Genetic Evaluation for Resistance to Metabolic Diseases in Canadian Dairy Breeds


*Canadian Dairy Network
**CGIL, University of Guelph
2007: nation-wide health recording
Mastitis, Displaced Abomasum, Ketosis, Milk Fever, Retained Placenta, Metritis, Cystic Ovaries, Lameness

2014: genetic evaluation for mastitis resistance

December 2016: implementation of genetic evaluation for metabolic disease resistance
Metabolic disease traits (MET):

- Clinical Ketosis (CK)
- Displaced Abomasum (DA)
  - 0 – no case
  - 1 – at least one case
  - in 100d after calving

- Sub-clinical Ketosis (SCK) = Milk β-hydroxybutyrate (BHB)
  - at first test-day, between 5 and 45 DIM
- **Indicator traits:**
  - Fat to Protein Ratio (F:P) at first test-day, between 5 and 45 DIM
  - Body Condition Score (BCS) from first lactation first classification
- Lactations 1 – 5 only
- First and later lactations health and milk recording traits: different but correlated traits
- Observations from lactations >2: repeated records of lactation 2
Data for GE

- **Producer recorded health traits**
  - All herds with **CK** or **DA** recording
  - Minimum disease frequency: 1% per herd-year
- **BHB**
  - All herds included
- **F:P and BCS**
  - Only herds with **CK** or **DA** recording

**Time threshold for all traits:** April 2007
# Cow-Lactation Records | # Cows
--- | ---
Ayrshire | 36,765 | 20,697
Holstein | 1,621,630 | 965,762
Jersey | 34,088 | 21,745
Holstein Data for GE: August 2016: Frequency (%) of clinical cases by lactation
Holstein Data for GE: August 2016
Completeness of data by trait

- CK: 20.41%
- DA: 46.17%
- F:P: 34.9%
- BHB: 57.71%
- BCS (1st): 42.9%

% of All Records
- Multiple-trait (9 traits in total)
- Linear
- Animal model
Model
MET and F:P

\[ y = H + YS + ASP + hy + a + pe + e \]

fixed effects:
- \( H \): herd
- \( YS \): year – season
- \( ASP \): age – season – parity

random effects:
- \( hy \): herd – year
- \( a \): animal additive genetic
- \( pe \): permanent environmental (lactations >1)
- \( e \): residual
Model

BCS

\[ y = HRC + AST + a + e \]

fixed effects:

- **HRC**: herd – round – classifier
- **AST**: age – stage of lactation – time of classification

random effects:

- **a**: animal additive genetic
- **e**: residual
Genetic Parameters

- Subset of Holstein data
- \(36,000\) cows with \(53,000\) records
- Same model as for GE
- Bayesian methods (Gibbs sampling)
- Holstein estimates to be used for Ayrshire and Jersey
Heritability (x100)

<table>
<thead>
<tr>
<th>Trait</th>
<th>First Lactation</th>
<th>Later Lactations</th>
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<tbody>
<tr>
<td>CK</td>
<td>4.1</td>
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<td>DA</td>
<td>6.3</td>
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<tr>
<td>F:P</td>
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<td>BHB</td>
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<td>BCS</td>
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First Lactation vs. Later Lactations
# Genetic Correlations (x100)

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<th>Later</th>
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Diseases well correlated among each other and across parities.
## Genetic Correlations (x100)

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**BHB strong indicator of CK (first and later lactations), followed by BCS and F:P**
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BHB, F:P and BCS moderate indicators of DA in first lactation. No associations in later lactations.
Genetic Evaluation
Results

- Estimated Breeding Values and reliabilities for CK, DA, and SCK for first and later lactations
- Metabolic Disease Resistance Index (MDR) and its reliability

All evaluations expressed as Relative Breeding Values (RBV): mean = 100 SD = 5 for base sires
MDR = 0.5*SCK + 0.25*CK + 0.25*DA

All components: 0.5*RBV_{First} + 0.5*RBV_{Later}

Sire MDR official when for first lactation SCK:
- min. 20 daughters
- min. 10 herds
- min. reliability:
  - 45% Holstein
  - 35% Ayrshire and Jersey
- Higher frequency and cost of CK compared to DA
- Sub-clinical ketosis (SCK) more common than CK
- Selection on SCK will induce a correlated response on CK and DA
- Higher heritability of SCK
- Quantity and quality of BHB records might be superior to producer-recorder health data
MDR Index

Expected responses: CK – DA – SCK
Weights: combined traits

RBV

CK-1
DA-1
SCK-1
CK-L
DA-L
SCK-L

0 0.05 0.1 0.15 0.2 0.25 0.3

CK:DA:SCK 1:1:1
CK:DA:SCK 1:1:2
CK:DA:SCK 2:2:1
MDR Index

Expected responses: CK – DA – SCK
Weights: First (1) vs. Later (L)

CK-1
DA-1
SCK-1
CK-L
DA-L
SCK-L

RBV

1:L 75:25
1:L 66:33
1:L 50:50
1:L 33:66
1:L 25:75
### GE Summary

**Sires with official MDR index**

<table>
<thead>
<tr>
<th>Breed</th>
<th>N</th>
<th>MDR</th>
<th>Reliability</th>
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<td>Mean</td>
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</table>
GE Summary

Holstein Sires with official MDR index

Number of sires
Holstein Sires with official MDR index
Difference in % Healthy Daughters: Top 10 – Bottom 10

CK-First: 6
CK-Later: 7
DA-First: 3
DA-Later: 3

Top - Bottom
MDR and EBV for other traits

Holstein sires (N=1520)
GE system for metabolic disease resistance developed

3 breeds: Ayrshire, Holstein, Jersey

Holstein genetic parameters for all breeds

Genomic evaluation: Holstein

RBV published for bulls only

Cows: (G)PA

MDR index recommended for sire selection

First official release: December 2016
Acknowledgements

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Ontario Genomics Institute