Sustainable dairy breeding using genomic selection and crossbreeding

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The breeding machine

Input:
- Breed
- Biological circumstances
- Economic frames
- Political frames
- Resources

Output:
- Genetic gain
- Inbreeding
- Risk
- Costs
Sustainable breeding

• Broad breeding goals taking all economic important traits into consideration
  • Expectation of the future
  • Welfare issues
  • Non marked values

• Inbreeding
  • An acceptable future rate of inbreeding must be ensured
    Use of optimal contribution selection methods
Total Merit Indices - history

• **1975-1985** TMI- introduced in Nordic countries including production and functional traits
• **1985-2007** TMI’s in Nordic countries gradually improved more traits – better methods
• **1990-2000** TMI – based on few traits popular in many countries
• **2008** Joint Nordic TMI – called NTM
• **Today** – everyone see the need for having a TMI including all economic important traits
# Gain from NTM for HOL

Correlations between EBV’s for AI bulls born 2001-2003

<table>
<thead>
<tr>
<th>Trait</th>
<th>Correlation with NTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>0.49</td>
</tr>
<tr>
<td>Growth</td>
<td>0.00</td>
</tr>
<tr>
<td>Fertility</td>
<td>0.39</td>
</tr>
<tr>
<td>Calving - direct</td>
<td>0.28</td>
</tr>
<tr>
<td>Calving - maternal</td>
<td>0.37</td>
</tr>
<tr>
<td>Udder health</td>
<td>0.46</td>
</tr>
<tr>
<td>Other health</td>
<td>0.47</td>
</tr>
<tr>
<td>Body</td>
<td>-0.04</td>
</tr>
<tr>
<td>Feet &amp; legs</td>
<td>0.12</td>
</tr>
<tr>
<td>Udder</td>
<td>0.40</td>
</tr>
<tr>
<td>Milking speed</td>
<td>0.09</td>
</tr>
<tr>
<td>Temperament</td>
<td>0.03</td>
</tr>
<tr>
<td>Longevity</td>
<td>0.51</td>
</tr>
</tbody>
</table>
Overall aim of NTM

- High yielding cow
- Improved genetic level for functional traits – health & fertility
- Leads to improved longevity and economically enhanced dairy cows

Fulfilled!!
How does genomic selection affect genetic gain and sustainability?

Genomic selection reduce the generation interval

\[ \Delta G = \frac{i \cdot r_{IA} \cdot \sigma_A}{L} \]

But do also affect the other factor!
Traditional progeny test scheme

Proven bull cohort 2005

Young bulls cohort 2010

Selection criterion

NTM

10

20
Traditional progeny test scheme and DGV’s

Proven bull cohort 2005

Young bulls cohort 2010

Selection criterion

Proven bull cohort 2005

Young bulls cohort 2010

Selection criterion
Effect of two stage selection

ACS, 2009
Effect of young AI sires - Turbo

Relative genetic gain

* apr. 50 mill DKK per year in Denmark

ACS, 2009
Overall effect of number of genotypings

Annual gain, €

Inbreeding

0.0%
0.5%
1.0%
1.5%
2.0%
2.5%
3.0%
3.5%

Genotypings

ACS and MKS, 2010
Composition of total gain

ACS and MKS, 2010
Potential ”new” traits

• In the ”old” plan we couldn’t wait for information in later lactations

• Now a balance between expression in 1\textsuperscript{st} 2\textsuperscript{nd} and 3\textsuperscript{rd} lactation is possible
  • Yield
  • Mastitis
  • Fertility
Genomic selection can

• Improve overall genetic gain
• Move the balance in genetic gain towards functional traits
• In theory reduce rate of inbreeding
  • But what about reality?
## Crossbreeding - also a way towards sustainability

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heterosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>2 - 3%</td>
</tr>
<tr>
<td>Fertility and calving ease and longevity</td>
<td>10 - 15%</td>
</tr>
<tr>
<td>Total merit</td>
<td>10%</td>
</tr>
</tbody>
</table>
Survey among dairy producers using crossbreeding

69 producers were asked about:
• Crossbreeding system
• Why they started crossbreeding
• Benefit from crossbreeding
• Problems

49 answers received
Crossbred herd have the same management level as purebred herds!

<table>
<thead>
<tr>
<th>Metric</th>
<th>Purebred Herds</th>
<th>Herds selected for the survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>305-day protein yield (kg), 1\textsuperscript{st} lact.</td>
<td>274</td>
<td>269</td>
</tr>
<tr>
<td>Stillbirth (%), heifer</td>
<td>8.3</td>
<td>7.8</td>
</tr>
<tr>
<td>Days from 1\textsuperscript{st} to last ins., cows</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>% of cows entering 2\textsuperscript{nd} lact.</td>
<td>78</td>
<td>81</td>
</tr>
</tbody>
</table>
Breeds and crossbreeding methods

Methods
• 55% of herds use 3 breeds
• 35% of herds use 2 breeds
• 10% of herds use another system

Breeds
• RDM, Holstein, Jersey – many herds
• SRB, Montbéliarde, Finish Ayrshire – some herds
• Brown Swiss, Fleckvieh – few herds
Parts of females being crossed

80-100%

40-80%

0-40%
Answers

• 40 producers still apply crossbreeding
  • 34 producers have used crossbreeding programs for more than 3 years

