Improving nutritional efficiency in ruminant production systems

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Dairy Research & Innovation Centre

Leading the way in Agriculture and Rural Research, Education and Consulting
Plan for talk

• Financial importance of feed efficiency
• Increased productivity
• Breeding for feed efficiency (proxies)
• Choice of production system
• Reducing feed waste
• Nutrition models
• Precision monitoring
Breakdown of variable costs

- Upland suckler cow and calf (late Spring calving) – feed is £210 of total £352 variable costs [60%]
- Barley finishing at 12 months – feed is £295 of total £392 variable costs [75%]
- Finishing autumn-born suckled calf at 18 months – feed is £163 of total £272 variable costs [60%]
- Grass finishing – feed is £87 of total £150 variable costs [58%]

Farm Management Handbook 2016/17
Langhill project

- Genotype x Environment experiment
- 50 years of selection for Milk solids yield
- Two management systems (5-year blocks) – currently High Energy and Standard Energy diets (~4.5 and 1.5 tonnes concentrates/cow/annum)
## Performance: July 2017-2018

<table>
<thead>
<tr>
<th></th>
<th>DMI (kg/d)</th>
<th>Milk Yield (kg)</th>
<th>Fat (%)</th>
<th>Protein (%)</th>
<th>Milksolids/DMI (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select</td>
<td>22.7</td>
<td>38.4</td>
<td>4.05</td>
<td>3.39</td>
<td>125.8</td>
</tr>
<tr>
<td>Control</td>
<td>20.5</td>
<td>33.3</td>
<td>3.67</td>
<td>3.19</td>
<td>111.4</td>
</tr>
<tr>
<td><strong>Standard Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select</td>
<td>20.0</td>
<td>29.2</td>
<td>4.36</td>
<td>3.38</td>
<td>113.0</td>
</tr>
<tr>
<td>Control</td>
<td>18.6</td>
<td>27.6</td>
<td>3.96</td>
<td>3.15</td>
<td>105.5</td>
</tr>
</tbody>
</table>
### Between animal variation

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Difference in feed eaten (same gain)</th>
<th>Financial gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabiliser bulls (UK)</td>
<td>Top ¼ vs Bottom ¼</td>
<td>25%</td>
</tr>
<tr>
<td>Simmental heifers (Ireland)</td>
<td>Top ⅓ vs Bottom ⅓</td>
<td>14%</td>
</tr>
<tr>
<td>Angus or Hereford bulls (Canada)</td>
<td>Top ⅓ &amp; Bottom ⅓</td>
<td>3.4 kg ‘as fed’</td>
</tr>
<tr>
<td>CH/CHx steers – high concs (SRUC)</td>
<td>Top ¼ vs Bottom ¼</td>
<td>28% (3.8 kg Dry Matter)</td>
</tr>
<tr>
<td>Luing steers – high forage (SRUC)</td>
<td>Top ¼ vs Bottom ¼</td>
<td>31% (4.2 kg Dry Matter)</td>
</tr>
</tbody>
</table>
Breeding for Feed Efficiency

- Progress with pigs and poultry over several decades demonstrates what is possible
- Moderate heritabilities (0.2 to 0.4) recorded in various studies worldwide
- Residual Feed Intake (RFI) or Net Feed Efficiency (NFE) used to break correlations with animal size – looks at intake relative to expectation based on weight and growth
- UK breeds now starting to generate EBVs for feed efficiency
Feed efficiency measurements

• Requires:
  – Accurate measurements of feed intake over a set test period (typically 60 days)
  – Accurate measurements of productivity (Live weight gains, fat depth, muscle depth)
Difficulties encountered

- Cost of recording: £500-1000 per animal
- Difficulty of sourcing the animals at the right age (seasonal patterns)
- Challenges in achieving good representation of the population for genetic evaluation (AI and natural service)
- Health issues of moving animals (from ringworm to BVD)
Nutrition biomarkers

Faeces

Urine

Milk

Breath

Hair

Blood
Nitrogen isotopic fractionation

- $^{14}\text{N}$ and $^{15}\text{N}$ behave differently in the animal, so:
  - Urine is depleted in $^{15}\text{N}$ relative to the diet
  - Milk and animal tissues are enriched in $^{15}\text{N}$ relative to the diet

- Ecologists use this to work out food chains
Nitrogen isotopic fractionation

- **AMINO ACIDS (Glutamate)**
  - Deamination
  - Transamination
- **AMMONIA**
- **UREA cycle**
- **ASPARTATE**
- **PROTEIN ($^{15}$N enriched)**
- **UREA ($^{15}$N depleted)**
$\Delta^{15}N$ (Delta-$^{15}N$)

- This is the change in $^{15}N$ content between different trophic levels...
- In this case between feed $^{15}N$ and animal protein (e.g. plasma protein) $^{15}N$
Proxies for feed efficiency?

Increase in $^{15}$N in protein vs. Feed Conversion Efficiency (%)

$R^2 = 0.64$

Wheadon et al., 2014; British Journal of Nutrition
Meta-analysis (38 diets)

Cantalapiedra-Hijar et al., 2018; Animal
Microbial genes as proxies?

• **49 microbial genes** found to be significantly associated with **feed conversion ratio (FCR)** explaining **88% of the variation in FCR** and were mainly in clusters 2 and 5.

• Microbial genes are related to known metabolic pathways, e.g. degradation of amino acids and proteins, protein and vitamin synthesis of microbes

Roehe *et al.* (2016) PLOS Genetics
Plan for talk

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- Choice of production system
- Reducing feed waste
- Beef nutrition models
- Precision monitoring
Choice of production system

- High maintenance requirement of suckler cows – spread across (usually) a single calf
- Intensive (cereal) finishing reduces ‘maintenance’ costs
Choice of production system

• High maintenance requirement of suckler cows – spread across (usually) a single calf
• Intensive (cereal) finishing reduces ‘maintenance’ costs

• However: suckler beef/high-forage systems may utilise feeds that other livestock cannot use – and result in premium products
Reducing feed waste

10 to 70% loss of DM between field and mouth
Reducing feed waste

- Silage making (additives; clamp preparation and management)
- Silage clamp and trough management at feeding
- Grazing management to ensure utilisation
- Feed storage to avoid spoilage
(Beef) nutrition models

- Has not been an active research area in the UK since the demise of the Rowett and ADAS Feed Evaluation Units
- Nothing published in the UK since AFRC (1993) so a wide range of models in use
- Genotypes (e.g. mature sizes) and feed resources are continually changing
- Inefficiency owing to these uncertainties
- Current AHDB project (SRUC and AFBI) addressing some of the issues
Excess fat

• 13.6% of beef carcasses too fat (Roehe et al., 2010)

• ‘Double whammy’:
  – Animals are fed too much for too long
  – Excess fat has to be trimmed
Animal imaging/sensors

- Intake/rumination
- Fermentation/digestion
- Heat production
- Growth/conformation
Improving feed efficiency

• Breeding has delivered increases indirectly (productivity, health, fertility effects)

• Lots of between-animal variation and tools mean we are starting to select directly

• Improve preservation, storage and feeding practices to reduce waste

• Update nutritional models, supported by new precision monitoring tools