736	24.4
5. La	571	7,579	12,172	737	24.8

Model: Random-Regression-Animal-Model

- Phenotypes:
  - DMI, BW and ECM

- Model per trait:
  - Multi-Lactation-Random-Regression-Animal-Model per trait
  - Legendre polynomials of 2nd order
  - Fixed Effects:
    - Herd-testweek
    - calving_age x lactationweek (Legendre, 2nd order)
    - Regression on inbreeding
  - Random effects:
    - Permanent environment
    - Genetic animal effect

- Single Step
  - 13’883 animals with phenotypes (for DMI & BW & ECM)
  - 1’433’391 animals with genotypes

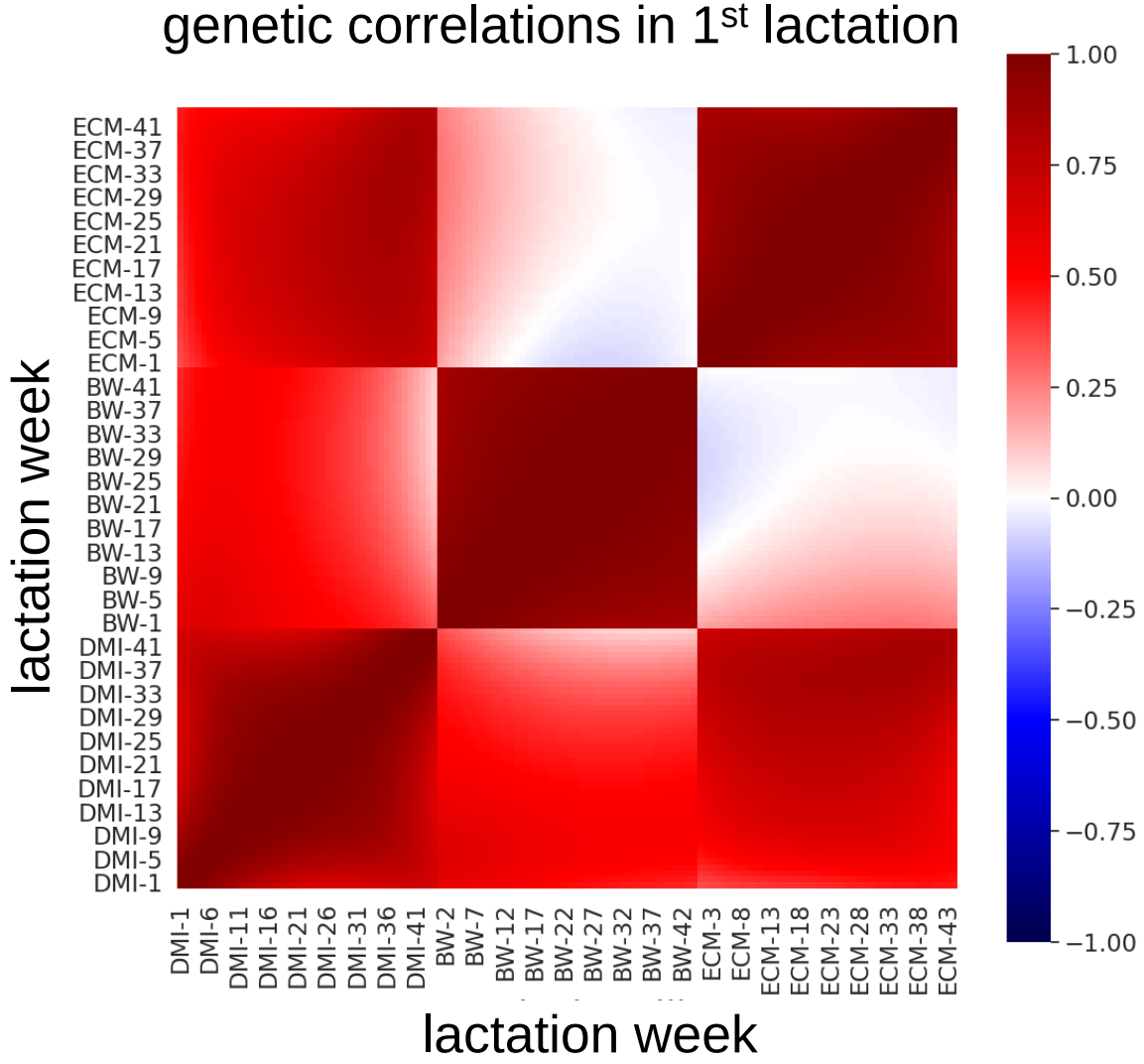
Advantages of modeling the underlying component traits in GE

