20. Breeding Practices in the Merino Industry

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Learning objectives

On completion of this topic you should understand:

- The structure of the commercial and ram breeding sectors of the industry
- The traits which influence production and how to include them in a breeding objective
- Merino genetic evaluation and breeding systems

Key terms and concepts

Commercial production sector, ram breeding sector, closed nucleus breeding scheme, open nucleus breeding scheme, breeding objective, selection index, micron premium, heritability, genetic correlation, genetic evaluation system, breeding program.

Introduction to the topic

In this topic we explore genetic improvement programs in the Merino industry. We start by looking at breeding trends in the commercial production sector, which are strongly related to market signals for the two main sheep products, wool and meat. We also briefly touch on the structure of the ram breeding sector which is the driver of genetic change for the industry. The traits which influence profit in commercial enterprises can be combined to develop breeding objectives, mainly for ram breeders but also for commercial breeders. These breeding objectives and the genetic variability of the individual traits involved are discussed at length. Evaluating both ram sources and individual animals for the objective and component traits is a key step in making selection decisions, and we will also discuss the development of across flock genetic evaluation systems for Merinos. Finally, we will look at an experiment currently under way which aims to provide objective information on alternative breeding systems used by Merino breeders.

20.1 The commercial and ram breeding sectors

Commercial production sector

The sheep industry in Australia has been traditionally dominated by the Merino which comprises around 85% of the national flock. The reason for this is that income from wool has historically dominated income from meat. However, since the early 2000's to the time that these notes were written (2005), meat prices have been high relative to wool. The response by many commercial producers has been to move away from their traditional wool focus, placing more emphasis on dual purpose enterprises. The immediate consequence of this trend has been that an increasing number of Merino ewes have been mated to terminal sires of other breeds to produce higher value lambs. In the longer term, there are two main issues for dual purpose commercial breeders:

- The need to implement crossing programs which enable breeders to maintain a sustainable Merino flock
- The need to improve maternal and easy care characteristics in their ewes.

Although wool production and prices have been in decline over the same periods, there will be an ongoing place for specialised wool producers. However, producers in this sector will increasingly find themselves under pressure to improve the quality of their product. That is, they will need to produce fine wool, with high staple strength, and free of faults and contamination.

Table 20.1 shows a comparison of the profitability of sheep enterprises, from Rogan (2003). When judged on 5 year average prices (1998 to 2003), wool enterprises where generally more profitable than lamb enterprises. With more recent prices (July 2003), profitability was generally higher than the 5 year average, with improved meat prices having an impact on all enterprises. Significantly, fine wool enterprises were still the most profitable.

Table 20.1 A comparison of the profitability of sheep enterprises. Source: Rogan, (2003).

Enterprise	Gross Margin ($/DSE) 5 year average prices	Gross Margin ($/DSE) July 2003 prices
Merino wethers (17 μ)	27.50	41
Merino wethers (19 μ)	22	19
Merino wethers (21 μ)	12	21
Merino ewes (17 μ)	31	48
Merino ewes (19 μ)	28	34
Merino ewes (21 μ)	22	36
First cross lambs	17	38
Second cross lambs	13	36

Future relativities of meat and wool prices will clearly have an important bearing on the structure of the Merino industry. The only thing certain in the long term is that these relativities will change. Commercial producers need to be able to either plan well to manage their enterprises so that they are less sensitive to market fluctuations, or be able to respond quickly to changing circumstances. Given that the breeding and production cycles in sheep are long, it is likely to be producers in the former category that will be successful in the long term.

Genetic progress in commercial flocks is driven mainly by genetic gain on the male side. Consequently, the most important breeding decisions made by commercial producers are ram purchases. The key questions to be considered when purchasing rams are:

