FEED EFFICIENCY
IN THE ITALIAN HOLSTEIN:
WORK IN PROGRESS

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Italian Holstein Association (ANAFI)
INTRODUCTION

- **Feed Efficiency**: Quantity of milk produced per quantity of **dry matter intake**

- **Feed cost** → Half of the total costs of dairy production

- Increase profitability of dairy production?
  - Reduce feed costs by *improving feed efficiency*

- **Feed trait** → Dry Matter Intake (DMI):
  - **Direct phenotypes** are scarce → difficult to collect (expensive & labor-intensive)

- **Indirect phenotypes**: milk yield & content; maintenance of the cow (body weight and/or conformation traits)
DMI & different approaches

- Heritable trait & varies across lactation stages and it is highly correlated with production and maintenance traits.

- **How to obtain this trait?**

- **One way** to obtain breeding values → **genomic selection**
  
  - phenotypes are measured in a subset of the population, and genomic predictions are calculated for other animals that have genotypes but not phenotypes.

- **Another way:** Prediction formulas based on routine data-collection
  
  → **Indirect measures:** for the «trait» can be used to assess genetic variation.

  → **Prediction trait:** a) Easy recordable; b) Routinely recorded; c) Inexpensive to measure; d) Heritable; e) Genetically correlated with the trait of interest
Italian Holstein state of the art

- Prediction equations for Live Weight (Finocchiaro et al., 2017 – ICAR Edinburgh June 2017), developed algorithm to predict live weight (based on real weight and type traits).

- Currently setting up breeding value estimation for Feed Efficiency by means of indirect traits.

- Since September 2015 Member of the ICAR Feed&Gas WG and gDMI II (international cooperation)
  - Analyzing a pilot data set on individual cow and heifers feed intake together with the Universities of Milan and Padua.

- Individual bull feed intake experiment will be set up at the ANAFI genetic center will be set up soon.
Live weight

- Tool for herd management and monitoring animals
- Used for calculating energy balance for a feeding ration
- Size of animals is related to animal maintenance costs, feed efficiency and gas emission

- Live weight data
  - Routine availability required → NO ROUTINE COLLECTION

- Solution: Estimate live weight from existing routine data
  - Age at type scoring
  - Type scores
  - ANAFI → developed algorithm to predict live weight
Work in progress

• Set-up phenotypic and genetic prediction equations for live weight using type traits
  • Estimate genetic parameters for live weight
  • Estimate selection indices for live weight

• Use of live weight for other purposes:
  1. **Functional index** → IES (Economical & Functional index) → New Anafi EBV (August 2016)
  2. **Feed efficiency**
     • Predicted feed efficiency (**short term**)
     • Predicted feed efficiency including DGV estimates based on individual measurements (**long term**)
Live weight work

• 36 herds with in total 6,895 individual weights from 3,256 cows in different parities
  • Weighing through milking robots (2013-2015)
  • Average live weight: 624.37 ± 64.24 kg

• Editing
  • Only first parity cows retained → 862 cows in 30 herds
  • Stage of lactation max 12 months; Cow age 22-41 months
  • Max days between individual live weight and type scoring ± 30 d

<table>
<thead>
<tr>
<th>Traits</th>
<th>Mean±SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured weight (kg)</td>
<td>588.99±50.12</td>
<td>500-700</td>
</tr>
<tr>
<td>Lactation stage (days)</td>
<td>141.57±78.35</td>
<td>10-365</td>
</tr>
<tr>
<td>Age at type scoring (months)</td>
<td>30.45±4.31</td>
<td>22-41</td>
</tr>
</tbody>
</table>
Phenotypic prediction of live weight

Setup model

1. \( Y = \text{HYM} + \text{MC} + \text{SL} + \text{other predictors} \)
2. \( Y - (\text{HYM} + \text{MC} + \text{SL}) = \text{other predictors} \)

- \( Y \): measured weight
- \( \text{HYM} \): herd-year-months of weighing
- \( \text{MC} \): month of calving
- \( \text{SL} \): stage of lactation

**Other predictors:**
- Age of cow at scoring
- Stature, chest width, body depth, rump width, BCS (when available)
### Phenotypic prediction of live weight: Model selection

<table>
<thead>
<tr>
<th>Linear terms</th>
<th>Quadratic terms</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Age, Stature, Rump width</td>
<td>Chest width, BCS</td>
<td>0.78819</td>
</tr>
<tr>
<td>2  Stature, Rump width</td>
<td>Age, Chest width, BCS</td>
<td>0.78819</td>
</tr>
<tr>
<td>3  Age, Stature, Rump width</td>
<td>Age, Chest width, BCS</td>
<td>0.78825</td>
</tr>
<tr>
<td>4  Age, Stature, Body depth, Rump width</td>
<td>Chest width, BCS</td>
<td>0.79120</td>
</tr>
<tr>
<td>5  Age, Stature, Rump width</td>
<td>Chest width, Body depth, BCS</td>
<td>0.79155</td>
</tr>
<tr>
<td>6  Age, Stature, Body depth</td>
<td>Chest width, BCS</td>
<td>0.79025</td>
</tr>
<tr>
<td>7  Age, Stature</td>
<td>Chest width, Body depth, BCS</td>
<td>0.79057</td>
</tr>
<tr>
<td>8  Age, Stature, Chest width, Body depth, BCS</td>
<td>Stature, Chest width, Body depth, BCS</td>
<td>0.79354</td>
</tr>
<tr>
<td>9  Age, Stature, Chest width, Body depth, Rump width, BCS</td>
<td></td>
<td>0.79141</td>
</tr>
<tr>
<td>10 Age, Stature, Chest width, Body depth, Rump width</td>
<td></td>
<td>0.74594</td>
</tr>
</tbody>
</table>
Phenotypic prediction of live weight

Setup model
1. \( Y = \text{HYM} + \text{MC} + \text{SL} + \) other predictors
2. \( Y - (\text{HYM} + \text{MC} + \text{SL}) = \) other predictors

Validation method
• Final data-set randomly splitted
  • 70% reference set
  • 30% validation set
• Done twice
  • In validation sets correlations between measured weight and predicted weight have been estimated and ranged between 0.62-0.70.

