

**STRATEGIES TO REDUCE THE AVERAGE FIBRE DIAMETER
OF THE AUSTRALIAN WOOL CLIP**

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SUMMARY

The case for a reduction in fibre diameter of Australian Merino wool is briefly summarised. Such a reduction could be achieved through a combination of bloodline substitution and selection within ram breeding flocks. Information sources from recent and current research are highlighted for each strategy. It is concluded that the necessary technology is largely available for achieving significant reductions in fibre diameter but that decision-aid tools and skilled advisers are required to make it happen.

INTRODUCTION

Surveys of consumer requirements for apparel products have highlighted the need for garments that are light in weight, soft-handling so that they can be worn next to the skin and casual in style and appearance. These requirements are supported by IWS surveys of European weavers demonstrating the rapid changes in fabric weights that have occurred over the past 10 years. For example, the IWS Munster Survey of German weavers shows a decline in the fabric weights of trousers from 300 to 230 g/m², suits and jackets from about 300 to almost 200 g/m² and skirts from 240 to 200 g/m² since 1983. With a standard outerwear weave, a 300 g/m² fabric could be achieved with wool averaging 22.5 µm while a 200 g/m² cloth of equivalent weave requires wool averaging 20 µm.

The average diameter of the Australian Merino wool clip is currently 22-22.5 µm. This average diameter and the diameter profile has shown little substantive change over the past 20 years, and probably for a much longer period. However, the stimulus from consumers for wool producers to alter diameter has been supported by price differentials in the market place that make an industry-wide reduction in diameter not only good sense for the long term future of the apparel wool industry but very attractive in improving the short term profitability of wool production enterprises. For example, the price margin between 20 and 22.5 µm wool in the late 1970's was only 9% but had risen to 34% in the second half of the 1980's and remains at 36% for the period since the reserve price scheme was abandoned.

Against this background, we need to highlight and promote the available strategies for reducing fibre diameter in commercial flocks. Sustainable reductions in fibre diameter are most likely to arise from genetic change. Nutritional manipulation of diameter will be short term and accompanied by severe, unfavourable changes in fleece weight. The time frame over which change will occur is an important consideration since genetic change is permanent but generally slow. The major genetic pathways to reducing fibre diameter are through bloodline (or ram source) substitution and/or by selection within ram breeding flocks.

