Exploring different definitions of *methane phenotypes* in Holstein cattle *in three European countries*

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Re-Livestock
RESILIENT FARMING SYSTEMS

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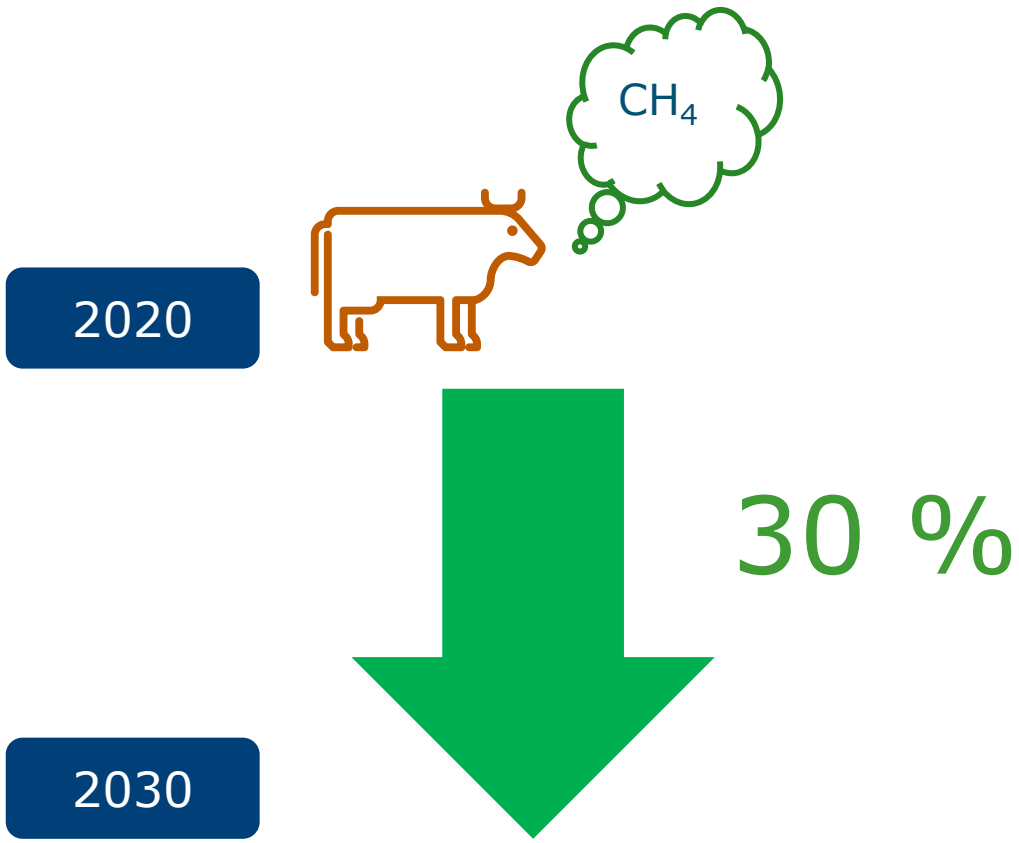
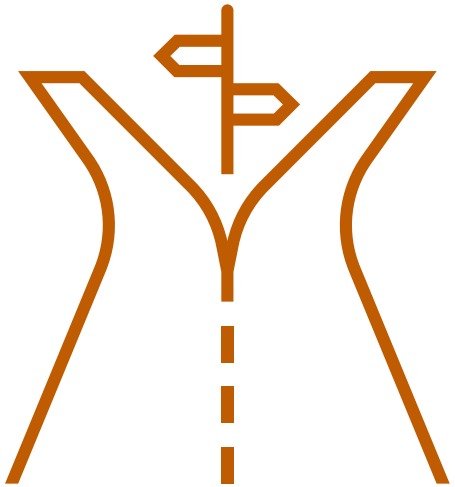
150 YEARS CRV
BETTER COWS > BETTER LIFE

Importance



Several countries are introducing or planning to introduce methane breeding values in the coming years



Challenge

There it is **not a common agreement** in terms of chosen **phenotype**, nor **trait definition** (measurement, editing procedures).

