Options for incorporating feed intake data into national selection indexes

Peter Amer, Stefan Meyer – AbacusBio
Filippo Miglior, Christine Baes, Caeli Richardson – CDN/University of Guelph
Mike Coffey, Eileen Wall - SRUC

Interbull Tallin 2017
Efficient Dairy Genome Project

- **Genome Canada** Large Scale Applied Research Project
  - Led by Filippo Miglior (Guelph) and Paul Stothard (Alberta)

- Improve feed efficiency (FE) and reduce methane emissions (ME) in dairy cattle using genomics

- Build a Canadian female reference population for FE and ME and link with international partners

- Measure farm level and societal cost benefits from incorporating the new traits into breeding programs
#1 – DE-SU PHOENIX 588

<table>
<thead>
<tr>
<th>Sire: HOUSAM60597003</th>
<th>Dams: HOUSA605721460</th>
<th>MGS: HOUSA605721460</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENSENADA TABOO PLANET-ET</td>
<td>DE-SU 7922-ET</td>
<td>SANDY-VALLEY BOLTON-ET</td>
</tr>
<tr>
<td>03-MAR-03</td>
<td>15-AUG-07</td>
<td>11-SEP-01</td>
</tr>
<tr>
<td>7.21%</td>
<td>7.49%</td>
<td>6.05%</td>
</tr>
<tr>
<td>12%</td>
<td>11%</td>
<td>11%</td>
</tr>
</tbody>
</table>

## Production GPA 12°APR
- **Herds:**
  - **Daughters:** 2854 99% 0.12
  - **Lactations:** 118 99% +0.12
  - **Reliability:** 72%

## Lifetime Profit Index GPA LPI
- **GPA LPI:** 3594
- **Rel.:** 69

## Conformation GPA 12°APR

<table>
<thead>
<tr>
<th>Herds</th>
<th>Daughters</th>
<th>Reliability: 68%</th>
</tr>
</thead>
</table>

### Scorecard GPA 12°APR

<table>
<thead>
<tr>
<th>Rating %</th>
<th>15</th>
<th>10</th>
<th>5</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
</table>

### Descriptive GPA 12°APR

<table>
<thead>
<tr>
<th>Udder Depth</th>
<th>5</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Udder Texture</td>
<td>7</td>
<td>Fleshy</td>
</tr>
<tr>
<td>Medullar Suspensory</td>
<td>8</td>
<td>Weak</td>
</tr>
<tr>
<td>Fore Attachment</td>
<td>8</td>
<td>Weak</td>
</tr>
<tr>
<td>Front Ext. Placement</td>
<td>7</td>
<td>Close</td>
</tr>
<tr>
<td>Rear Attachment Height</td>
<td>7</td>
<td>High</td>
</tr>
<tr>
<td>Rear Attachment Width</td>
<td>11</td>
<td>Narrow</td>
</tr>
<tr>
<td>Test Length</td>
<td>7</td>
<td>Short</td>
</tr>
<tr>
<td>Foot Angle</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Head Depth</td>
<td>4</td>
<td>Shallow</td>
</tr>
<tr>
<td>Bone Quality</td>
<td>4</td>
<td>Square</td>
</tr>
<tr>
<td>Rear Leg Side View</td>
<td>5</td>
<td>Curved</td>
</tr>
<tr>
<td>Set of Rear Legs</td>
<td>1</td>
<td>Desirable</td>
</tr>
<tr>
<td>Rear Legs Rear View</td>
<td>4</td>
<td>Square</td>
</tr>
<tr>
<td>Stature</td>
<td>0</td>
<td>Short</td>
</tr>
<tr>
<td>Height at Front End</td>
<td>-2</td>
<td>Low</td>
</tr>
<tr>
<td>Chest Width</td>
<td>2</td>
<td>Narrow</td>
</tr>
<tr>
<td>Body Depth</td>
<td>0</td>
<td>Shallow</td>
</tr>
<tr>
<td>Angularity</td>
<td>4</td>
<td>Non-Angular</td>
</tr>
<tr>
<td>Loin Angle</td>
<td>0</td>
<td>High</td>
</tr>
<tr>
<td>Rump Angle</td>
<td>1</td>
<td>High</td>
</tr>
<tr>
<td>Pin Satin</td>
<td>2</td>
<td>Undesirable</td>
</tr>
<tr>
<td>Di width</td>
<td>6</td>
<td>Narrow</td>
</tr>
</tbody>
</table>

