Heritability of methane emission in young Norwegian Red bulls

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Breeding program for Norwegian Red

Recruiting AI bulls:

• 100,000 NR bull calves born per year
• The 8,000 with highest EBV are genotyped
• Geno buys \( \approx 150 \) 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
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
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**
  \[ \text{CH}_4 = \text{age} + \text{group-testday} + \text{pe} + \text{animal} + e \]

  • 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

<table>
<thead>
<tr>
<th>Variance component</th>
<th>CH$_4$ per visit</th>
<th>CH$_4$ mean per day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Standard error</td>
</tr>
<tr>
<td>pe</td>
<td>153</td>
<td>194</td>
</tr>
<tr>
<td>animal</td>
<td>532</td>
<td>216</td>
</tr>
<tr>
<td>residual</td>
<td>1479</td>
<td>8</td>
</tr>
<tr>
<td>Heritability</td>
<td>0.24</td>
<td>0.10</td>
</tr>
<tr>
<td>Repeatability</td>
<td>0.32</td>
<td></td>
</tr>
</tbody>
</table>
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
Correlations between EBV for methane (CH4) and indexes from routine genetic evaluations

<table>
<thead>
<tr>
<th>Trait</th>
<th>Correlation to CH4</th>
<th>Correlation to CH4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass weight</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Angularity/rib structure¹</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Body depth¹</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Body total score¹</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Stature¹</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>

¹ Trait not included in the Norwegian total merit index

Positive correlation = High CH4 associated with high index for other traits

Unfavorable index correlation to body conformation traits

Negative correlation = low CH4 associated with good genetic merit for other traits

Favorable index correlation to calving traits

- Calf size, direct²: -0.36
- Calving ease, direct: -0.34
- Stillbirth, direct: -0.25
- Hock quality¹: -0.23
- Bone structure¹,³: -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).
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