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Norwegian University of Life Sciences
Faculty of Biosciences

Heritability of methane emission in young Norwegian Red bulls

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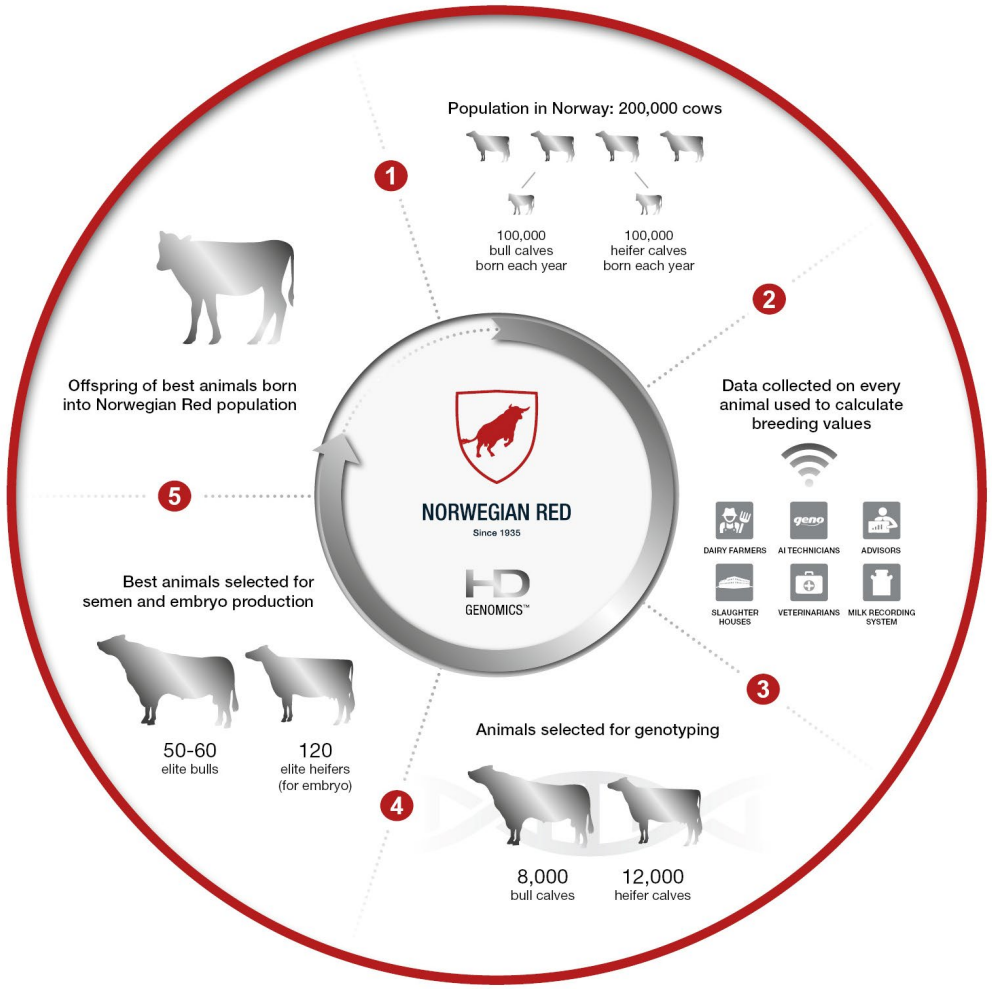
Breeding program for Norwegian Red

Recruting AI bulls:

- 100.000 NR bull calves born per year
- The 8.000 with highest EBV are genotyped
- Geno buys ≈ 150 bull calves each year
- 50 selected AI sires per year



Measuring methane on young bulls at Geno's test station

- ≈ 150 bull calves to test station each year
- Arrive 3-4 months old
- Pens with ≈10 bulls
- GreenFeed (www.c-lockinc.com) equipment for CH_4 recording
- Measure methane last month before leaving test station (at 11-12 mo old)
- On average 40 days with methane data
- Phenotype data on both selected AI bulls and non-selected

