Heritability of methane emission in dairy cows estimated from GreenFeed measures in commercial herds

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Methane data from Norwegian dairy herds

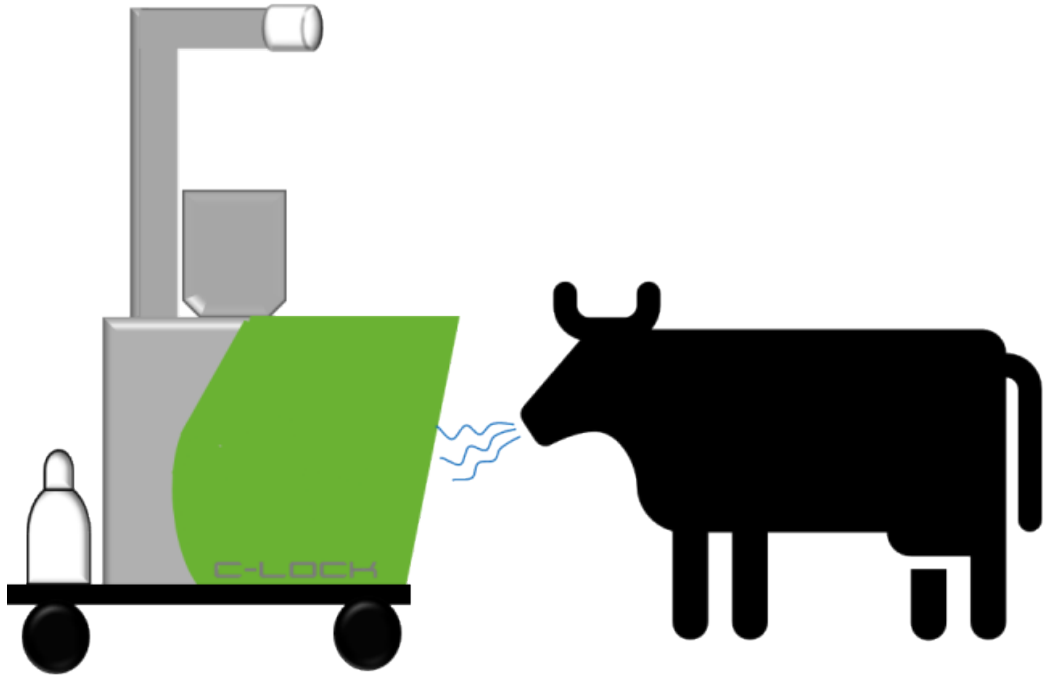
- Geno has installed GreenFeed (www.c-lockinc.com) equipment for methane (CH_4) recording for individual cows at commercial dairy farms
- 17 GreenFeed units
- Phenotyping ~1000 Norwegian Red cows per year

Aim: Genetic evaluation of methane emission for Norwegian Red

GreenFeed equipment

Record CH_4 for individual cows

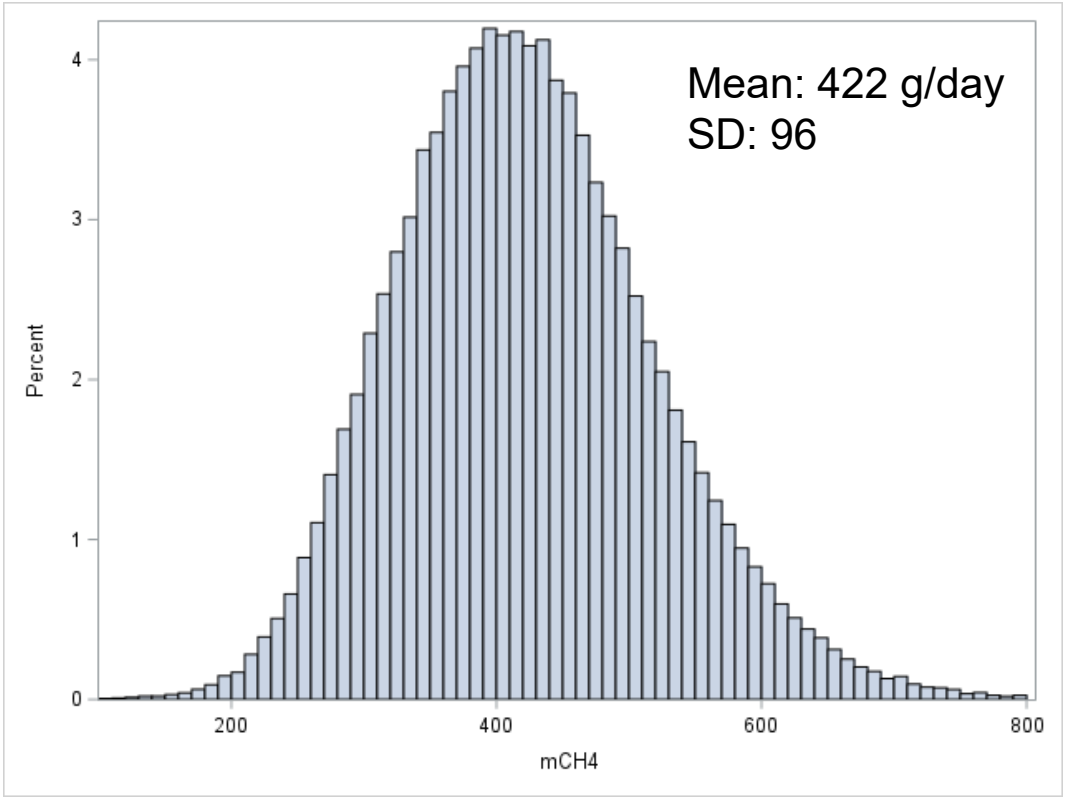
- 2-5 visits per day
- Offer small amounts of concentrates for motivation
- Time restrictions: Minimum time since last visit
- Require minimum 2 minutes with correct head position for good data (accepted record)
- From each visit an estimate of the cow's methane emission grams per day



