NATURAL RESOURCES
INSTITUTE FINLAND

Genetic correlations between **feed efficiency**, **production** and female **fertility** in Nordic Red Dairy cattle

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Outline

- Background
- Objective of the study
- Data
- Studied traits
- Results
  - Heritability estimates
  - Genetic correlations
- Take home message


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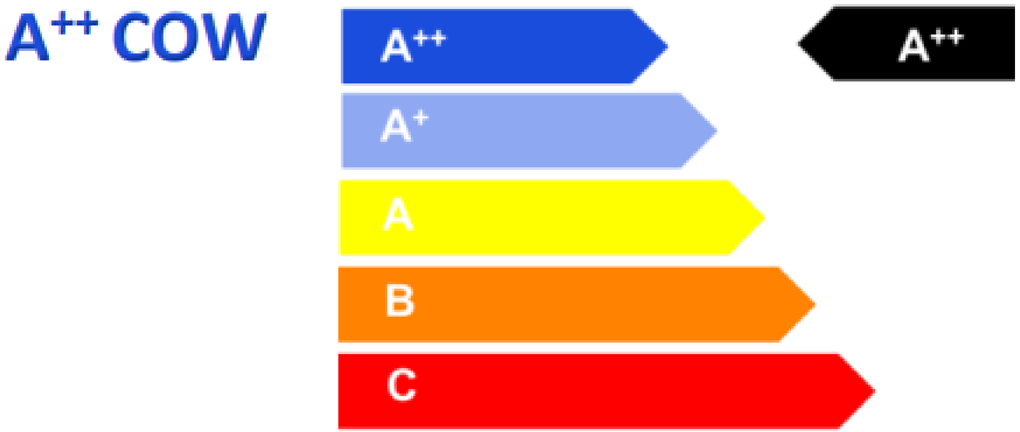
Background

Breeding Dairy Cattle for Resource Efficiency and Environmental Sustainability

A++COW –project

- Project lead by Luke 2019-2022
- Consists of 4 work packages
  1) Novel phenotypes
  2) Modelling feed efficiency
  3) Genomic prediction
  4) Economic and environmental benefits



breeding for resource efficient cows

Objectives of the study

Main aim of WP4 Economic and environmental benefits is

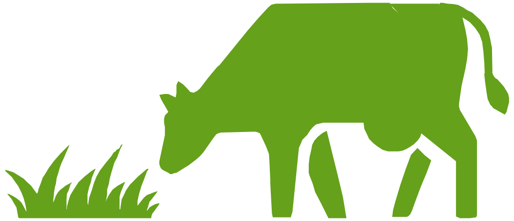
To assess the economic and environmental impacts of including feed efficiency into dairy cattle breeding programs

To assess the impacts and forecast the future – certain parameters are needed

Objective of this study was to assess the genetic correlations between production, female fertility and different feed efficiency traits

→ Parameters can be used for simulation studies

Data



- Feed efficiency data was collected from 4 research herds in Finland during 2002-2021
- Included in total 18 581 records from 645 Nordic Red Dairy cows
  - For variance component estimation records > 4 SD from the mean were removed
- To study the genetic correlation between fertility and feed efficiency, 3037 ICF records were added to the data

- Traits of interest:

Feed efficiency:

1) Regression on expected feed intake, ReFI
2) Residual feed intake, RFI
3) Metabolic body weight, MBW

Production:

4) Milk yield, MY
5) Protein yield, PY
6) Fat yield, FY

Female fertility:

7) Interval from calving to first insemination, ICF

Studied traits

	N obs	Mean	SD	Min	Max
DMI (kg/d)	**18581**	**19.7**	**2.8**	**8.6**	**31.0**
eDMI (kg/d)	**18030**	**19.8**	**2.1**	**8.4**	**29.18**

Feed efficiency trait 1:

1) **Regression on expected feed intake (ReFI)** (Lidauer et al., WCGALP 2022)
   - as regression of DMI on feed requirements (expected DMI)
     - Energy requirement=4.18*ECM+0.603*MBW+34.8*GAIN-27.6*LOSS (Agnew et al., 2003)

   - Modelled as : $\mathbf{DMI}_{\mathbf{ijkl}} = \beta_i \times \mathbf{eDMI}_{ijkl} + \kappa_j \times \mathbf{eDMI}_{ijkl}\ \psi_l \times \mathbf{eDMI}_{ijkl} + \alpha_l \times \mathbf{eDMI}_{ijkl} + \varepsilon_{ijkl,}$

     where β_i is the fixed regression coefficient for the herd-feed year i,
     κ_j is the random regression coefficient of herd-test-month j,
     ψ_l is the random regression coefficient for the permanent environmental effect of cow l,
     α_l is the random regression coefficient for the additive genetic effect of cow l, and
     ε_{ijkl} is the random residual.