Measuring methane emission in young Norwegian Red bulls

Methane (CH_4) data from September 2020 to April 2023

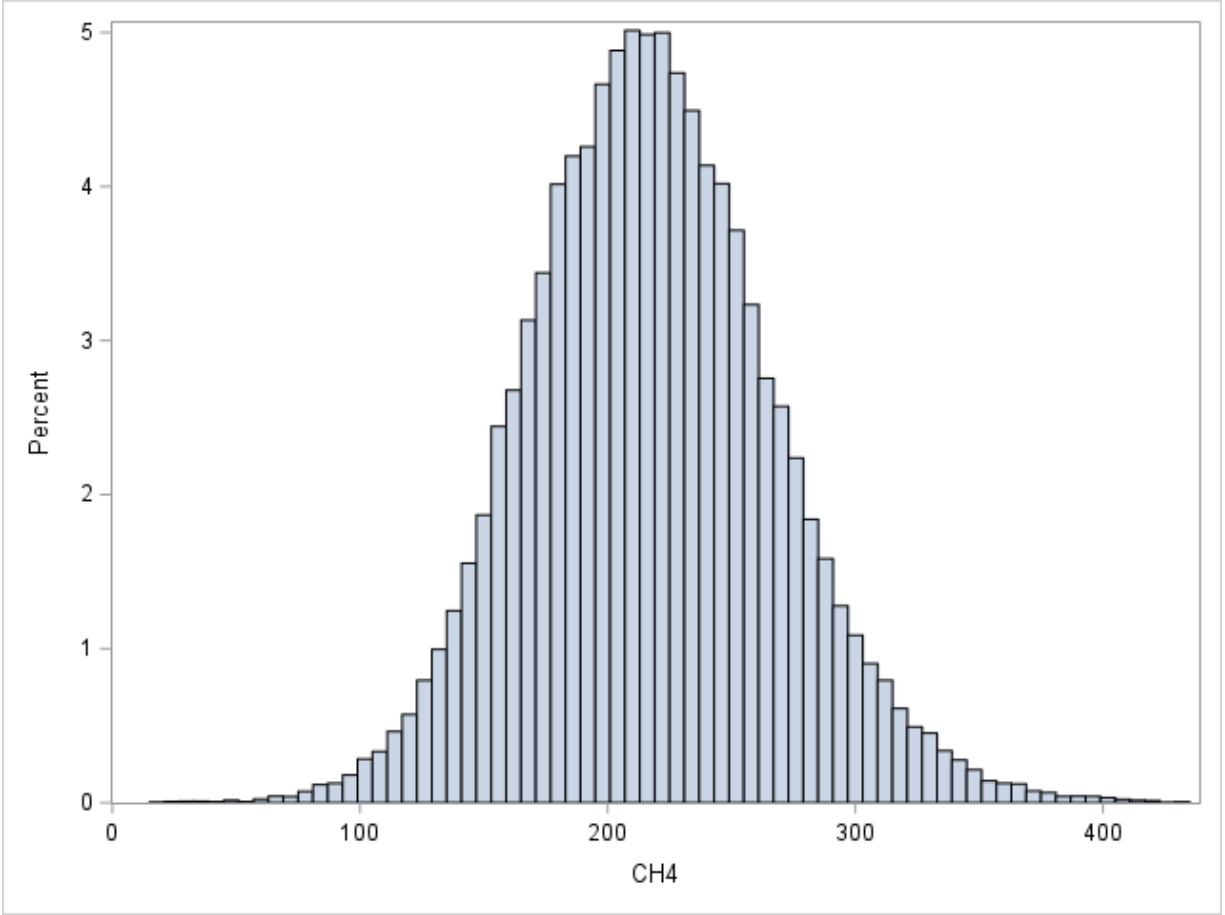
- Data edits:
  - Bulls > 10 CH_4 measures
  - Testdays > 10 CH_4 measures

- Final data:
  - 76 094 observations (GF visits)
  - 212 young Norwegian Red bulls
  - 964 testdays
  - From 13 to 794 GF visits per bull, mean 359
  - From 10 to 115 visits per day, mean 79

Methane emission young Norwegian Red bulls

Distribution of CH4 records (g/day)

- Mean: 218 g/day
- SD: 50 g/day
- 212 young bulls
- September 2020 to April 2023



