BREEDING STRATEGIES TO MEET THE SPECIFICATIONS OF FINE WOOL MARKETS

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SUMMARY
Fine wool Merino breeding objectives that include crimp frequency (cf) and staple length (sl) are examined with the view that they reflect current and possible future divergent markets. The three alternative objectives examined have common aims of increased clean fleece weight (cfw), decreased mean fibre diameter (mfd) and maintained staple strength (ss): goals regarded to be a standard (base breeding objective) with which to make comparisons. The first objective aims to maintain cf at a high level. It is demonstrated that this can be achieved only with selection on cf and at the expense of cfw, indicating that producers of such wools require a considerable price premium for that wool type to remain competitive. The second breeding objective aims to increase sl and decrease cf. This can be readily achieved as a result of favourable correlations among cf, sl and cfw. A third objective aims to maintain cf at a high level and also increase sl. This objective is feasible, but can only be justified at a high price premium for cf (+22%).

Keywords: Merino, selection, breeding objective, staple length, crimp frequency

INTRODUCTION
The fine and superfine sector of the Australian wool industry exhibits an increasing range of wool types that are directed toward various market segments. Among other qualities, these wools display a range of crimp frequency (cf) and staple length (sl) characteristics. Growers of some of these wools are being increasingly challenged by market discounts for ‘overlength’ wool as a result of increasing uptake of genetic improvement programs. Performance breeders who include an increase in clean fleece weight (cfw) in their breeding objective and objectively measure this trait are experiencing sl increases as a direct result of the positive correlation between cfw and sl. Producers who have adopted breeding strategies such as SRS™ and ‘Elite’ wool (Watts 1998), also produce wools that have lower cf and longer sl compared to ‘traditional’ fine and superfine wools.

Although there are no firm statistical data, anecdotal evidence indicates that at present, the majority of wool buyers are prepared to pay higher prices for high cf types (Curtis and Stanton 2002), and producers of such wools are of the opinion that they do receive price premiums for those wools. Similarly, evidence provided by Swan et al. (2000) shows clear discounts for superfine wools once the sl exceeds approximately 85mm. This situation is further confused by processing studies showing that different crimp types appear to have specific advantages and disadvantages at different stages of processing and this will probably ensure the continued development of a range of fine wool types into the future (Haigh and Robinson 2002; Smith 2003).
This study examines breeding objectives that reflect different attitudes to cf. Selection scenarios are set up to evaluate the consequences for economically important traits under different breeding objectives that focus on cf and sl. The relationship between cf and the price received is unknown, so a desired gains approach is applied to examine the consequences of breeding strategies that include cf.

**METHOD**

**Breeding objectives.** The base objective used for comparison aims to increase cfw, decrease mfd and maintain ss. The three alternative breeding objectives modelled in this study have varying emphasis on cf and sl (see below). The selection criteria applied to the different objectives include hogget (h) and adult (a) cfw (kg), mfd (µm), cf (cr/cm), sl (mm) and coefficient of variation of fibre diameter (cvd, %) (as an indicator of staple strength (ss, N/ktex)). Greasy fleece weight (gfw, kg) is a monitored trait.

1. **Maintain high crimp** – increase cfw, decrease mfd, maintain ss and maintain (high) cf
2. **Low crimp, long staple length** – increase cfw and sl, decrease mfd and cf, and maintain ss
3. **High crimp, long staple length** – increase cfw and sl, decrease mfd, maintain ss and (high) cf

**Parameter estimates.** Table 1 shows the heritability and phenotypic variance of traits used in this prediction study. These, along with the phenotypic and genetic correlations were obtained by consolidation of parameter estimation studies of the CSIRO Fine Wool Project (FWP) flock (e.g. Purvis and Swan 1997; Smith et al. 2001; Swan, A.A. unpublished data). Phenotypic and genetic correlations between hsl and hcf and the other traits are shown in Table 1. Correlations among asl and acf and other traits are comparable with those for the hogget traits and correlations among all other traits were similar to those reported elsewhere (see above).

<table>
<thead>
<tr>
<th></th>
<th>hgfw</th>
<th>agfw</th>
<th>hcfw</th>
<th>acfw</th>
<th>hmf</th>
<th>amf</th>
<th>hcvd</th>
<th>acvd</th>
<th>hss</th>
<th>ass</th>
<th>hsl</th>
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<th>hcf</th>
<th>acf</th>
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<tbody>
<tr>
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<td>0.09</td>
<td>0.19</td>
<td>0.06</td>
<td>0.12</td>
<td>1.11</td>
<td>1.32</td>
<td>4.89</td>
<td>3.77</td>
<td>85.64</td>
<td>78.09</td>
<td>70.04</td>
<td>64.79</td>
<td>0.44</td>
<td>0.56</td>
</tr>
<tr>
<td>h^2</td>
<td>0.44</td>
<td>0.43</td>
<td>0.42</td>
<td>0.40</td>
<td>0.65</td>
<td>0.67</td>
<td>0.45</td>
<td>0.46</td>
<td>0.35</td>
<td>0.33</td>
<td>0.53</td>
<td>0.34</td>
<td>0.34</td>
<td>0.40</td>
</tr>
<tr>
<td>r_p hsl</td>
<td>0.29</td>
<td>0.14</td>
<td>0.39</td>
<td>0.25</td>
<td>0.15</td>
<td>0.15</td>
<td>0.04</td>
<td>0.11</td>
<td>-0.06</td>
<td>-0.04</td>
<td>0.01</td>
<td>1.00</td>
<td>0.60</td>
<td>-0.27</td>
</tr>
<tr>
<td>r_e hsl</td>
<td>0.27</td>
<td>0.17</td>
<td>0.42</td>
<td>0.33</td>
<td>0.10</td>
<td>0.01</td>
<td>0.05</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
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<td>-0.10</td>
<td>-0.05</td>
<td>-0.16</td>
<td>-0.08</td>
<td>0.10</td>
<td>0.05</td>
<td>0.03</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>-0.27</td>
<td>-0.14</td>
<td>1.00</td>
<td>0.60</td>
</tr>
<tr>
<td>r_e hcf</td>
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<td>-0.09</td>
<td>-0.29</td>
<td>-0.15</td>
<td>0.09</td>
<td>0.05</td>
<td>0.01</td>
<td>0.00</td>
<td>-0.14</td>
<td>-0.07</td>
<td>-0.39</td>
<td>-0.20</td>
<td>1.00</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Standard errors for phenotypic correlations <0.02 and for genetic correlations from 0.06 – 0.10.

