Breeding programs for Merino sheep

Andrew Swan

Animal Genetics and Breeding Unit
University of New England

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Outline

1. Breeding objectives
   - Market trends
   - Traits to include in breeding objectives
   - Opportunities to advance breeding objectives

2. Genetic evaluation
   - Bloodline differences
   - Across flock evaluation to estimate breeding values
   - Opportunities to advance genetic evaluation
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Market trends

Significant change in price relativities between wool and meat

<table>
<thead>
<tr>
<th>Year</th>
<th>Wool</th>
<th>Meat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993/94</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>2003/04</td>
<td>54</td>
<td>46</td>
</tr>
</tbody>
</table>

source: ABARE

Andrew Swan
Merino Breed Programs
Drivers of change

- Sheep meat:
  - Growth in export markets
  - New management practices and technologies, including genetic improvement
  - Expansion in production to new areas

- Wool:
  - Reduction in prices in real terms
  - Competition from other fibres
Role of the Merino

- Sheep industry has traditionally been wool focused, based on Merino
- Lamb production was a byproduct
  - Terminal sires × 1st cross dams in high rainfall areas
- More recent trend to dual purpose enterprises
  - Terminal sires × Merino dams
  - 25% of Merino dams mated to terminal sires in 2005
Development of the Merino for future enterprises

Dual purpose

- *Joint* development of specialised lines
- Terminal sire breed selected for meat
- Merino selected for improved wool and reproduction
- Flexible and efficient system for commercial Merino flocks

Specialist wool

- Fine / superfine flocks
- Focus on breeding for wool quality
Impact of drought

- Sheep numbers down from 111m in 2001 to 88m in 2007
- High cost of production

Uncertainty in objectives

- Supply and demand not in equilibrium
- Longer term impacts of climate change on types of enterprise and adaption of animals
Economically important wool traits

- Clean fleece weight
- Mean fibre diameter
- Staple strength
- Wool style
- Garment comfort
Price signals

Source: Wool cheque micron price schedule 2002 - 2004
(www.woolcheque.com.au)
### Wool traits have high heritabilities

<table>
<thead>
<tr>
<th>Trait</th>
<th>$h^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greasy fleece weight</td>
<td>0.37</td>
</tr>
<tr>
<td>Yield</td>
<td>0.56</td>
</tr>
<tr>
<td>Clean fleece weight</td>
<td>0.36</td>
</tr>
<tr>
<td>Mean fibre diameter</td>
<td>0.59</td>
</tr>
<tr>
<td>CV fibre diameter</td>
<td>0.52</td>
</tr>
<tr>
<td>Staple strength</td>
<td>0.31</td>
</tr>
</tbody>
</table>

From Safari et al 2005, LPS 92:271
Economically unfavourable genetic correlations

Fleece weight and fibre diameter $\approx +0.3$

Emphasis on fibre diameter depends on attitude to risk
Economically unfavourable genetic correlations

- Staple strength and fibre diameter $\approx +0.3$
- Include staple strength in objective
- Costly to measure strength directly
  - Use CV fibre diameter as a selection criterion
  - $r_g(SS, CV) \approx -0.5$
Improvement of fleece value is readily achievable

- Base selections on an index
- Use *micron premiums* to determine emphasis
  - 3% = Maximise fleece weight, maintain diameter
  - 7% = Moderate gains in both traits
  - 14% = Maximise response in diameter, maintain fleece weight

*Micron premium* = % change in price for a one micron improvement in diameter
Breeding directions for meat traits

- **Slaughter lambs:**
  - Higher growth rates
  - Leaner, better muscled carcasses

- **Breeding ewes:**
  - Appropriate mature size?
  - Leaner or fatter?

