Animal Breeding in a nutshell

Where to Go

Breeding objectives

How to get there

Trait measurement
- Which traits
- Which animals
  - Males / females
  - Progeny test
  - Nucleus / commercial
  --Genotypings

Estimation of breeding value
- Phenotypes
- Pedigree
- BLUP
- Genetic Markers

Reproductive technology
- Artificial Insemination
- MOET
- JIVET
- Cloning

Selection, culling & Mating
- Index / EBV’s
- Balancing merit and inbreeding
- Other issues
Issues related to optimal design

- Increase in genetic merit
  - Select as few as possible
  - Select across ages
- Inbreeding
  - …but select not too few
- Crossbreeding
  - Exploit this?
- Breeding objective
- Connections
- Measurement strategies
- Reproduction technology
- Running Cost
Aspects that need to be balanced:

- Selection accuracy versus generation interval
  - Short generation intervals are good for fast progress, but young breeding animals have lower EBV accuracy

- Selection accuracy versus selection intensity
  - Money available for testing (either performance or DNA) can be used to test a few animals accurately, or to test more animals with lower accuracy. For example, testing fewer young bulls but giving them more test progeny.

- Selection intensity versus generation interval
  - Selecting fewer animals for breeding each year and keeping those longer (e.g. see exercise with AGES in GENEUP.

- Selection intensity versus inbreeding

- The relative emphasis in selection for multiple traits

- Cost versus benefits
Design examples

- One-tier breeding program

Select and replace

Breeding males

Breeding females

Select and Replace

Male progeny

Female progeny
Optimizing age structure

Accuracy changes with age class

Without genomic selection

<table>
<thead>
<tr>
<th>ageclass</th>
<th>N in group</th>
<th>mean</th>
<th>SD</th>
<th>Nr Selected</th>
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<tbody>
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<td>50</td>
<td>10.00</td>
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With genomic selection

<table>
<thead>
<tr>
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<th>N in group</th>
<th>mean</th>
<th>SD</th>
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<td>5.4</td>
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<tr>
<td>2</td>
<td>50</td>
<td>10.00</td>
<td>0.8</td>
<td>4.6</td>
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</table>
Genetic Evaluation helps

BLUP EBV Optimizes generation interval

- Dilemma between young and old sires
Closed nucleus breeding schemes

- Start selection in base
- Maintain selection in base
- Stop selection in base
- Genetic merit
- 2 generation lag
More genetic improvement (about 15%)

Data collection (records/pedigree) also needed in base but usually more intensive in nucleus
Reproductive technologies

- Reproductive boosting
  - Artificial insemination, AI
  - Multiple Ovulation and Embryo Transfer, MOET
  - Oocyte Pickup
  - Juvenile In Vitro Embryo Transfer, JIVET

- Sexing of semen and embryos

- Cloning

- Whizzy Genetics - breeding in a test-tube
Juvenile sheep MOET/JIVET

Sheep:

MOET progeny:

Months:

0  1½  6½  7  8  13  13½

Birth  Get records  MOET Birth
Select & MOET  MOET Birth  Select & MOET  Get records

Generation interval 6½ months
Genetic gain versus genetic diversity

- Sustainable breeding programs require optimal selection balancing genetic gain and genetic diversity

- Potential short term benefits from reproductive technologies are inhibited by the need to maintain diversity
  - Because early selection requires family information (parent average)
Why restrict inbreeding

- Avoid loss of genetic variation/genetic diversity
- Inbreeding depression
- Increase of homozygotes with deleterious recessives
- Inbreeding is closely associated with risk (and genetic drift)
How to restrict inbreeding?

• Mating policies mostly affect
  • progeny inbreeding (*short term*)
  • but not *long term* rate of inbreeding $\Delta F$
  • The long term inbreeding rate depends on *effective population size*

• Long term inbreeding is restricted by
  restricting the average co-ancestry among selected parents
Calculating Effective Population Size: \( Ne \)

Accounting for unequal sex ratio

Effective pop’n size (Ne) reduces towards sex with fewer breeding individuals

\[
Ne = \frac{4 \cdot N_m \cdot N_f}{N_m + N_f}
\]

<table>
<thead>
<tr>
<th>Males / generation</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>5</th>
<th>20</th>
<th>1</th>
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<tr>
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<td>( N )</td>
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<td>7.9</td>
<td>19.5</td>
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Balancing inbreeding and merit

- Select only the very best bull.
- Select a number of bulls from different families.
Economic evaluation of breeding programs

Benefit: \( dG.N \) accumulates each year

Cost \( C \)

Future returns are discounted: \( 1/r^t \)

in year \( t \) \( (N.t.dG - C).(1/r^t) \).

<table>
<thead>
<tr>
<th>year</th>
<th>Genetic Mean ($)</th>
<th>Benefit (M)</th>
<th>Cost (M)</th>
<th>discount factor</th>
<th>NPV (M$)</th>
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<tbody>
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<tr>
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<tr>
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<tr>
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<td>7</td>
<td>140</td>
<td>0.5</td>
<td>0.71</td>
<td>99.14</td>
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Commercial producers
20 million ewes

Multipliers
1 million ewes

Nucleus
50,000 ewes

Genetic lag

Genetic improvement

Cost/ewe

<table>
<thead>
<tr>
<th>No GS</th>
<th>GS</th>
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<tbody>
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dG/ewe

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<tbody>
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Cost-Benefit industry wide

50k Nuc ewes
20M Comm

<table>
<thead>
<tr>
<th></th>
<th>No GS</th>
<th>GS</th>
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<td>Cost</td>
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<td>dG</td>
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Cost-Benefit Study

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<tbody>
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<tr>
<td>Nuc ewes</td>
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<tr>
<td>10k Comm</td>
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NPV Study

Graph showing the comparison between No GS and GS cost-benefit analysis.

- X-axis: Time (in units)
- Y-axis: NPV (Benefit-Cost)
- Graphs for No GS and GS showing increasing NPV over time.