Opportunity

Re-Breeding livestock for resilience

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Demonstrate the **potential** of **animal breeding** in climate change **mitigation** and **adaptation**

To improve **accuracy** and **predictive ability** of **EBV** for **mitigation** and **adaptation** traits

To design **breeding strategies** that **reduce** GHG emission and **contribute** to adaptation to climate change

Measurement standardization → Raw data processing → Trait definition → Final phenotype

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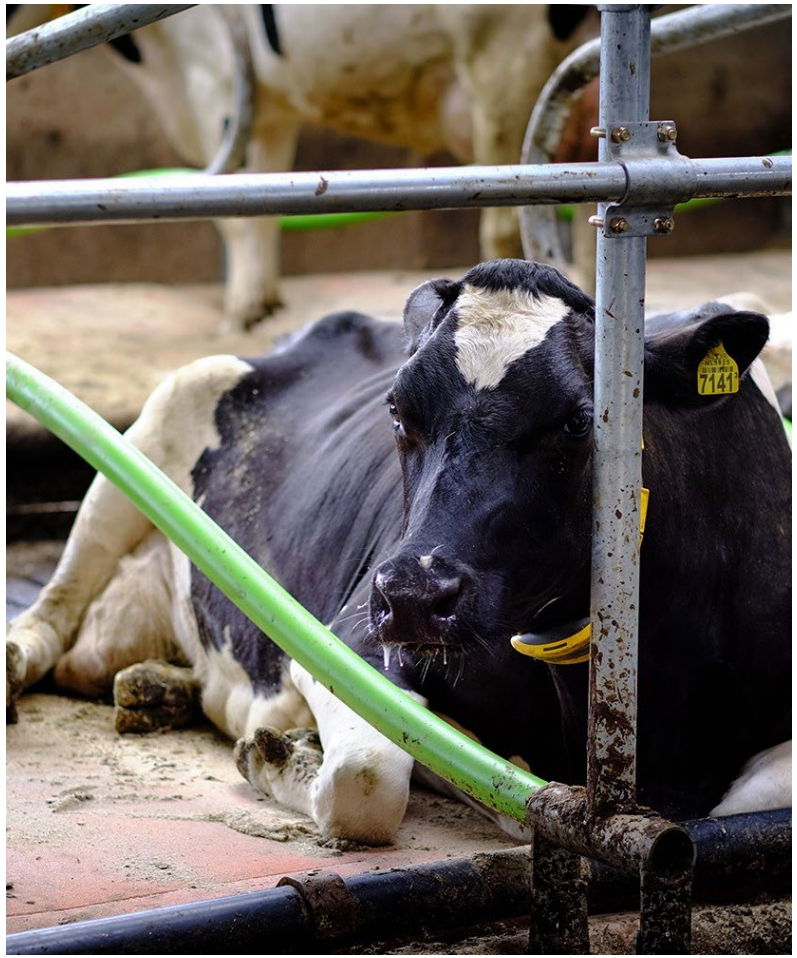
Objectives

1. Investigate *six distinct methane phenotypes* across three countries.

2. Estimate *genetic parameters* for these methane phenotypes, including genetic correlations between countries.



Methane phenotypes

METHANE CONCENTRATION

1. conc Average *methane concentration* per visit (ppm)
2. #peaks *Number* of *methane peaks* per minute
3. ratio between *methane* and *carbon dioxide* concentration

