Individual Feed Intake Model of a Dairy Cow Based on Feeding Behavior

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Volcani Center
The annual income of dairy industry is more than 2 billion euro

About 900 cooperative and family owned dairy farms

Almost 13,500 people work in the dairy industry

About 70% of the expenses are on food for the cows
The aim

To develop a feed intake model for the individual dairy cow using variables that are being measured in commercial farms
Measured in commercial farms

- Body weight
- Activity
- Milk indicators
  - Milk yield
  - Milk components
  - Electrical conductivity
- Feeding behavior
  - Feeding time
  - Number of meals
Dry Matter Intake (DMI) measured in research farms

ARO’s research farm

A commercial farm

Individual DMI measurements are possible in tie-stall barns, small-scale operations, or research centers

Pictures borrowed from Ilan Halachmi’s lab.
Motivation

1. Assess the cow individual feed efficiency
2. Breed improvement / Replacement policy
3. Detect health problems
4. Nutrition calculation
Referred DMI models

1. **NRC Model (NRC 2001)**

\[
DMI_{NRC} = \left( (0.372 \times FCM) + (0.0968 \times BW^{0.75}) \right) \times (1 - e^{-0.192 \times (w0l+3.67)})
\]

2. **2004 Model (Halachmi et al. 2004)**

\[
DMI (\%)_{0,i} = \left( b0_0 + b1_i \frac{MY_0}{BW_0} + b2_i \frac{MY_{-1}}{BW_{-1}} + b3_i \frac{MY_{-2}}{BW_{-2}} + b4_iBW_0 + b5_i \frac{MY_{-1}}{BW_0} + b6_i fat + e \right)
\]

3. **Covariate Model**

4. **Simple Linear Regression Model**

\[
DMI = .008037 \times \text{kg BW} + .3134 \times \text{kg 4% FCM} + .2286 \times \text{DIM} - .002176 \times (\text{DIM})^2 + .00000705 \times (\text{DIM})^3
\]


Halachmi, I. et al., 2015. Feeding behavior improves prediction of dairy cow voluntary feed intake but cannot serve as the sole indicator.
# Referred DMI models results

<table>
<thead>
<tr>
<th>Model</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.79</td>
</tr>
<tr>
<td>2</td>
<td>0.73</td>
</tr>
<tr>
<td>3</td>
<td>0.64</td>
</tr>
<tr>
<td>4</td>
<td>0.36</td>
</tr>
<tr>
<td>5</td>
<td>0.65</td>
</tr>
</tbody>
</table>
The Data

- Dataset of 120 cows during 117 days
- Interesting findings:
The Data

[Graph showing the relationship between DMI (Dry Matter Intake) and Meal Time (Minutes)]
The Model

Two DMI models were assessed: ‘daily’ and ‘single meals’

\[ Y = (\beta_0 + \gamma_{0,k} + \delta_{0,j}) + (\beta_1 + \delta_{1,j}) \text{mealTime}_{i,j,k} \]
\[ + \beta_2 \text{numOfMeals}_{i,j,k} + (\beta_3 + \delta_{3,j}) \text{daysInMilking}_{i,j,k} \]
\[ + \beta_4 \text{fatPercent}_{i,j,k} + \beta_5 \text{proteinPercent}_{i,j,k} + \beta_6 \text{lactation}_{i,j,k} \]
\[ + \beta_7 \text{BW}_{i,j,k} + \beta_8 \text{activity}_{i,j,k} + \epsilon_{i,j,k} \]
## Results: Model vs. Reality

<table>
<thead>
<tr>
<th></th>
<th>Daily</th>
<th>Single Meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision Livestock Farming (PLF)</td>
<td>0.93</td>
<td>0.88</td>
</tr>
<tr>
<td>Not PLF</td>
<td>0.74</td>
<td>0.78</td>
</tr>
</tbody>
</table>
1. This feasibility study suggests that our model is accurate

2. When using our model attitude results with about 20% improvement
Future plan

• Model validation (different cows\farms\countries)
• Model improvement – use of other sensors
• Applications
  • Economic decisions based on individual cows value
  • Control-charts and other modelling tools
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Thank you for listening!
Are there any questions?

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Direct monitoring of feed intake

Pictures borrowed from Ilan Halachmi’s lab


Single Meal Model

Daily Model