https://www.c-lockinc.com/

Methane emissons per cow per day

- GreenFeed-data from 2020 og 2021:
  - 15 GreenFeed units
  - 814 NRF cows
  - 370.642 CH_4 measures (visits)



Data:

- Edits:
  - 100 < CH_4 g/day < 800
  - Days In Milk (DIM) <350
  - Min 5 days with CH_4 records per cow
  - Min 5 cows per Herd-TestDay (HTD)
- 1 rec per cow per day (mean of GF visits): CH_4 g/day
- 104.304 observations
- 717 cows with phenotype

Genetic analyses

- Estimated variance components with DMUAI (Madsen and Jensen, 2013)
- Linear animal repeatability model:

$$CH4 = parity + lactW + HTD + animal + pe + e$$

CH4: gram per cow per day, computed as the average of the cow's individual visits each day

Fixed effect of parity 4 classes: 1, 2, 3, and 4+

Fixed effect of lactationstage (lactW), in weeks : 1-50

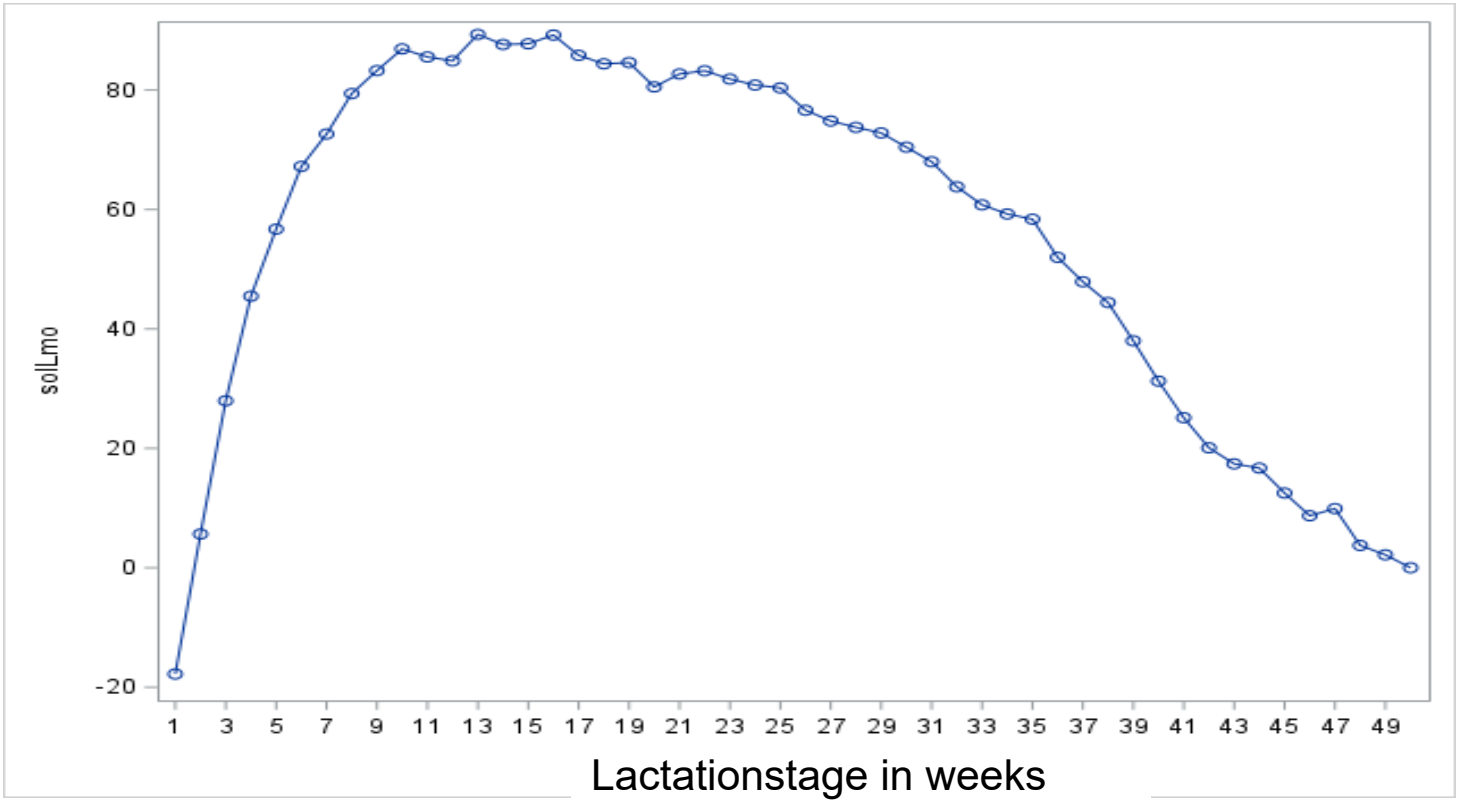
Random herd-testdag (HTD): 5179

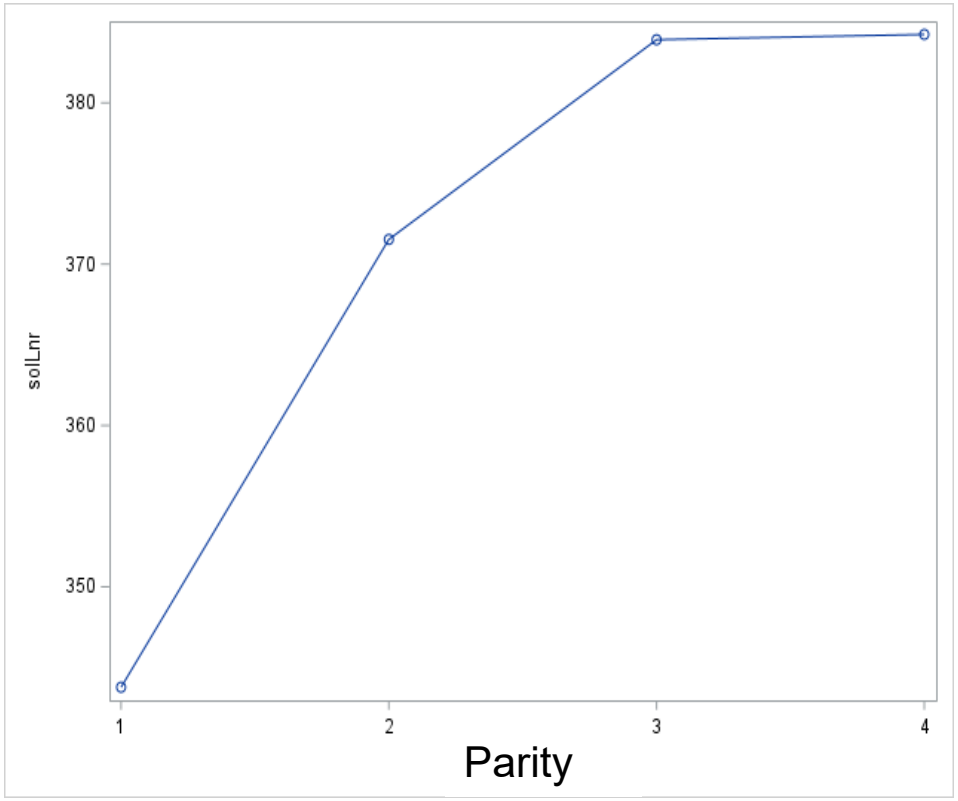
Random animal and permanent environment (pe)

