A Star Tech, The Final Front-MIR: Estimated breeding values for mid-infrared derived predictions of energy traits in dairy cows.

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Speaker: Steph Smith
A STAR TECH: 
THE FINAL FRONT-MIR

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Scene Selection

Scene 1
Introducing MIR

Scene 2
The importance of phenotypes

Scene 3
Developing prediction tools for energy traits

Scene 4
Developing prediction tools for the incidence of ketosis

Scene 5
Tool application

Scene 6
Conclusions & thanks
Objective: Can we detect other physiological or biochemical signatures from milk MIR spectra?
Scene 1: mid-infrared technology

Research animal measurements

MIR spectral data

Alignment & calibration

Statistical analysis

Predicted trait

Internal cross – validation

Initially developed by McParland et al. 2011
“In the age of the genotype…

PHENOTYPE IS KING!”

- Mike Coffey
Scene 2: Importance of phenotypes

SRUC Dairy Research herd

The data
- 922 Holstein – Friesian dairy cows
- 2003 – 2014
- 5 lactations
- c.520,000 records

Cows subject to long term 2 x 2 factorial exp.

Phenotypes recorded:
- Milk yield
- Fat %, protein %
- Live weight
- Body condition score
- Dry matter intake

Diet components:
- Organic matter digestibility (% DM)
- Metabolizable energy (MJ/kg DM)
- Crude protein (g/kg DM)
- Organic matter (g/kg DM)

Blood sample analyses:
- BHB
- NEFA
- Urea
- Lactoferrin

Scene 2: Importance of phenotypes
Scene 2: Importance of phenotypes

SRUC Dairy Research herd

Modelling

Fixed effects
✓ Genetic group
✓ Feed group
✓ Calving age (months)
✓ Year of calving by season of calving interaction
✓ Year of record by month of record interaction
✓ Year of record by experimental farm interaction
✓ Days in milk (poly 4)

Random effects
✓ Days in milk (poly 4) by animal interaction

Smoothed daily phenotypic records for each cow/lactation/days-in-milk

Use to calculate body energy traits:
✓ Daily energy balance (EB, megajoules/day)
✓ Daily energy intake (EI, megajoules/day)
Energy balance (MJ/d)

Calculated based on milk yield, fat and protein content, dry matter intake, body weight, body condition score

\[
\text{EB} = \frac{\text{Energy in}}{\text{Energy out}}
\]

Feed \hspace{2cm} \text{Maintenance, lactation, methane}

For example a score of 55 means that the cow is in positive energy balance by an excess of 55MJ, at the time measured
Effective energy intake (MJ)

Calculated based on organic matter intake, digestible crude protein, metabolisable content.

\[
\text{El} = \frac{\text{Energy in}}{\text{Energy used to digest}}
\]

For example a score of 230 means that a cow has consumed 230 MJ of food, once it has been processed, at the time measured.

Equations developed by Emmans (1994); Banos and Coffey (2010)
Scene 3: MIR-derived energy prediction tools

Energy balance

R = 0.84
SEC = 22.7
SDEP = 19
RPD = 1.6

Energy intake

R = 0.84
SEC = 24.2
SDEP = 21.7
RPD = 1.6
Ketosis is a metabolic disorder in which the body has to derive energy from ketone bodies.

**BHB** = B-hydroxybutyrate and is a very stable ‘ketone body’

**NEFA** = Non-esterified fatty acids and a measure of fat mobilisation.

Scene 4: MIR-derived ketosis prediction tools

### Predicted NEFA

Partial Least Squares Analysis

Validation
Scene 4: MIR-derived ketosis prediction tools

- BHB
  - $R = 0.87$
  - $SEC = 0.28$
  - $SDEP = 0.23$
  - $RPD = 1.8$

- NEFA
  - $R = 0.88$
  - $SEC = 0.36$
  - $SDEP = 0.3$
  - $RPD = 1.9$
Scene 5: Tool application

- Records from Jan 2013 – April 2017
- All data standardised according to latest files (and available unstandardised)
- Over **13.7 million** animal testdates worth of spectral, **4490** herds
- Predictions
  - **13.6 million** fatty acid estimates (32)
  - **12.4 million** BHB and NEFA estimates
  - **12.5 million** energy balance, intake and content estimates

> ![Image]
### Scene 5: Tool application

<table>
<thead>
<tr>
<th>Trait</th>
<th>N</th>
<th>$\sigma_a^2$</th>
<th>$\sigma_{pe}^2$</th>
<th>$h^2$</th>
<th>$c^2$</th>
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<td>EEI</td>
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<td>178.15</td>
<td>7.26</td>
<td>0.10</td>
<td>&lt;0.001</td>
<td>0.10</td>
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</tbody>
</table>
Scene 5: Tool application
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Predictions from 366 herds, >150,000 animals and almost 2 million animal testdates
Scene 5: Tool application

Predictions from 366 herds, >150,000 animals and almost 2 million animal testdates
Scene 5: Tool application

PLI vs. PTA for sires for energy balance

17.8 MJ/day
Scene 5: Tool application

PLS vs. PTA for sires for energy intake

16.8 MJ/day
• Demonstrated the ability to predict BHB and NEFA using MIR
• Could be used routinely as an early-indicator of potential health issues
• Energy balance predicted routinely from MIR at NMR; BHB and NEFA predictions due to accompany these
This work was funded by Innovate UK, BBSRC and the Scottish Government. This was completed with project partners National Milk Records, UK, who undertook the MIR analysis of the milk samples, and Marks and Spencer's.

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