Proxies for methane output in dairy cattle: evaluation of suitability as indirect traits for breeding goal

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Why methane?

GHG
$\text{CH}_4$ → (anthropogenic) climate change

Feed efficiency
Strong relationship between $\text{CH}_4$ and feed intake

Emerging phenotype
- Environmental sustainability
- Farm efficiency
Mitigation strategies

diet
e.g. < fibres, > starch (van Gastelen et al., 2015)

probiotics
e.g. yeasts

supplements
e.g. ionophore antibiotics, tannins, saponins

defaunation
i.e. elimination of protozoa

immunization
e.g. against methanogenic *Archaea*

breeding
cumulative and permanent results

reviewd by Martin et al., 2010
The breeding option

- **direct selection** against methane emissions
- **ruminal CH$_4$** to be measured on individual animals
- e.g. **respiration chambers, GreenFeed**
- cumulative, sustainable, long-term, least-cost strategy

methane emissions shown to be **heritable**

heritability estimates: e.g. $h^2 \sim 0.20$ in beef cattle (Donoghue et al. 2013)
However

• Direct measurement of methane output is expensive, time-consuming and labor intensive
• Not really applicable on a large scale and routine basis (required for a breeding programme)

finding alternative measures that are related to methane production/emission and can be feasibly collected on a large scale and routine basis
need for proxies

**Proxies** are traits/measurements that “approximate” individual methane output, and have desirable characteristics (cheap, easy to measure, robust ...)

Methane production in the rumen is related to many biological processes:
- Feed intake
- Body weight
- Rumination
- Milk yield
- Milk composition
- etc ...

Borrowing from a “minor” guitarist: this is the quest for our “**proxy**” lady
# Types of proxies

<table>
<thead>
<tr>
<th>proxy</th>
<th>easy</th>
<th>accuracy</th>
<th>cost</th>
<th>invasive</th>
<th>throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk MIR</td>
<td>***</td>
<td>high</td>
<td>low</td>
<td>no</td>
<td>high</td>
</tr>
<tr>
<td>Rumen fatty acids</td>
<td>*</td>
<td>moderate</td>
<td>high</td>
<td>limited</td>
<td>moderate</td>
</tr>
<tr>
<td>Rumen volume / sonogram</td>
<td>**</td>
<td>?</td>
<td>moderate</td>
<td>no</td>
<td>limited</td>
</tr>
<tr>
<td>Feed intake / efficiency</td>
<td>**</td>
<td>very high</td>
<td>high</td>
<td>no</td>
<td>moderate</td>
</tr>
<tr>
<td>Body weight / milk yield</td>
<td>*****</td>
<td>moderate</td>
<td>low</td>
<td>no</td>
<td>moderate</td>
</tr>
<tr>
<td>Rumen activity (sensors)</td>
<td>****</td>
<td>moderate</td>
<td>moderate</td>
<td>no</td>
<td>huge</td>
</tr>
<tr>
<td>Laser methane detector</td>
<td>****</td>
<td>controversial</td>
<td>high</td>
<td>no</td>
<td>high</td>
</tr>
</tbody>
</table>
A couple of illustrations

**rumen sensors**
(rumination tag)

measure rumination activity (time) and movement of the animals

rumination activity has been associated to **metabolism** (e.g. blood glucose, proteins, ...) and **DMI**

[Soriani et al., JAS 2012]

probably related also to **methane** emissions!
A couple of illustrations

predicting equations

e.g.
• from **DMI** [de Haas et al., 2011]
• from **combination of traits** (production, body weight, DMI, ruminal liquor parameters etc ...) [Biscarini, unpublished]

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>correlation</strong></td>
<td>0.566</td>
<td>0.626</td>
<td>0.786</td>
</tr>
<tr>
<td><strong>std dev</strong></td>
<td>0.124</td>
<td>0.118</td>
<td>0.056</td>
</tr>
</tbody>
</table>
future perspectives

Systematic review of possible proxies for CH4: pros and cons, suitability for breeding

This work is being carried on within two European projects:

- Ruminomics (FP7)
- Methagene (COST action)

Meta-analysis of results from literature/other studies
Thanks!

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