- Pedigreefile: 5576 animals

Effects of lactation stage and parity

Solutions for fixed effects





Heritabiliy of methane emissions

CH4 g/day average per cow per day

Variance component	estimate	Standard error (SE)
Herd-testday (σ^2_{htd})	910	23
Additiv genetic (σ^2_a)	2969	430
Permanent environment (σ^2_{pe})	630	296
Residual (σ^2_e)	4062	18

$$h^2 = \sigma^2_a / (\sigma^2_a + \sigma^2_{pe} + \sigma^2_{htd} + \sigma^2_e)$$

Heritability : 0.34 (SE= 0.04)

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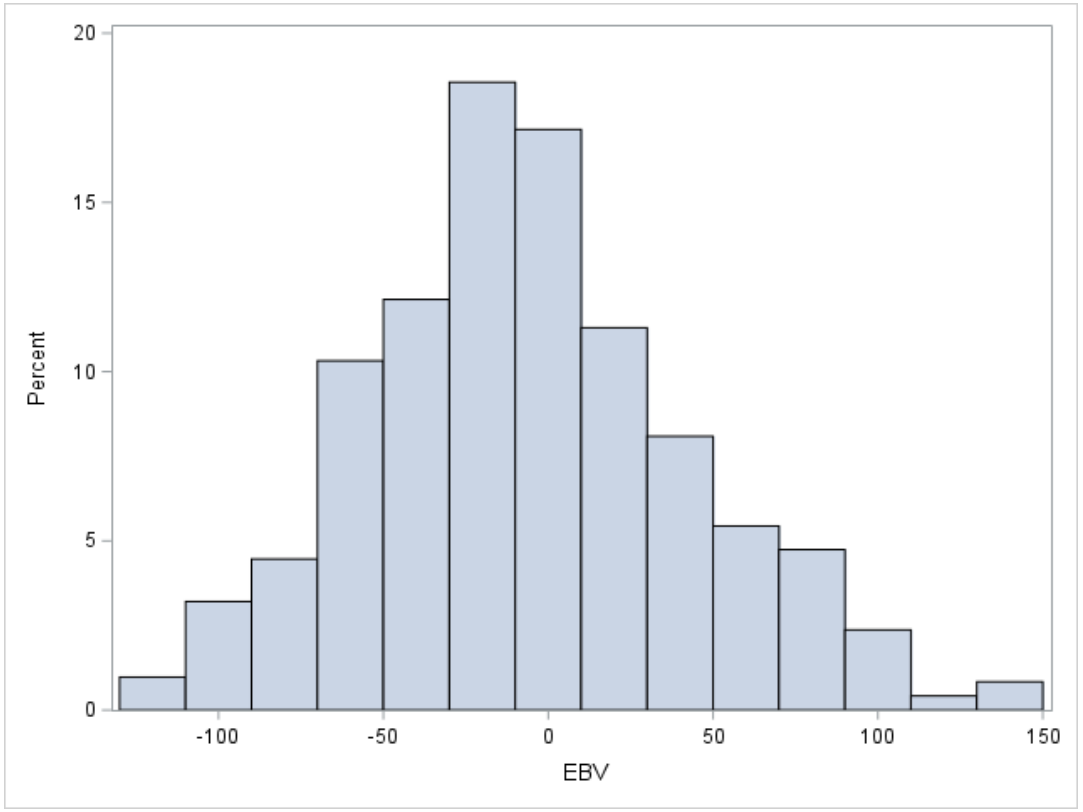
International studies:

- Methan measures from «Sniffer» for Holstein h^2: 0.11 – 0.45 (Lassen and Difford, 2020)