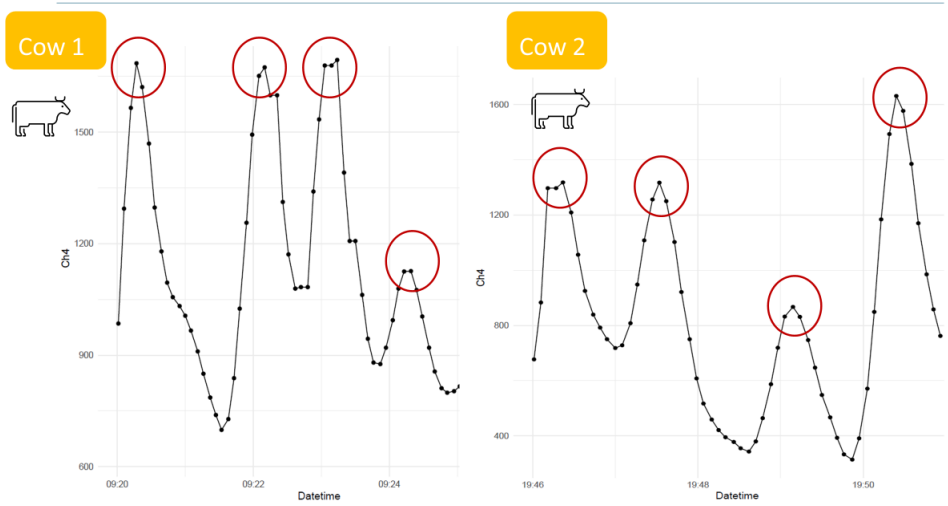
METHANE PRODUCTION

(g/d)

4. Madsen Methane production based on Madsen equation
5. Kjeldsen Methane production based on Kjeldsen equation
6. Tier2 Methane production based on Tier2 (IPCC) equation

Methane concentration phenotypes

1. Average CH_4 concentration
2. Number of peaks per minute
3. CH_4/CO_2 ratio



Formulas for Methane Production

Madsen *et al.* (2010) equation

CO_2 = 180 × 24 × (5.6 MBW + 22 ECM + 1.6*10-5 * num days in gestation)

Kjeldsen *et al*. (2024) equation

CO_2 = ß0 + (ß1 × ECM) + (ß2 × DIM) + breed + parity + (ßbreed, parity) + (ßDIM, DietCF × DIM × DietCF) + (ßECM, DIM × ECM × DIM) + (ßDIM, breed × DIM) + (ßMilkCF, parity × MilkCF)

Tier2 *et al.* (2019) equation

NEm = CF * MBW NE_1 = Milk * (1.47 + 0.4 * Kg Fat)

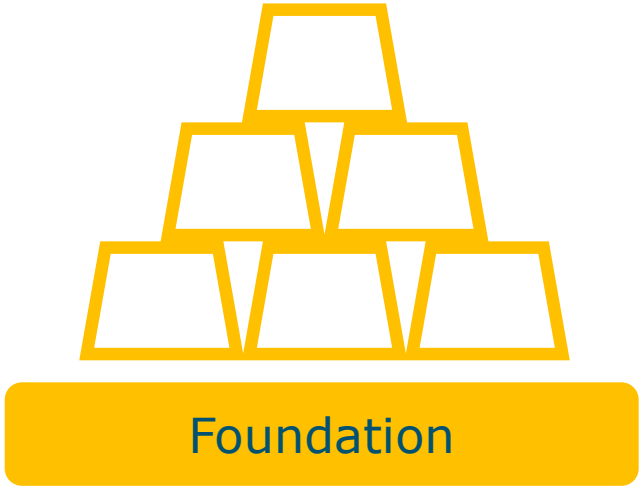
REM = 1.123 – (0.004092) * DE + 0.00001126 * (DE^2 – 25.4/DE)

GE = (1000*(Nem+Nea+NE_1+Nep)/REM/ DE /100

CH_4 = GE * 0.065 / 55.65

Data preparation

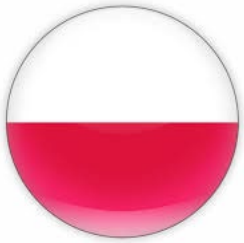
- Weekly records
- Minimum 5 records (visits) per week
- Use calendar week
- Background correction within visit: average 5 lowest measurements per visit
- Max duration: 5 min
- Lactation grouping 1, 2, 3+
- 3 lactation stages: 0-90, 91-150, 151-365



