Implementation of Feed Saved evaluations in the U.S.

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Background

- Improving feed efficiency can impact numerous aspects of dairy production
  - Feed is the largest single expense in dairy production
  - More efficient animals may produce less manure and GHG
  - Reduced feed requirements will also decrease land utilization for crops
- Requires feed intake measured on individual animals
  - In dairy animals, also need to avoid negative impacts on production, fertility, and health
Initial project

- NIFA grant – 2010 to 2017
  - “Genomic Selection and Herd Management for Improved Feed Efficiency of the Dairy Industry”
- Initiated U.S. feed efficiency database
- Demonstrated that feed efficiency, as measured by RFI, is a heritable trait that can be improved through genetic selection
- Low reliabilities due to small reference population

- Cow data collected mid-lactation for at least 28 days; most at least 42 days
- More than 537k daily records of intake and yield
- More than 110k component measurements collected regularly
- Body weight, BCS, health events, diet composition
FFAR & CDCB project

• Beginning 2019
• Goal to collect feed efficiency phenotypes for 3,600 additional cows
• Collaborating institutions:
  • Michigan State University, Iowa State University, University of Wisconsin, University of Florida, Animal Genomics & Improvement Lab (ARS, USDA)
Data Collected for FFAR project

• **Official start Spring 2019**
  • Cow data collected mid-lactation for at least 28 days; most at least 42 days
  • More than 235k daily records compiled – dry matter intake, milk yield
  • More than 46k component measurements collected routinely (fat percent, protein percent, lactose percent, SCC, etc.)
  • More than 63k body weight measurements
  • BCS, health events collected
  • Diet composition measured regularly
Data Processing

- Daily data compiled and edited, checks for outliers and missing data by CDCB and contributing institution
- Residual feed intake (RFI) calculated following methodology developed throughout NIFA project
- RFI data combined/confirmed with associated data from CDCB Cooperator database (pedigree, birthdate, calving dates, parity, etc.)
Calculating RFI

- Energy sink model following Tempelman et al., 2015

\[ DMI = \text{parity} \times \sum_{k=0}^{5} DIM + b_1 \text{MilkE} + b_2 \text{MBW} + b_3 \Delta BW + \text{ration}(exp) + \text{testwk} + \epsilon \]

- Parity class by 5th order Legendre polynomial of DMI on DIM
- Milk Energy
- Metabolic body weight (BW^{0.75})
- Change in body weight
- Random effect of experiment-specific ration
- Random effect of test week
# Current RFI Phenotypes

<table>
<thead>
<tr>
<th>Institution</th>
<th>NIFA 2010</th>
<th>CDCB/FFAR</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miner Agric. Res. Inst. (NY)</td>
<td>58</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Virginia Tech</td>
<td>96</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td>Purina Anim. Nutr. Ctr. (MO)</td>
<td>184</td>
<td></td>
<td>184</td>
</tr>
<tr>
<td>U.S. Dairy Forage Res. Ctr. (WI)</td>
<td>624</td>
<td></td>
<td>624</td>
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<tr>
<td>Univ. of Wisconsin</td>
<td>1,054</td>
<td>623</td>
<td>1,677</td>
</tr>
<tr>
<td>Michigan State Univ.</td>
<td>315</td>
<td>251</td>
<td>566</td>
</tr>
<tr>
<td>Iowa State Univ.</td>
<td>1,006</td>
<td>207</td>
<td>1,213</td>
</tr>
<tr>
<td>Animal Genomics &amp; Imprv. Lab</td>
<td>834</td>
<td>370</td>
<td>1,204</td>
</tr>
<tr>
<td>Univ. of Florida</td>
<td>582</td>
<td>338</td>
<td>920</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4,753</strong></td>
<td><strong>1,789</strong></td>
<td><strong>6,542</strong></td>
</tr>
</tbody>
</table>

