OPERATIONAL MEASURES OF EFFICIENCY: MAKE THEM MEASUREABLE ON LARGE SCALE

Session “What the hell is resilience and efficiency?”

Hélène Gilbert – Egbert F. Knol
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MAKE THEM MEASUREABLE ON LARGE SCALE

Session “What the hell is resilience and efficiency?”

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Efficiency: what is the objective?

Pig Farm final product = meat  
Consumer starting product = Meat?  
Human edible proteins?
What is the farmer object?

The pig

Pig Farm final product = meat
What is the farmer object?
The pig, using sun to grow

Pig Farm final product = meat
What is the farmer object?
The pig, using sun to grow, raised from a litter

Pig Farm final product = meat
What is the farmer object?
The pig, using sun to grow, raised from a litter, born from a sow

Pig Farm final product = meat
What is the farmer object?
The pig, using sun to grow, raised from a litter, born from a sow, among multiple sows raised in a farm

Pig Farm final product = meat
What is the fuel?

Pig Farm final product = meat

= MJ DE
## Kilo or energy or cost per kg gain

*Which unit to consider?*

<table>
<thead>
<tr>
<th>Diet ME (kcal/kg)</th>
<th>Diet CP (%)</th>
<th>49d body wt (g)</th>
<th>Feed intake 35-49d (g)</th>
<th>Feed:gain 35-49d</th>
<th>Energy efficiency (Mcal/kg gain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3200</td>
<td>18</td>
<td>2950</td>
<td>2580</td>
<td>2.34</td>
<td>7.43</td>
</tr>
<tr>
<td>2900</td>
<td>16</td>
<td>2920</td>
<td>2760</td>
<td>2.49</td>
<td>7.19</td>
</tr>
<tr>
<td>2600</td>
<td>14</td>
<td>2880</td>
<td>2900</td>
<td>2.72</td>
<td>6.97</td>
</tr>
<tr>
<td>2300</td>
<td>13</td>
<td>2910</td>
<td>3270</td>
<td>2.99</td>
<td>6.70</td>
</tr>
<tr>
<td>1900</td>
<td>11</td>
<td>2910</td>
<td>3670</td>
<td>3.31</td>
<td>6.37</td>
</tr>
<tr>
<td>1600</td>
<td>9</td>
<td>2890</td>
<td>4300</td>
<td>4.01</td>
<td>6.41</td>
</tr>
</tbody>
</table>

*Table 1.* Effect of diet dilution from 35-49d of age on broiler performance.

Adapted from Leeson et al. (1996)
Is efficiency only energy?

Which unit to consider?

= MJ DE

What about Protein efficiency?
AA?
Minerals?
Vitamins?
Farmer approach

Total feed efficiency =

Pork farm out
Feed farm in
Total feed efficiency (TFE)
TFE TOPIGS Research farm Beilen

Total Feed Efficiency over the past 10 years

\[ y = -0.02x + 42.64 \]
Efficiency of the production system

~ Knol 2010
Losses

Efficiency of the production system

~ Knol 2010
Losses
Efficiency of the production system

→ Need models and measures
Model: define

Total feed intake

Gestation
- Maintenance
- Reproduction
- Intra-uterine fluids
  - Placenta
  - Foetus
  - Mammary gland
  - Body protein
  - Body fat

Lactation
- Maternal gain
- Physical activity
- Milk
- Mammary gland growth
- Mobilized tissue

Grower-finisher
- Maintenance
- Protein deposition
- Fat deposition
- Residual feed intake
Model: quantify

Total feed intake

- Gestation
  - Maintenance
  - Reproduction
  - Maternal gain
  - Physical activity
- Lactation
  - Maintenance
  - Milk
  - Mammary gland growth
  - Mobilized tissue
- Grower-finisher
  - Maintenance
  - Protein deposition
  - Fat deposition
  - Residual feed intake

- 70%
- 6%
- 18%
- 6%
- 29%
- 99%
- 5%
- -32%
- 40%
- 29%
- 31%
- 0
Model: quantify

Total feed intake

- Gestation
  - Maintenance
  - Reproduction
  - Maternal gain
  - Physical activity

- Lactation
  - Milk
  - Mammary gland growth
  - Mobilized tissue

- Grower-finisher
  - Maintenance
  - Protein deposition
  - Fat deposition
  - Residual feed intake

- 339 kg
  - 70%
  - 6%
  - 18%
  - 6%

- 145 kg
  - 29%
  - 99%
  - 5%
  - -32%

- 3119 kg
  - 40%
  - 29%
  - 31%
  - 0
### Model: quantify

<table>
<thead>
<tr>
<th></th>
<th>Model Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake during gestation (kg)</td>
<td>339</td>
</tr>
<tr>
<td>Feed intake during lactation (kg)</td>
<td>145</td>
</tr>
<tr>
<td>Feed intake during nursery (kg)</td>
<td></td>
</tr>
<tr>
<td>Feed intake during growing-finishing (kg)</td>
<td></td>
</tr>
<tr>
<td>Sum of FI of grower-finishers (kg)</td>
<td>3119</td>
</tr>
<tr>
<td>Total feed intake per litter (kg)</td>
<td>3602</td>
</tr>
<tr>
<td>No animals slaughtered per litter</td>
<td>12.6</td>
</tr>
<tr>
<td>Slaughter weight (kg)</td>
<td>116.3</td>
</tr>
<tr>
<td>Live weight sold per litter (kg)</td>
<td>1463</td>
</tr>
<tr>
<td><strong>TFE</strong></td>
<td><strong>2.461</strong></td>
</tr>
</tbody>
</table>
## Model: validate