\( Y: \) measured weight
\text{HYM}: \) herd-year-months of weighing
\text{MC}: \) month of calving
\text{SL}: \) stage of lactation
\text{Other predictors:}
  • Age of cow at scoring;
  • Stature, chest width, body depth, rump width, BCS (when available)
Statistics & Genetic Parameter estimates

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean ± SD</th>
<th>Range</th>
<th>h² ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured weight</td>
<td>595.03 ± 61.27</td>
<td>500 – 700</td>
<td>0.50 ± 0.06</td>
</tr>
<tr>
<td>Predicted weight</td>
<td>598.29 ± 46.45</td>
<td>453 – 742</td>
<td></td>
</tr>
</tbody>
</table>

Algorithm applied to National Dataset

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean ± SD</th>
<th>Range</th>
<th>h² ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted weight 1ˢᵗ parity cows</td>
<td>597.98 ± 41.24</td>
<td>500 – 700</td>
<td>0.21 ± 0.01</td>
</tr>
<tr>
<td>Predicted weight ≥ 2ⁿᵈ parity cows</td>
<td>689.00 ± 50.82</td>
<td>550 – 800</td>
<td></td>
</tr>
</tbody>
</table>
From live weight towards efficiency (1)

**Feed efficiency** = Milk/Dry matter intake (DMI)

- Several traits are considered in order to link those to feed efficiency:
  - Metabolic weight;
  - 4% fat corrected milk yield and fat yield (FCM);
  - Energy corrected milk (ECM).

- Based on these is possible to derive traits such as DMI or Feed efficiency
  - Metabolic weight (Live weight^{0.75}) is proportional to maintenance needs for animals (Kleiber, 1932);
  - ECM –energy used in order to produce milk (Sjaunja et al., 1991).
  - DMI (NRC,2001);
From live weight towards efficiency (2)

Phenotypic estimates of full data-set

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield kg/d</td>
<td>31.65 ± 8.12</td>
<td>3.40-60.60</td>
</tr>
<tr>
<td>Protein %</td>
<td>3.34 ± 0.34</td>
<td>2.12-4.56</td>
</tr>
<tr>
<td>Fat %</td>
<td>3.67 ± 0.70</td>
<td>1.93-6.21</td>
</tr>
<tr>
<td>FCM</td>
<td>29.89 ± 7.60</td>
<td>4.42-59.51</td>
</tr>
<tr>
<td>ECM</td>
<td>29.97 ± 7.35</td>
<td>4.53-58.60</td>
</tr>
<tr>
<td>Predicted BW</td>
<td>601.14 ± 42.77</td>
<td>450-700</td>
</tr>
<tr>
<td>Metabolic BW</td>
<td>121.35 ± 6.49</td>
<td>97.71-136.00</td>
</tr>
<tr>
<td>Predicted DMI</td>
<td>22.87 ± 2.93</td>
<td>11.41-35.09</td>
</tr>
<tr>
<td>Predicted FE</td>
<td>1.37 ± 0.22</td>
<td>0.23-2.34</td>
</tr>
</tbody>
</table>
From live weight towards efficiency (3)

Preliminary phenotypic and genetic estimates

Phenotypic estimates of sample data-set

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted BW</td>
<td>598.15±39.86</td>
<td>450-700</td>
</tr>
<tr>
<td>Metabolic BW</td>
<td>120.90±6.05</td>
<td>97.78-136.00</td>
</tr>
<tr>
<td>ECM</td>
<td>31.18±6.70</td>
<td>6.97-57.56</td>
</tr>
<tr>
<td>Predicted DMI</td>
<td>23.33±2.73</td>
<td>12.86-34.63</td>
</tr>
<tr>
<td>Predicted FE</td>
<td>1.38±0.20</td>
<td>0.45-2.25</td>
</tr>
</tbody>
</table>

Genetic estimates of sample data-set

<table>
<thead>
<tr>
<th>Trait</th>
<th>h²± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted BW</td>
<td>0.21±0.01</td>
</tr>
<tr>
<td>ECM</td>
<td>0.36±0.003</td>
</tr>
<tr>
<td>Predicted DMI</td>
<td>0.41±0.003</td>
</tr>
<tr>
<td>Predicted FE</td>
<td>0.42±0.003</td>
</tr>
</tbody>
</table>
Phenotypic feed efficiency trend
Feed efficiency versus total merit index (PFT) for young and proven bulls
EBV pFE and IES of Italian HF bulls

IES → aim to maximize the genetic progress, both in the economic and for health and welfare traits.

IES → show how many euros, estimated in the entire productive lifetime, will contribute the use of a given bull with respect to the average population.
EBV pFE and IES of Italian HF bulls
Final remarks

• We’re on our way to establish routine evaluation for:
  • Feed efficiency

• We aim at EBV, DGV and GEBV
  • Direct individual measurements together with a genomic approach, of DMI are very helpful for more efficient selection strategies and for a better genetic control on daily feed intake.

• Current selection goal already improves feed efficiency, but extra attention can increase genetic gain

• Indices will be included in total merit index

• Questions?