Total Genetic Resource Management

TGRM
Rules-based approach to Design

- Different methods have been developed for handling different animal breeding issues (eg. selection, inbreeding, crossing).
  - When we try to mix different methods (or mix different rules) we are likely to miss the best overall design.

- Following strict rules leads to missed opportunities. We should:
  - Fine-tune the rules as appropriate
  - Break the rules when appropriate
A genetic evaluation system helps to design breeding programs.

Select on phenotype

Select on EBV

Year of Birth

1992
1993
1994
1995
1996
1997

Phenotype

Year of Birth

1992
1993
1994
1995
1996
1997

BLUP EBV
Animal breeding actions

Selections
Purchases  Matings  Cullings  etc.

Breeding

Experience  Attitudes
Constraints  Costs

A Gap

Breeding Program
Design Rules

EBVs  QTLs  Accuracies
Pedigree  Data  Parameters  Economics  Methods  Markers

Breeding Program
Design Rules
A classic decision system

- Constraints
- Attitudes
- Data, Knowledge and Science
- Scientific tools
- Application
A Dynamic Tactical Decision System

- Attitudes
- Constraints
- Data, Knowledge and Science
- Flexible Scientific tools
- Application

Possible outcomes
Accepted outcome
Key actions for Animal Breeders

- Selection

- Mating

\[ \Sigma = \text{“Mate selection”} \]
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“Total Genetic Resource Management”

Covers …

- Selection
- Crossbreeding
- Costs
- Genetic diversity
- Optimal selection
- Progeny inbreeding
- Connection between herds
- Limits on reproduction
- Marker Assisted Selection
- Use of AI, MOET, IVF
- Corrective mating
- Managing trait distribution
- Funding limits
- Quarantine barriers
- Logistical constraints
- etc
TGRM approach ...

A candidate solution ...

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<td>4 ...</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>mate</td>
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</table>

[... one breed or a mixture of breeds]

Evaluate for (eg.) ...

- Progeny merit
  - EBV, inbreeding, heterosis ...
- Genetic diversity
  - including long-term inbreeding.
- Connection across herds
  - plus dispersal to comm. herds.
- Costs
  - AI and MOET, stock purchase ...
- Logistical factors
  - paddocks, stock movements ...
- Broken constraints
  - fund limits, quarantine barriers ...

Try to find a better solution

Sum to give dollar value of this solution
A mate selection objective function:

\[
\frac{x'G}{2M} + \lambda \frac{x'Ax}{4M^2} + \phi F + \chi C - \text{cost} + \text{practical constraints} + + +
\]

- \(x'G\) is the weighted mean EBV of selected parents.
- \(x\) is a vector of number of matings to be made by each candidate. We need this to be handle to handle mating.
- \(M\) is the total number of matings to be made.
- \(x'Ax/4M^2\) is the weighted mean coancestry of selected parents.
- \(\lambda\) is a weighting factor that is typically negative, to discourage low effective population sizes.
- \(A\) is the numerator relationship matrix.
- \(\phi\) is the weighing on progeny inbreeding (\(F\)).
- \(\chi\) is the weighing on progeny heterosis (\(C\)).
- \(\text{cost}\) is the cost of the mating policy implied by \(x\).
# Vector \( x \): Number of matings

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\[ \sum = \text{Target number of matings} \]

\[ \sum = \text{Target number of matings} \]
Genetic algorithm for mate selection

Female No. (= 'locus')

1  2  3  4  5  6  7  8  9  10

Recombination

Mutation

'Allele' = male allocated for breeding
Possible outcomes
Judgement
Opportunities
Constraints
Attitudes
Issues
Costs

Data construction
TGRM Control Center
Action: A mating list
Genetic evaluation service
TGRM Server
Analysis, monitoring, billing
Breeding operation

Internet driven
Internet driven
Internet driven
Achieving Trait Constraints

All progeny are predicted to be above the restriction of +545Kg

Predicted progeny Milk EBVs
All progeny are predicted to be narrowly distributed about -0.15 degrees

Achieving Trait Constraints

Predicted progeny
Rump Angle EBVs
Achieving Trait Constraints

Targeting two different objectives in one cycle of matings

Predicted progeny Fat EBVs
Imposing constraints
(eg. Sire use, QTL outcome, trait distributions)

Result with some constraints applied.
MAS: Targetting QTL/gene outcomes
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## Use of sires across flocks

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**TOTALS:** 1027 39 196 382 97 333
Examples of Costs that can be accommodated

- **Reproductive costs.**
  - AI, MOET, JIVET
  - find breakeven costs
- **Seedstock purchase costs**
  - rationalise the balance between price and value
- **Seedstock maintainance costs**
  - optimise herd size
- **Limits on funds available**
Examples of other factors that can be controlled.

- **Mating logistics**
  - number and size of mating paddocks
  - “don’t migrate young rams”
  - “put young ewes only to old rams”
- **Opportunities and constraints**
  - “Lets consider using this New Zealand sire”
  - “I want to use all my 50 doses of this ram’s semen”
  - “Use this link sire for at least 25 matings”
  - “Don’t use any one bull for less than 25 matings”
- ** Desired outcomes**
  - narrow variation in birthweight, fat, etc
  - corrective matings
The fate of a stud-born bull ...

Select as a stud breeding sire

Use as a commercial herd bull

- Farm 1
  - Export market

- Farm 2
  - Domestic market

- Farm 3
  - Tick resistance

- Farm 4
  - Crossbred heifers

Cull
The fate of many stud-born bulls ...

Select as stud sires

Use as commercial herd bulls

Farm 1
Export market

Farm 2
Domestic market

Farm 3
Tick resistance

Farm 4
Crossbred heifers

Cull
Breeding program

Profit
The End