Supporting genetic management of a live cattle population with gene bank material

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Centre for Genetic Resources, the Netherlands
CGN – Dutch Gene Bank

- Creation and management of genenbank collections
- Supporting rare breeds
  - Advise on genetic management
  - Software tools
  - Providing genetic material for Breeding
- ...

Dutch cattle breeds – collection (2012)

<table>
<thead>
<tr>
<th>Breed</th>
<th>#donors</th>
<th>total # doses</th>
<th>Used for breeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandrood</td>
<td>34</td>
<td>5653</td>
<td>Yes</td>
</tr>
<tr>
<td>Friesian</td>
<td>177</td>
<td>26395</td>
<td>Yes</td>
</tr>
<tr>
<td>Friesian Red</td>
<td>48</td>
<td>17294</td>
<td>Yes</td>
</tr>
<tr>
<td>Groningen White Headed</td>
<td>77</td>
<td>17338</td>
<td>Yes</td>
</tr>
<tr>
<td>Holstein Friesian</td>
<td>4717</td>
<td>123805</td>
<td>No</td>
</tr>
<tr>
<td>Lakenvelder</td>
<td>30</td>
<td>1705</td>
<td>No</td>
</tr>
<tr>
<td>Maas-Rijn-IJssel</td>
<td>244</td>
<td>22052</td>
<td>No</td>
</tr>
<tr>
<td>Verbeterd Roodbont</td>
<td>13</td>
<td>1190</td>
<td>No</td>
</tr>
<tr>
<td>Witrik</td>
<td>12</td>
<td>3406</td>
<td>No</td>
</tr>
</tbody>
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Genetic management

- Small effective population size
  - High inbreeding rate
  - Loss of genetic diversity
  - Inbreeding depression and genetic defects

- Gene bank can help
  - More sires available
    - Larger $N_e$
  - Generation length increases

- How effective?
Theory and Practice

- When only current gene bank semen is used to inseminate all females for ever
  - $F$ asymptotes to $1/2n_{sires}$
  - Delta $F$ becomes 0
  - Generation length indefinite
  - Only genetic diversity in gene bank will be conserved

- Practice
  - Gene bank sires related and inbred
    - Higher $F$ in the end
  - Stochastic variation
  - Living sires will be used as well
  - Semen stock not indefinite

Sonesson et al. 2002
Genet. Res. 80: 27
Test based on real population

- Computer simulation
  - Brandrode Cattle

- Live population
  - About 1100 Animals
  - About 80 bulls available for breeding
  - In about 20 larger herds
  - Many small herds (<20 cows)

- Gene Bank
  - 34 Bulls available for AI

- Inbreeding and relatedness determined
  - Combination of SNP and pedigree data
  - All genebank bulls typed
Average relatedness among genebank bulls slightly lower than live population
Computer simulations

- Brandrode population simulated
  - First year real population
  - Next 30 years with genebank use
  - 20 runs to determine variation

- Gene-bank
  - Remains constant for 30 years

- Scenario’s
  - Only genebank bulls (each bull same chance)
    - n=2, 5, 10 or 34
  - Ten genebank bulls and bulls live population
    - 100%, 20%, 5%, 0% gene bank bulls


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Simulation results: only genebank sires

<table>
<thead>
<tr>
<th>n</th>
<th>Expected</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.250</td>
<td>0.361 – 0.379</td>
</tr>
<tr>
<td>5</td>
<td>0.100</td>
<td>0.114 – 0.138</td>
</tr>
<tr>
<td>10</td>
<td>0.050</td>
<td>0.068 – 0.084</td>
</tr>
<tr>
<td>34</td>
<td>0.015</td>
<td>0.054 – 0.062</td>
</tr>
</tbody>
</table>
Simulations: fraction sired by gene bank bulls

- Even moderate use of gene bank material decreases inbreeding rates
Discussion

- Exclusive use of gene bank material freezes the population
  - Inbreeding level stays constant
    - $\frac{1}{2}n_{\text{bulls}} +$ fraction due to relatedness bulls
  - Genetic level stays constant
    - Average breeding value of bulls
  - Genetic diversity stays constant
    - Only what is present in the bulls
      - Vital that genetic diversity of the population is captured in the gene bank
  - No adaptation and genetic progress
    - Renewal of gene bank material is needed
Conclusions

• Gene banks can help to manage live populations

• Important how many and which sires in gene bank

• Renewal strategy for gene bank needed

Acknowledgements

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