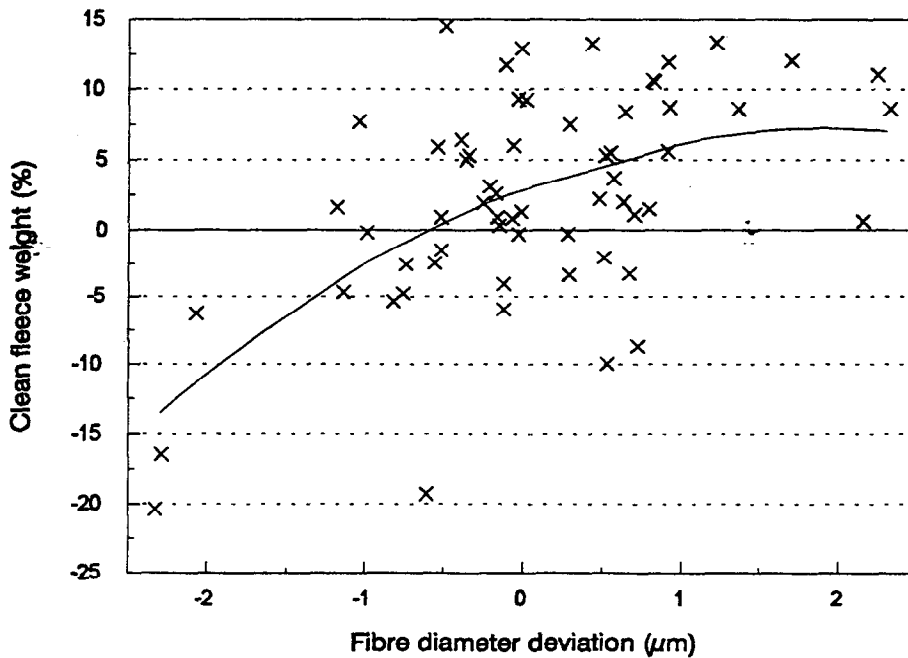
DIAMETER REDUCTION BY BLOODLINE SUBSTITUTION

Variation between bloodlines

Analyses of wether trials by Atkins et al (1992,1995) have provided the commercial Merino sector with reasonably precise estimates of differences between bloodlines (Fig 1). While such data are best used to identify alternative ram source options for an individual flock, some general issues for the whole industry can be identified.

Firstly, the fitted relationship between fleece weight and fibre diameter across bloodlines is significantly curved (Fig 1). Thus, on average, moderate reductions in diameter for medium to strong wool bloodlines will not lead to a substantial change in genetic potential for wool production. Secondly, at the fine end of the distribution of bloodlines, reduction in diameter is generally associated with significant reduction in fleece weight. Although the net result of bloodline substitution might still be favourable in economic terms, a sustainable long term premium will be required to support such an option. Thirdly, the distribution of bloodlines in the fine-medium range of diameters (say -2 to -1 μm in Fig 1) is very sparse, indicating the lack of options available for producers wishing to access such rams.

Figure 1. Distribution of bloodlines from wether trial analysis (from Atkins et al 1995)



The impact of any change to finer diameter bloodlines on other aspects of wool quality is relatively small. The wether trial analyses indicate that reduction in diameter will generally lead to an improvement in assessed style, reduced staple length (of small economic value in the current wool market) and little predictable impact on wool colour or wool tenderness. However, any individual producer contemplating a change in bloodline source would need to consider the likely impact of a particular change on such quality traits.

Predicability of grading-up

If an alternative bloodline source is identified by a commercial producer, there are some alternative strategies for utilising the new bloodline. For example;

#1 The cautious producer may require more information and so a simple on-farm wether comparison may be run by purchasing wethers of the new bloodline and running them with wethers from the current flock. Provided an even-up shearing is used and at least 50 wethers from both sources are available, such a private comparison may be valuable.

#2 Repeated ram purchases from the new source can be used to 'grade-up' the breeding ewe flock to the new bloodline. Using typical values for flock structure and ram replacement, about 50% of the genetic value of a new stud source would be captured in 5 years, 80% in 10 years and about 95% in 15 years.

#3 Ewes and rams of the new source may be purchased so that a 100% upgrade to the new source would be achieved almost immediately.

#4 A less expensive combination of #2 and #3 may be to purchase rams to upgrade the breeding flock but purchase wethers of the new source to partially or totally upgrade the wether flock.

The most likely strategy would be the repeat ram purchases from the new source (#2 above). Mortimer et al (1994) have examined the predicability of this process given good starting estimates of the current bloodline production level (benchmark performance) and the likely production of the alternative bloodline. Data from a large strain and bloodline crossing experiment conducted at Trangie since 1984 have been used to study this question. They showed that for fibre diameter, and all other aspects of wool quality, the performance of first cross and backcross progeny were fully predicted by an additive model of the effects of the parental bloodlines. Thus, each stage of the grading-up process can be predicted by knowing the relative performance of the two bloodlines and the proportion of genes contributed by the two sources. For the production traits (fleece weights and body weights), some non-additive effects will tend to marginally increase the performance of the intermediate (or crossbred) genotypes. The level of between-animal variability for both wool quality and production was apparently unaltered from the variability levels in the purebred bloodlines. However, the flock itself will be more variable during the grading-up process since different age groups will contain different average proportions of genes from each source.