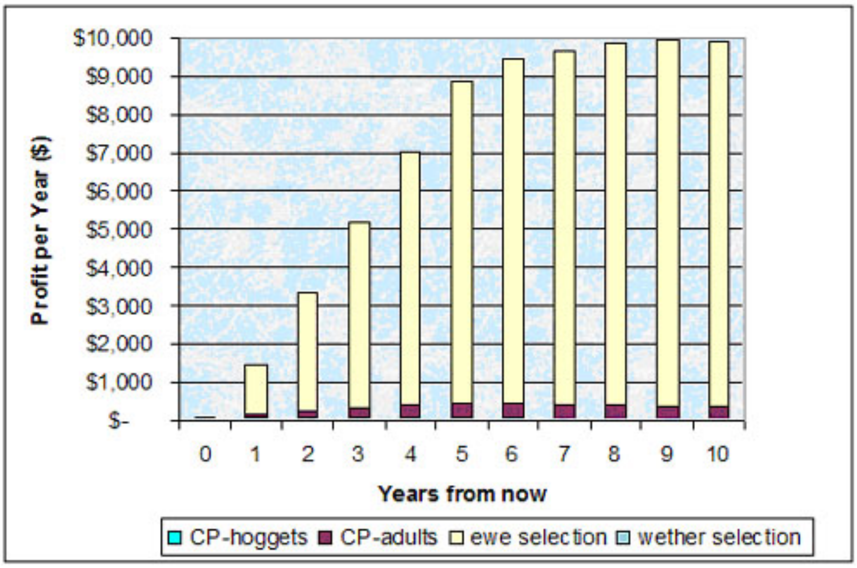
- *Which ram breeder should I buy my rams from?* Bloodline comparisons originating from wether trials are commonly used for this purpose (these are discussed later). However, knowing how a particular bloodline performs relative to others is only part of the equation: the commercial producer also needs to know that the ram source has a compatible breeding objective, and can demonstrate genetic progress towards that objective.
- *Which rams should I buy from the ram breeder?* In theory, provided the ram source is making genetic progress, it should be sufficient to buy rams without performance figures with the expectation of purchasing "average" rams. Over time, the average will improve due to genetic progress. In practice however, performance figures are available on individual rams (this is also discussed later), and it makes sense to use these when buying rams.

The importance of ram purchases in driving genetic gain in commercial flocks has meant that extension programs focussed on adoption of genetic technologies have targeted ram buyers. The idea behind this strategy is to create consumer demand for genetic information from ram buyers.

In the past, little attention has been given to ewe selection in commercial flocks. Given that most of the genetic gain comes from the ram side, most producers have been content to select replacement ewes on visual traits. This situation is changing as cheap and reliable measurement technologies are being developed for use on-farm. These include electronic scales for weighing animals, often combined with automatic drafting systems, on-farm fibre diameter measurement (OFFM) instruments, and electronic eartags. These technologies can be used for "Individual Animal Management", which involves managing animals as individuals according to their performance. Importantly, a single measurement can be used more than once, thus spreading the cost across multiple decisions. An example of this is recording fibre diameter on ewes at hogget shearing. The measurements can be used to select the ewes for breeding, and to prepare and market the wool clip within defined micron ranges. Because fibre diameter is a highly repeatable trait, these hogget measurements can be used again in later years, provided individuals are identified.

The following chart (Figure 20.1) shows the additional annual profit which can be obtained by using fibre diameter measurements for clip preparation (CP) and selection in a 2000 ewe breeding flock, starting at 20 microns, and cutting on average 5.6 kg of greasy wool. The figures are based on a market period between 1998 and 2003. The benefits are substantial, and dominated by the cumulative effects of ewe selection.

Figure 20.1 The additional annual profit obtained by using fibre diameter measurements for clip preparation (CP) and selection in a 2000 ewe breeding flock, starting at 20 microns, and cutting on average 5.6 kg of greasy wool Source: Atkins and Semple, (2005).



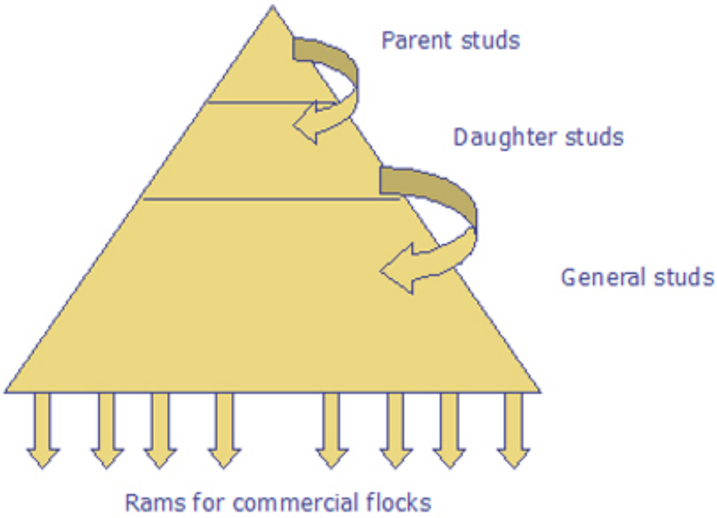
The use of measurements for mate allocation in dual purpose enterprises has been investigated by Richards and Atkins (2004). These authors developed a method they refer to as "simultaneous assortment", using measurements of body weight and fibre diameter to identify groups of animals with higher body weight for meat production, and lower diameter for wool production.

To summarise this section, most of the genetic progress in commercial flocks is driven by the selection which takes place in ram breeding flocks. Choosing the ram source and the individual rams to purchase are therefore key decisions for the commercial producer. Increasingly however, commercial producers will collect more comprehensive information on individual animals, and this information can be used in selection and culling decisions.