**Solutions**

- Index selection on appropriately defined objective
- Efficiency of dual purpose enterprises
Genetic parameters for meat traits

Heritabilities

- Body weight ranges from 0.15 (birth) to 0.4 (adult)
- Fat and eye muscle depth 0.2 to 0.3

Yearling trait relationships

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Muscle</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle</td>
<td>0.30</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>0.10</td>
<td>0.50</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Increasing importance of reproduction

150% lambing!
Genetic parameters for reproduction

- Reproduction traits have low heritabilities ($\leq 0.10$)
- Large phenotypic variance, so long term response can be good
- But sex limited and expressed after initial selection age

<table>
<thead>
<tr>
<th>Trait</th>
<th>nlw</th>
<th>sc</th>
<th>wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lambs weaned</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrotal circumference</td>
<td>0.30</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Body weight</td>
<td>0.35</td>
<td>0.35</td>
<td>0.40</td>
</tr>
</tbody>
</table>
Prospects for increased progress in reproduction

- Genetic gain limited by lack of direct recording:
  - Body weight used as a proxy
  - Male fertility not widely exploited

Include female reproduction as a selection criterion

- New data collection standards for genetic evaluation
- Efficient data capture using electronic ear tags
Selection for production traits versus fitness?

- Example
  - High fleece weight sheep may have limited fat reserves to divert to reproduction when resources are scarce (Adams et al 2006)

- Other fitness traits
  - Longevity, lambing ease, disease resistance

Ensure both production and fitness traits are included in the breeding objective, measure them, and select in target environment.
Selection indexes for Merinos

- Object and SheepObject software systems
  - Model flow of Merino genes into multiple enterprises
  - Wool, meat, dual purpose
  - Allow development of customised indexes

- Standard indexes available through MERINOSELECT
  - Dual Purpose, Merino, Fine wool enterprises
  - Micron premiums from 3.5 to 20%
  - + staple strength, + worm egg count
Index examples

<table>
<thead>
<tr>
<th>Index Option 1</th>
<th>Index Option 2</th>
<th>Index Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Purpose 7%</td>
<td>Fine 10%+SS+WEC</td>
<td>Merino 14%+SS</td>
</tr>
</tbody>
</table>

10-year responses to selection in each trait:

- **Fleece weight - CFW (%):**
  - Index Option 1: 2.9
  - Index Option 2: 3.0
  - Index Option 3: 0.1

- **Fibre diameter - FD (µm):**
  - Index Option 1: 8.6
  - Index Option 2: 0.6
  - Index Option 3: -1.2

- **Body weight - WT (kg):**
  - Index Option 1: 4.9
  - Index Option 2: 1.2
  - Index Option 3: 2.0

- **Staple strength - SS (N/ktx):**
  - Index Option 1: 0.2
  - Index Option 2: 1.6
  - Index Option 3: 2.1

- **Reproduction rate - NLW (%):**
  - Index Option 1: 2.5
  - Index Option 2: 0.2
  - Index Option 3: 0.4

- **Worm egg count - WEC (%):**
  - Index Option 1: -2.8
  - Index Option 2: 20.0
  - Index Option 3: 1.1

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Opportunities to advance breeding objectives

For research and application

- **Dual purpose objectives**
  - Balance between weight/carcass and mature size/body composition

- **More direct recording of objective traits**
  - Reproduction and other fitness traits

- **CRC Information Nucleus Flock**
  - Development of new meat and wool traits
  - EBV’s for industry sires on hard to measure traits
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Bloodline differences

- The Merino is a very diverse breed
- Fine, medium, and strong wool strains of different genetic origin, developed in different environments
- Bloodlines within strains vary considerably in fleece weight, fibre diameter and body weight
Bloodline comparisons

- Head to head comparisons made in wether trials
- A tool for commercial Merino producers to compare ram sources
- Combined analysis at http://www.merinobloodlines.com.au
Bloodline differences for CFW and MFD

source: NSW DPI Primefact 700
Bloodline differences are related to profitability

Figure 3a. Bloodline deviations for Gross Margin per DSE relative to Fibre Diameter