Performance in extreme environments

One of the limitations of wether comparisons has been the relatively narrow sample of bloodlines within each comparison. So, little information has been available on fine wool genotypes in typical broad wool production environments. The recent expansion of the CSIRO fine wool project to include fine wool genotypes in central west NSW and Western Australia will provide more credible information on such extremes (Swan et al 1993). The impact of such environments is being assessed not only on sheep production and quality traits but also through direct observation of the processing capabilities of such wools. A further challenge for industry is to try and capture production information on such extreme comparisons that have been (or will be) derived from private comparisons run by individual producers.

DIAMETER REDUCTION IN RAM BREEDING FLOCKS

If bloodlines covering the full spectrum of fibre diameter were available and the consequences on production of diameter change were modest, it could be sensibly argued that the industry should selectively use available bloodlines to allow the wool fibre of desired quality to be produced without altering ram breeding practices. However, we have already seen that there are sparse areas of the diameter distribution, particularly fine-medium genotypes, and that the costs in fleece weight of reducing diameter using fine wool genotypes can be large. What, then, should be the implications for the Merino ram breeding sector? For example, is it more efficient to select for higher production within the desirable fine wool genotypes or to select for improved quality (particularly reduced diameter) within medium and broad wools in the hope of maintaining or losing little of the current productivity of these genotypes? The answer will depend on the production / quality relationships within and between genotypes and the time horizon for change. Coelli and Atkins (1995) examine part of this question and conclude that within-flock selection among medium wools to reduce fibre diameter should be an effective strategy. Further, market signals indicate a demand for wool finer than that currently produced in significant quantities, so that diameter reduction in fine wool genotypes should also continue.

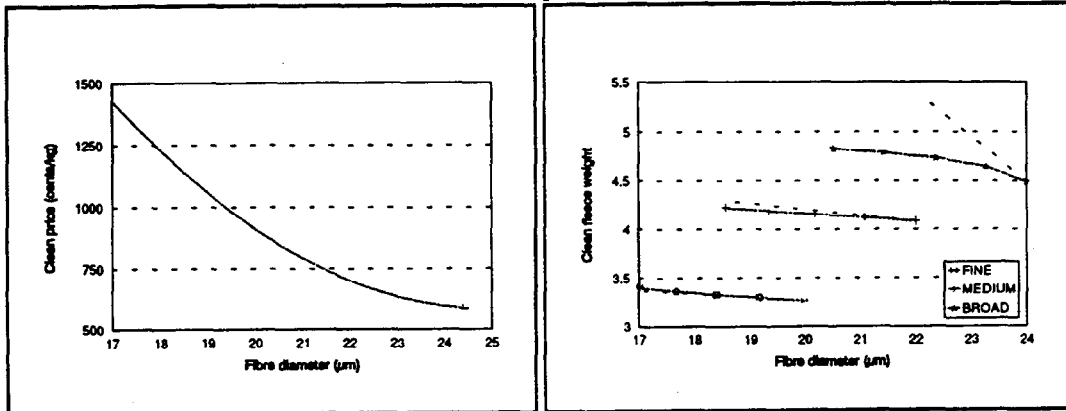
Utilising within-flock variation

We can assist ram breeders to maximise genetic gain by aiding in the development of appropriate breeding objectives, ensuring that genetic parameters used in prediction and evaluation are relevant, and promoting the use of the most accurate selection techniques. Since ram breeders will be selecting from different starting points of average fibre diameter, the possibility that different breeding programs are required for different diameter ranges warrants attention.

The relationship between price and diameter is curvilinear such that the premiums for finer wool have increased at a faster rate than those for medium wools. An analysis of wool prices (adjusted to a common base) over the period 1975-94 (Fig 2a) shows the extent of this curvilinearity. The degree of curvature is even more dramatic in the second half of this time period. A selection index seeks to maximise genetic response in economic profitability using relative economic values assessed at the current level of production. That is, the economic value of a trait is estimated as the partial derivative of the profit function with respect to the trait in question, while all other traits are set at their current average levels (Ponzoni 1986). Where the price / production relationship is curved, these economic values will change as genetic response is achieved. Dekkers et al (1994) showed how responses over a time period may be optimised given a curvilinear price relationship. Applying these same methods to Merino strains with starting values of 20 μm (fine), 22 μm (medium) and 24 μm (broad) and the price function fitted in Fig 2a, the optimum selection indexes resulted in responses shown in Fig 2b. Also shown in Fig 2b, as dashed lines, are the expected 20 year responses to selection based on relative economic values using the partial derivative approach estimated at year zero.

