Conserving a single gene versus overall genetic diversity with the help of optimal contributions

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Old low input/low output breeds

- Harbour unique genetic variation
- Conservation in gene banks
  - Genetic diversity should be maximised
Maximising genetic diversity in a gene bank

- Optimal contributions is the method of choice
- Minimises $c'Ac$
  - $A = \text{numerator relationship matrix}$
  - Pedigree based or Molecular based
  - $c = \text{contribution vector}$
  - Sums to 1
  - Excluded animals have 0 contribution

- Constraints
  - No negative contributions
  - Equal contributions of selected candidates
  - Male and female contributions sum to 0.5
- Software program: Gencont
Conservation of special genes

- Often interest in specific genes
  - Coat or colour varieties
    - Curly coat in American Bashkir Curly horses
  - Poultry colour varieties
  - Elimination of specific genes
    - Scrapie sensitive alleles in sheep
    - Introgressions from other breeds
- Risk of losing other diversity when targeting a specific allele
  - Maximise diversity while constraining allele frequencies
Targeting specific alleles with optimal contributions

- Constraint on sexes: \( s = Qc \)
  - \( s = [0.5 \ 0.5] \)
  - \( Q \) = two column vector, per animal \([1 \ 0]\) if male or \([0 \ 1]\) if female
  - \( c \) = contribution vector

- Can be replaced by allele frequencies
  - \( s = [0.0 \ 1.0] \) or \([0.05 \ 0.95]\) or \([0.5 \ 0.5]\) or any other frequency
  - \( Q \) = two column vector: \([1 \ 0]\) if homozygote 1 \([0.5 \ 0.5]\) if heterozygote \([0 \ 1]\) if homozygote 2
  - \( c \) = contribution vector
Does conservation of individual genes with optimal contributions work?

- Holstein population with 568 animals
  - Genotyped with 50K SNP
- Simulation of Conservation of 20 animals with equal contributions (5% each) in genebank
- Random choice of 100 loci
  - First subsequent loci with frequency 0.05/0.95; 0.10/0.90; 0.25/0.75; 0.5/0.5
- Target frequencies in genebank
  - Eliminate minor allele (0.0/1.0)
  - Original frequency
  - Maximise diversity (0.5/0.5)
  - Eliminate major allele (1.0/0.0)
Results: Genetic diversity (% fixed alleles)

- %fixed in original population: 6.1%
- %fixed in gene bank without target freq.: 10.1%
- %fixed in gene bank with target frequency 0.0/1.0

<table>
<thead>
<tr>
<th>Original frequency</th>
<th>% fixed in gene bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05/0.95</td>
<td>10.1</td>
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<tr>
<td>0.10/0.90</td>
<td>10.1</td>
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<tr>
<td>0.25/0.75</td>
<td>10.2</td>
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<tr>
<td>0.50/0.50</td>
<td>10.7</td>
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Larger loss if target frequency differs more from original
Results: Genetic diversity (% fixed alleles)

<table>
<thead>
<tr>
<th>Original frequency</th>
<th>Target frequency</th>
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<tbody>
<tr>
<td></td>
<td>0.0/1.0</td>
<td>original</td>
<td>0.50/0.50</td>
<td>1.0/0.0</td>
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<tr>
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<td>10.2</td>
<td>11.2</td>
<td>X</td>
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<td>10.2</td>
<td>10.6</td>
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<tr>
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<td>10.2</td>
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<td>12.0</td>
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<tr>
<td>0.50/0.50</td>
<td>10.7</td>
<td>10.1</td>
<td>10.1</td>
<td>10.8</td>
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- Larger loss if target frequency differs more from original
Practical example: Groningen White headed and B19

- Rare breed: around 60 bulls left, 98 if gene bank animals included
- Blood group B19 only known in this breed
- Should we breed for (more?) B19?
  - Do we loose other diversity if B19 is fixed?
- 42 animals with blood group known, including 14 of 98 bulls
- Other bulls genotype estimated with BLUP (Gengler et al 2007)
Allele frequencies and average relatedness

- Whole population
  - Allele frequency: 21.1%
  - Average relatedness: 0.085
  - with optimal contributions: 0.050

- Average relatedness with optimal contributions and target frequency:
  - 0.075 for 5%
  - 0.050 for 25%
  - 0.054 for 50%
  - 0.132 for 100%

- Loss of diversity when B19 animals are lost
- Loss of diversity when B19 is fixed
Conclusions

• Targeting specific alleles while conserving animals can lead to a substantial loss of diversity

• Optimal contributions restrict the loss

• The more the target allele frequency differs from the population allele frequency the higher the loss