Nordic Cattle Genetic Evaluation
a tool for practical breeding
with red breeds

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Nordic Cattle Genetic Evaluation (NCGE)
a tool for practical breeding with red breeds

1. Introduction
2. Breeding structure
3. Data collection
4. Genetic evaluation
5. Publication of EBVs
6. Breeding goal
7. Future plans
8. Final remarks and conclusion
Nordic Cattle Genetic Evaluation
Established 01.01.2002 by:

Faba breeding
Swedish Dairy Association
Danish Cattle
Nordic Cattle Genetic Evaluation - history

- 2002 - Established
- 2002 – Development has started
- 2005 – first EBVs published – type, milk ability, temperament and fertility
- 2006 – Yield and mastitis
NAVs board

- Finland
  - Jaana Kiljunen
  - Anna Lappalinen
- Sweden
  - Lennart Andersson
  - Lars-Inge Gunnarsson (chairman)
- Denmark
  - Henrik Nygaard
  - Jan Duchwaider (vice chairman)
NAV – Goal

- To use international accepted methods for estimation of BVs
- To focus on development of methods within the “Nordic traits” – mastitis, fertility etc.
- To improve the breeding work using new registrations
NAV – Goal

- To give the practical cattle breeding the best selection tool to achieve maximal genetic progress

or with other words

- How do we get the best possible methods for estimation of BVs within our Nordic Total Merit index in use in practice
Perspectives - Joint Nordic estimation of breeding values

- Simultaneously use of all data and relationships between Nordic animals
- All cows and sires can be directly compared
Perspectives – joint Nordic Estimation of breeding values

- Use resources more efficient:
  - Development of new method
  - Routine evaluation
- Joint platform for practical breeding work
EBVs can be compared across the Nordic countries

1. Cow 9, Finland
2. Cow 5, Sweden
3. Cow 1, Denmark
4. Cow 2, Denmark
5. Cow 6, Sweden
Nordisk Avlsværdi Vurdering

Nordic Cattle Genetic Evaluation

Denmark
- 42,000 RDM
- 372,000 HF
- 60,000 Jersey

Sweden
- 141,000 SRB
- 158,000 HF

Finland
- 165,000 FAY
- 71,000 HF
<table>
<thead>
<tr>
<th>Country</th>
<th>2006</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>113</td>
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<tr>
<td>Country</td>
<td>2006</td>
<td>2000</td>
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<tr>
<td>-----------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Denmark</td>
<td>4500</td>
<td>7600</td>
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</tr>
<tr>
<td>Sweden</td>
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</table>
## Average yield, all breeds

<table>
<thead>
<tr>
<th></th>
<th>Milk</th>
<th>Fat</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Denmark</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>7610</td>
<td>327</td>
<td>264</td>
</tr>
<tr>
<td>2006</td>
<td>8778</td>
<td>378</td>
<td>301</td>
</tr>
<tr>
<td><strong>Finland</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>7775</td>
<td>332</td>
<td>264</td>
</tr>
<tr>
<td>2006</td>
<td>8639</td>
<td>361</td>
<td>297</td>
</tr>
<tr>
<td><strong>Sweden</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>8537</td>
<td>351</td>
<td>286</td>
</tr>
<tr>
<td>2006</td>
<td>9107</td>
<td>376</td>
<td>310</td>
</tr>
</tbody>
</table>
## Average yield, RDC, 2006

<table>
<thead>
<tr>
<th>Country</th>
<th>Milk</th>
<th>Fat, kg</th>
<th>Protein, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>8560</td>
<td>364</td>
<td>300</td>
</tr>
<tr>
<td>Finland</td>
<td>8472</td>
<td>363</td>
<td>293</td>
</tr>
<tr>
<td>Sweden</td>
<td>8633</td>
<td>373</td>
<td>301</td>
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</table>
### Average yield, RDC, 2006