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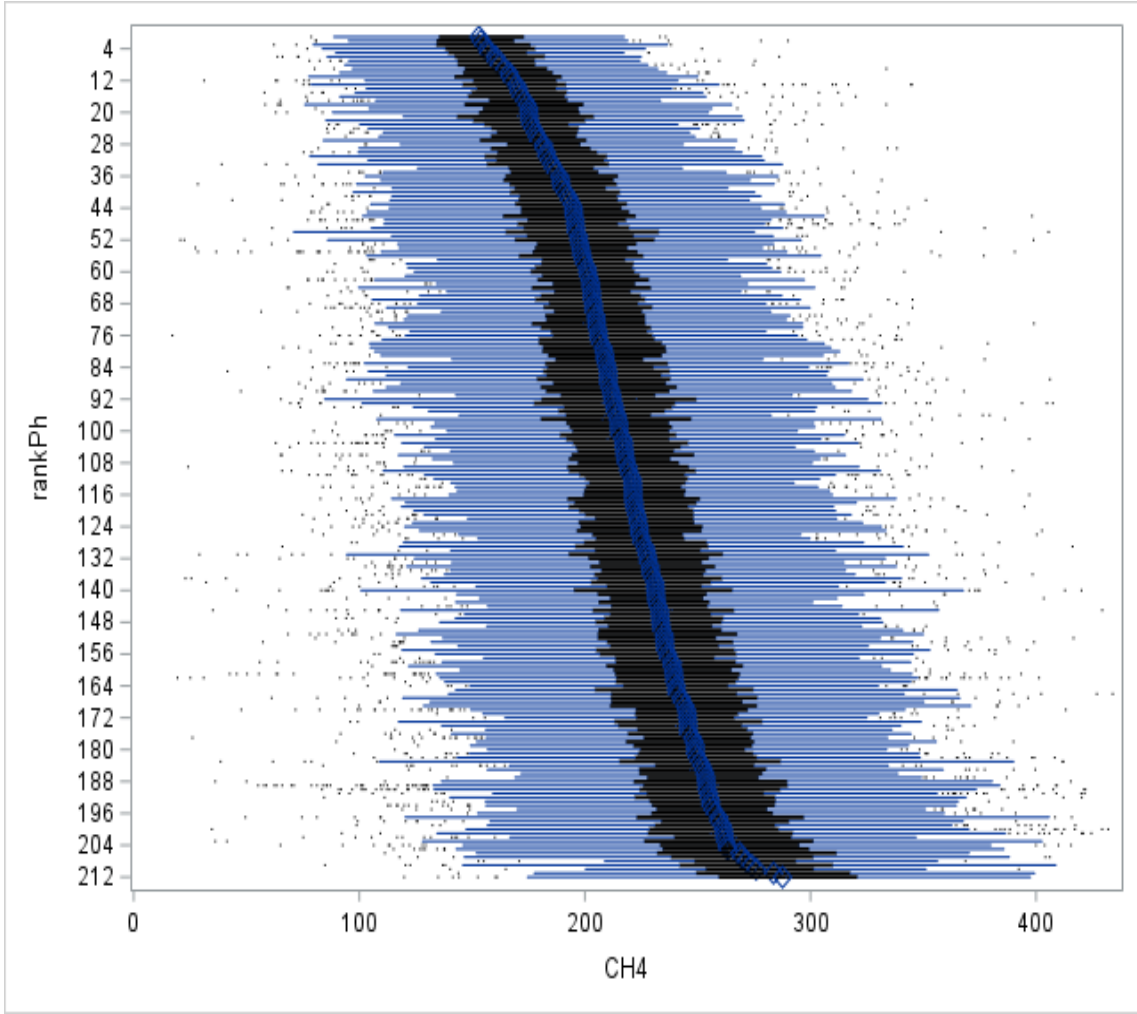
Variation in methane emission within and between bulls

Phenotypic variation in methane

- Boxplot of methane records per bull, sorted by increasing mean value
- Mean CH4 (g/day) from 153 to 287



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Estimating heritability

- **Traits**
  - CH_4 g/day (per visit)
  - CH_4 mean per bull per day (8 713 records)

- Estimating variance components using DMU (Madsen and Jensen, 2013)

- **Linear animal repeatability model**

  CH_4 = age + group-testday + pe + animal + e

- Fixed effects of age in weeks (23 classes) and group-testday (964 days)
- Random effects of permanent environment (pe) and animal