Data Description

- 116,369 records
- 7,129 cows
- 63 farms
- 2019-2024

- 12,455 records
- 3,211 cows
- 34 farms
- 2018-2023



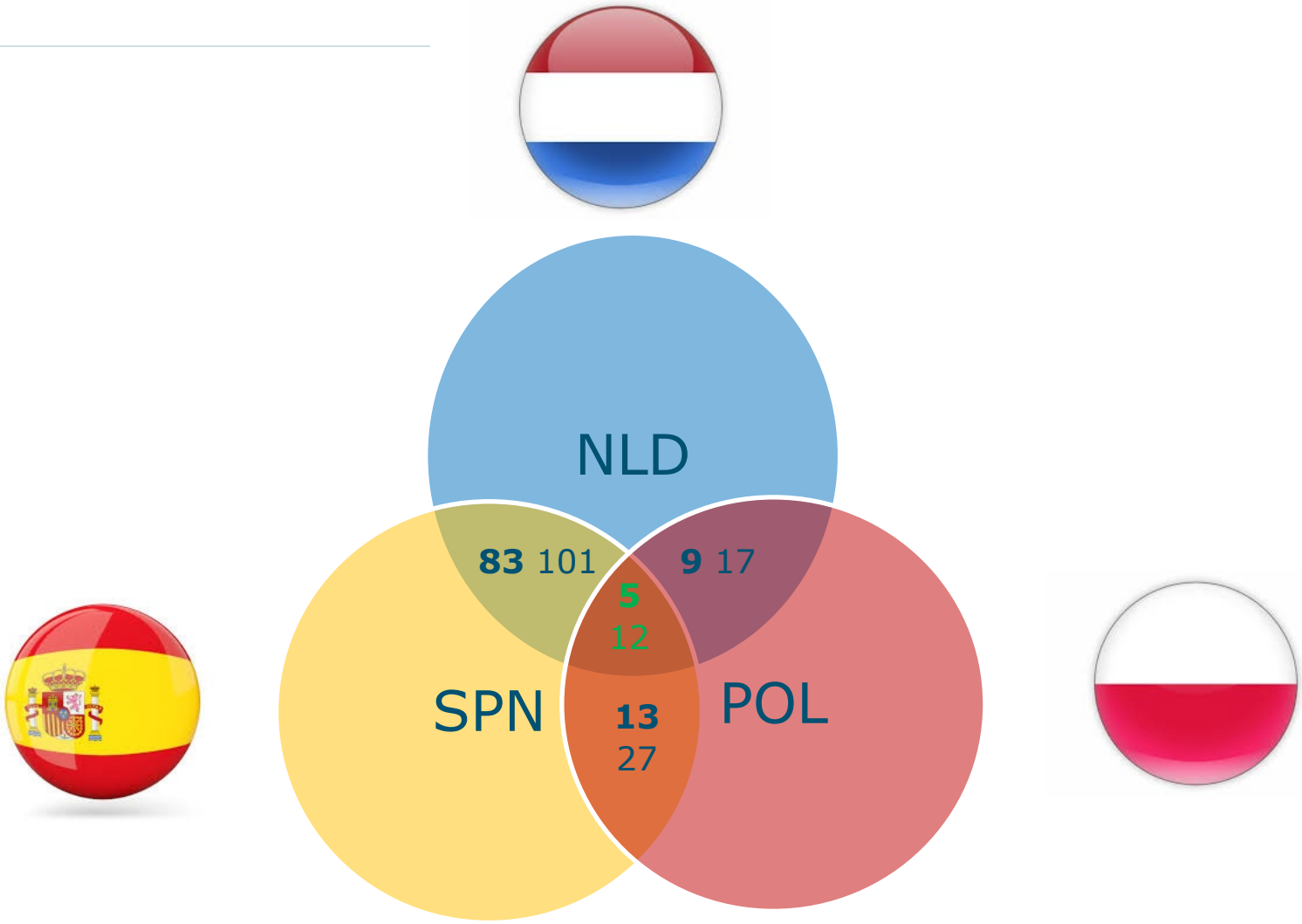
- 7,134 records
- 475 cows
- 2 farms
- 2014-2016

1-3+ parities
405 DIM

Pedigree Description

- 140,515 individuals
- 92,821 individuals after pruning
- 22 generations on average