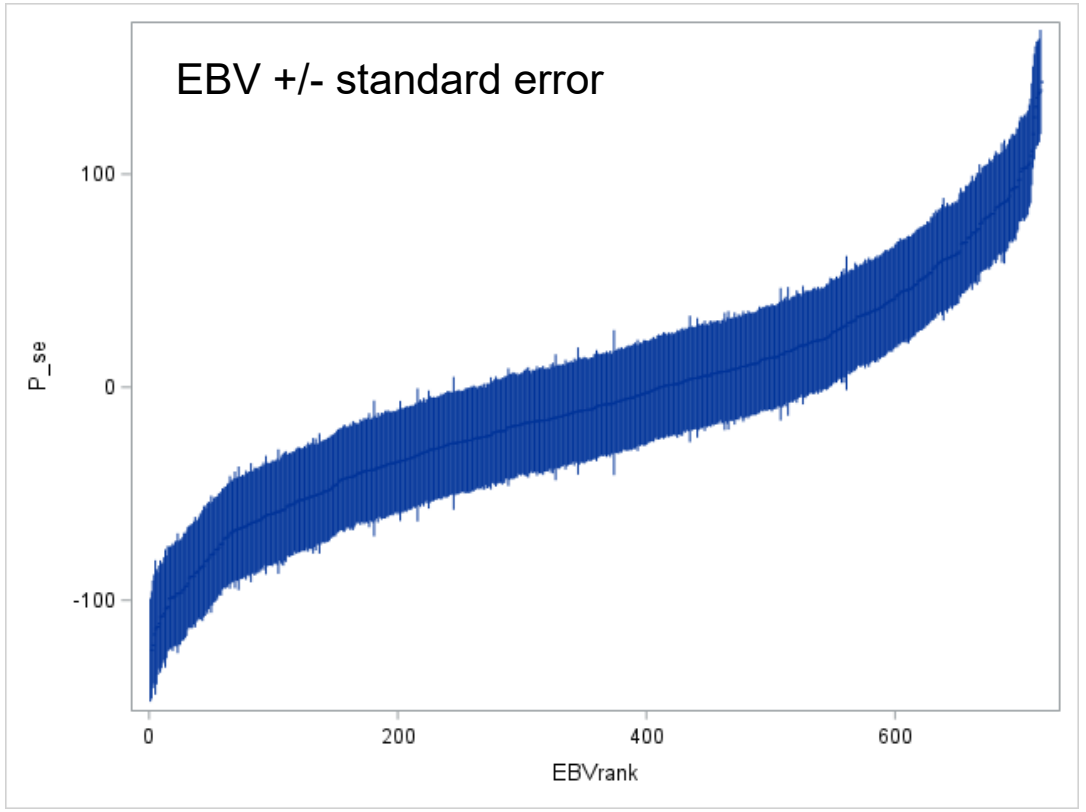
- Methan measures from GreenFeed in research herds (Wallace et al., 2019, Manzanilla Pech et al., 2021)

  – Finland, 100 cows h^2: 0.15
  – Italia, 409 cows, h^2: 0.11
  – Canada, 279 cows, h^2: 0.36
  – Sveits, 59 cows, h^2: 0.24

Breeding values for cows with methane phenotype



EBV given as CH4 g/day



standard errors range between 22 and 34

Associations between methane and other traits

Traits with the highest positive correlation	Correlasjon
Angularity[1]	0.25
BodyDepth[1]	0.22
Stature[1]	0.19
Protein Yield, kg 305d	0.19
BodyTotalScore[1]	0.16
Milk Yield, kg 305d	0.15
HeartGirth[1]	0.15
Fat Yield, kg 305d	0.14
FootAngle	0.14
RumpWidth[1]	0.12
Central Ligament	0.10
ChestWidth[1]	0.10
CarcassWeight	0.10

- Correlations between EBV for CH_4 and indexes from routine genetic evaluations for all other traits
- 710 cows with CH4 phenotype
- Positive correlation = High CH_4 associated with good genetic merit for other traits
- Unfavorable index correlation to milk production and body conformation traits

[1] Trait not included in the Norwegian total merit index

Associations between methane and other traits

Traits with the strongest negative correlation	Correlation
Interval from calving to first ins lact >1	-0.24
Interval from calving to first ins lact 1	-0.20
No of inseminations cow	-0.18
No of inseminations cow 1	-0.17
Calf size[2] direct	-0.17
SilentHeat[1]	-0.15
TopLine[1]	-0.15
Clinical Mastitis 2	-0.12
Clinical Mastitis 1	-0.12
RearUdderWidth	-0.11
Clinical Mastitis 3	-0.10

[1] Trait not included in the Norwegian total merit index
[2] Calf size: High score is small calf

- Correlations between EBV for CH_4 and indexes from routine genetic evaluations for all other traits
- 710 cows with CH4 phenotype
- Negative correlation = low CH_4 associated with good genetic merit for other traits
- Favorable index correlation to fertility and health traits

Results so far:

- Promissing
- Good CH_4 data from GreenFeed
- Genetic variation for CH_4 in Norwegian Red
- Breeding for lower CH_4 emission is feasible

Further research:

- Accuracy of genomic breeding values
- Genetic correlations to other important traits
  - Feed efficiency, milk yield, health and fertility…
- Merge methane and feed efficiency projects
- Trait definition
- How to breed a feed efficient, climate friendly cow?

We aim to balance climate effects, feed efficiency, production, health and fertility in a sustainable breeding goal for Norwegian Red