Optimizing Breeding Programs

Effect of Reproductive Technologies and Measurement

Armidale Animal Breeding Summer Course 2014
Decisions in breeding programs

Where to go? breeding objective (which traits)

Who and what to measure? performance, DNA test, genetic evaluation

Who to select and mate? reproductive technol., gains vs inbreeding
Animal Breeding in a nutshell

Breeding objectives

How to get there?

Trait measurement

Estimation of breeding value

Reproductive technology
- Artificial Insemination
- MOET
- JIVET
- Cloning

Selection, culling & Mating

Where to Go?
Making genetic progress is about

Selecting only the very best

Selecting accurately

Keeping generation intervals short

Reproductive rates affect all of the above!
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

• Selection intensity versus inbreeding

• The relative emphasis in selection for multiple traits

• Cost versus benefits
Aspects that need to be balanced

Selection accuracy

Selection intensity

Generation Interval

Inbreeding

Multiple traits

Cost Benefit

\[ \frac{i_m r_{IAM} + i_f r_{IAf}}{L_m + L_f} \sigma_A \]
the more accuracy, the more response
Accuracy of predicting a breeding value increases as an animal gets older.

Assumed heritability = 25%

Need to balance accuracy and generation interval!
BLUP helps selecting between old and young bulls

- EBVs can be compared directly over age classes
- Selection on BLUP EBVs optimizes generation interval

![Diagram showing proven and young sires with a truncation point between 175 and 195.](image)
Optimizing age structure

Accuracy changes with age class!

Without genomic selection

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<th>ageclass</th>
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With genomic selection

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Open nucleus systems

• Select the best animals from lower tiers to compete for being nucleus parents

• degree of ‘openness depends on
  ▪ difference between nucleus and commercial
  ▪ spread of their breeding values

• Open to nuclei
Design Examples

Two-tier breeding program

Central Nucleus
(pigs, poultry, some dairy)

or Dispersed
(sheep, cattle)

Commercial producers

Nucleus

Commercial producers
Nucleus: could be defined as
"the mothers and fathers of the future bulls”
Open Nucleus

Difference in genetic mean between nucleus and base (~2 generations)

Truncation Point

Elite matings
80% from nucleus
20% from base
Open Nucleus

Difference in genetic mean between nucleus and base (~ 2 generations)

Truncation Point

Elite matings
70% from nucleus
30% from base

More measurement in base,
more spread of EBV,
more selected from base

nucleus

base
Best to select on EBV, irrespective of accuracy /genotyped or not / age

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### Example of BLUP selection

**Terminals - Top 150**

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**Analysis Date Friday, 15 June 2001**

- **Increasing & Accuracies**
  - **Sire**
  - **Sire of Dam**

**Selection intensity**

These are sibs so might not select all of them as flock sire.
Balancing inbreeding and merit

This graph will look different for each population

somewhere here might be optimum

select only the very best bull

select a number of bulls from different families

inbreeding or co-ancestry
Selection for milk Yield and Fertility

Multiple traits

<table>
<thead>
<tr>
<th>economic weights</th>
<th>progeny milk</th>
<th>measured milk</th>
<th>response milk</th>
<th>(4 yrs) fertility</th>
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Effect of Reproductive Technologies
Making genetic progress is about

\[ R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_A \]

Selecting only the very best

Selecting accurately

Keeping generation intervals short

Reproductive rates affect all of the above!
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
Reproductive (boosting) technologies

- Increases selection intensities
- Increases accuracy of EBVs
- Decreases generation intervals
- Increases inbreeding
Artificial Insemination

- More intensive use of best sires
- Use of overseas bulls
- Establish links between herds
- Progeny testing

- More rapid dissemination of superior genes
Multiple Ovulation and Embryo Transfer - MOET

• More intensive use of best cows
  – “turns a cow into a sow”

• Use of overseas cows
Adult dairy MOET scheme

Cow:

MOET progeny:

Normal progeny:

More offspring of top cow *after* testing it
Juvenile dairy MOET scheme

Cow:

MOET progeny:

Normal progeny:

More offspring of top cow before testing it
Select base on parent average
Genetic gain versus genetic diversity

• Early selection can only be based on family information

• 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
Genetic Gain vs Inbreeding After 20 Years

Tom Granleese et al., AAABG 2013

![Graph showing genetic merit vs inbreeding coefficient at 20 years. The graph compares genetic merit for different scenarios: AI/N, AI/N + MOET, and AI/N + MOET + JIVET. The x-axis represents the inbreeding coefficient at 20 years, ranging from 0 to 0.4, and the y-axis represents genetic merit (genetic SD) at 20 years, ranging from 0 to 10. Each scenario is represented by a different line color: black for AI/N, red for AI/N + MOET, and green for AI/N + MOET + JIVET.]
Between versus within family selection

Own information (performance or genotype):
More variation within families
More within-family selection – less inbreeding

Advantage of genomic selection
Reprod technol. In a breeding design context

- Genetic improvement
- Measurement
- Sexing, cloning
- Dissemination

Nucleus

Commercial producers

AI, MOET, JIVET

Genetic lag
Effect of Measurement
Some important points about MT selection

1. The ultimate response of a trait will depend on:

   - choice
   - what has been measured
   - genetic parameters

   - its relative economic weighting
   - accuracy of its EBV
   - correlation with other EBVs

   We can control these

   This includes genomic information!
### Selection for milk Yield and Feed Intake

<table>
<thead>
<tr>
<th>economic weights</th>
<th>progeny milk</th>
<th>measured milk</th>
<th>response milk</th>
<th>(4 yrs) feed</th>
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<td>-</td>
<td>1.23</td>
<td>0.56</td>
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To achieve response for a trait, we need to give it some weight but we also need some data!
Decision Support

Where to go?

Who and what to measure?

Who to select and mate?

Tools

BreedObject, Indexes

Not much

EBVs, Indexes, TGRM

Tactical Decisions

vs

Strategic Decisions ➔ Prediction and Simulation models
Maximize the accuracy of selection candidates (offspring)
We have $$ for 15 phenotypes, who?

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<th># GP</th>
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Need to consider

- Added value to a family
- Merit of the family
- Size of the family
- Relatedness to other candidates

Predict future potential gain:

→ Merit versus diversity

<table>
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<th>Pedigree structure</th>
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Evaluating Breeding programs

• Deterministic vs Stochastic Simulation

• Optimization strategies