Ram breeding sector

The traditional structure of the ram breeding sector was a closed nucleus with three tiers of ram breeding flocks, as depicted in Figure 20.2 below. In the top tier were a small number of parent studs, who supplied rams to the next level of daughter studs, who in turn supplied rams to general studs. The two lower levels were effectively ram multipliers supplying rams for commercial flocks. In addition, the studs in these lower tiers purchased rams only from their parent stud. The same buyer loyalty was evident amongst commercial flocks. An important feature of this structure was that genetic material did not move from lower tiers to higher tiers. This meant that all genetic change was driven by the parent studs.

Figure 20.2 Traditional closed nucleus structure of the ram breeding sector. Source: Swan, (2006).



In the 1970's this structure began to break down. Ram buyers at all levels became more mobile, seeking rams from non-traditional sources. The most important driver of this trend has been the availability of objective information on the profitability of ram sources from wether trials, and individual rams from across flock evaluation. In addition, the use of artificial insemination (AI) has enabled the widespread use of superior genes across the industry. This has led to a much flatter structure in the ram breeding sector and few if any of the original parent studs can still claim that status.

Rams are also more likely to be bred outside the traditional stud sector. For example, many large scale commercial flocks have realised that they can reduce ram purchasing costs by having a small ram breeding nucleus of their own, often acting as multipliers and making extensive use of AI.

A further development was the adoption of open nucleus breeding schemes, stimulated by theory developed by scientists such as John James (James, 1977). The theory shows that genetic gain will increase if genes flow not only from the nucleus downwards, but from the lower tiers upwards. The limitation of open nucleus schemes is that they require all participants to share a common breeding objective. So although there are quite successful small scale open nucleus schemes, large scale programs with a national focus such as the Australian Merino Society have not continued successfully.

20.2 Breeding objectives and traits for improvement

Setting a breeding objective is a critical first step in establishing a breeding program in any livestock industry. The process involves determining the emphasis to place on the traits which affect profitability in *commercial* enterprises. This is a key point: the most important breeding decisions are made in studs and other ram breeding flocks, but these decisions must be consistent with improving commercial profitability in a sustainable fashion.

Breeding objectives can be formally specified by constructing a profit equation for the commercial target flock, written in terms of the traits which influence variable costs and returns. These profit equations are essentially gross margin analyses, similar to those presented in Table 20.1 above and discussed in Topic 13. The relative economic value of individual traits is then calculated as the effect on the profit associated with a single unit change in that trait. These economic values determine the emphasis to be placed on individual traits in the breeding objective. By combining relative economic values with information on genetic relationships between the traits in the breeding objective and selection traits, selection indexes can be constructed. It is important to also consider biological relationships in this process, in an approach referred to as bio-economic modelling.

Selection indexes are widely used to rank animals in the Merino industry. However, the bio-economic approach described above is not the only way to develop an index. It is also possible to set a breeding objective in terms of the trait changes required over a certain time period, under a pre-determined flock structure in the breeding unit, and then work backwards to derive an appropriate index. This will be referred to as the *targeted approach* to setting breeding objectives and was called the 'desired gain approach' in Topic 14 .

While many Merino breeders use indexes in their breeding programs, there are many who employ different breeding philosophies. Despite these differences, breeding objectives within sectors of the industry are often similar in broad terms. For example, for ram breeders targeting specialist wool production, it is clear that cutting more wool of higher value is a sensible goal.

The economically important traits for Merino breeding include:

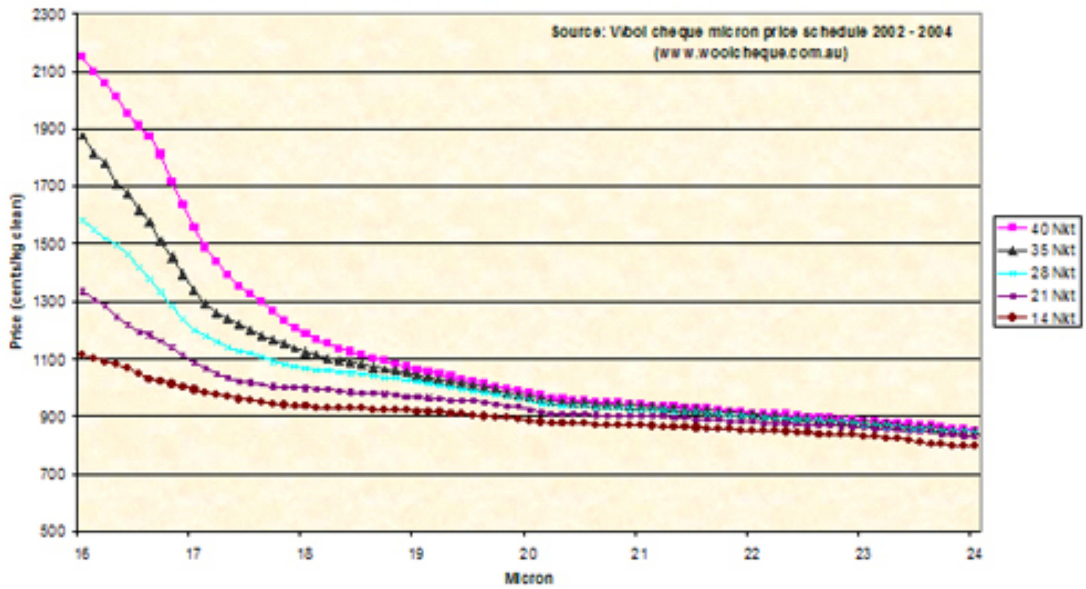
- Wool production (fleece weight)
- Wool quality (including fibre diameter, staple strength, and style)
- Growth and carcase traits
- Reproduction
- Disease resistance (to internal parasites, fleece rot and fly strike)
- Easy care and welfare related traits
- Feed efficiency