→Additive genetic effect is equal to % of saved feed
→Allows to account for multiplicativity of feed efficiency factors

Studied traits

	N obs	Mean	SD	Min	Max
DMI (kg/d)	**18581**	**19.7**	**2.8**	**8.6**	**31.0**
ECM (kg/d)	**18542**	**29.3**	**4.4**	**11.6**	**45.8**
MBW (kg)	**18573**	**120.0**	**9.2**	**85.4**	**156.7**
BW GAIN (kg/d)	**18498**	**0.28**	**0.24**	**0**	**1.29**
BW LOSS (kg/d)	**18128**	**0.07**	**0.23**	**0**	**1.70**

<u>Feed efficiency trait 2:</u>

2) Residual feed intake (RFI)

- "Traditional RFI"
- Modelled as: $DMI_{ijkl} = HTM_i + \beta_1 ECM_j + \beta_2 MBW_j + \beta_3 BWG_j + \beta_4 BWL_j + LACTCURVE_k + pe_l + a_l + e_{ijkl}$,

where HTM_i is the fixed effects of herd-test-month i,

$\beta_1, \beta_2, \beta_3, \beta_4$ are the fixed regression coefficients of the energy sinks nested within herd-feeding year j,

$LACTCURVE_k$ is the fixed lactation curve modelled by the 4th order Legendre polynomial and Wilmink function in days in milk k,

pe_l is the random permanent environmental effect of cow l,

a_l is the random additive genetic effect of cow l, and

e_{ijkl} is the random residual.

Studied traits

	N obs	Mean	SD	Min	Max
MBW (kg)	**15899**	**120.2**	**9.4**	**83.4**	**157.6**

3) Metabolic body weight (MBW)

- Part of the Saved Feed index
- Describes the part of the energy needed for Maintenance
- Modelled as: $MBW_{ijklm} = HTM_i + LACTCURVE_{jk} + CAGE_l + pe_m + a_m + e_{ijklm}$,

Where HTM_i is the fixed effect of herd-test-month i,

$LACTCURVE_{jk}$ is the fixed lactation curve modelled by the 4th order Legendre polynomial and Wilmink function in days in milk j nested within herd-5year-period k,

$CAGE_l$ is the fixed calving age modelled by 2nd order polynomial in calving age month l,

pe_m is the random permanent environmental effect of cow m,
a_m is the random additive genetic effect of cow m, and
e_{ijklm} is the random residual.

Studied traits

Production traits:

	N obs	Mean	SD	Min	Max
MY (kg/d)	**18559**	**27.4**	**4.6**	**8.7**	**44.5**
PY (kg/d)	**18536**	**1.00**	**0.15**	**0.40**	**1.54**
FY (kg/d)	**18556**	**1.21**	**0.21**	**0.37**	**2.05**

4) Milk yield (MY)
5) Protein yield (PY)
6) Fat yield (FY)

All modelled as: $Y_{ijkl} = HTM_i + LACTCURVE_{jk} + CAGE_l + pe_m + a_m + e_{ijklm}$,

Where HTM_i is the fixed effect of herd-test-month i,

$LACTCURVE_{jk}$ is the fixed lactation curve modelled by the 4th order Legendre polynomial and Wilmink function in days in milk j nested within herd-5year-period k,

$CAGE_l$ is the fixed calving age modelled by 2nd order polynomial in calving agemonth l,

pe_m is the random permanent environmental effect of cow m,
a_m is the random additive genetic effect of cow m, and
e_{ijklm} is the random residual.

Studied traits

Fertility trait:

7) Interval from calving to first insemination (ICF)

- Indicates cow's ability to resume cyclicity after calving and manifests estrus behaviour
- Measured in days from calving
- Yield deviation records from the official genetic evaluation of fertility for the cows in pedigree were used

	N obs	Mean	SD	Min	Max
ICF_YD	**3037**	**1.1**	**24.0**	**-77.3**	**107.6**

RESULTS

Variance components

Pedigree included 5650 RDC animals
Genetic analyses performed as single-trait runs using MiX99

	σ^2_{kappa}	σ^2_{pe}	σ^2_{a}	σ^2_{e}	h^2
ReFI	0.002	0.002	0.003	1.931	**0.31**
RFI		0.83	0.26	1.35	**0.11**
MBW		8.93	64.40	4.07	**0.83**
MY		6.87	5.08	3.65	**0.33**
PY		0.008	0.003	0.005	**0.21**
FY		0.014	0.009	0.011	**0.26**
ICF		-	13.23	565.15	**0.02**

Calculated for the average eDMI (19.8 kg)!