It can be seen that given the price signals over the period 1975-94, selection strategies based principally on reduced fibre diameter are appropriate for all strains (Fig 2b). The optimised and partial derivative procedures only differed substantially in the broad wool strain where premiums for slightly finer wool were very low. The optimised objective, though, was to position the flock in a fibre diameter range that was more responsive to price as distinct from the marginal case which placed most emphasis on increasing fleece weight.

Figure 2a Fitted relationship between price and fibre diameter for the period 1975-94. **Figure 2b** Predicted responses to selection over 20 years using the optimum(—) and base period(- - -) index.



The potential responses achievable over 20 years can also be determined from Fig 2b. Selection differentials equivalent to about 3% and 60% for males and females selected respectively, with selection emphasis on production traits of 60% and 50% on males and females respectively, and a generation interval of 3.5 years were assumed in the calculations for all strains. Such values should be achievable by most breeding programs. Given these assumptions, predicted changes in fibre diameter over 20 years were about 3 µm in fine wools and slightly more in the broader strains. Achieving such responses across the whole spectrum of Australian Merino wool, even with the lags involved in capturing this gain by commercial clients of studs, would allow apparel wool fabrics to compete more effectively in a light weight garment climate.

The responses predicted in Fig 2b assume that the genetic parameters for fleece weight and fibre diameter are similar in all strains. Recent evidence of Swan and Piper (1993) and Coelli and Atkins (1995) suggest that parameters may differ in fine wools, particularly the genetic correlation between fleece weight and fibre diameter. It is not clear whether such differences are specific to bloodlines or specific to a diameter range. Further information on such parameters is required together with evidence and demonstration from realised selection responses, as will be obtained from the recently established Trangie Joint Selection lines (Atkins and Taylor 1993).

Further adoption of genetic technologies that aid selection will allow the predicted response rates to be more easily attained and/or to increase the potential rates of response. For example, a greater adoption of selection index methods in evaluation and selection will result in an increase in achieved selection differentials. At least some of the wastage in selection emphasis is due to both an inappropriate breeding objective and independent culling on several traits (A.E. Casey, unpublished data). Selection among females and across age group selection among sires were highlighted by Atkins and Casey (1994) as areas of current inefficiency in Merino stud breeding programs. A move towards BLUP analysis procedures would be of significant value in improving selection among adults even where sire pedigrees only are maintained.

Utilising across-flock variation

The development of central test sire evaluation (Roberts et al 1991) has increased the opportunity for utilising between flock genetic variation within ram breeding flocks providing some certainty of likely outcome. Published estimates for the genetic value of individual sires (Casey et al 1995) can allow ram breeders to identify rams of merit and then purchase semen for use. The process becomes more valuable where a link has been established between the flock and central test, either by one or more home-bred rams being submitted to central test or by semen purchase from a ram already evaluated in central test.

For the situation of a stud flock wishing to reduce fibre diameter by using outside sires, a difficulty currently exists because medium-wool and fine-wool central test sites are not formally linked. This issue needs to be redressed urgently to allow medium to broad wool ram breeders to identify individual rams that may be of value to their genetic improvement program. It is not just a matter of using link rams but also devising an appropriate analysis procedure to overcome the wide genetic differences that exist between medium and fine wool bloodlines.