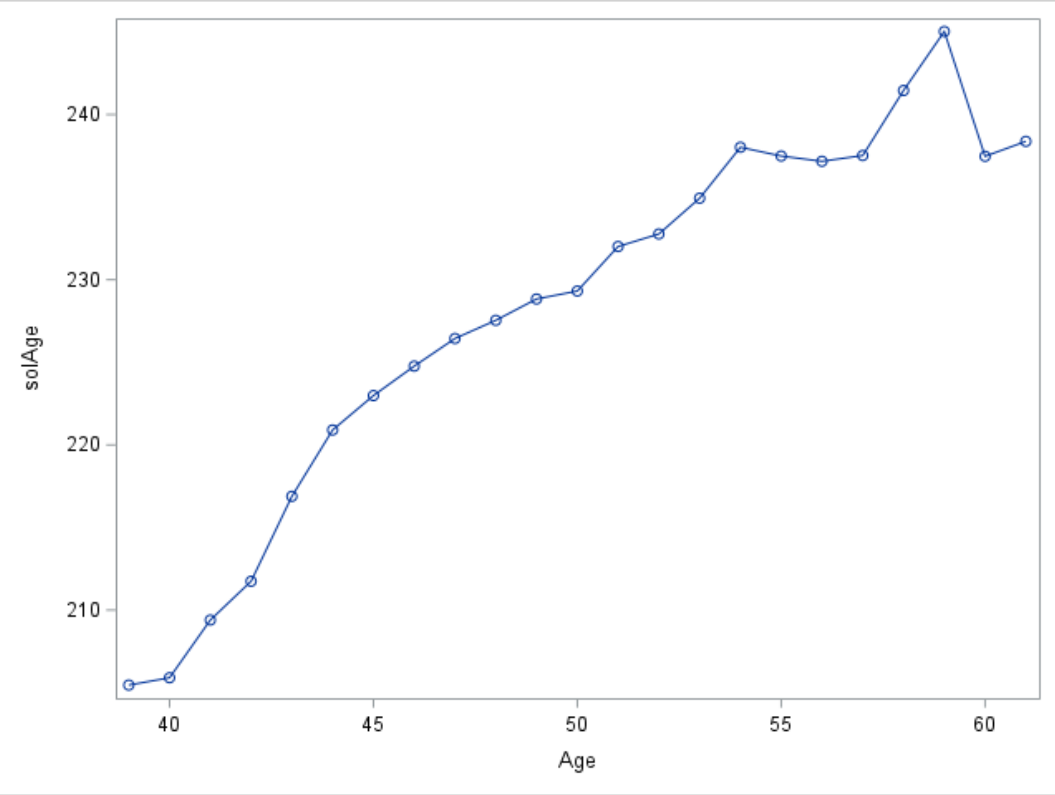
- Pedigree file: 4 233 animals

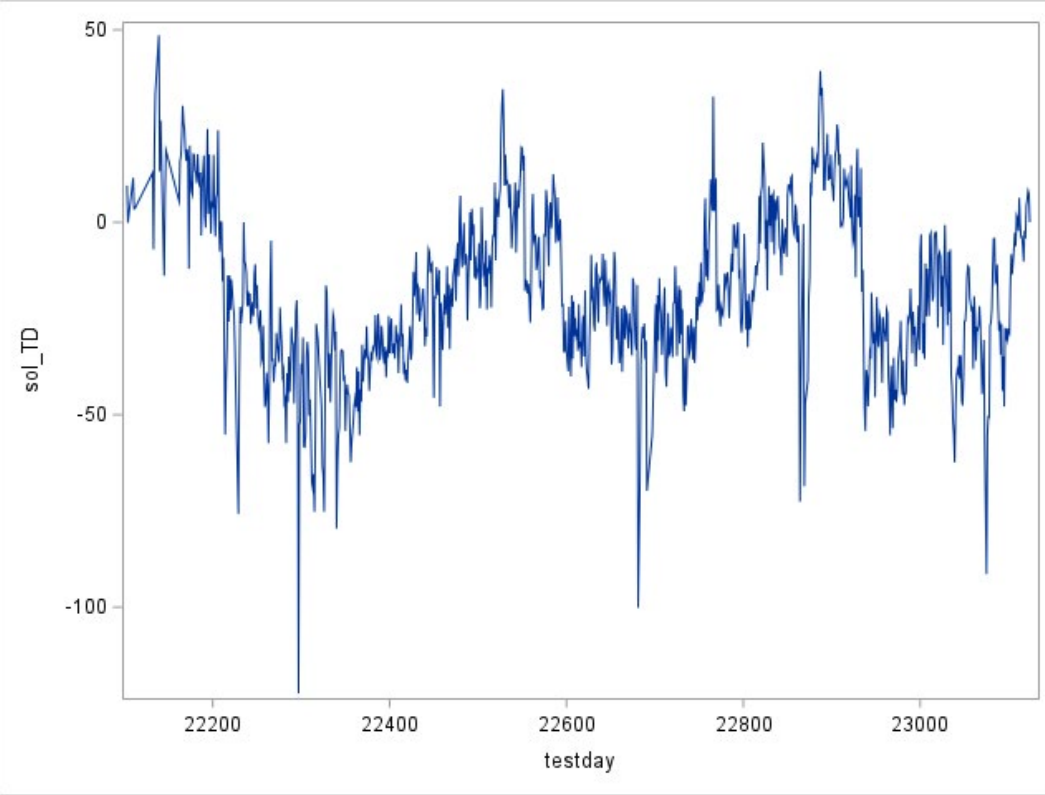
Estimated heritability

	CH_4 per visit			CH_4 mean per day	
Variance component	Estimate	Standard error		Estimate	Standard error
pe	153	194		141	188
animal	532	216		538	211
residual	1479	8		278	5
Heritability	**0.24**	**0.10**		**0.56**	**0.20**
Repeatability	0.32			0.71	