<table>
<thead>
<tr>
<th></th>
<th>Milk</th>
<th>Fat, kg</th>
<th>Protein, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Denmark</strong></td>
<td>8560</td>
<td>364</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>(9232)</td>
<td>(380)</td>
<td>(309)</td>
</tr>
<tr>
<td><strong>Finland</strong></td>
<td>8472</td>
<td>363</td>
<td>293</td>
</tr>
<tr>
<td></td>
<td>(9122)</td>
<td>(358)</td>
<td>(309)</td>
</tr>
<tr>
<td><strong>Sweden</strong></td>
<td>8633</td>
<td>373</td>
<td>301</td>
</tr>
<tr>
<td></td>
<td>(9645)</td>
<td>(386)</td>
<td>(322)</td>
</tr>
<tr>
<td>Country</td>
<td>Fat %</td>
<td>Protein %</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>4.25</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>4.29</td>
<td>3.46</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>4.32</td>
<td>3.39</td>
<td></td>
</tr>
</tbody>
</table>
## Average yield RDC, 2006

<table>
<thead>
<tr>
<th>Country</th>
<th>Fat %</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>4.25</td>
<td>3.50</td>
</tr>
<tr>
<td>Finland</td>
<td>4.29</td>
<td>3.46</td>
</tr>
<tr>
<td>Sweden</td>
<td>4.32</td>
<td>3.39</td>
</tr>
</tbody>
</table>
Breed characteristics RDC compared to Holstein

- **Yield traits**
  - 700-900 kg milk; 5-15 kg fat, 10-20 kg protein (RDC less)

- **Stature**
  - 4-6 cm (RDC lowest)

- **Mastitis**
  - 2-3% (RDC less mastitis)

- **Fertility**
  - Calving interval 15 days (RDC shortest)

- **Live born calves**
  - 3-5% (RDC less still born)
Total Merit – RDC compared to Holstein

M. Lidfeldt (2006):

SRB and Swedish Holstein same level – Total Merit
Tested young bulls

- 270 RDC bulls
- 370 Holstein
- 60 Jersey

- 30% of the females inseminated by young bulls
- Progeny group size 90-250 (smallest DNK largest FIN)
Harmonization of registration

Denmark, Finland and Sweden have nearly 100% similarity in registration
Cow database

Data flow in relation to the central data base
Registration

- **Pedigree:**
  - Complete pedigree (unique id)

- **Traits:**
  - Production
  - SCC
  - Type traits, milking speed and temperament
  - Longevity
  - Fertility traits
  - Calving traits
  - Disease treatments - mastitis
Harmonization of registration

- **Ongoing harmonization work:**
  - **Type traits**
    - Exactly the same traits are scored (Finland 4 new, Denmark 1 new)
  - **Joint manual**
  - **Nordic classifier workshop every 2nd year**
  - **Hoof trimming data, other future reg.**
### Mammary system - 2004

<table>
<thead>
<tr>
<th>Measure</th>
<th>SWE</th>
<th>DNK</th>
<th>FIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fore udder</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rear udder height</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Rear udder width</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Udder support</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Udder depth</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Teat length</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teat thickness</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Teat place. (front)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teat place. (back)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Udder balance</td>
<td>X</td>
<td></td>
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</tr>
</tbody>
</table>
# Mammary system - 2007

<table>
<thead>
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<th></th>
<th>SWE</th>
<th>DNK</th>
<th>FIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fore udder</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rear udder height</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rear udder width</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Udder support</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Udder depth</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Teat length</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Teat thickness</td>
<td>X</td>
<td>X</td>
<td>x</td>
</tr>
<tr>
<td>Teat place. (front)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Teat place. (back)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Udder balance</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Data registration and quality

- Coming years:
  - Functional traits will be recorded on large scale outside the Nordic countries
  - Data quality need attention
  - Focus on easy and accurate registration – also a challenge for Nordic countries
  - New traits
Progeny testing – correct sire

Bull A

Bull B
Progeny testing – correct recording

Bull A

Bull B
Progeny testing

- Error in registration of pedigree or phenotype
- Less reliable EBVs
- Less accurate selection of breeding animals
- Less genetic progress
Estimation of breeding values

Use the registered data in the best possible way

Estimate accurate EBVs

- Improved statistical models
- New traits
Estimation of breeding values

- Improved statistical models
- More accurate EBVs
- More accurate selection of breeding animals
- Higher genetic progress
Genetic evaluation

Finland, Sweden and Denmark benefits from their similar registration systems in the Joint Nordic Genetic Evaluation
Same traits measured in all countries