• 9 producers have stopped crossing
Crossbreeding meet the expectations of dairy producers

• 33 out of 34 producers have a positive or really positive outcome
  • 50 - 60% for longevity, health and feet and legs 😊😊
  • 15 - 30% for fertility, economy, plus calf- and cow mortality 😊
• All herds expect to have a "crossbred" herd 5 years ahead

"Crossbred cows have lower yield, but is much better for functional traits"
Important challenges

• Unequal size among cows
• Lack of acceptance among colleagues
Challenges for the advisory system

- More information/knowledge
- Possibility for inclusion of more breeds
- Better management tools
Analyses of crossbred cows in Denmark
Increasing number of females with and
Demands for animals included in the analyses

- At least 6 producing crosses and at least 6 producing Holstein cows per birth year within herd
- Crosses are defined as animals with "red" sire and "black" dam
- Animals born in 2004 and later

Data: 4,314 HOL and 1,979 crosses
About the results

• Results are given as within herd differences between crosses and Holstein

• The level of crosses is:

\[
\frac{1}{2} X + \frac{1}{2} X + \text{heterosis}
\]

• The level of pure bred is:

\[
\frac{1}{2} X + \frac{1}{2} X
\]
## 305 days yield

<table>
<thead>
<tr>
<th></th>
<th>Milk, kg</th>
<th>Fat, kg</th>
<th>Protein, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; lactation</td>
<td>- 177</td>
<td>+ 4</td>
<td>- 1</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; lactation</td>
<td>- 203</td>
<td>+ 6</td>
<td>+ 1</td>
</tr>
</tbody>
</table>
Survival until second calving

+ 2 percentage point

(78 % versus 76 %)
# Stillbirth and calving ease

<table>
<thead>
<tr>
<th></th>
<th>Stillbirth%</th>
<th>% easy calving</th>
</tr>
</thead>
<tbody>
<tr>
<td>First calving</td>
<td>- 1.3 %*</td>
<td>+ 5 %*</td>
</tr>
</tbody>
</table>

* Given in percentage point
# Fertility traits

<table>
<thead>
<tr>
<th></th>
<th>Age at first ins.</th>
<th>Interval from first to last ins.</th>
<th>Number of ins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers</td>
<td>- 8 days</td>
<td>- 2 days</td>
<td>- 0.06</td>
</tr>
<tr>
<td>1. parity</td>
<td>- 5 days*</td>
<td>- 8 days</td>
<td>- 0.10</td>
</tr>
</tbody>
</table>

* Days from calving to first insemination
If the analyses were based only on crosses with high SRB contribution:

869 animals

- 1.991 animals

- then results were more favorable for the crosses.
### 305 days yield 1st lactation:

<table>
<thead>
<tr>
<th>Component</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk, kg</td>
<td>-34</td>
</tr>
<tr>
<td>Fat, kg</td>
<td>+8</td>
</tr>
<tr>
<td>Protein, kg</td>
<td>+5</td>
</tr>
</tbody>
</table>

### Heifer calving:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stillborn, percentage point</td>
<td>-2 %</td>
</tr>
<tr>
<td>Easy calving, percentage point</td>
<td>+4 %</td>
</tr>
</tbody>
</table>

### Fertility 1st lactation:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval from calving to first ins.</td>
<td>-4 days</td>
</tr>
<tr>
<td>Interval from first to last ins.</td>
<td>-7 days</td>
</tr>
</tbody>
</table>
Equality between Danish breeds

- Calculations based on:
  - Registrations for:
    - Yield
    - Health
    - Fertility
    - Still birth etc.
  - Actual economic values

The difference between breeds is less than 25 euro per cow year
Economical results from a selected group of Danish Dairy farms (Centrovice, 2009)

<table>
<thead>
<tr>
<th></th>
<th>Jersey</th>
<th>HOL</th>
<th>RDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. herds</td>
<td>55</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>Herd size</td>
<td>164</td>
<td>178</td>
<td>154</td>
</tr>
<tr>
<td>Avr. kg ecm</td>
<td>8549</td>
<td>9933</td>
<td>9016</td>
</tr>
<tr>
<td>Animal sale</td>
<td>+ 135 $</td>
<td>+ 211 $</td>
<td>+ 432 $</td>
</tr>
<tr>
<td>Profit per year cow</td>
<td>2586 $</td>
<td>2590 $</td>
<td>2821 $</td>
</tr>
</tbody>
</table>
Recommended breeds:

- **Breed group I:**
  - Holstein

- **Breed group II:**
  - Danish Red
  - SRB (Swedish Red)
  - FAY (Finish Ayrshire)
  - NRF (Norwegian red)

- **Breed group III:**
  - Montbéliarde
  - Jersey
Traditional crossbreeding system

Can it be done another way?
COMBI CROSS

Level 1
Pure breeding

Level 2
Two breed cross

Level 3
Three breed cross

Level 4
Terminal cross

[Images of cattle and meat]
Distribution of breed groups using COMBI CROSS in a 200 cow herd

- 70 pure bred cows
- 50 two bred cows
- 80 three bred cows
- 80 beef cross per year
Conclusion

- Those producers applying crossbreeding are satisfied
- Cross bred animals are competitive
- Heterosis is also expressed in well managed herds
- Equal breed are available
- Pure breeding is necessary
- New systems in line

Crossing is a strong alternative which increase sustainability in dairy farming