Genomic Evaluation for Resistance to Fertility Disorders in Canadian Dairy Breeds
Health Recording and Genetic Evaluation in Canada

- **2007**: national dairy health data collection system (8 diseases)
- **2014**: mastitis resistance (AY, HO, JE)
- **2016**: metabolic disease resistance (AY, HO, JE)
- **2020**: resistance to fertility disorders (AY, HO, JE)
Fertility Disorders - Phenotypes

• Traits (0 = no case, 1 = at least one case):

- Cystic Ovaries (CO): calving – 305 DIM
- Metritis (MET): calving – 150 DIM
- Retained Placenta (RP): calving – 14 DIM
Fertility Disorders - Model

- Multiple-trait linear animal model
  \[ H = (\text{pedigree} + \text{genotypes}) \text{ based relationships} \]
- No ‘indicator’ traits in the model
- First and later lactations: different (correlated) traits
- Observations on lactations > 2 treated as repeated observations for lactation 2
- 6 traits in total
Fertility Disorders - Model

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

**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
Fertility Disorders - Methods

- Single-Step method (MiX99 software)
- Reference population: all genotyped animals in the pedigree
- Estimation of GEBV (phenotypes + pedigree + genotypes)
- Calculation of DGV (reference)
- Estimation of SNP effects
- Calculation of DGV for other genotyped animals (not in Single-Step)

- GEBV - monthly, DGV (new animals) - weekly
• Proofs expressed as **RBV** (mean = 100, SD = 5 for ‘base’ sires) with reversed sign: higher RBV = better resistance

• Combined CO, MET and RP proofs:
  - 1st and later lactation for a given disorder
  - equal weights (on RBV scale)

• Sire proof (any combined trait) ‘**Official**’ when:
  - min. 5 herds with phenotypes
  - min. reliability of 70% (HO) and 50% (AY and JE)

• Sire ‘**Official**’ for Fertility Disorders when ‘Official’ for any combined trait
Fertility Disorders – Genetic Parameters

- Subset of HO data
- ~76,000 cows with ~120,000 records
- Same model as for GE
- Only $A$ (= pedigree-based relationships) in genetic co-variance structure
- Bayesian method (Gibbs sampling)
- HO estimates to be used for AY and JE
Fertility Disorders – Genetic Parameters

- **Heritability:** 0.02 ÷ 0.03 (across all traits)
- **Genetic correlation between first and later lactation traits:** from 0.55 (CO) to 0.70 (MET)
- **CO genetically uncorrelated with MET and RP**
- **Genetic correlations between MET and RP:**
  - 0.54 (first lactation)
  - 0.51 (later lactations)
<table>
<thead>
<tr>
<th></th>
<th>AY</th>
<th>HO</th>
<th>JE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenotypes</td>
<td>35,854</td>
<td>1,968,876</td>
<td>24,653</td>
</tr>
<tr>
<td>Cows</td>
<td>17,783</td>
<td>1,004,586</td>
<td>14,085</td>
</tr>
<tr>
<td>Sires</td>
<td>844</td>
<td>21,750</td>
<td>1,109</td>
</tr>
<tr>
<td>Pedigree</td>
<td>36,027</td>
<td>1,726,630</td>
<td>33,337</td>
</tr>
<tr>
<td></td>
<td>AY</td>
<td>HO</td>
<td>JE</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Available</strong></td>
<td>11,066</td>
<td>1,929,299</td>
<td>240,665</td>
</tr>
<tr>
<td><strong>Genotyped Cows</strong></td>
<td>1,500</td>
<td>59,186</td>
<td>1,039</td>
</tr>
<tr>
<td><strong>Genotyped Sires</strong></td>
<td>523</td>
<td>10,609</td>
<td>779</td>
</tr>
<tr>
<td><strong>Genotyped Animals in Pedigree</strong></td>
<td>2,602</td>
<td>81,886</td>
<td>2,812</td>
</tr>
</tbody>
</table>
### Fertility Disorders – GE Results – August 2020

#### RBV for Official Sires

<table>
<thead>
<tr>
<th>Breed</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY</td>
<td>261</td>
<td>100</td>
<td>5.1 ÷ 5.7</td>
<td>79 ÷ 84</td>
<td>111 ÷ 115</td>
</tr>
<tr>
<td>HO</td>
<td>6,604</td>
<td>99 ÷ 101</td>
<td>5.0 ÷ 5.3</td>
<td>73 ÷ 80</td>
<td>114 ÷ 120</td>
</tr>
<tr>
<td>JE</td>
<td>124</td>
<td>100</td>
<td>4.8 ÷ 5.4</td>
<td>79 ÷ 89</td>
<td>110 ÷ 116</td>
</tr>
</tbody>
</table>
### Fertility Disorders – GE Results – August 2020