Beltsville, MD USDA herd
RFI evaluations

- RFI used as phenotype for genetic evaluation in Holsteins
- Follows typical pipelines as most other CDCB evaluations (2-step methodology)
  - **Traditional evaluation**—animal repeatability model
    - Effects for age-parity group, trial date, herd management group, permanent environment, herd-sire interaction
    - Regressions on genomic evaluations for milk net energy and body weight composite
  - **Genomic evaluation**—uses deregressed evaluations from traditional evaluation in a model similar to BayesAto estimate SNP effects
    - Provides estimates for all genotyped Holsteins
    - Standard set of ~79k SNP used as with all other official CDCB evaluations
Feed Saved – RFI and BW C

- Simple interpretation
- Captures both energy wasted due to biological inefficiency and energy wasted due to excessive body size
- REL higher than just RFI

\[
PTA_{FSAV} = -138 \times PTA_{BWC} - 1 \times PTA_{RFI} \text{ pounds/lactation}
\]

### Body Weight Composite (BWC)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Relative value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature</td>
<td>23</td>
</tr>
<tr>
<td>Strength</td>
<td>72</td>
</tr>
<tr>
<td>Body depth</td>
<td>8</td>
</tr>
<tr>
<td>Dairy form</td>
<td>-47</td>
</tr>
<tr>
<td>Rump width</td>
<td>17</td>
</tr>
</tbody>
</table>

Values are weights (expressed as percentages) from composite formula calculated by Holstein Association USA (2017) and, therefore, do not sum to 100.
Inclusion of International data (CAN)

- RFI phenotype exchange between CDCB and Lactanet
  - For the purposes of genetic evaluation
  - CAN genotypes for these cows available at CDCB

- Data added for April 2021 evaluation
  - 660 RFI records from 568 cows from 3 Canadian herds
  - Genomic reliability gained 1 to 2 percentage points

- CDCB/FFAR Feed Efficiency team are also participants in the Canadian Resilient Dairy Genome Project
Genomic Evaluations

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Saved PTA (lb/lactation)</td>
<td>21.4</td>
<td>128.0</td>
<td>-689</td>
<td>922</td>
</tr>
<tr>
<td>Feed Saved Reliability (%)</td>
<td>38.4</td>
<td>3.6</td>
<td>10</td>
<td>95</td>
</tr>
</tbody>
</table>
Economic Impact

• Inclusion of Feed Saved should improve US profitability by $8 million per year

• Feed Saved evaluations are currently available to the industry as a stand-alone trait

• Plans to incorporate the trait into an economic selection index in the near future
Additional economic revisions

- Based on the same data collected for the Feed Saved evaluations, additional research has led to the following updates:
  - Estimated maintenance requirements have been found to be ~50% greater than those suggested by the NRC (2001) and greater than twice those previously used in NM$
    - Added maintenance cost applied to BWC in NM$ update
  - Feed costs required for milk, fat, and protein production will be adjusted
    - Feed required for milk will be reduced (0.225 lb. DMI reduced to 0.12 lb. DMI) in NM$ update
    - Reductions also in feed required for fat (5.42 lb. DMI reduced to 5.0 lb. DMI) and for protein (7.50 lb. DMI reduced to 6.0 lb. DMI)
“Challenges & Benefits related to implementation”

• Challenges
  • Utilizing new data source from research farms
  • New stream of data requires careful quality control
  • Incorporation of data collected from numerous environments and different experimental designs
  • Limited data availability \(\rightarrow\) low reliabilities
  • Identify consistent, representative sources of phenotypes
“Challenges & Benefits related to implementation”

• **Benefits**

  • Provide producers and the dairy industry with a new tool to increase profitability
  • Provide a tool that can improve the dairy industry’s environmental impact
  • Encourage further data collection
  • Update previous estimates that only used theoretical values
  • Foster international collaboration in order to have meaningful impact on the global industry
Acknowledgments

CDCB & AGIL colleagues
FFAR/CDCB Feed Efficiency team
Data providers
Dairy producers
Thank You!