These are discussed in the following sections.

Wool traits

Including fleece weight in the breeding objective is relatively straightforward: put simply, cutting more clean wool per hectare increases profitability. The introduction of wool quality traits however, increases complexity, in part because of antagonistic relationships between traits. The emphasis to place on individual wool quality traits is determined by their effect on wool price. Figure 20.3 shows that fibre diameter is an important determinant of price, with price increasing as fibre diameter is reduced. The effects are most dramatic below 18 microns in this selling period.

Figure 20.3 The relationship between fibre diameter and price at different staple strengths between 2002/03 and 2004/05. Source: AWEX, (2004).



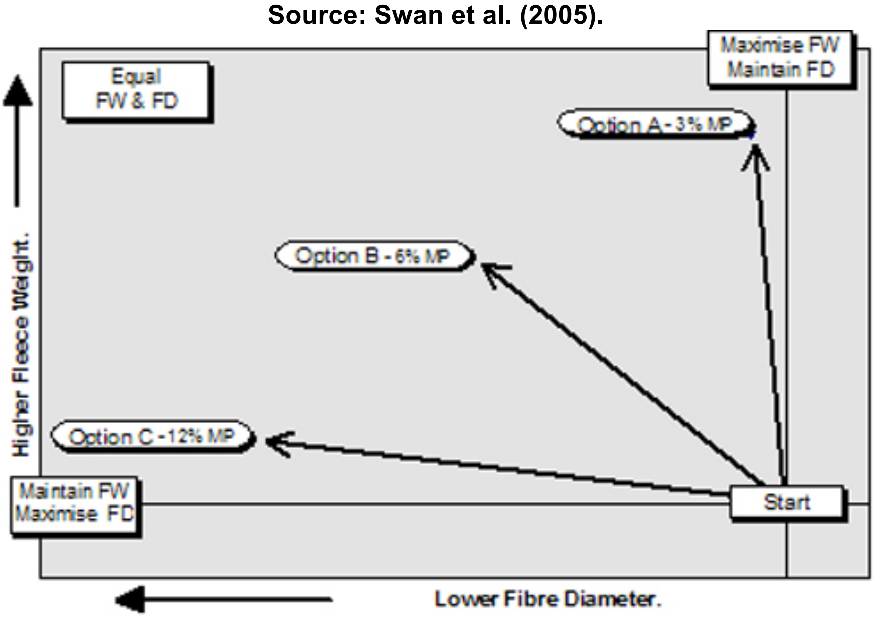
Although wool prices have fluctuated dramatically over a long period of time, there have always been premiums for finer wool. Consequently, reducing fibre diameter has been a key component of Merino breeding objectives.

From Figure 20.3, it is apparent that the two key traits which lend themselves to improved profitability are fibre diameter and staple strength. It is also apparent that their relative importance changes between wool clips. For example, staple strength had a larger effect on price in 16 to 18.5 micron clips in these selling seasons. This introduces an important concept: the effect of wool quality traits on price is often *non-linear.* So for example, a one micron reduction in fibre diameter results in a bigger increase in price at 17 microns than it does at 22 microns.

Wool quality traits can be included in breeding objectives using a price premium approach, and this is most commonly used for fibre diameter. Merino breeding objectives are almost universally described in terms of their assumed *micron premium*. The micron premium is the percentage change in price associated with a one micron reduction in fibre diameter. For example, if wool price increases from 1000 cents per kg to 1100 with a one micron reduction in fibre diameter, this would equate to a 10% micron premium.