- 64,813 NLD
- 45,408 SPN
- 13,676 POL



Statistical Model

$$y = Fixed\ Effects + a + pe + e$$

$$Herd * year * season * robot + Lact_{stage} + parity$$

ASReml 4.2

BIV and TRI analyses

Number of observations and *animals* per country

TRAIT		conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
	**NLD**	116208	116369	101367	10763	74729	14809
		7110	*7129*	*6945*	*806*	*6608*	*855*
	**SPN**	12223	12403	7330	6058	7289	10273
		3204	*3210*	*1693*	*1405*	*1682*	*2663*
	**POL**	7121	7076	7078	7134	7134	7134
		475	*474*	*475*	*475*	*475*	*475*

Mean and (standard deviation) per country

	TRAIT	conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
	NLD	401.3 (178.9)	1.47 (0.44)	0.06 (0.02)	290.5 (125.5)	316.6 (124.1)	355.5 (69.1)
	SPN	357.6 (197.7)	0.57 (0.15)	0.07 (0.02)	341.6 (100.5)	353.4 (101.1)	459.6 (77.8)
	POL	534.8 (142.2)	0.99 (0.12)	0.08 (0.01)	379.3 (94.5)	358.2 (61.4)	334.5 (54.8)

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Heritabilities and permanent environmental ratio with (SE)

	Parameter	conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
	h^2	0.19 (0.02)	0.34 (0.05)	0.10 (0.01)	0.06 (0.06)	0.10 (0.02)	0.10 (0.01)
	pe	0.28 (0.01)	0.13 (0.03)	0.14 (0.01)	0.33 (0.04)	0.18 (0.01)	0.14 (0.01)
	h^2	0.18 (0.04)	0.14 (0.06)	0.15 (0.05)	0.21 (0.07)	0.12 (0.05)	0.15 (0.08)
	pe	0.27 (0.02)	0.74 (0.06)	0.25 (0.03)	0.31 (0.05)	0.34 (0.04)	0.25 (0.03)
	h^2	0.36 (0.09)	0.21 (0.11)	0.28 (0.08)	0.32 (0.09)	0.25 (0.09)	0.28 (0.08)
	pe	0.23 (0.07)	0.53 (0.10)	0.23 (0.06)	0.28 (0.07)	0.37 (0.07)	0.23 (0.06)

Heritabilities and permanent environmental ratio with (SE)

	Parameter	conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
	h^2	0.19 (0.02)	0.34 (0.05)	0.10 (0.01)	0.06 (0.06)	0.10 (0.02)	0.10 (0.01)
	pe	0.28 (0.01)	0.13 (0.03)	0.14 (0.01)	0.33 (0.04)	0.18 (0.01)	0.14 (0.01)
	h^2	0.18 (0.04)	0.14 (0.06)	0.15 (0.05)	0.21 (0.07)	0.12 (0.05)	0.15 (0.08)
	pe	0.27 (0.02)	0.74 (0.06)	0.25 (0.03)	0.31 (0.05)	0.34 (0.04)	0.25 (0.03)
	h^2	0.36 (0.09)	0.21 (0.11)	0.28 (0.08)	0.32 (0.09)	0.25 (0.09)	0.28 (0.08)
	pe	0.23 (0.07)	0.53 (0.10)	0.23 (0.06)	0.28 (0.07)	0.37 (0.07)	0.23 (0.06)

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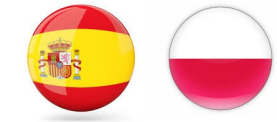
Moderate heritabilities for most of the traits

Genetic correlations and (standard errors)

Trait	conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
	0.65 (0.31)	-0.29 (0.22)	0.79 (0.54)	0.85 (+1)	0.37 (0.64)	0.48 (0.53)
	-0.05 (0.64)	NC	0.08 (0.64)	-0.59 (+1)	0.48 (0.76)	0.92 (0.81)
	0.45 (0.50)	0.79 (0.59)	0.35 (0.92)	-0.45 (0.59)	0.49 (1.0)	0.69 (1.0)

