Performance curves for on-farm optimization: evaluation of published growth models

Frederik Leen, EAAP 2016, Belfast
Why economic optimization?

- Optimize input use and output production
- Maximise economic return
- Strategy to enhance farm profitability
Recap of some production economics

- Description of technical transformation of inputs into output
- Shape can be estimated with data driven techniques
- E.G. Estimate parameters of a Cobb-Douglas: \( Y = A(x_1^\alpha x_2^\beta) \)
Rationale for the study

• A production function can also be mechanistically modelled
• Enables farm-specific curvature of the function
• This is not the case with data-driven techniques

But which performance curves are accurate and enable on-farm calibration, in order to be used in on-farm optimization?
Objective of the study

• Evaluate a list of published empiric dynamic performance curves:
  - for accuracy
  - model performance after calibration with limited data
  - today only results for growth models will be presented
M&M: data sources

4 animal performance trials:

• All pigs Piétrain x Hybrid cross
• 4 sexes in each trial: barrows, boars, GnRH-vaccinated boars, gilts
• Fed *ad libitum* on multi-phase diets
• Trials A,B: individually housed, standardized conditions
• Trials C,D: group housed, controlled commercial conditions
M&M: overview of models

Monomolecular:

\[ W(t) = W_f - (W_f - W_0)e^{-kt} \]

Gompertz:

\[ W(t) = W_0e^{\left(\frac{\mu_0}{D}(1-e^{-Dt})\right)} \]

Bridges:

\[ W(t) = W_f(1 - e^{-e^mt^a}) \]

Giesen:

\[ W(t) = \int_{t_0}^{t} ae^{-bt-\frac{c}{t}} \, dt \]

CFIW:

\[ W(t) = W_f - (W_f - W_0)e^{-k \sum_{t_0}^{t-1} a(1-e^{-bWt})} \]

Richards:

\[ W(t) = \frac{W_0W_f}{[W_o^D+(W_f^D-W_0^D)e^{-kt}]^{1/D}} \]

Concave or Sigmoid shape and inflexion point depend on parameter \( D \)
M&M: Accuracy

The lower the RMSE, the better!

Root mean squared error (RMSE) of predictions vs. observations:

$$\sqrt{\frac{\sum_{1}^{n}(y_{obs} - y_{pred})^2}{n}}$$
M&M: Performance after calibration

All observations for a sex in a trial

Observations at start, +/- 40 kg, +/- 70 kg and at delivery

Model calibrated to these observations

RMSE for predictions with calibrated model

$$\sqrt{\frac{\sum_{i=1}^{n}(y_{obs}-y_{pred})^2}{n}}$$

Calibrated model quality: linear regression of Observed vs. Predicted values:

$$Observation = \alpha + \beta \times Prediction$$

$$\alpha \approx 0 \text{ and } \beta \approx 1$$
Results: live weight models

- Bridges: 3.8 kg
- Giesen: 3.6 kg
- Gompertz: 4.0 kg
- CFIW: 4.7 kg
- Monomolecular: 4.7 kg
- Richards: 4.7 kg
Results: model performance after calibration

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<thead>
<tr>
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<th>Before calibration</th>
<th>After calibration</th>
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<tbody>
<tr>
<td>Bridges</td>
<td>3.8</td>
<td>4.5</td>
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<tr>
<td>Giesen</td>
<td>3.6</td>
<td>4.2</td>
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Mean RMSE (kg)
Results model performance after calibration

Bridges

\[ y = 0.9914x + 0.3063 \]
\[ R^2 = 0.9824 \]
\[ \alpha = 0 & \beta = 1 \]

Giesen

\[ y = 0.9782x + 1.3773 \]
\[ R^2 = 0.9849 \]
\[ \alpha \neq 0 & \beta \neq 1 \]
Conclusions & Recommendations

• Both Giesen and Bridges yield a good estimate of a sex-specific weight curve
• Results indicate that Bridges is slightly better

• Remark
  – Stability of model parameters over several production cycles needs investigation.
Thank you

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