Genetic and genomic analysis of superovulatory response in Canadian Holsteins

Cindy Jaton*1,2, A. Koeck1, M. Sargolzaei1,3, C. A. Price4, F. S. Schenkel1, and F. Miglior1,5

1CGIL, University of Guelph, Guelph, ON 2CIAQ, St-Hyacinthe, QC, 3Semex Alliance, Guelph, ON, 4Université de Montréal, Faculté de Médecine Vétérinaire, St-Hyacinthe, QC, Canada, 5CDN, Guelph, ON, Canada
Dairy embryos produced in vivo

Total: 340,000

Canada: 68,000 (20%)

Rest of the world: 272,000 (80%)

(IETS, 2013)
Exportation

Source: Canadian Dairy Information Center (www.dairyinfo.gc.ca)
Opportunities and challenges

• Variability of superovulatory response

• High cost of superovulation and embryo transfer

• No genetic or genomic analyses for superovulatory response in Canada

Are EBVs for superovulatory response useful to the industry?
Objectives

• Estimate genetic parameters of superovulatory response traits

• Estimate breeding values (EBVs) for superovulatory response traits
  o examine their relationship with other routinely evaluated traits in Canada

• Perform GWAS on novel traits
Data set

- Provided by Holstein Canada

- Originally:
  - 168,855 records
  - 1980 to 2014 (March)

- After editing:
  - 137,446 records
  - 1992 to 2014 (March)

- Only successful flushes kept (min. 1 embryo)

- Data editing:
  - Complete and unique records
  - Age of the donor: 8 to 180 months
  - Clinics with min. 50 records
• **Total number of embryos:**
  - All embryos recovered from a flush
  - Includes degenerated or dead embryos

• **Number of viable embryos:**
  - Embryos recovered that have been notified to Holstein Canada as transplanted or frozen
### Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Total (N)</th>
<th>Average</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Records (flush)</td>
<td>137,446</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Donors</td>
<td>54,463</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sires</td>
<td>3,513</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Service sires</td>
<td>2,250</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Clinics</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Embryos</td>
<td>1,265,333</td>
<td>9.21</td>
<td>7.24</td>
<td>1</td>
<td>87</td>
</tr>
<tr>
<td>Viable embryos</td>
<td>1,044,416</td>
<td>7.60</td>
<td>5.92</td>
<td>0</td>
<td>58</td>
</tr>
</tbody>
</table>
Clinic

Number of viable embryos vs Total number of embryos
Service type

- Total number of embryos
- Number of viable embryos

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Total Embryos</th>
<th>Viable Embryos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd owner</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>In vitro</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>AI Technician</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>
Model

\[ y = X\beta + Z_d d + Z_{ss} ss + Z_{pe} pe + e \]

Where:

- \( y \) = total number of embryos or number of viable embryos
- \( \beta \) = vector of fixed effects (age-service type, age\(^2\)-service type, year-month, clinic-year, and service type)
- \( d \) = vector of random animal additive effect of the donor
- \( ss \) = vector of random animal additive effect of the service sire
- \( pe \) = vector of permanent environmental effects of the donor
- \( e \) = Vector of random residuals
- \( X, Z_d, Z_{ss}, \) and \( Z_{pe} \) = corresponding incidence matrices
## Genetic parameters (SE)

<table>
<thead>
<tr>
<th></th>
<th>Trait</th>
<th>$h_d^2$</th>
<th>$h_{ss}^2$</th>
<th>$r_d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log</td>
<td>Total Embryos</td>
<td>0.148 (0.007)</td>
<td>0.007 (0.001)</td>
<td>0.240</td>
</tr>
<tr>
<td></td>
<td>Viable Embryos</td>
<td>0.135 (0.007)</td>
<td>0.014 (0.002)</td>
<td>0.229</td>
</tr>
<tr>
<td>Anscombe</td>
<td>Total Embryos</td>
<td>0.174 (0.008)</td>
<td>0.006 (0.001)</td>
<td>0.281</td>
</tr>
<tr>
<td></td>
<td>Viable Embryos</td>
<td>0.144 (0.007)</td>
<td>0.014 (0.002)</td>
<td>0.243</td>
</tr>
</tbody>
</table>
## EBV correlations

<table>
<thead>
<tr>
<th>Trait</th>
<th>Total Embryos (n = 1,391)</th>
<th>Viable Embryos (n = 1,251)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPI</td>
<td>-0.23</td>
<td>-0.14</td>
</tr>
<tr>
<td>Milk yield</td>
<td>-0.26</td>
<td>-0.21</td>
</tr>
<tr>
<td>Protein yield</td>
<td>-0.29</td>
<td>-0.24</td>
</tr>
<tr>
<td>Fat yield</td>
<td>-0.21</td>
<td>-0.15</td>
</tr>
<tr>
<td><strong>Reproduction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daughter fertility</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>56-d non-return rate</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Number of services</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>First service to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>conception</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>Calving to first service</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Days open</td>
<td>0.21</td>
<td>0.21</td>
</tr>
</tbody>
</table>
## Best and worst donors

<table>
<thead>
<tr>
<th>Trait</th>
<th>No. donors</th>
<th>Mean</th>
<th>Top 10%</th>
<th>Bottom 10%</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Embryos</td>
<td>32,403</td>
<td>9.23</td>
<td>15.61</td>
<td>4.27</td>
<td>11.3</td>
</tr>
</tbody>
</table>
Genome-wide association study

• 57,976 cows and sires:
  ○ 5,535 genotyped (≥50K panel)
  ○ Imputation of genotypes to HD (FlImpute → Sargolzaei et al., 2014)

• De-regressed EBVs
  ○ Threshold reliability >10%
  ○ 4,186 individuals considered
    • 763 males
    • 3,423 females

• Single-SNP regression (SSR) using genomic relationship matrix
GWAS

Number of viable embryos
Pros & Cons for dairy producers

- Invest in females that have more potential to respond to superovulation
- Additional information for the purchase of a donor
- Not all dairy producers use superovulation (10-20%)
- Elite dairy cows will be superovulated regardless of their genetic evaluation for superovulation
Potential benefits for industry

- Added value for AI industry
  - bulls with daughters that should produce more embryos

- Veterinarians could customize superovulatory protocols of donors based on genetic potential for superovulation (research)
Conclusions

• Selection for superovulatory response in Canadian Holstein cows is possible
• Superovulatory response is a novel trait and mostly uncorrelated with other performance traits
• Additional information for breeding decisions
Acknowledgments

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  o Chris McGivern
  o Grace Cyperling

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  o CIAQ
  o NSERC of Canada
  o DairyGen of CDN
Thank you!