Breeding for improved feed efficiency and reduced enteric methane of dairy cattle

Yvette de Haas and Roel Veerkamp
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countries. They have become widely disseminated in Sweden and Norway, and there are now control associations in Finland, Russia, Germany and Scotland. In most places an attempt is made to carry out the weighing and valuation of the feed, as in Denmark; but, in some parts of Norway, where the cows subsist entirely on grass in the summer and on hay and straw in the winter, it is thought that the estimate of the feed will be too inaccurate, and therefore the work of the control assistant is limited to managing the test milking, testing for butter fat, and keeping a record of the milk and butter yield.

Where there is no record of the consumption of feed, there will be no basis for a fair comparison of the milk and butter yield in the various herds, because the amount of feed will always affect the yield of butter; but, even without a record of the feeding, the “control” will give every farmer valuable information regarding the yield of milk and butter of the individual cows, so that he can positively distinguish the best, the good, and the poor cows; and he gets an opportunity to find those cows that give particularly rich milk, which is of immense importance, if it is, as we believe, that giving rich or poor milk is for each cow a peculiar and inherited quality.

Note—
1 pound, Danish, is the same as 1.12 English.
1 Krone = $0.268.
1 Øre = $0.025 Krone = ¼ cent.

[Presented by the Committee on Cooperation in Animal Breeding.]
Translated from the Danish manuscript.

COW-TESTING ASSOCIATIONS.

Colon C. Lilige, Coopersville, Mich.

A cow-testing association is a cooperative business association among the dairy farmers of a community for the purpose of testing their cows for economical production. Each cow is charged with the food she consumes and given credit for the butter fat she produces for the entire year at market prices. A competent person is employed by the association to go from farm to farm and weigh and compute the ration, weigh and test the milk and keep accurate records of the same.
Traditional breeding

Pedigree

Estimated breeding value (BLUP)

Phenotypes
Genomic selection

Pedigree

Genomic breeding value

Phenotypes
In The Netherlands

We developed (a procedure to predict) feed intake (DMI) breeding values for Dutch bulls and cows

First genetic evaluation in 2014
DMI data

- Data from 1990 onwards:
  - Data providers
    - Wageningen Livestock Research
    - ILVO
    - Trouw Nutrition
    - Schothorst Feed Research
    - AVEVE
    - CRV
      - Alders herd – 240 cows
      - in 2019: 4 more herds to follow
5649 cows with DMI data
- 2380 cows with data and genotypes
- 3269 cows with data without genotypes
5649 total cows from 1085 sires

- 530 sires with genotypes
- 555 sires without genotypes
**Predictor traits**

- Genomic EBV DMI directly from DMI genetic evaluation combined with national EBV for four predictor traits:
  - Kg milk
  - Kg fat
  - Kg prot
  - Live weight

<table>
<thead>
<tr>
<th>Genetic correlations</th>
<th>DMI1</th>
<th>DMI2</th>
<th>DMI3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg milk</td>
<td>0.55</td>
<td>0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>Kg fat</td>
<td>0.58</td>
<td>0.60</td>
<td>0.58</td>
</tr>
<tr>
<td>Kg prot</td>
<td>0.59</td>
<td>0.61</td>
<td>0.59</td>
</tr>
<tr>
<td>Live Weight</td>
<td>0.67</td>
<td>0.45</td>
<td>0.41</td>
</tr>
</tbody>
</table>

- Selection index weighted based on reliabilities
- Model reliabilities
### Reliabilities DMI – only genomics

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>55,437</td>
<td>2,249</td>
<td>123</td>
<td>2,922</td>
</tr>
<tr>
<td></td>
<td>+ 22,391</td>
<td>+ 965</td>
<td>+ 429</td>
<td>+ 1,502</td>
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<tr>
<td>2016</td>
<td>77,828</td>
<td>3,214</td>
<td>166</td>
<td>4,424</td>
</tr>
<tr>
<td></td>
<td>+ 51,610</td>
<td>+ 1,149</td>
<td>+ 368</td>
<td>+ 2,529</td>
</tr>
<tr>
<td>2017</td>
<td>129,438</td>
<td>4,363</td>
<td>200</td>
<td>6,941</td>
</tr>
<tr>
<td></td>
<td>+ 30,510</td>
<td>+ 1,082</td>
<td>+ 182</td>
<td>+ 1,409</td>
</tr>
</tbody>
</table>

