Genetic selection for lower predicted methane emissions in dairy cattle

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Introduction

- Mitigation of enteric methane (CH\textsubscript{4}) emission in ruminants is an important area of research
  - Nutrition
  - Microbes
  - Genetic variation
- Breeding
  - Direct
  - Indirect
  - Feed efficiency
  - Predicted methane emission

New!

Aim of study

To establish whether first lactation cows differed phenotypically, genetically and genotypically for their individual predicted enteric CH\textsubscript{4} emission

Potential of genetic selection to reduce CH\textsubscript{4} emissions
Collected data

- Experimental farm: 613 cows
  - Feed intake (daily)
  - Ration composition (twice weekly)
  - Body weight (weekly)
  - Milk production & milk contents (weekly)

- Blood samples: 588 cows
  - Illumina 50k Chip
  - 43,011 SNP

Available data

- After all editing steps:
  - 548 animals
  - 17,759 cow-week records
    - 225 days (100 – 305 days)

- Analysed traits:
  - Dry matter intake (DMI, in kg/d)
  - Residual feed intake (RFI, in MJ/d)
  - Fat and protein corrected milk (FPCM, in kg/d)
  - Predicted methane emission (PME, in gr/d)

Trait definition

Predicted methane emission (in gram/day):
(Intergovernmental Panel on Climate Change Tier-2 methodology (IPCC, 2000))

\[
\text{PME (in gr/d)} = \frac{\text{feed intake (in kg DM/d)} \times \text{energy content of kg DM} (18.4 \text{ (MJ/kg DM)})}{\text{energy generated by methane} (0.05565 \text{ (MJ/g)})} \times \text{percentage methane of gross energy} (0.06) \times \text{scaling factor} \left[1 + (2.38 – \text{level of intake (multiples of maintenance level)}) \times 0.04\right]
\]
PHENOTYPIC

Lactation curve PME

Lactation curves – milk & PME
Relation PME with FPCM

Phenotypic correlations

<table>
<thead>
<tr>
<th></th>
<th>PME</th>
<th>FPCM</th>
<th>DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPCM</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI</td>
<td>0.99</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>RFI</td>
<td>0.72</td>
<td>-0.45</td>
<td>0.72</td>
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</tbody>
</table>

PME = Predicted methane emission (g/d)
FPCM = Fat and protein corrected milk production (kg/d)
DMI = Dry matter intake (kg/d)
RFI = Residual feed intake (MJ/d)
## Heritabilities

<table>
<thead>
<tr>
<th>Lactation period (weeks)</th>
<th>PME</th>
<th>PME/FPCM</th>
<th>PME/RFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-42</td>
<td>0.35</td>
<td>0.31</td>
<td>0.32</td>
</tr>
<tr>
<td>1-5</td>
<td>0.29</td>
<td>0.29</td>
<td>0.34</td>
</tr>
<tr>
<td>6-10</td>
<td>0.30</td>
<td>0.18</td>
<td>0.50</td>
</tr>
<tr>
<td>11-15</td>
<td>0.26</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>16-20</td>
<td>0.40</td>
<td>0.67</td>
<td>0.21</td>
</tr>
<tr>
<td>21-25</td>
<td>0.42</td>
<td>0.70</td>
<td>0.34</td>
</tr>
<tr>
<td>26-30</td>
<td>0.35</td>
<td>0.60</td>
<td>0.43</td>
</tr>
</tbody>
</table>

## Genetic correlations

<table>
<thead>
<tr>
<th>Lactation period (weeks)</th>
<th>PME - FPCM</th>
<th>PME - RFI</th>
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</thead>
<tbody>
<tr>
<td>0-42</td>
<td>0.31</td>
<td>0.32</td>
</tr>
<tr>
<td>1-5</td>
<td>-0.66</td>
<td>0.84</td>
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<tr>
<td>6-10</td>
<td>0.18</td>
<td>0.50</td>
</tr>
<tr>
<td>11-15</td>
<td>0.42</td>
<td>0.18</td>
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<td>0.60</td>
<td>0.43</td>
</tr>
</tbody>
</table>
Accuracies of predicting PME

<table>
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<tr>
<th>Model Type</th>
<th>R_{gg}'</th>
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</thead>
<tbody>
<tr>
<td>Polygenic</td>
<td>0.21</td>
</tr>
<tr>
<td>Polygenic + SNP</td>
<td>0.37</td>
</tr>
</tbody>
</table>

\( g \) = true breeding value
\( g' \) = predicted breeding value

Posterior QTL probabilities for cumulated PME

Bayes Factor of 10.1
Possible impact on PME

- 0.22 genetic s.d. per year, i.e.
  - Classical breeding programme (progeny testing milk)
  - Genomic selection, with low accuracy and short generation interval (Calus et al., 2011)

- Ten years: 13 to 9 gr PME /kg FPCM
  i.e. 30% reduction

- Realistic?
  - How much effort will be put on this trait
  - Association with real methane emission

Take home message

Breeding for reduced predicted methane emission is possible and opens up opportunities to breed more environment-friendly cows!

Acknowledgements

- Dutch Dairy Board (PZ)
- Senter Novem (currently: Agentschap NL)
- RobustMilk - Grant Agreement KBBE-211708

Thank you for listening