The range of micron premiums used by breeders is effectively determined by the genetic relationship between fleece weight and fibre diameter. Although this relationship is antagonistic, the correlation is not strong (around 0.3), so there is still a range of micron premiums which can be used to simultaneously improve both traits. This is depicted in the Figure 20.4.

Figure 20.4 The genetic relationship between fleece weight and fibre diameter. Source: Swan et al. (2005).



In practice, most breeders use micron premiums between 3 and 20% in their objectives, despite the fact that micron premiums can be higher than this. This is particularly true for fine wool growers. So in effect, many breeders use the targeted approach when setting their objectives with respect to these traits.

Most of the economically important wool traits are moderately to highly heritable, as shown in the Table 20.2. This means that they can readily be changed through selection.

Table 20.2 Heritability of wool traits. Source: Safari et al. (2005).

Trait	Heritability
Greasy fleece weight	0.37
Yield	0.56
Clean fleece weight	0.36
Mean fibre diameter	0.59
CV of fibre diameter	0.52
Staple strength	0.34
Staple length	0.46

As we have already seen, the genetic relationships between wool traits also have a major bearing on the genetic progress which can be made. Information on genetic parameters for sheep can be found in the review paper of Safari et al. (2005), and on an interactive web site (www.gparm.csiro.au). Important genetic correlations include (with estimates from the Safari et al. (2005) review):

- Greasy and clean fleece weight (favourable: 0.86): this high correlation means that greasy fleece weight can be used as an effective selection criterion to improve the objective trait of clean fleece weight, which is more expensive to measure.
- Fleece weight and fibre diameter (antagonistic: 0.28 to 0.36): discussed above.
- Fibre diameter and staple strength (antagonistic: 0.37): the implication of this correlation is that breeding objectives with a strong focus on reducing fibre diameter will lead to reduced staple strength if the trait is not considered in the objective.
- CV of fibre diameter and staple strength (favourable: -0.52): strength is much more expensive to measure than CV, and because of this strong relationship, CV is often used as a selection criteria for strength.

The consequences of ignoring staple strength are shown in the Table 20.3, which contains predicted responses after 10 years of selection, using genetic parameters from CSIRO's Fine Wool Project flock (Swan et al. 2000). The responses showed a marked reduction in staple strength.

Table 20.3 The consequences of ignoring staple strength. Source: Swan et al. (2000).

Micron premium	CFW (Kg)	MFD (micron)	SS (N/Ktex)	BWT (Kg)
3%	0.3	-1.4	**-7**	3
15%	0.1	-3.6	**-9**	1
30%	0.0	-3.9	**-8**	1

Swan et al. (2000) showed that this problem can be addressed by including a price premium for staple strength in the breeding objective, and using CV of fibre diameter as a selection criterion for strength. However, the response in fibre diameter was not as great. The responses after 10 years are shown in Table 20.4.

Table 20.4 Responses to selection when a price premium for staple strength is included in the breeding objective. Source: Swan et al. (2000).

Micron premium	Strength premium	CFW (Kg)	MFD (micron)	SS (N/Ktex)
3%	*1%*	0.3	-0.6	**-1**
15%	*3%*	0.0	-2.9	**0**
30%	*5%*	-0.1	-3.3	**0**

To summarise this section, the important traits in wool breeding objectives are clean fleece weight, mean fibre diameter, and staple strength. The two latter traits are quality traits, because their impact is on the price per unit of wool. Quality traits can be accommodated through a price premium approach, and Merino breeding objectives are frequently described by their percentage micron premium.

Growth and carcase traits

While Merino breeding objectives have traditionally focussed on wool traits, as discussed above there is considerable interest developing in growth and carcase traits. The Merino has an important impact in the meat sheep industry, contributing the majority of the genes in the lamb and mutton sold to consumers. The main role of the Merino is as a maternal breed, and as demonstrated by Fogarty et al. (2002), the genes of the dam make an important contribution to profitability in meat enterprises.

Body weights have been measured widely in ram breeding flocks for some years. In flocks which record both sire and dam effects, it is possible to partition the breeding value into direct and maternal components. The maternal component is mostly related to the milking ability of the dam, and is more important at the weaning and post-weaning ages. The influence of maternal effects declines with age. Safari et al. (2005) summarised estimates of heritability of body weight at weaning, post weaning, and adult ages in Merinos, with averages across studies of 0.23, 0.33 and 0.41 respectively.

Carcase traits are also increasingly being measured in Merinos, and the traits which influence carcase value and meat quality are shown in the Table 20.5, along with heritability estimates summarised by Safari et al. (2005):

Table 20.5 Heritabilities for meat and carcase traits.
Source: Adapted from Fogarty, (2004) and Safari et al. (2005).