Practical advantage
- One BV per animal

Theoretical reasonable assumption
- INTERBULL-correlations high
- G x E studies no significant effects
- No effect within country even though we have 20 years with a significant increase in production

All models are validated with statistical tests
Genetic evaluation

Data

- Denmark
- Sweden
- Finland

NAV model

Joint ranking of animals
- Expressed on rolling "cow base" – mean 100
- Expressed with a standard deviation of 10

NAV- EBVs

NAV

Nordisk Avlsværdi Vurdering • Nordic Cattle Genetic Evaluation
Nordic Cattle Genetic Evaluation – routine evaluation

- 2005 – First EBVs joint EBVs published – type, milk ability, temperament and fertility
- 2006 – Yield and mastitis
Nordic Cattle Genetic Evaluation – ongoing development work

- Calving traits
- Update of yield model
- Other diseases
- Total Merit index
Peterslund, SRB

Peterslund daughters milking in Sweden, Finland or Denmark
From national to Nordic - SRB-bull Peterslund

**National**
- Danish EBVs
- Finish EBVs
- Swedish EBVs

**Nordic**
- 47 daughters
- 2,674 daughters
- 9,658 daughters
- Nordic EBVs 12,379 daughters
Breeding values can be compared across Denmark, Finland and Sweden

Number of daughters
- Denmark: 47
- Sweden: 9,658
- Finland: 2,074

Yield index
- Denmark: 111
- Sweden: 111
- Finland: 113

Udder health

NAV
Nordisk Avlsværdi Vurdering
Nordic Cattle Genetic Evaluation
Danish, Finnish and Swedish EBVs can be compared directly for:

- Yield
- Mastitis
- Fertility traits
- Type traits
- Temperament and milk ability
Routine genetic evaluation

- 3 breed groups – RDC, Holstein and Jersey

- Frequency:
  - Today: 7 times a year: yield and type and 4 times a year all other traits
  - 2008 onwards: 6 times per year all traits
EBV - yield

- Multi trait multi lactation TD model
  - TD data from Finland and Denmark, 305 Day data from Sweden
  - 1,2 and 3 lactation
  - Milk, fat and protein
EBV – udder health - Nordic

Definition of mastitis traits:

- 15 days before calving until 50 days after calving in 1st parity
- 51 days after calving until 300 days after calving in 1st parity
- 15 days before calving until 150 days after calving in second parity
- 15 days before calving until 150 days after calving in third parity
EBV – udder health - Nordic

Information traits:

- SCC day 5-150 after calving in 1st parity
- SCC day 5-150 after calving in 2nd parity
- SCC day 5-150 after calving in 3rd parity
- Udder depth 1st parity
- Fore udder attach. 1st parity
EBV – udder health
Genetic parameters

- Clinical mastitis 4%
  - SCC 13%
  - Udder conformation 25%

- Genetic correlations:
  - CM different lactations 0.70-0.95
  - CM-SCC 0.60
  - CM-Udder conformation 0.35-0.50
EBV–udder health - Reliability \( (r_{IA}^2) \)

- **Udder health in theory**
  - Based on CM - max 100%
  - Based on SCC – max 36% \( (r_g^2) \)

- **Udder health in practice (DNK)**
  - 40% first proof same time as production
  - 60-65% based on 1. lact. daughters

- FIN and SWE higher \( r_{IA}^2 \) due to larger daughter group size!
# Fertility index

<table>
<thead>
<tr>
<th>Information</th>
<th>Economic weight in fertility index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; ins-last ins heifers</td>
<td>X</td>
</tr>
<tr>
<td>Number of ins heifers</td>
<td>X</td>
</tr>
<tr>
<td>Calv.-1&lt;sup&gt;st&lt;/sup&gt; ins cows</td>
<td>X</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; ins -last ins cows</td>
<td>X</td>
</tr>
<tr>
<td>Number of ins cows</td>
<td>X</td>
</tr>
<tr>
<td>Fertility treatment cows</td>
<td>X</td>
</tr>
<tr>
<td>Heat strength cows</td>
<td>X</td>
</tr>
</tbody>
</table>
Nordic routine evaluation

- Presentation of breeding values
  - Common base
  - Common standard deviation
- Number of routine runs per year
  - Dates for publishing EBVs
- Breeders in Denmark, Finland and Sweden can see the same EBVs at the same time
Nordic presentation of EBVs