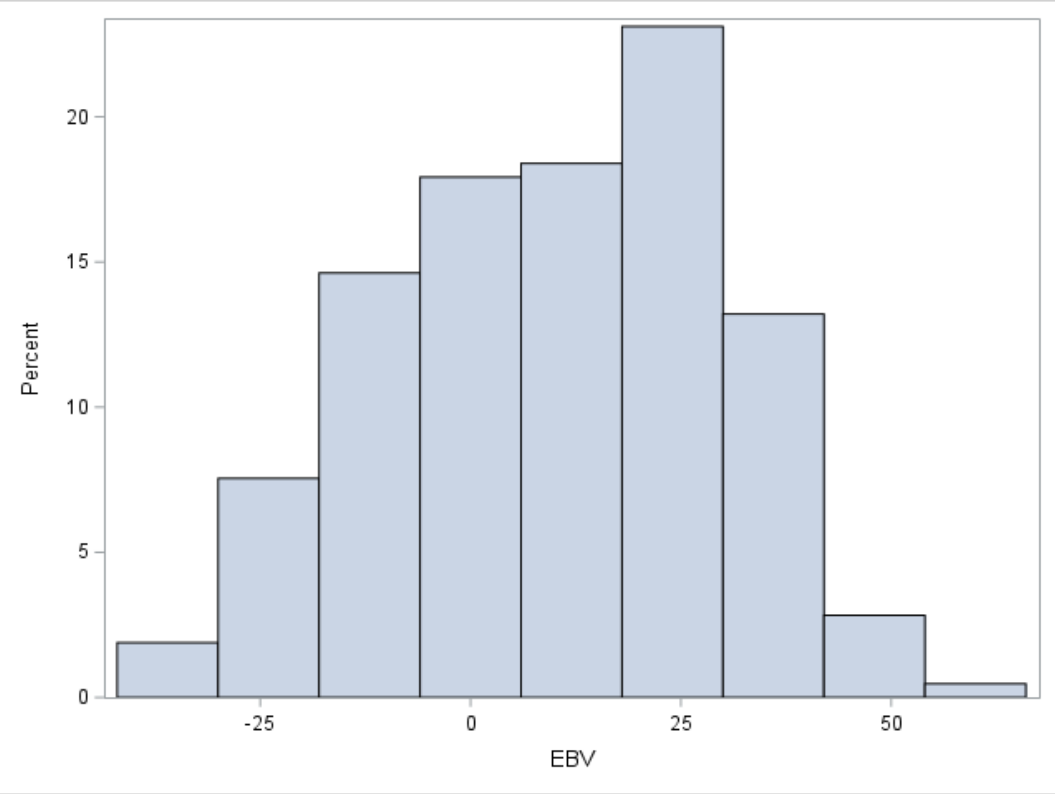
Effects of age and group-testday

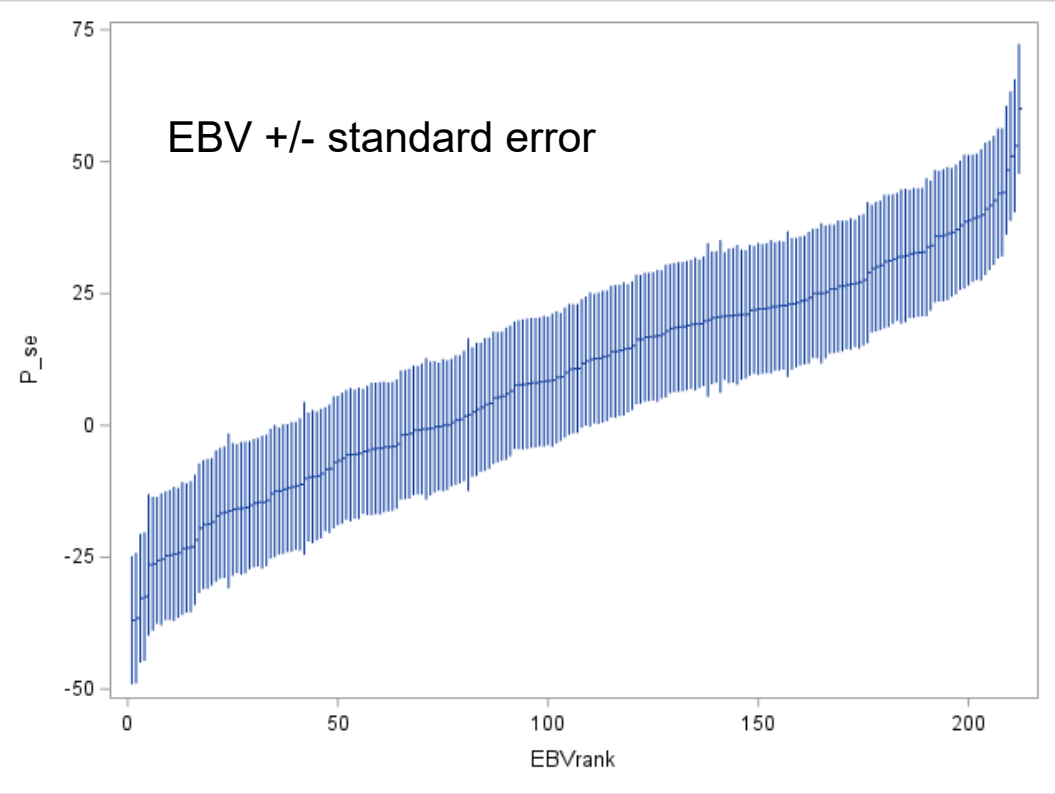
Fixed effect solutions:





Breeding values for bulls with CH4 phenotype





EBV range from -37 to 60, with standard error between 12 and 15

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Correlations between EBV for methane (CH4) and indexes from routine genetic evaluations

Traits with the strongest positive and negative correlations to EBV for CH_4:

	Correlation to CH4
Carcass weight	0.34
Angularity/rib structure[1]	0.29
Body depth[1]	0.27
Body total score[1]	0.26
Stature[1]	0.25

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

	Correlation to CH4
Calf size, direct[2]	-0.36
Calving ease, direct	-0.34
Stillbirth, direct	-0.25
Hock quality[1]	-0.23
Bone structure[1,3]	-0.22

[2] Calf size: High score is small calf

[3] Bone structure: High score is very fine and thin bones low score for coarse bones (broad and thick).