Genetic and phenotypic correlations

Genetic correlations in upper triangle and phenotypic correlations below

	ReFI	RFI	MBW	MY	PY	FY	ICF
ReFI		0.29	-0.01	-0.14	-0.14	-0.26	0.01
RFI	0.65		0.76	0.22	0.37	0.18	0.04
MBW	0.02	0.19		0.28	0.35	0.15	0.40
MY	-0.09	0.09	0.18		0.79	0.76	0.25
PY	-0.07	0.13	0.20	0.89		0.69	0.06
FY	-0.18	-0.01	0.14	0.76	0.76		0.05
ICF	0.01	0.08	-0.01	0.00	-0.02	-0.01	

Genetic and phenotypic correlations

	ReFI	RFI	MBW	MY	PY	FY	ICF
ReFI		**0.29** (0.21)	**-0.01** (0.12)	**-0.14** (0.17)	**-0.14** (0.18)	**-0.26** (0.16)	**0.01** (0.34)
RFI	0.65		0.76	0.22	0.37	0.18	0.04
MBW	0.02	0.19		0.28	0.35	0.15	0.40
MY	-0.09	0.09	0.18		0.79	0.76	0.25
PY	-0.07	0.13	0.20	0.89		0.69	0.06
FY	-0.18	-0.01	0.14	0.76	0.76		0.05
ICF	0.01	0.08	-0.01	0.00	-0.02	-0.01	

Genetic correlations were analysed by bi-variate analyses using the yield deviations for all traits and MiX99 software

Genetic and phenotypic correlations

	ReFI	RFI	MBW	MY	PY	FY	ICF
ReFI		**0.29**	**-0.01**	**-0.14**	**-0.14**	**-0.26**	**0.01**
RFI	0.65		**0.76** (0.23)	**0.22** (0.27)	**0.37** (0.27)	**0.18** (0.29)	**0.04** (0.52)
MBW	0.02	0.19		0.28	0.35	0.15	0.40
MY	-0.09	0.09	0.18		0.79	0.76	0.25
PY	-0.07	0.13	0.20	0.89		0.69	0.06
FY	-0.18	-0.01	0.14	0.76	0.76		0.05
ICF	0.01	0.08	-0.01	0.00	-0.02	-0.01	

Genetic correlations were analysed by bi-variate analyses using the yield deviations for all traits and MiX99 software

Genetic and phenotypic correlations

	ReFI	**RFI**	**MBW**	**MY**	**PY**	**FY**	**ICF**
ReFI		**0.29**	**-0.01**	**-0.14** (0.17)	**-0.14**	**-0.26**	**0.01**
RFI	0.65		**0.76**	**0.22** (0.27)	**0.37**	**0.18**	**0.04**
MBW	0.02	0.19		0.28	0.35	0.15	**0.40** (0.39)
MY	-0.09	0.09	0.18		0.79	0.76	**0.25** (0.45)
PY	-0.07	0.13	0.20	0.89		0.69	0.06
FY	-0.18	-0.01	0.14	0.76	0.76		0.05
ICF	0.01	0.08	-0.01	0.00	-0.02	-0.01	

Take home messages

What we wanted to study:

- Genetic correlations between feed efficiency, production and female fertility traits?
  - ➢ Favourable and low to moderate genetic correlations between ReFI and production traits
  - ➢ Unfavourable genetic correlation between RFI and production traits
  - ➢ No genetic correlation between feed efficiency and ICF
    - ➢ Moderate correlation between MBW and ICF
  - ➢ SE's for genetic correlations are high, but the estimates are reasonable
- Which feed efficiency measure more suitable for breeding, ReFI or RFI?
  - ➢ Higher heritability for ReFI
  - ➢ With ReFI – more efficient cows are also more yielding cows
  - ➢ With RFI – more efficient cows are smaller and less yielding cows
- Next step: To study the economic and environmental impact of including ReFI or RFI into the dairy cattle breeding program – use of these parameters in simulations

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Thank you!

VIKINGGENETICS

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