### Reliability Changes

- **2015**: 18% (Base)
- **2016**: +7%
- **2017**: +8%
- **2018**: +5%
- **2019**: +38%
Reliabilities for bulls with genomic predictions, but no daughters with DMI

 Avg: 25%
 Max: 77%
Reliabilities for bulls with genomic predictions and daughters with DMI

- Avg: 25%
- Max: 77%
- Avg: 47%
- Max: 91%
Reliabilities for all bulls in pedigree of genetic evaluation DMI + predictors

- Avg: 25%
- Max: 77%
- Avg: 47%
- Max: 91%
- Avg: 62%
- Max: 92%
Saved Feed Cost (SFC)

- \( SFC = \) saved feed cost for maintenance
  = feed intake – feed for production
  
  -> feed for:
      maintenance
      difference in digestion
      activity

- Unit: euro/lactation
To sum up:

- >5600 cows with feed intake data
  - Increase over the years (about 1000/year)
  - Increase in genomic reliability

- DMI used to define SFC
  - SFC part of NVI

- Big step to breed for efficient cow
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Cows ruminate

Ruminants account for up to 18% of the world CH$_4$ production

>90% of CH$_4$ excreted through the breath

Animal nutrition
Microbes
Genetics
Climate agreement - *klimaatakkoord*

- **Objective** (for NL) is to achieve a greenhouse gas (GHG) emission reduction of 49% in 2030 (compared to 1990) *(and of 95% in 2050)*

- In 1990 – total GHG emissions were 228 megaton CO$_2$-eq
- In 2030: this has to be reduced to 116 Mton
  - The current mitigation strategies will enable a reduction to 165 Mton
  - The climate agreement has to bridge the gap of 49 Mton
If we continue to do what we already do:

- Methane, g/d
- Methane, g/kg milk

Current pop. means:

CH$_4$: 392 g/d
Milk: 9000 kg (305 d)
Intensity: 16g CH$_4$/kg milk
This is what breeding can do:

Current Trend
Active selection for lower CH4 per cow
Theoretical maximum

\[
\begin{align*}
\sim 16 \text{ g CH}_4/\text{kg} \\
\sim 15.6 \text{ g CH}_4/\text{kg} (-2.5\%) \\
\sim 15.4 \text{ g CH}_4/\text{kg} (-6.0\%) \\
\sim 13.9 \text{ g CH}_4/\text{kg} (-13\%)
\end{align*}
\]
This is what breeding can do:

- Current Trend
- Active selection for lower CH₄ per cow
- Theoretical maximum

- ~16 g CH₄/kg
- ~14 g CH₄/kg (-11%)
- ~11 g CH₄/kg (-27%)
- ~7 g CH₄/kg (-54%)
That is why we are collecting data on farm
That is why we are collecting data on farm

- Barn (18)
- GreenFeed (18)
- Sniffer (15)

Intersection:
- Barn and GreenFeed: 3
- Barn and Sniffer: 8
- GreenFeed and Sniffer: 5
- Barn, GreenFeed, and Sniffer: 11

Wageningen University & Research
Towards a breeding value for methane
Towards a breeding value for methane

Heritabilities for methane range between 0.1 and 0.4
Towards a breeding value for methane

Our ambition is to record data on 100 commercial farms
Take home messages

- Genomics did open the era of breeding for novel traits
  - Large reference populations are still needed

- Successful publication of EBV for feed intake and feed efficiency in the Netherlands

- Working towards breeding as mitigation tool to reduce enteric methane emissions of dairy cattle
Thank you!