Trait	Heritability
Live measurements:	
Fat depth	0.26
Eye muscle depth	0.24
Carcase measurements:	
Fat depth	0.32
Eye muscle depth	0.30
Eye muscle area	0.41
Lean meat yield	0.35
Meat pH	0.18
Meat colour	0.16

The traits are moderately heritable, and importantly, fat depth and eye muscle depth can be measured on live animals using ultrasound scanning.

Reproduction

Increased reproduction rates are a key driver of profitability, more so in meat and dual purpose sheep enterprises than they are in specialist wool enterprises. In many wool enterprises where the environment and management of stocking rate limit feed resources, many producers would support the notion that there is an intermediate optimum for reproduction. While this may be a valid argument, it is also true that many sheep producers need to increase reproductive efficiency, either through genetic or management means. For example, in wool enterprises using OFFM for selection of replacements, the benefits are considerably higher for flocks with higher reproduction rates because higher selection intensities can be applied.

The reproduction traits commonly defined in sheep are:

- Fertility: ewes lambing per ewe joined
- Litter size: lambs born per ewe lambing
- Lamb survival: lambs weaned per lamb born
- Number of lambs weaned: lambs weaned per ewe joined.

Number of lambs weaned is the trait commonly included in the breeding objective, and it is easy to see that it is derived from the other three traits:

$$\frac{\text{Number of lambs weaned}}{\text{Ewe joined}} = \frac{\cancel{\text{Ewes lambing}}}{\text{Ewe joined}} \times \frac{\cancel{\text{Lambs born}}}{\cancel{\text{Ewe lambing}}} \times \frac{\text{Number of lambs weaned}}{\cancel{\text{Lamb born}}}$$

These traits have low heritabilities but have high phenotypic variation. Although the rate of genetic progress will be slow (due to low heritability), it is still possible to make substantial improvements (due to the large variation). Heritabilities and coefficients of variation from the CSIRO Fine Wool Project flock are shown in Table 20.6.

Table 20.6 Heritabilities and coefficients of variation for reproduction traits in Merinos. Source: Swan et al. (2001).

Trait	Heritability	CV (%)	Genetic correlation with body weight
Lambs weaned	0.04	71	0.35
Fertility	0.07	47	0.12
Litter size	0.08	25	0.37
Survival	0.02	45	0.16

Also shown in the last column of Table 20.6 are positive correlations between reproduction traits and body weight. Similar correlations have been observed in a range of other studies, as seen in the reviews of Safari et al. (2005) and Fogarty (2004). The genetic relationships between wool traits and reproduction are generally close to zero (see Safari et al. 2005), but this is one area of the literature on genetic parameters where the information is limited.

A number of reproduction genes of large effect have been identified in sheep populations internationally. However, in many cases, they of limited use to Australian Merino breeders, because the effects are too extreme (eg the FecB "Booroola" gene) or have unusual patterns of inheritance (eg the FecI "Inverdale" gene). Nevertheless, given the low heritability of reproduction traits, identification of reproduction genes is an area worthy of investigation.

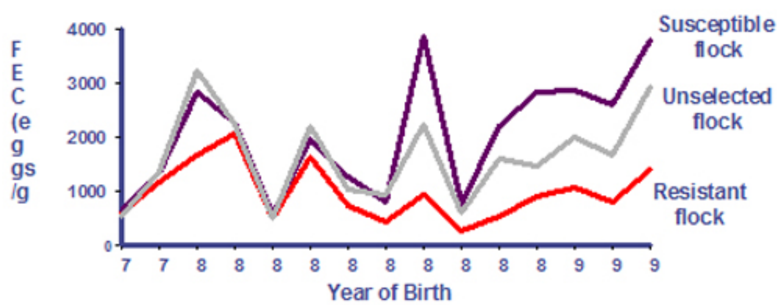
Disease resistance

The major diseases of sheep are internal parasites (gastrointestinal roundworms), fleece rot and flystrike, footrot, and Johne's disease. While these diseases cause serious economic losses, they are difficult to include in breeding objectives for several reasons:

- Selection for resistance by traditional breeding methods requires exposure to the disease. This is not acceptable to ram breeders, particularly for fly strike, footrot and Johne's disease (internal parasites are a slightly different case because the great majority of sheep flocks show some level of infection which can be measured). For this reason, it is regularly argued that genetic markers for disease traits would be highly valuable.
- It is generally not possible to quantify production losses on the other traits in the objective. For example, there is commonly no effect of internal parasites on fleece weight, particularly when drenching programs are in place. The approach used successfully for internal parasites in Merinos is to incorporate the trait using the methodology of "desired gains" (Brascamp, 1984). This involves setting the percentage emphasis to place on the disease trait relative to the other breeding objective traits, as shown by Woolaston (1994). For example, a breeder may decide to place 50% selection emphasis on disease resistance within a 6% micron premium breeding objective.