### Functional GPA 12°APR
- **Difference from Breed Average (SD):**
- **Breed Avg:**
  - **Hard Life:**
  - **Somatic Cell Score:**
  - **Lactation Persistency:**
  - **Daughter Fertility:**
  - **Milking Speed:**
  - **Milking Temperament:**
  - **Calving Ability:**
  - **Daughter Calving Ability:**
#1 – DE-SU PHOENIX 588

<table>
<thead>
<tr>
<th>Sire: HOUSSAM597003</th>
<th>Dam: HOUSSAM5721460</th>
<th>MGS: HOUSSAM3115353</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENSENADA TABOO PLANET-ET</td>
<td>DE-SU 7922-ET</td>
<td>SANDY-VALLEY BOLTON-ET</td>
</tr>
<tr>
<td>03-MAR-03</td>
<td>15-AUG-07</td>
<td>11-SEP-01</td>
</tr>
<tr>
<td>7.21%</td>
<td>7.49%</td>
<td>6.05%</td>
</tr>
<tr>
<td>12%</td>
<td>11%</td>
<td>11%</td>
</tr>
</tbody>
</table>

### Production GPA 12*APR

<table>
<thead>
<tr>
<th>Herds</th>
<th>GPA %K</th>
<th>Herbs</th>
<th>GPA LPI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lifetime Profit Index (LPI)

<table>
<thead>
<tr>
<th>GPA LPI</th>
<th>Rel.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3594</td>
<td>69</td>
</tr>
</tbody>
</table>

### Conformation GPA 12*APR

<table>
<thead>
<tr>
<th>Herbs</th>
<th>Daughters</th>
<th>Reliability: 68%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Descriptive

<table>
<thead>
<tr>
<th>Trait</th>
<th>Rating</th>
<th>%K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Functional

<table>
<thead>
<tr>
<th>Trait</th>
<th>Rating</th>
<th>Rel.</th>
<th>Avg.</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Variables

- **Production**
- **Durability**
- **Health and Fertility**
- **Efficiency**

ABACUS BIO LIMITED
Feed intake into UK dairy and beef indexes

**Profitable Lifetime Index – £PLI**
An economic breeding index for UK autumn block and all year round calving herds

**What is the £PLI?**

The national Profitable Lifetime Index (£PLI) is published by DairyCo Breeding as part of its genetic evaluation service. The £PLI is a within-breed genetic ranking index developed for UK dairying conditions in consultation with industry partners and is expressed as a financial value.

The £PLI will:

- Promote yield while protecting milk quality
- Increase emphasis on fertility
- Improve functional type – feet & legs and udders
- Increase emphasis on longevity
- Reduce costs associated with maintenance
- Improve udder health
- Improve calving performance

**£PLI explained**
Feed intake into UK dairy and beef indexes

Genomic prediction of total feed intake

MIR prediction of total feed intake

Profitable Lifetime Index – £PLI
An economic breeding index for UK autumn block and all year round calving herds

What is the £PLI?
The national Profitable Lifetime Index (£PLI) is published by DairyCo Breeding® as part of its genetic evaluation service. The £PLI is a within-breed genetic ranking index developed for UK dairying conditions in consultation with industry partners and is expressed as a financial value.

The £PLI will:
- Promote yield while protecting milk quality
- Increase emphasis on fertility
- Improve functional type – feet & legs and udders
- Increase emphasis on longevity
- Reduce costs associated with maintenance
- Improve udder health
- Improve calving performance

£PLI explained
We already “account for” feed intake in the existing indexes.
Components of lifetime energy expenditure

<table>
<thead>
<tr>
<th>Replacement Heifer</th>
<th>1st lactation cow</th>
<th>2nd lactation cow</th>
<th>3rd lactation cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inefficient Digestion</td>
<td>Inefficient Metabolism</td>
<td>Protein</td>
<td>Fat</td>
</tr>
<tr>
<td>Retention</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BCS Mobilization
What happens when select for total feed intake?