<table>
<thead>
<tr>
<th>Model Prediction</th>
<th>Observed in Beilen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake during gestation (kg)</td>
<td>339</td>
</tr>
<tr>
<td>Feed intake during lactation (kg)</td>
<td>145</td>
</tr>
<tr>
<td>Feed intake during nursery (kg)</td>
<td>28</td>
</tr>
<tr>
<td>Feed intake during growing-finishing (kg)</td>
<td>218</td>
</tr>
<tr>
<td>Sum of FI of grower-finishers (kg)</td>
<td>3119</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

➔ Overestimation model less than 0.5%
### Model: evaluate, test sensitivity

<table>
<thead>
<tr>
<th>Trait Description</th>
<th>Normal Value</th>
<th>+1 std dev</th>
<th>TFE</th>
<th>change in TFE</th>
<th>%</th>
<th>abs%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline, 20 traits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 HGP-BF (mm)</td>
<td>15.3</td>
<td>18.3</td>
<td>2.583</td>
<td>0.121</td>
<td><strong>4.9</strong></td>
<td><strong>4.9</strong></td>
</tr>
<tr>
<td>2 Average daily gain (g/d)</td>
<td>730</td>
<td>807</td>
<td>2.380</td>
<td>-0.082</td>
<td><strong>-3.3</strong></td>
<td><strong>3.3</strong></td>
</tr>
<tr>
<td>3 Litter size at farrowing</td>
<td>15.1</td>
<td>18.2</td>
<td>2.406</td>
<td>-0.056</td>
<td><strong>-2.3</strong></td>
<td><strong>2.3</strong></td>
</tr>
<tr>
<td>4 Litter mortality during lactation %</td>
<td>10%</td>
<td>22%</td>
<td>2.497</td>
<td>0.036</td>
<td><strong>1.4</strong></td>
<td><strong>1.4</strong></td>
</tr>
<tr>
<td>5 Body weight at start lactation (kg)</td>
<td>219</td>
<td>253</td>
<td>2.497</td>
<td>0.035</td>
<td><strong>1.4</strong></td>
<td><strong>1.4</strong></td>
</tr>
<tr>
<td>6 Slaughter weight (kg)</td>
<td>116.3</td>
<td>123.8</td>
<td>2.494</td>
<td>0.033</td>
<td><strong>1.3</strong></td>
<td><strong>1.3</strong></td>
</tr>
<tr>
<td>..</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Killing out %</td>
<td>78%</td>
<td>80%</td>
<td>2.462</td>
<td>-0.00013</td>
<td><strong>-0.005</strong></td>
<td><strong>0.005</strong></td>
</tr>
<tr>
<td>20 Number of mammary glands</td>
<td>15.1</td>
<td>16.1</td>
<td>2.462</td>
<td>0.00001</td>
<td><strong>0.000</strong></td>
<td><strong>0.000</strong></td>
</tr>
</tbody>
</table>
Need models and measures
Measures

Animal(s)
Measures
Animal(s)
Measures or proxy?

Animal(s)

Google scholar: feed efficiency and

Genomic

Biomarkers

Microbiota / Metagenomics


0 10000 20000 30000 40000
Measures or proxy?
Thousands of biomarkers discovered, how many used in practice?
The biomarker case

From discovery to use on-farm

Lack of generality in the discovery process?
Lack of decision tools?
Difficulty to quantify potential side effects?

➔ Should/Can we discover on farm?
Measures
Animal(s) AND environment
Measures and records
Animal(s) AND environments

Time $\Rightarrow$ dynamics of the responses

Huynh Tran et al, 2017
Measures and records
Animal(s) AND environments

Group composition ➔ variability of the group
➔ competition / stimulation interactions

Huynh Tran et al, 2017
Measures and records
Animal(s) AND environments

Treatments / events / changes of environment and management...

Dynamics + individual variability + external events
→ Resilience!

Taghipoor et al, 2017
Why measuring?

❖ Detect health issues
❖ Feed according to the requirements – Precision feeding
❖ Improve the population performance – in multiple E decision tools needed
Message from pig breeders

❖ Choose your objective: precision management, health improvement, selection?
❖ Choose your unit of:
  ➢ Interest: farm, pen, or animal (suggestion: farm)
  ➢ Input: MJ/Kcal; ME/DE; feed/euros/sun
  ➢ Output: kg milk, kg fat+protein

❖ Choose your measurements, plan the validation and decision tools (biomarkers, image analyses, microbiome…)
  ❖ Choose your efficiency
❖ Think dynamics and groups
  ❖ Choose your resilience
Message from pig breeders

- Find your system losses: management + animal
- Quantify maintenance requirements and keep them under control
- Quantify the relevance of the production parameters (and cull the lowest 5%, regardless)
- Record, record, record