Recording of feed efficiency under on-farm conditions

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The project „Efficient Cow“
Recording feed efficiency is a challenge!

• Ways of recording feed efficiency
  • Record the feed intake precisely for a small group of animals on station
  • Estimate feed intake of many animals on farm based on animal and diet information with impact on the feed intake
  • Work with further auxiliary traits like mid-infrared-spectra

• Efficient Cow
  • Finding ways to record/estimate feed efficiency on-farm
  • Looking for possible auxiliary traits for practical use
Recorded data
Data recorded

- General information about farm (housing, feeding, ...)
- Recording of health data
- Documentation of claw trimming
- Test for ketosis based on milk
- Linear scoring of all cows across lactations
- At each time of milk recording in 2014
  - Body weight, body measures, BCS, lameness scoring
  - Information about diet and estimation of feed intake
  - Routine information about milk recording + MIR-spectra
- Austrian main breeds
  - Fleckvieh / Simmental (FL), Brown Swiss (BS), Holstein (HF)
### Recorded data – Fleckvieh / Simmental (FL)

<table>
<thead>
<tr>
<th>COWS</th>
<th>N</th>
<th>LACT 1</th>
<th>LACT 2</th>
<th>LACT &gt;=3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM</td>
<td>3,942</td>
<td>25,913</td>
<td>25.06 (±5.97)</td>
<td>27.94 (±8.37)</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>3,992</td>
<td>29,812</td>
<td>685 (±79)</td>
<td>735 (±83)</td>
</tr>
<tr>
<td>WAIST</td>
<td>3,989</td>
<td>30,078</td>
<td>251 (±14)</td>
<td>259 (±14)</td>
</tr>
<tr>
<td>CHEST</td>
<td>3,989</td>
<td>30,086</td>
<td>208 (±10)</td>
<td>212 (±10)</td>
</tr>
<tr>
<td>MUSC 1-9</td>
<td>3,984</td>
<td>29,888</td>
<td>5.58 (±1.21)</td>
<td>5.72 (±1.33)</td>
</tr>
<tr>
<td>BCS 1-5</td>
<td>3,988</td>
<td>30,089</td>
<td>3.32 (±0.52)</td>
<td>3.33 (±0.55)</td>
</tr>
<tr>
<td>LAME 1-5</td>
<td>3,987</td>
<td>29,812</td>
<td>1.13 (±0.43)</td>
<td>1.2 (±0.53)</td>
</tr>
</tbody>
</table>
Estimation of dry matter intake (DMI)
Estimating feed intake (Gruber et al. 2004)

feed intake = breed + lactgroup + lactday + weight +
+ milk yield + concentrate + NEL (forage)

- **breed**: Fleckvieh, Brown Swiss or Holstein
- **lactgroup**: lactation group (1, 2+3, e4)
- **lactday**: day in milk (days)
- **weight**: body weight (kg)
- **milk yield**: milk yield, not ECM (kg/day)
- **concentrate**: concentrate amount (kg/day)
- **NEL (forage)**: net energy lactation in forage (MJ/kg)
Comparison of 5 models predicting feed intake

<table>
<thead>
<tr>
<th>Model</th>
<th>obs.</th>
<th>pred.</th>
<th>RMSPE</th>
<th>Bias</th>
<th>Regression</th>
<th>Random</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRC</td>
<td>20.3</td>
<td>21.7</td>
<td>1.80</td>
<td>64.7%</td>
<td>4.1%</td>
<td>31.3%</td>
</tr>
<tr>
<td>NorFor</td>
<td>21.3</td>
<td>21.7</td>
<td>1.52</td>
<td>6.1%</td>
<td>37.7%</td>
<td>56.3%</td>
</tr>
<tr>
<td>TDMI</td>
<td>20.3</td>
<td>20.2</td>
<td>1.71</td>
<td>0.3%</td>
<td>22.3%</td>
<td>77.3%</td>
</tr>
<tr>
<td>Zom</td>
<td>20.3</td>
<td>21.9</td>
<td>3.16</td>
<td>26.3%</td>
<td>27.9%</td>
<td>45.8%</td>
</tr>
<tr>
<td>Gruber</td>
<td>20.3</td>
<td>20.5</td>
<td>1.17</td>
<td>3.6%</td>
<td>2.9%</td>
<td>93.4%</td>
</tr>
</tbody>
</table>

Models: NRC (NRC, 2001), NorFor (Volden et al. 2011), TDMI (Huhtanen et al. 2011), Zom (Zom et al., 2012), Gruber (Gruber et al. 2004)

RMSPE: square root of mean square prediction error (MSPE) in kg DM/day

Jensen et al., 2015
Observed vs. predicted feed efficiency

\[ y = 0.21 + 0.792 \times \]

\textit{RMSE} = 0.12 kg
\textit{R}^2 = 0.82
Pearson Corr. = 0.91
Spearman Rank Corr. = 0.89