Genetic correlations and (standard errors)

	conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
	0.65 (0.31)	-0.29 (0.22)	0.79 (0.54)	0.85 (+1)	0.37 (0.64)	0.48 (0.53)
	-0.05 (0.64)	NC	0.08 (0.64)	-0.59 (+1)	0.48 (0.76)	0.92 (0.81)
	0.45 (0.50)	0.79 (0.59)	0.35 (0.92)	-0.45 (0.59)	0.49 (1.0)	0.69 (1.0)

Moderate to high positive correlations

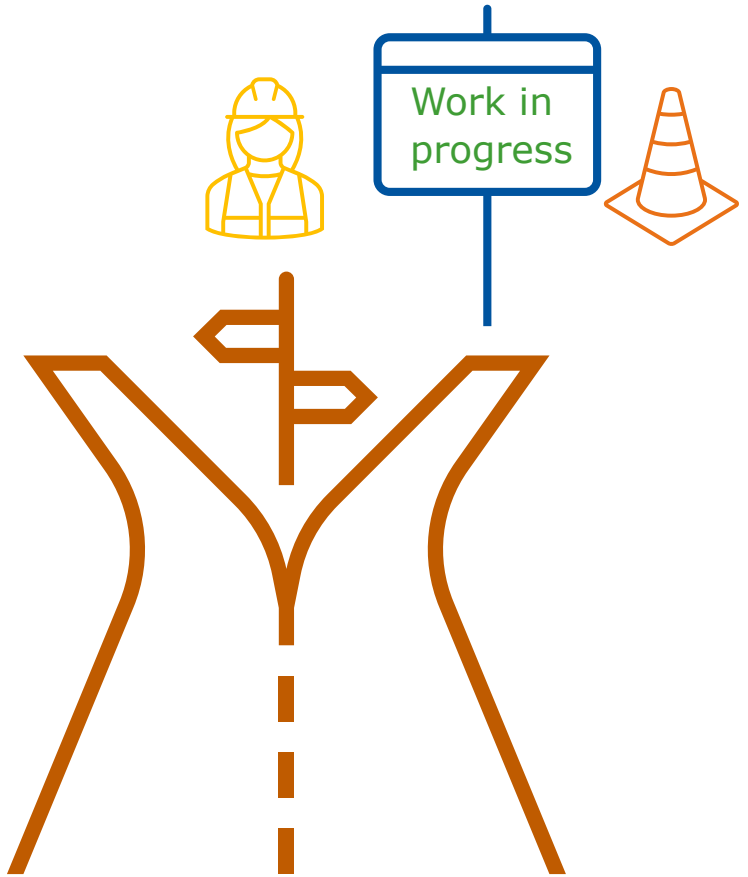
Conclusions

- Low-moderate genetic links between the countries (some dozens of sires)
- Moderate heritabilities for all traits in the 3 countries
- Positive moderate genetic correlations among countries (despite the high standard errors)

- First inter-country correlations for several methane phenotypes
- First step towards international, standarization, evaluation and implementation

Next

- Add genomic information to the analyses
- Investigate the data structure further
- Run country-specific model



Acknowledgements

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Integraal aanpakken
Samen werken aan duurzame & klimaatverantwoorde veehouderij

Project: From Breeding Values to Bull Selection

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Thank you for your attention

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Genetic Correlations and Phenotypic Correlations

Trait	conc	#peaks	ratio	Madsen	Kjeldsen	Tier2
conc		0.04 (0.01)		0.65 (0.01)	0.68 (0.01)	0.06 (0.02)
#peaks	0.41 (0.06)			0.02 (0.02)	0.05 (0.02)	-0.04 (0.02)
ratio	NE			0.90 (0.00)	0.94 (0.01)	0.02 (0.02)
Madsen	0.70 (0.14)	0.86 (0.48)	0.74 (0.09)		0.98 (0.00)	0.33 (0.02)
Kjeldsen	0.86 (0.11)	0.86 (0.31)	0.96 (0.01)	0.92 (0.02)		0.24 (0.02)
Tier2	0.20 (0.16)	-0.28 (0.14)	0.02 (0.18)	0.49 (0.27)	0.16 (0.37)	