Genetic architecture of methane emissions from dairy cows

Marcin Pszczoła, Sebastian Mucha, Tomasz Strabel, Ewa Selll-Kubiak

GRANT NO: OPUS 2013/09/B/NZ9/03179
$\text{CH}_4 = \text{Greenhouse gas}$
$\text{CH}_4 = 2\% - 12\%$ energy loses
Does genetic variance in CH$_4$ exist?
27% of variation in daily CH$_4$ emission is heritable

Pszczola et al. JAS, 2017
Which genes control CH$_4$ emission?
CH$_4$

Eructation (~90%)

Gas (~9-8%)

Breath (~1-2%)
Measuring scheme

FTIR GASMET equipment

Automated milking system

Milking device

Probe

Feeding bin

Probe

Feeding bin

Automated milking system

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## Collected CH$_4$ data

<table>
<thead>
<tr>
<th>Farm 1</th>
<th>Farm 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-NOV</td>
<td>2016-FEB</td>
</tr>
<tr>
<td>2016-JUN</td>
<td>2016-SEP</td>
</tr>
<tr>
<td><strong>227</strong></td>
<td><strong>54</strong></td>
</tr>
<tr>
<td>24,336</td>
<td>1,535</td>
</tr>
<tr>
<td>39,680</td>
<td>39,680</td>
</tr>
</tbody>
</table>
Daily CH₄ emission

\[ CH₄ [l/d] = \frac{CH₄ [ppm]}{CO₂ [ppm]} \times HPU [l/d] \]
GWAS
Method

Bayesian Variable Selection (BayZ)

Assumptions:

\[
\beta \sim \begin{cases} 
N(0, \sigma^2_{\beta_0}) & \text{with probability } \pi_0 \\
N(0, \sigma^2_{\beta_1}) & \text{with probability } \pi_1 
\end{cases} \\
\pi_1 = 0.001
\]

500k MCMC iterations for posterior means

15k BURN-IN
Model

**Fixed**
Lactation (1 or 2+)
General lactation curve ($3^{rd}$ ord. Leg. pol.)
Year-week of the measurement (accounting for Farm)

**Random**
Animal ($2^{nd}$ ord. Leg. pol.)
Permanent environment ($2^{nd}$ ord. Leg. pol.)
Error
Identified SNP
50 SNP with BF>10
3 SNP with BF>30
Variance explained

TOTAL
0.154%
Variance explained

- TOTAL 0.154%
- 10 > BF < 30 0.122%
- BF > 30 0.032%
Previously reported QTL

*cow qtlDB (www.animalgenome.org)
Previously reported QTL

- milk production & composition
- body size

*cow qtlDB (www.animalgenome.org)*
Previously reported QTL

milk production & composition

health status

body size

feed efficiency

*cow qtlDB (www.animalgenome.org)
5 candidate genes found

*BIOMART (Ensembl Bos Taurus UMD 3.1)
5 candidate genes found

- **CYP51A1**
  - BTA 4

- **PPP1R16B**
  - BTA 13

- **NTHL1, TSC2, PKD1**
  - BTA 25

*BIOMART (Ensembl Bos Taurus UMD 3.1)*
metabolism

GO TERMS
GO TERMS

metabolism

lipids

steroids

nitrogen

lysocome (Energy)
GO TERMS

metabolism

lipids

nitrogen

steroids (Energy)

lysosome

protein synthesis & gradation
metabolism

- lipids
- steroids
- nitrogen

lysosome (Energy)

protein synthesis & gradation

blood vessel
endothelial cells regulation

GO TERMS
GO TERMS

- metabolism
  - lipids
  - steroids
  - nitrogen
  - lysosome (Energy)

- development

- protein synthesis & gradation

- blood vessel endothelial cells regulation
GO TERMS

metabolism
  - nitrogen
  - lipids
  - steroids
  - lysosome (Energy)

development
  - endothelial barrier
  - blood vessels
  - digestive tract

protein synthesis & gradation
  - blood vessel
  - endothelial cells regulation
Conclusions

- Small proportion of the genetic variance explained
- QTL in genomic regions for traits related to CH$_4$
- Candidate genes possibly relevant to CH4 emission
CH$_4$ emission has complex genetic architecture