The trait used to measure internal parasite resistance is faecal egg count (FEC), measured in eggs per gram. FEC is moderately heritable, with Safari et al. (2005) reporting a value of 0.27 averaged across 16 studies. Several long term selection lines have been established in Australian Merinos, including the Rylington Park flock run by the WA Department of Agriculture (Greeff et al. 1995), and CSIRO's Haemonchus selection lines (Piper, 1987). These flocks have achieved impressive selection responses, as shown by the following trends from the CSIRO flock (Figure 20.5).

Figure 20.5 Changes in FEC in susceptible, unselected and resistant CSIRO flocks. Source: Swan, (2006).



The genetic correlations between FEC and wool and growth traits are generally held to be close to zero (Safari et al. 2005). Under these circumstances inclusion of the trait in wool breeding objectives is not problematic: the relative response of FEC to production traits is determined by the emphasis in the desired gains objective as described above. An alternative view for which there is some support is that the correlations between FEC and wool traits are slightly antagonistic (Eady 1998). If this is the case, it becomes even more important to design the breeding objective appropriately.

There are indications (Karlsson et al. 2003) that in some cases scouring and dags are associated with parasite resistance – particularly hypersensitivity scouring in winter rainfall environments. The current recommendation is that breeding for parasite resistance in winter rainfall regions should include selection on both FEC and dag score because those traits are both indicators of parasite resistance, but are not closely correlated.

The genetics of fly strike (body strike) and its precursor fleece rot have also been extensively studied in Merinos. While there is a large variation in heritability estimates for these traits, they are generally held to be low to moderately heritable (Raadsma et al., 1997). Importantly, fleece rot and fly strike have a high genetic correlation, and it is possible to apply indirect selection on fly strike by selecting on fleece rot as an indicator trait. In order to demonstrate this, a long term selection line was established by NSW Department of Primary Industries at Trangie NSW. The flock included lines selected for and against increased resistance (resistant and susceptible lines respectively). After 14 years of selection, the resistant line showed 27% lower incidence of natural fleece rot, and 5% lower incidence of natural body strike in comparison to the susceptible line (Mortimer et al. 1998). Correlated responses for production traits were unfavourable for fleece weight, favourable for fibre diameter, and showed little change for body weight. Li et al. (1999) investigated fleece rot in the CSIRO Fine Wool Project flock, finding that the trait was unfavourably correlated to both fleece weight and fibre diameter. However, a relatively strong correlation between greasy wool colour and fleece rot in this flock (0.47) demonstrates that colour may have some value as a selection criterion as suggested by Cottle (1996).

Easy care and welfare related traits

There is growing interest in genetic improvement of easy care and animal welfare related traits in Merinos. The main driver of this is consumer demand that animal products be obtained from humanely managed enterprises which minimise stress on animals. In addition, with reduction in the amount of labour available to many enterprises, easy care and easy to handle sheep are highly desirable. There may also be associated improvements in productivity and product quality.

One promising area is the improvement of temperament and maternal behaviour. Murphy et al. (1994) showed that measures of temperament based on the *Isolation Box Test* were repeatable at different ages, and were also related to maternal rearing ability. Selection on these traits should lead to correlated responses in lamb survival, and therefore number of lambs weaned. In addition, improved temperament has also been shown to be genetically correlated with tenderness in cattle (Burrow 1997). Because of these relationships, it may be useful and relatively easy to include temperament in the breeding objective as a selection criterion for reproduction and carcase traits.

Another very important area relates to the sheep industry's commitment to phase out the mulesing operation by 2010. Mulesing has been an important practice in the control of fly strike at the breech (around the tail of the sheep). One of the solutions identified to aid in the phase out is to breed sheep which are less susceptible to breech strike by selecting for indicator traits such as breech wrinkle and bare area around the breech. There is currently very little information available on the heritability of these traits and their relationships with production traits. Research programs are currently being developed to address this important need.

Feed costs, intake and efficiency

Feed is a major cost in sheep enterprises in Australia: Lee et al. (2002) quote unpublished data which estimates that the annual feed cost of a breeding ewe unit represents up to 80% of the value of wool produced. Feed intake and efficiency are difficult traits to include in breeding objectives, because they are very expensive to measure. As a consequence there are very few estimates of genetic parameters.

The approach commonly used to account for feed costs in the objective is to include relationships between body weight and reproductive status with feed intake in the bio-economic model (e.g. Australian Agricultural Council: Ruminant Subcommittee, 1990), and to assume there are no genetic differences between animals in feed intake and efficiency. These relationships show increased feed consumption with higher body weights, and for ewes rearing more lambs. As a consequence, higher growth and reproduction must be offset in the model by either adjusting stocking rate to the same feed requirements, or by purchasing additional feed.