<table>
<thead>
<tr>
<th>High GM</th>
<th>Low FD</th>
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<tbody>
<tr>
<td>75</td>
<td>125</td>
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<tr>
<td>136</td>
<td>52</td>
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<td>14</td>
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<td>5</td>
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source: NSW DPI Primefact 700
### Choosing a ram source using wether trial results

#### Steps for commercial Merino producers

1. Decide on the breeding objective
2. Benchmark performance of current ram source against alternatives
3. Consider all traits
4. Review breeding programs of ram sources
5. Constraints (price, availability, location)
Across flock evaluation to estimate breeding values

MERINOSELECT since 2005
Development of across flock evaluation in Merinos

- Wether trials
- Central Test Sire Evaluation (CTSE)
- Within flock evaluations using on-farm data
- Merging of on-farm data into across flock evaluations in late 1990’s
  - MerinoBenchmark and MGS
- Merging of across flock evaluations to form MERINOSELECT in 2005
- Sheep CRC Information Nucleus Flock in 2007
Credibility is the key to adoption

1. Strong breeder involvement
   - Success only possible through partnership between breeders, service providers and researchers

2. Data quality
   - CTSE requirements, MERINOSELECT QA system

3. Reporting standards
   - ASBV’s and FBV’s defined by linkage and accuracy

4. Breeding values predict progeny performance reliably
   - Good genetic evaluation model
Developing the MERINOSELECT evaluation model

- Wide range in performance due to bloodline and environmental differences
- Genotype × environment interaction
- Limited pedigree recording
Wide range in performance

Issue 1:
- Expression of EBV’s depends on mean level of production

Solution:
- Analyse data on a percentage (or equivalent) scale

Example

Sire A has an EBV of +10% for fleece weight

<table>
<thead>
<tr>
<th>Flock</th>
<th>Mean (kg)</th>
<th>EBV (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>2.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Y</td>
<td>4.2</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Wide range in performance

Issue 2:

- Can’t treat all animals in the breed as a single "population"

Solution:

- Use a genetic groups model to define an "anchor point" for each flock / bloodline
Without genetic groups

Animals are inappropriately regressed to the overall population mean.
With genetic groups

Animals are regressed to their genetic group (bloodline) mean.
Genotype $\times$ environment interaction

Issue:
- Sires’ progeny may not perform as expected in different flocks or across years

Solution:
- Adjust for sire $\times$ flock-year effects in the model
- Breeding values reflect average performance across environments

OK if genetic correlation between environments is $> 0.8$
Limited pedigree recording

Issue:

- Genetic trends underestimated in flocks with limited pedigree

Most evaluation models treat animals with unknown pedigree as base animals, so their EBV’s are regressed to the base

Solution:

- Define time period genetic groups in flocks with limited pedigree
- Use multi-sire mating model where syndicates are known
Limited pedigree recording

Other issues:

- Differential recording of pedigree between tiers within flocks, assortative mating
- Reproductive traits and dam pedigree recorded together
- Accuracy of breeding values

Collecting better pedigree information

- DNA pedigree $\rightarrow > $10 / head
- Pedigree by association using RFID $\rightarrow < $5 / head
Pedigree by association

Richards et al (2007) AAABG
Getting MERINOSELECT results

- Analyses updated monthly
- MERINOSELECT web site
  - Trait leading sires readily accessibly
  - Follow "Search" link, then "ASBV Enquiries" link
- Merino Superior Sires web site
  - http://mss.csiro.au
  - Easy to explore ASBV’s
  - Limited to CTSE sires
Opportunities to advance genetic evaluation

Sheep CRC Information Nucleus Flock

- Progeny testing 100 high genetic merit industry sires annually
  - Comprehensive phenotyping to provide direct EBV’s on hard to measure traits

- New traits for meat and wool
  - Eating quality and health benefits in meat
  - Wool quality traits related to garment comfort

- A resource for genetic improvement and breeding objective development
Opportunities to advance genetic evaluation

More intensive recording programs to increase progress
- Increased pedigree recording
- Reproduction and other fitness related traits
- Focus on elite nucleus?