Genotyping dairy females

Jennie Pryce, Ben Hayes, Mike Goddard
Potential benefits of genotyping females

Improve the reliability of genomic selection
Provide farmers with new management tools
1) Identify elite females (or males)
2) Best heifers to become replacements
3) Certainty of parentage
4) Avoid inbreeding
5) Avoid genetic defects
The contribution of females to the reference population

- As genomic selection replaces progeny-testing of bulls, risk that the reliability of genomic BVs will decrease
  - Distance between reference and predicted population increases (e.g. Lillehammer et al., 2010)
  - Especially a risk for small populations (McHugh et al., 2011)
The contribution of females to the reference population

- Strategies to reduce deterioration in reliability:
  1. Exchange genotypes between countries
  2. Use denser SNP chips and better statistical tools
  3. Genotype females to include in the reference population
The contribution of females to the reference population

• Genotyped females need to be incorporated cautiously
  – Preferential treatment a risk
  – Randomly selecting females may be more beneficial
10,000 Holstein cow project

Genotype 10,000 cows with excellent records
✓ fertility, survival, production

Collaboration with > 75 Herds
Australia wide, and Holstein Australia

Work closely with Australian Dairy Herd Improvement Scheme (ADHIS) to implement, quality control

**Improve reliability of ABVg towards level approaching proven bull**
10,000 Holstein cow project

Tasks

✓ Collect samples – **10,114 collected**

✓ Genotype for 50,000 DNA markers (SNPs)

✓ Deliver to ADHIS - **9,900** passed quality control

✓ Enhance ADHIS system to handle cows in reference set

✓ Quality check results, assess impact on ABVg reliabilities for young bulls, etc

o Results back to farmers
Jer-nomics project

Genotype ~ 4,000 Jersey cows with excellent herd recording data
Increase reliability of Jersey genomic breeding values
Collaboration with > 75 Herds, Jersey Australia

Tasks
- 3900 samples collected, DNA extracted,
- Samples genotyped
- Same pipeline as 10K Holsteins
Genotyped animals

Number of animals in reference population:

- 12,649 Holstein (~10k females)
- 5,204 Jerseys

Effect on reliability of adding genotyped females:

4-8% improvement
The reliability of genomic breeding values of 437 young bulls

<table>
<thead>
<tr>
<th>Trait</th>
<th>Bulls only</th>
<th>Bulls + cows</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>54</td>
<td>61</td>
<td>7</td>
</tr>
<tr>
<td>Fat</td>
<td>54</td>
<td>61</td>
<td>7</td>
</tr>
<tr>
<td>Milk</td>
<td>54</td>
<td>61</td>
<td>7</td>
</tr>
<tr>
<td>Survival</td>
<td>30</td>
<td>36</td>
<td>6</td>
</tr>
<tr>
<td>Fertility</td>
<td>33</td>
<td>37</td>
<td>4</td>
</tr>
<tr>
<td>Somatic cell count</td>
<td>43</td>
<td>51</td>
<td>8</td>
</tr>
</tbody>
</table>
1000 Bull genomes project

• Sequencing still more expensive than SNP chip genotyping

• Alternative strategy
  • Sequence key ancestors and impute genotypes from sequenced animals into all animals genotyped with SNP chips

• Common need for reference genotype file from sequence

• 1000 bull genomes project
  ✓ Provide a database of genotypes from sequenced bulls
  ✓ Global effort!
Using sequencing to increase the reliability

• The causative mutations are in the data set!

• Genomic prediction
  • No longer have to rely on LD with SNP
    – Higher accuracy of prediction (rare variants)?
    – Better persistence of accuracy across generations

• Better prediction across breeds?
  – SNP-QTL associations more consistent across breeds
The genomic era is here. How can dairy farmers use the technology?

How much can farmers afford to pay for genotyping?

Select replacements
Mating plans to control inbreeding
Achieve certainty in parentage of individual cows
Avoid genetic defects
Selling pedigree heifers at a premium
Replacement heifers

Aim: Calculate the benefit of genotyping (7k), based on keeping the best heifers as replacements

Assumptions

- Reliability of parent average (30%)
- Reliability of EBV(g) (60%)
- 1 unit of EBI = €1 extra profit
- SD of EBI = €62

1) Selection on parent average not possible
2) Selection on parent average replaced with selection using EBV(g)s

Selection index theory
Replacements per 100 cows

- 40 heifer calves available
- 20 replacements Required (top 20)
- 20 heifers to sell
Replacements per 100 cows

- 40 heifer calves available
- 20 replacements Required (top 20)
- Benefit of genotyping is €46 (ignoring parent average)
- 20 heifers to sell
Replacements per 100 cows

40 heifer calves available

If include parent average
Breakeven cost is about €15

20 replacements Required (top 20)

20 heifers to sell

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Genomic relationships compared to pedigree relationships
Impact of strategies on inbreeding and value/cow/year

<table>
<thead>
<tr>
<th>Method of controlling inbreeding</th>
<th>Genomic inbreeding</th>
<th>Pedigree inbreeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genomics</td>
<td>2.5% ($12.50)*</td>
<td>1.1% ($5.50)</td>
</tr>
<tr>
<td>Pedigree</td>
<td>1.4% ($7)</td>
<td>1.5% ($7.50)</td>
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$12.50*4 = $50 per lifetime or €39
Parentage verification

Useful for large herds (especially seasonal calving systems)
Match calves to sires and potentially dams (if available)

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<tr>
<th>SNP Panel</th>
<th>50K SNP</th>
<th>3K SNP</th>
<th>300 SNP</th>
<th>150 SNP</th>
<th>100 SNP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sires matched</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>98%</td>
<td>87%</td>
</tr>
<tr>
<td>Number of sires matched correctly (of those matched unambiguously by the program)</td>
<td>100%</td>
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<td>100%</td>
<td>98%</td>
<td>97%</td>
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What’s it worth? (at €29 test)

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### What’s it worth? (at €15 test)

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**TOTAL**

€30.90
Conclusions

Adding females to the reference population increases reliability by up to 8% in Australia.

Genotyping females is profitable at €29, benefits become very attractive at €15.
Acknowledgements

Dairy Future’s Co-operative Research Council
ADHIS