- Common base
  - Cow base – 2 birth years (1.6.2002-1.6.2004)
  - Average 100 all traits
  - Same base for cows/heifers and sires
  - Base update at each routine run
Nordic - genetic base

EBV

Bulls

Cows

95 96 97 98 99 00 01 02 03 04
Standard deviation

- Express the variation around a mean

- Standard deviation 10
  - 67% of the sires has EBVs between 90 and 110 for traits without genetic changes over years
  - Standardizations factors for all traits based on bulls born in 1997-98 with a Nordic 1st batch of daughters
## Presentation of EBVs

<table>
<thead>
<tr>
<th>Country</th>
<th>Until 15 April 2005</th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Sweden</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>Finland</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Denmark</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>Denmark type</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Breeding goal

Get maximum economic gain
Sub index – across lactation e.g. Protein

EBV

- EBV 1 lact – 50%
- EBV 2 lact. - 30%
- EBV 3 lact – 20%
Sub index – across traits within same group of traits e.g. Yield

EBV – Yield index

- EBV milk
- EBV fat
- EBV protein
<table>
<thead>
<tr>
<th></th>
<th>Milk</th>
<th>Fat</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both Holstein and Red breeds</td>
<td>Nordic</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>
Genetic trend Fertility index

- Sweden
- Denmark
- Finland
Genetic trend for Udder health

Average EBV Udder health

Bulls birth year

- Denmark
- Finland
- Sweden
### Effect of index for udder health

#### Danish Holstein

<table>
<thead>
<tr>
<th>Sire’s index for udder health</th>
<th>1st parity</th>
<th>3rd parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 85</td>
<td>21.7%</td>
<td>28.9%</td>
</tr>
<tr>
<td>86-95</td>
<td>18.3%</td>
<td>26.0%</td>
</tr>
<tr>
<td>96-105</td>
<td>15.3%</td>
<td>23.8%</td>
</tr>
<tr>
<td>106-113</td>
<td>13.9%</td>
<td>21.0%</td>
</tr>
<tr>
<td>≥ 114</td>
<td>10.7%</td>
<td>17.0%</td>
</tr>
</tbody>
</table>
Total Merit index (+ more trait groups)

EBV – Total Merit

\[ b_1 \times \text{EBV Yield} \]

\[ b_2 \times \text{EBV Udder health} \]

\[ b_3 \times \text{EBV Fertility} \]
## Correlation with TMI – Red breeds

<table>
<thead>
<tr>
<th></th>
<th>Denmark</th>
<th>Finland</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>0.73</td>
<td>0.62</td>
<td>0.56</td>
</tr>
<tr>
<td>Fertility</td>
<td>0.15</td>
<td>0.22</td>
<td>0.20</td>
</tr>
<tr>
<td>Mastitis</td>
<td>0.44</td>
<td>0.32</td>
<td>0.34</td>
</tr>
<tr>
<td>Other disease</td>
<td>0.32</td>
<td>-</td>
<td>0.19</td>
</tr>
<tr>
<td>Longevity</td>
<td>0.45</td>
<td>0.30</td>
<td>0.50</td>
</tr>
</tbody>
</table>
General about methods

- Use the best methods which can be handled in practice
- Update of genetic parameters
- We have to use our data as efficient as possible
- Focus on supporting the strength of Nordic cattle breeding – functional traits
Estimation of breeding values in the future

- Decisions have to be taken Joint Nordic instead of within country:
  - Registration
  - Methods and models
  - Presentation of EBVs
  - Sub breeding goals
  - Future research and development
Remember

• 10% extra genetic gain has the same value, regardless how we achieve it:
  • More accurate registrations
  • Better statistical models
  • Improved selection procedure
  • QTL (SNP)
  • Etc.
Benefits by joint Nordic evaluation

- Efficient use of resources
- More reliable EBVs
- Common platform for AI industry
Conclusion

NAV want to give:

*The practical cattle breeding the best selection tool to achieve maximal genetic progress*
EBVs can be compared within the Nordic countries

1. Cow 9, Finland
2. Cow 5, Sweden
3. Cow 1, Denmark
4. Cow 2, Denmark
5. Cow 6, Sweden