**Average Reliability of RBV for Official Sires**

<table>
<thead>
<tr>
<th>Lactation</th>
<th>Trait</th>
<th>AY (N = 261)</th>
<th>HO (N = 6,604)</th>
<th>JE (N = 124)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First</strong></td>
<td>CO</td>
<td>53</td>
<td>78</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>MET</td>
<td>59</td>
<td>81</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>59</td>
<td>81</td>
<td>61</td>
</tr>
<tr>
<td><strong>Later</strong></td>
<td>CO</td>
<td>60</td>
<td>81</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>MET</td>
<td>61</td>
<td>81</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>62</td>
<td>82</td>
<td>60</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>59</strong></td>
<td><strong>81</strong></td>
<td><strong>61</strong></td>
</tr>
</tbody>
</table>
Fertility Disorders – GE Results – December 2019

Average Reliability of RBV for Young Bulls (Born in 2019)

<table>
<thead>
<tr>
<th>Lactation</th>
<th>Trait</th>
<th>AY (N = 2,336)</th>
<th>HO (N = 70,027)</th>
<th>JE (N = 3,031)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>CO</td>
<td>18</td>
<td>61</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>MET</td>
<td>20</td>
<td>62</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>20</td>
<td>62</td>
<td>15</td>
</tr>
<tr>
<td>Later</td>
<td>CO</td>
<td>20</td>
<td>62</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>MET</td>
<td>21</td>
<td>62</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>21</td>
<td>62</td>
<td>16</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td><strong>20</strong></td>
<td><strong>62</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>
Fertility Disorders – GE Results – August 2020

Proof Correlations (x100) – HO Official Sires (N = 6,604)

- **Combined RBV:**
  - CO – MET: 23
  - CO – RP: 12
  - MET – RP: 74

- **Combined RBV – First/Later lactation RBV:**
  
<table>
<thead>
<tr>
<th></th>
<th>First</th>
<th>Later</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO:</td>
<td>96</td>
<td>97</td>
</tr>
<tr>
<td>MET:</td>
<td>94</td>
<td>95</td>
</tr>
<tr>
<td>RP:</td>
<td>95</td>
<td>96</td>
</tr>
</tbody>
</table>
Top 10 vs. Bottom 10 HO Official Sires by (Combined) Trait RBV

<table>
<thead>
<tr>
<th>Sire</th>
<th>TOP</th>
<th>BOTTOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-1</td>
<td>95</td>
<td>88</td>
</tr>
<tr>
<td>MET-1</td>
<td>99</td>
<td>89</td>
</tr>
<tr>
<td>RP-1</td>
<td>100</td>
<td>93</td>
</tr>
<tr>
<td>CO-L</td>
<td>95</td>
<td>77</td>
</tr>
<tr>
<td>MET-L</td>
<td>98</td>
<td>86</td>
</tr>
<tr>
<td>RP-L</td>
<td>98</td>
<td>79</td>
</tr>
</tbody>
</table>

% Healthy Lactations

Lactanet
CANADIAN NETWORK FOR DAIRY EXCELLENCE
LPI & Genotyped HO Sires (N = 9,816)
Correlations: (Combined) CO - Other Traits

- Daughter Fertility
- Non-Return Rate
- Protein Yield
- Rear Attachment Width
- Mammary System
- Fore Attachment
- Days Open
- First Service to Conception - Cows

Correlation values:
-25, -15, -5, 5, 15, 25, 35, 45
LPI & Genotyped HO Sires (N = 9,816)
Correlations: (Combined) MET - Other Traits

- Pro$
- LPI
- Real Leg Side View
- Teat Length
- Body Depth
- DMI
- Calf Survival - Cows
- Calving Ease - Heifers
- Daughter Calving Ability
- Herd Life

Correlation Scale:
-25 -15 -5 5 15 25 35 45

Chart indicates correlations between the traits mentioned and their respective values.
Summary

- GE system for resistance to fertility disorders developed
- Single-Step method
- 3 traits: Cystic Ovaries, Metritis, Retained Placenta
- 3 breeds: Ayrshire, Holstein, Jersey
- Holstein genetic parameters used for all breeds
- RP and MET: favorably correlated with LPI and Pro$
- CO: small unfavorable correlation with LPI and Pro$

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