Genetic trends, generation interval, and inbreeding changes since the implementation of genomic selection in US dairy cattle

Daniela Lourenco

• Official genomic evaluations in US
  • 2009: Holstein, Jersey, Brown Swiss
  • 2013: Ayrshire
  • 2016: Guernsey

• Increase genetic gain
  • Reliabilities
  • Generation interval

• 50 - 100% for yield traits
• 3 - 4x for low $h^2$ traits
  • DPR, PL, SCS

Is GS working as expected in all breeds?
Objectives

Genetic trends
Generation interval
Inbreeding changes

- Holstein
- Jersey
- Brown Swiss
- Guernsey
- Ayrshire
Data

- August 2021 evaluation run
  - Milk, fat, protein, SCS
  - Productive life, daughter pregnancy rate, livability
- Based on evaluation breed code (within breed)
- Birth year since 1975
- Official genetic base year 2015
- USA, 840, and CAN only

**Bulls** – 154,602
- USA: 89.34%
- 840: 3.09%
- CAN: 7.57%

**Cows** – 27,802,645
- USA: 80.93%
- 840: 18.98%
- CAN: 0.08%
Bulls

- >= 10 daughters with lactation records
- If PTA milk missing, then delete
- PBV weighted by no. of daughters per trait

<table>
<thead>
<tr>
<th>Genomics indicator</th>
<th>Breed Evaluation</th>
<th>Total (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AY</td>
<td>BS</td>
</tr>
<tr>
<td>Nongenotyped (%)</td>
<td>62.32</td>
<td>57.97</td>
</tr>
<tr>
<td>Genotyped (%)</td>
<td>37.68</td>
<td>42.03</td>
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</table>

Total (No.) 2,107 2,803 2,662 134,461 12,569 - 154,602
Cows

- >= 1 calving (lactation record)
- If PTA milk missing then delete
- Sire ID must be known
- Milk, fat, and protein must contribute to sire eval.

<table>
<thead>
<tr>
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<th>Total (%)</th>
<th>Total (No.)</th>
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</thead>
<tbody>
<tr>
<td>Nongenotyped (%)</td>
<td>AY 99.48</td>
<td>95.38</td>
<td>26,518,215</td>
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<tr>
<td></td>
<td>BS 97.48</td>
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<td>GU 98.46</td>
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<td>HO 95.72</td>
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<td>JE 91.27</td>
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<td>Total 95.38</td>
<td>95.38</td>
<td>26,518,215</td>
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<tr>
<td>Genotyped (%)</td>
<td>AY 0.52</td>
<td>4.62</td>
<td>1,284,430</td>
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<tr>
<td></td>
<td>BS 2.52</td>
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<tr>
<td></td>
<td>GU 1.54</td>
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<td>HO 4.28</td>
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<td>JE 8.73</td>
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<tr>
<td></td>
<td>Total 4.62</td>
<td>4.62</td>
<td>1,284,430</td>
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<tr>
<td>Total (No.)</td>
<td>137,962</td>
<td>243,936</td>
<td>27,802,645</td>
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<td>24,877,547</td>
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<td>2,400,208</td>
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</table>

Cow Birth Year
- Nongenotyped
- Genotyped

No. of Cows
Trends

• No four path selection model (Dechow & Rogers, 2018)
• Mean Predicted Breeding Value/Year plotted for bulls and cows separate
• Linear and nonlinear regression – to fit the small sample size
• PROC REG used to estimate breakpoints for each 5 years
• PROC NLIN to fit the piecewise model
• Generation interval for sires and dams of bulls and cows
• Parents and progeny same breed code
• (Animal birth – parents birth)/365.25
• Inbreeding levels only for genotyped animals
• Linear and nonlinear regression
Genetic trends – Holstein (2009)

**Bulls**

- Average PBV - Fat Yield (kg)
- Bull Birth Year

**Cows**

- Average PBV - Fat Yield (kg)
- Cow Birth Year
Genetic trends – Jersey (2009)

**Bulls**

- Average PBV - Fat Yield (kg)
  - All Bulls
  - All Bulls - Segm Reg

- Average PBV - Productive Life (Months)
  - All Bulls
  - All Bulls - Segm Reg

**Cows**

- Average PBV - Fat Yield (kg)
  - All Cows
  - All Cows - Segm Reg

- Average PBV - Productive Life (Months)
  - All Cows
  - All Cows - Segm Reg
Genetic trends – Brown Swiss (2009)

**Bulls**

- Average PBV - Fat Yield (kg)
- Bull Birth Year

**Cows**

- Average PBV - Fat Yield (kg)
- Cow Birth Year
Genetic trends – Ayrshire (2013)

**Bulls**
- Average PBV - Fat Yield (kg)
- Bull Birth Year

**Cows**
- Average PBV - Fat Yield (kg)
- Cow Birth Year

**Average PBV - Productive Life (Months)**
- Bull Birth Year
- Cow Birth Year
Genetic trends – Guernsey (2016)

Bulls

- Average PBV - Fat Yield (kg)
- Average PBV - Productive Life (Matures)

Cows

- Average PBV - Fat Yield (kg)
- Average PBV - Productive Life (Matures)
Generation interval

Holstein Bulls

Jersey Bulls

Brown Swiss Bulls

Ayrshire Bulls

Holstein Cows

Jersey Cows

Brown Swiss Cows

Ayrshire Cows
Inbreeding – bulls

- **Holstein Bulls**:
  - Genomic Inb
  - Genomic Inb - Segm Reg
  - Ped Inb
  - Ped Inb - Segm Reg

- **Jersey Bulls**: Genomic Inb
  - Genomic Inb - Segm Reg
  - Ped Inb
  - Ped Inb - Segm Reg

- **Brown Swiss Bulls**: Genomic Inb
  - Genomic Inb - Segm Reg
  - Ped Inb
  - Ped Inb - Segm Reg

- **Ayrshire Bulls**: Genomic Inb
  - Genomic Inb - Segm Reg
  - Ped Inb
  - Ped Inb - Segm Reg

- **Guernsey Bulls**: Genomic Inb
  - Genomic Inb - Segm Reg
  - Ped Inb
  - Ped Inb - Segm Reg
Conclusions I

- Benefits of genomic selection
- Holstein and Jersey (50% to 100%)
  - Early adoption and amount of data
  - Refined selection indexes
- Less benefit for Brown Swiss, Ayrshire, Guernsey
  - Amount of data
  - Later adoption for Ayrshire and Guernsey
  - Five more years of increased adoption of GS
Conclusions II

- Overall reduction in generation interval
  - 2 to 3 years for breeds with higher level of adoption
  - Sires and dams of bulls
  - Sires of dams

- Inbreeding levels are increasing
  - More focus on how GPTA are used

- Trends may differ
  - Data editing + selection of animals
  - Methods
Dairy producers who supplied data through their participation in the Dairy Herd Improvement program and Dairy Records Processing Centers that edited and relayed information on to the Council of Dairy Cattle Breeding