Positive correlation = High CH_4 associated with high index for other traits

Unfavorable index correlation to body conformation traits

Negative correlation = low CH_4 associated with good genetic merit for other traits

Favorable index correlation to calving traits

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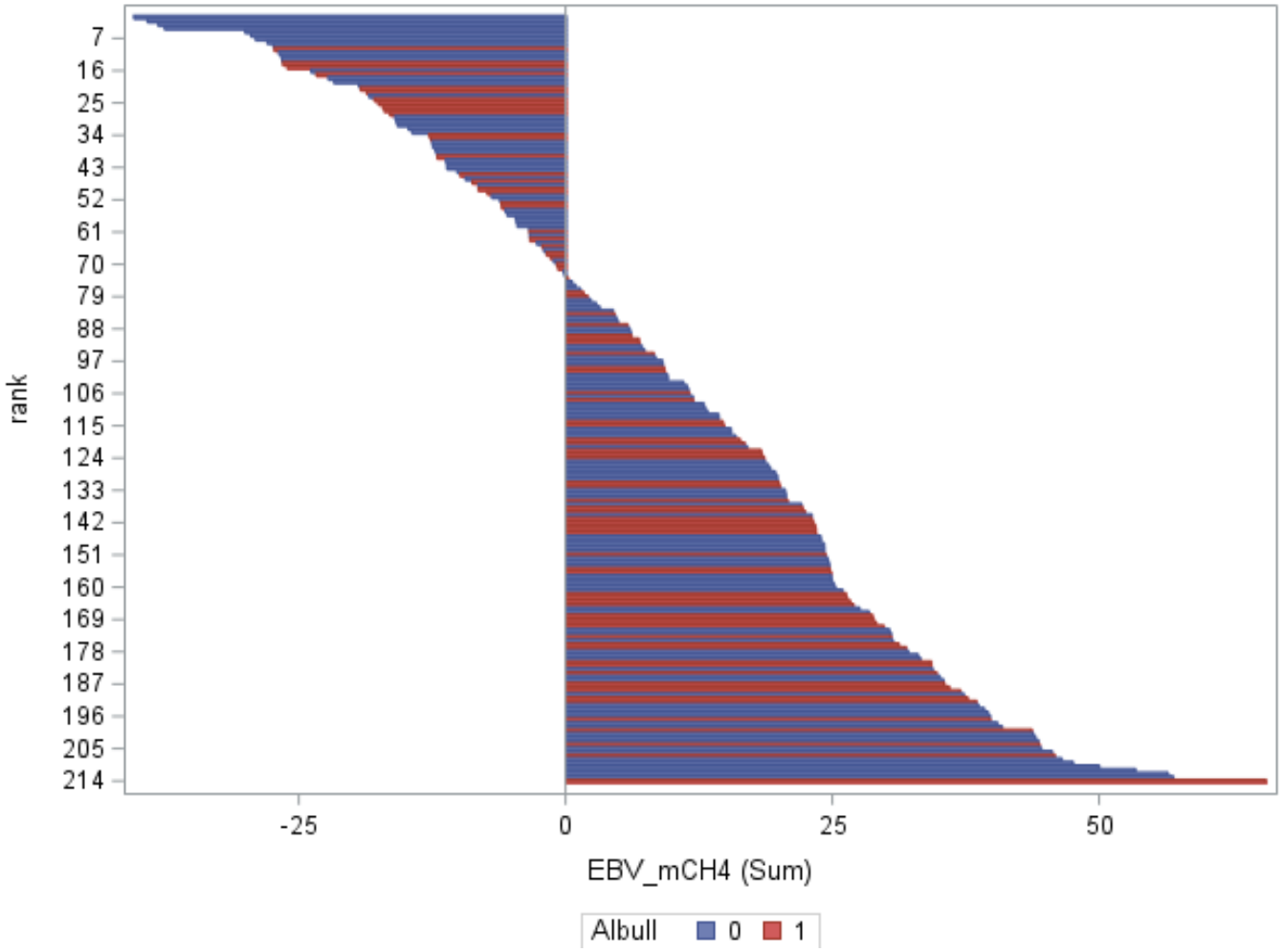
Breeding values for methane emission young Norwegian Red bulls



- Predicted breeding values for methane for 212 young Norwegian Red bulls with CH_4 phenotype
- Sorted from lowest to highest
- Color indicate AI-bull selection:

  Selected (**red**)

  Not selected (**blue**)

Results so far:

- Promising
- Good CH_4 data from GreenFeed
- Genetic variation for CH_4 in NR
- Breeding for lower CH_4 emission is feasible

Further research:

- CH_4 young bulls vs lactating dairy cows
- Accuracy of genomic breeding values
- Genetic associations to other important traits
  - Feed efficiency, milk yield, health and fertility…
- Merging methane and feed efficiency projects
- Trait definitions
- 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

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