Gruber et al., 2016 (in preparation)
Standardizing for 100\textsuperscript{th} day in milk
Standardizing

• Weight, DMI, NEL-Intake, ECM and ECM / NEL got standardized for lactation day 100 and no pregnancy
• Added the mean of the estimated random effects of each cow and test day to the expected value of an average cow on this farm
• Used software
  • R version 3.2.4 - R Core Team (2016)
  • R packages
    • lme4 – Bates et al. (2014)
    • data.table – Dowle et al.(2015)
    • ggplot2 – Wickham (2009)
### Used Models

<table>
<thead>
<tr>
<th>Y</th>
<th>Lactation group**</th>
<th>Day in milk</th>
<th>Day of gestation</th>
<th>Weight</th>
<th>MJ NEL / kg DMI</th>
<th>Organic farm</th>
<th>Maize %***</th>
<th>g XP / MJ NEL</th>
<th>Age at first calving</th>
<th>* farm</th>
<th>* animal within fram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>X</td>
<td>log²</td>
<td>X²</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DMI</td>
<td>X</td>
<td>log²</td>
<td>X³</td>
<td>X²</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NEL-Intake</td>
<td>X</td>
<td>log²</td>
<td></td>
<td>X²</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>ECM</td>
<td>X</td>
<td>X²</td>
<td>X²</td>
<td>X²</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ECM / NEL</td>
<td>X</td>
<td>X³</td>
<td>X²</td>
<td>X²</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

* ... (Nested) random effects are marked grey, all others used as fixed effects
** ... 1., 2. and ≥3. Lactation, except ECM/NEL: 1.+2. and ≥3. Lactation
*** ... 3 groups: no maize, < 35% and ≥35% maize in diet
<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>MAX</th>
<th>LACT 1</th>
<th>LACT 2</th>
<th>LACT ≥3</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 2796 cows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥3 observations in lact.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEIGHT</td>
<td>477</td>
<td>983</td>
<td>664 (±59)</td>
<td>707 (±62)</td>
<td>751 (±69)</td>
</tr>
<tr>
<td>ECM</td>
<td>9.88</td>
<td>49.20</td>
<td>27.82 (±5.2)</td>
<td>30.79 (±5.26)</td>
<td>31.87 (±5.47)</td>
</tr>
<tr>
<td>DMI</td>
<td>11.07</td>
<td>27.27</td>
<td>18.98 (±2.22)</td>
<td>20.88 (±2.26)</td>
<td>21.54 (±2.34)</td>
</tr>
<tr>
<td>NEL-INTAKE</td>
<td>94.3</td>
<td>181.7</td>
<td>129.4 (±12.6)</td>
<td>142 (±13.6)</td>
<td>144.9 (±14.5)</td>
</tr>
<tr>
<td>ECM / LM0.75</td>
<td>0.092</td>
<td>0.351</td>
<td>0.212 (±0.035)</td>
<td>0.225 (±0.036)</td>
<td>0.223 (±0.037)</td>
</tr>
<tr>
<td>ECM / NEL</td>
<td>0.116</td>
<td>0.308</td>
<td>0.219 (±0.025)</td>
<td>0.220 (±0.027)</td>
<td>0.220 (±0.028)</td>
</tr>
<tr>
<td>FORAGE-ECM %</td>
<td>32.3</td>
<td>99.1</td>
<td>61.0 (±7.9)</td>
<td>57.3 (±8.3)</td>
<td>56.5 (±8.3)</td>
</tr>
</tbody>
</table>
Link between weight and DMI (FL)

![Graph showing the relationship between weight and DMI.](image-url)
Link between weight and ECM (FL)
Link between weight and ECM / metab. weight (FL)
Link between weight and ECM / NEL (FL)

![Graph showing the relationship between weight and ECM/NEL (FL) with data points and trend lines for different lactation stages.](image)

- **X-axis**: WEIGHT (kg)
- **Y-axis**: ECM / NEL (kg / MJ)

Legend:
- **1./2. Lact.**
- **≥3. Lact.**

Mean of weight (FL)
Conclusions
Conclusions for practical use

• Data recording from about 5,300 cows under on-farm-conditions was a big challenge
• Body weight has high impact on feed efficiency
• Recording of body weight was easier to handle than taking different body measures, but time of weighing influences result
• Practical use of diet information would need also reliable weights and information on mobilization (maybe from MIR spectra)
• With estimated DMI efficiency traits like residual feed intake (RFI) doesn’t make sense and results have been carefully interpreted.
  • What do we really see, when cows differ in kg ECM / MJ NEL?
Perspective

• Discussion about Findings out of Efficient Cow started in Austria

• Short term: only weight (or auxiliary traits like conformation traits - frame, muscularity, body measures) as important impact factor on feed efficiency possible

• Long term: estimation of breeding values for claw health and metabolism interesting

• But all results and ideas have to get discussed with our partners in Germany and Czech Republic
Acknowledgement

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Thank you for your attention!