CHOOSING THE APPROPRIATE STRATEGY

In the preceding sections it has been shown that the necessary technology is largely available to achieve significant reductions in fibre diameter by both bloodline substitution in commercial flocks and within-flock selection in current ram breeding sources. Achieving industry change, though, relies on individual commercial producers making appropriate decisions supported by a ram breeding sector that offers both variability and directed change.

The opportunities for commercial wool growers to produce fine wool vary depending on the objective of the producer.

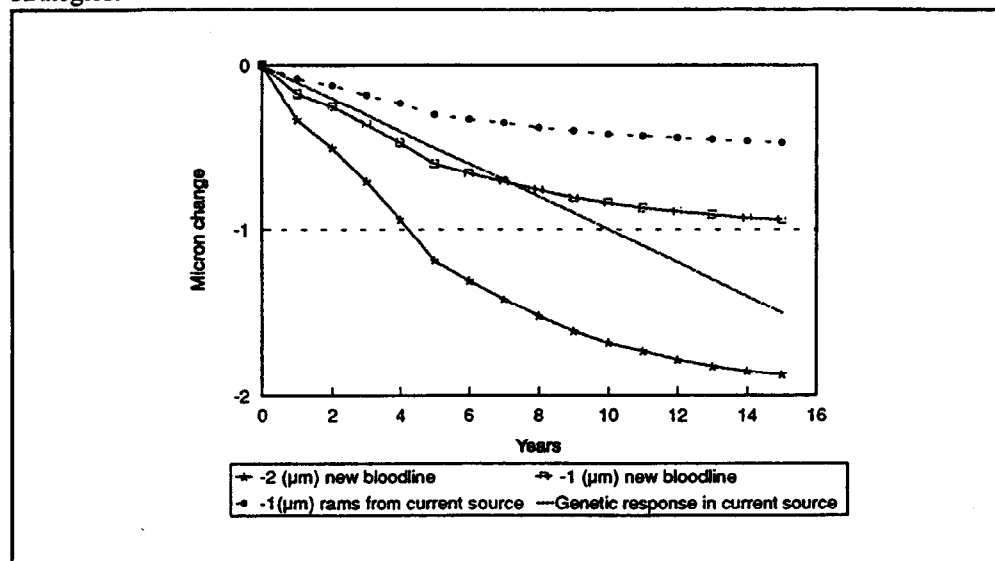
Fine tuning. If the objective was to make a small downward change, selection of finer rams from the current ram source may achieve the objective. Fig 3 shows the impact over 15 years of consistently selecting rams that are 1 μm finer (on phenotype) than average, leading to a 0.5 μm reduction in fibre diameter. Retaining this effect relies on continuing to select finer rams.

Significant change. If a change of at least 1 μm is required, then it must be in conjunction with some change at the ram breeding level. Substituting a bloodline with a diameter of 1 μm less than the current bloodline source will take 15 years to achieve most of the diameter reduction (Fig 3). Alternatively, if the current bloodline is itself reducing diameter by, say, 1 μm in 10 years, the overall economic outcome may be enhanced by staying with the current source and achieving long-term benefit than by changing source to achieve short-term benefit (Fig 3). Note that it is necessary for commercial producers to evaluate the likelihood that the current source will achieve its objective for diameter reduction. Reliable and credible information on predicted and achieved genetic trends in ram breeding flocks will be required to assist this evaluative process.

Substantial change. On the other hand, an objective to reduce diameter by 2 μm will always favour a bloodline change even if the current source was reducing diameter by 1 μm over 10 years (Fig 3). Further complexity arises by considering other strategies for grading-up (see earlier) and the implications of genetic change in diameter on other traits of commercial importance.

The essential issue is that the appropriate strategy is not a global one and can often be a complex decision. What is clearly required is a decision aid to allow the economic implications of alternative strategies to be calculated over a given time horizon, and skilled advisers to allow such an aid to be wisely used. These same skilled advisers are required to promote and adapt the optimum strategy for an individual to the production circumstances.

Figure 3 Expected response in fibre diameter of commercial flock for alternative breeding strategies.



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