- Flexibility to define target trait(s) freely
  - ➢ Also adjust later easily, if necessary

- Advantages of the model
  - Genetic curves change over time (feed efficiency is a different trait in different periods and lactations)
  - Residuals modelled per measurement
    - Different to phenotypic RFI approaches
    - Switching to daily measurements would be straight forward
    - ➢ Precise modelling
    - ➢ Future improvements relatively easy

Estimation of variance components

- 4 periods per lactation of 11 weeks each
- Multi-trait model
- Back-regression on random regression



Genetic evaluation of feed efficiency traits

- Calculation of kg Feed Saved based on EBV for DMI, ECM and BWC
  - 305 days in lactations 1, 2 and 3
  - as sum of lactations 1, 2, and 3

$$GEBV_{FeedEfficiency} = -GEBV_{DMI} + \boxed{4.5}\, GEBV_{BWC} + \boxed{0.4}\, GEBV_{ECM}$$

assumption: on average
4.5 kg DMI for 1 kg BWC

assumption: on average
0.4 kg DMI for 1kg ECM

GEBV corrs	BWC	DMI	ECM
BWC	1	0.15	-0.07
DMI		1	0.74
ECM			1

- Genetic variance: 247 kg feed saved per lactation 1-3 (~ 3.5% of total feed intake)
- Reliability of the gEBV for feed efficiency: ~ 40%
- Publication as relative EBV (RZFeedEfficiency, RZFE)

RZFeedEfficiency

EBV correlations RZFeedEfficiency to other traits

- GEBV correlations calculated for 352‘692 genotyped females born 2021 and 2022

Breeding value	Trait complex	Correlation to RZFE
RZG	total merit	0.02
RZ€	total merit (€)	0.05
RZM	production	-0.07
RZN	longevity	0.05
RZE	conformation	-0.11
RZR	reproduction	0.02
RZHealth	health	-0.03
RZKm	calving, maternal	0.03
RZKd	calving, direct	0.10
RZCalffit	young stock survival	0.06

- Overall low GEBV correlations among RZFE and other main complexes
  - ➢ feed efficiency is independent from other main traits

What characterizes feed-efficient and less feed-efficient animals?

- GEBV profiles top/bottom 25% according to RZFE of genotyped SBT females born 2021/2022
- Total = 352‘692 females (per quartile 88‘173 females)

Weibl. 2021/22	Top 25 %	Bottom 25 %	Diff. T-L
RZFE	**107,9**	**91,5**	**16,4**
FE kg	607	-657	1264
ECM (L123_kg)	743	625	118
BWC (L123_kg)	0,6	2,2	-1,5
DMI (L123_kg)	-307	917	-1224
BW (L123_kg)	4,1	27,1	-23,0

all kg figures refer to the sum of 3 lactations

- Significant differences between top and bottom animals in RZFE and FE kg
- Similar production level
  - Top RZFE +39 kg ECM/lactation
- Hardly any difference in BWC
  - But Top RZFE slightly lighter
- ➢ **Top females need less feed**
  - ➢ **For similar production level**

Summary - RZFeedEfficiency (RZFE)

- The German trait definition and genetic evaluation considers milk production and weight gain as output and refers to the entire productive life (3 lactations)
- Reliability (40%) is still limited
- Feed efficiency is heritable and has significant genetic variation (1 gSD ~ approx. 3.5% total feed intake)
- Feed efficiency is genetically mostly independent from other breeding goal traits
  - Genetic trend slightly negative, almost no trend
  - ➢ Previous breeding for milk output maximization (performance per cow and lactation independent of feed intake) has led to a significant increase in milk production = output, but obviously not to an increase in efficiency

➢ **The basis for genetic improvement of feed efficiency is the RZFeedEfficiency (RZFE), which was introduced in April 2024**

RZFeedEfficiency