Replacement Heifer

1st lactation cow

2nd lactation cow

3rd lactation cow

ENERGY EXPENDITURE THROUGHOUT LIFETIME

Inefficient Digestion

Inefficient Metabolism

Protein

Fat

Lactose

Maintenance

BCS Retention

Activity

BCS Mobilization
Variation in fatness

Up to 60% fat in milk
Unfavourable associations

• Feed intake and residual feed intake potentially unfavourably correlated with
  • Body reserves
  • Health
  • Fertility
  • Activity
  • Animal welfare
  • Foraging ability
  • Diet selectivity
Prediction trade-off

Feed intake

Total genetic variation in novel metric

ENERGY EXPENDITURE THROUGHOUT LIFETIME

Variation predicted by existing selection criteria

Milk, Live weight
Prediction trade-off

Feed intake

Total genetic variation in novel metric

ENERGY EXPENDITURE THROUGHOUT IFETIME

Variation predicted by existing selection criteria

Milk, Live weight

Total genetic variation in novel metric

Variation predicted by existing selection criteria

= Variation in wasted feed
The “Multi-trait Prediction” solution

• Use growth/milk as correlated predictors of total feed intake

But…….

• Major over-haul of the breeding objective
• Major over-haul of genetic evaluation to integrate new trait
• Feed intake recorded in animals where the correlation does not exist?
• Many genetic evaluation systems modular
• Becoming more modular as genomics included
The “Residuals” solution

- Residual feed intake
  - Feed eaten after accounting for energy sinks linked to production (e.g. milk, growth, live weight) and viability (e.g. Body Condition Score, fatness)
Problems with “Residuals”

- Adjusting one genetic trait for another genetic trait can lead to false variation

- Not all energy sinks recorded accurately on all selection candidates (fatness!)

- Integrating information from multiple data capture systems

- Multi-collinearity in adjustment coefficients
Sub-index Feed efficiency
Future Lifetime Performance Index

LPI

- Production
- Durability
- Health and Fertility
- Efficiency
Sub-index Feed efficiency

- Current index stays as it is
- What added predictive value on feed intake relative to production do we have?

Efficiency sub-index(s)

Feed efficiency – Emissions intensity

EBVs and accuracies

Selection index principles

EBVs and accuracies

Total Feed Intake
Emissions measures

Growth
Milk
Live weight
Fat
Fertility
Simulation

• Sires with 80 daughters
• 100%, 30% or 10% of daughters recorded for feed intake
• Milk records, Live weight records

• Index correlations (of sires) with true (simulated) overall merit

Profit = Milk Revenue – Heifer feed costs – Cow feed costs + “Other” trait subindex
Simulation results – ignoring live weight

Feed intake in the objective

Residual feed intake

Loss of milk yield as a predictor of feed intake

100% Feed intake
30% Feed intake
10% Feed intake

Correlation with TMR
Simulation results

- 100% Feed intake
- 30% Feed intake
- 10% Feed intake

Bar chart showing:
- Feed intake in the objective
- Residual feed intake
- Wasted feed sub-index

Correlation with TOM:
- Index 0
- Index 1
- Index 2
- Index 3
- Index 4
- Index 5

Live weight
Wasted feed sub-index

• Predicting
Total feed intake – feed milk – feed LW

$$\text{EBV(TFI)} - \alpha \cdot \text{EBV(milk)} - \beta \cdot \text{EBV(LW)}$$

EBVs are not on correct scale to take a difference!
Wasted feed sub-index (with de-regressed EBV $\text{dEBV}$)

• Predicting Total feed intake – feed milk – feed LW

$[\text{dEBV(TFI)} - \alpha \cdot \text{dEBV(milk)} - \beta \cdot \text{dEBV(LW)}] \times \lambda$

$\lambda$ accounts for the reliabilities (regresses back to the mean)
Take home messages

• Feed intake data likely doesn’t warrant a rebuild of genetic evaluation system and breeding objective
• Residual feed intake works, but does not work well with international sharing of data
• Sub-index approach is an appealing alternative
• Accounts for
  • Low and variable reliabilities of feed intake data
• Need to use information from live weight