**Relative economic values.** Relative economic values (REVs) for cfw, mfd and ss were calculated from a profit equation based on long term average production data from the CSIRO FWP flock, and wool prices derived from Australian wool auction data as described by Swan et al. (2000). Although the economic
value for sl in that study was curvilinear, the REV for sl assumed here is equivalent to a linear price premium (+2%).

Price premiums for mfd and ss were +20% and +4% respectively and were the same for all breeding objectives. In addition, for objective 1 (maintain high cf) the price premium for cf was based on previous investigations by Smith et al. (2002) and was set at +17%. For objective 2 (low cf, long sl), the price premium for cf was nominally set at -10% and, as mentioned above, for sl was +2%. For objective 3 (high cf, long sl), the price premium for sl was again set at +2% and the REV required to maintain cf was equivalent to a cf price premium of +22%.

**Predicted response to selection.** Response to selection was predicted using the information described above and the software program SELIND (Cunningham and Mahon 1974).

**RESULTS**
The predicted response to selection in the base breeding objective and in the three alternatives where cf and sl are included as additional selection criteria, are compared in Table 2.

**Table 2. Predicted response in economically important fleece traits for three breeding objectives and for different sets of selection criteria.**

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>Predicted response per 10 years of selection</th>
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<tbody>
<tr>
<td></td>
<td>cfw</td>
</tr>
<tr>
<td>Base breeding objective: increase cfw, decrease mfd, maintain ss</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>1. Maintain high cf + increase cfw, decrease mfd, maintain ss</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>2. Low cf, long sl + increase cfw, decrease mfd, maintain ss</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>38.84</td>
</tr>
<tr>
<td>3. High cf, long sl + increase cfw, decrease mfd, maintain ss</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>33.34</td>
</tr>
</tbody>
</table>

The base objective does not explicitly include cf and sl in the breeding strategy, but correlated responses in those traits are predicted and presented in Table 2. Predicted changes in cf and sl in the base objective
closely reflect those of all three alternative objectives when cf and sl are not included as selection criteria in those alternatives (details not reported).

For objective 1 (maintain high cf), cf was restricted to zero change, and although the predicted responses in ss and mfd are similar to the base objective, this is only achieved with predicted loss in hogget and adult cfw of 20g and 80g respectively over 10 years of selection.

Under breeding objective 2 and where cf is a selection criterion, the rate of response in cf is predicted to be approximately 0.5cr/cm over 10 years: an approximate four-fold increase over the response in the base objective. The addition of sl as a selection criterion increases sl by approximately 10mm over the same period. These changes in cf and sl are accompanied by a relatively small decrease in the rate of change in mfd and an increase in cfw.

In objective 3, no change in cf was achieved with only limited adverse effects on gains in the other traits compared to the base objective. With the addition of sl to the selection criteria, cf can be maintained in adults at essentially no change, with a modest increase in the rate of gain in sl, and to a lesser degree cfw and with little impact on the rate of reduction in mfd.

**DISCUSSION**

Under the assumption of 20% micron premium, it is not possible to meet all the goals of breeding objective 1. Cf can only be maintained with a slight loss in cfw. This indicates that producers of high crimp wool types require a price per kg clean for their wool that balances the loss in fleece weight to remain competitive in terms of returns per hectare from wool. Based on the wool price data used in this prediction exercise, the +17% cf price premium required to maintain cf, and therefore compensate for the cost of producing such wool is equivalent to approximately 360c/kg clean for hogget wool and 265c/kg clean for adult wool. The loss in cfw is small, and if producers can attract the price premium above, it is more than sufficient to compensate for the loss of income arising from lower fleece weight. Preliminary evidence provided by Curtis and Stanton (2002) indicates that high cf (high mean fibre curvature) wools currently attract premiums that compensate for any loss in cfw as a result of production of high cf wools. It has been shown previously by Smith et al. (2002) that cf can be held constant while increasing cfw under a lower (8%) micron premium index and the cf REV required to do that is equivalent to a +12% price premium for cf.

According to the predicted responses from objective 2, low cf, long sl wools are readily achievable in addition to current industry objectives. This is possible because cf is inversely correlated with both sl and cfw, and the correlation between cf and mfd is negligible in fine wool sheep (Smith et al. 2001).

Objective 3 is arguably the most important strategy for the future of the fine wool industry. Many fine wool growers will continue to produce high cf types while ever they are competitive in the market.
However, they may come under pressure to grow that wool type with a longer sl. This study demonstrates that objective 3 is achievable with little compromise to other economically important traits.

In conclusion, without making direct comparisons of economic gains, this study demonstrates that acceptable trait gains can be made under all three breeding objectives. However, it also illustrates that the rewards need to be significant in order to meet breeding objectives where antagonistic relationships between the traits are involved.

REFERENCES