This can be extended by including feed intake (or efficiency) directly in the breeding objective. This requires knowledge of the heritability of feed intake and its correlations with other traits in the objective. Ponzoni (1986) developed a profit equation using this approach, making a number of assumptions about the genetic parameters in the process. Even so, Ponzoni (1986) observed that selection indexes were sensitive to changes in the cost of feed.

Lee et al. (2002) summarise genetic parameters for feed intake and efficiency in Australian Merinos, and these are shown in Table 20.7. It should be noted that the precision of these parameters is low.

Table 20.7 Genetic parameters for feed intake and efficiency in Australian Merinos (heritabilities shown in bold on the diagonal, genetic correlations below the diagonal). Source: Lee et al. (2002).

	Intake	Intake /live wt	Live weight	Wool growth	Wool growth efficiency	Fibre diameter
Intake	**0.12**					
Intake/live wt	*NA*	**0.10**				
Body weight	0.57	-0.29	**0.36**			
Wool growth	-0.02	-0.23	0.24	**0.37**		
Wool growth efficiency	-0.63	-0.63	0.02	0.84	**0.25**	
Fibre diameter	0.40	0.31	0.20	0.18	-0.03	**0.66**

The implications of these estimates are:

- There was genetic variation in feed intake, but with the techniques used to estimate intake of pasture using controlled release capsules the heritabilities were low.
- Selecting for increased body weight will lead to increased intake, but intake per unit live weight will decrease.
- Selection to increase wool growth should not have a great impact on intake, but would lead to increased wool growth efficiency.
- Selection to reduce fibre diameter will lead to reduced intake.

The genetics of feed intake and efficiency is an area where our knowledge is lacking in sheep. One problem area seems to be that heritabilities have been based on estimates of intake from controlled release capsules in grazing animals. This is in contrast with studies in beef cattle where intake is measured directly in feedlot conditions: heritability estimates are typically higher under these conditions (Arthur et al. 2004). If the same methods to estimate intake were used in sheep, it should be possible to obtain more reliable estimates of correlations with production traits. These correlations are critical to inclusion of feed intake in breeding objectives, since the trait will never be directly measured as a selection criterion. While it might be argued that intake measured under feedlot conditions is not the same as pasture intake, there a growing number of sheep in feedlots throughout Australia.

Another area of interest which has not been investigated in detail in sheep is the relationship between Insulin-like Growth Factor 1 (IGF1) and feed efficiency. In cattle and pigs low IGF1 levels are genetically associated with high feed efficiency (Bunter et al. 2005). This means that IGF1, which is relatively inexpensive to measure, can be used as a selection criterion for feed efficiency in these species.

Visual traits

Subjectively assessed traits have traditionally been very important to Merino breeders. While many breeders have adopted scientific breeding principles based on selecting for the traits which drive profit, they still place some level of emphasis on visual traits. This level of emphasis varies depending on the breeder.

The traits involved can be grouped as conformation, wool quality, and pigmentation traits. The conformation traits include face cover, body and neck development (wrinkle), feet and leg conformation, jaw conformation, and back and shoulder conformation. The wool quality traits include style, colour, crimp definition, staple weathering and fleece rot resistance. Pigmentation covers both wool and skin. These traits are regularly measured in the central test sire evaluation system, and detailed information on sire performance for visual traits can be viewed in individual site reports which can be downloaded from the Merino Superior Sires web site (http://mss.csiro.au).

In terms of economic importance, wool quality traits are the easiest to include in the breeding objective, because price premiums are observed in the wool market. Therefore traits such as style and colour can be included in the objective by assigning a price premium. Swan et al. (2000) demonstrated that style does not deteriorate even when the breeding objective does not include the trait, because it is either favourably or neutrally correlated with other wool traits. In addition, by including style directly in the objective, these authors showed that that simultaneous improvement of fleece weight, fibre diameter, staple strength and style is possible.

However, most breeders include visual traits in their breeding programs as independent culling levels, typically selecting on visual traits before selecting on an index. This reduces progress towards the breeding objective, depending on how much emphasis is placed on the visual traits. A useful measure of the impact of visual traits in this context is *selection emphasis* (Atkins, 1997), which is the proportion of the available selection differential which has been realised in the selected animals. Across a range of studs investigated by Atkins (1997), the average selection emphasis was only 55% in males and 44% in females.

Breeding objectives software

Several software packages have been developed to aid in establishing breeding objectives in Merinos. These packages derive selection indexes for a given objective.

The first and most widely used is *Object*, developed by NSW DPI in the early 1990's (Atkins et al. 1994). *Object* calculates economic values based on the structure of the commercial sheep enterprise, production values for the traits considered, and future market scenarios. The software uses the micron premium concept discussed above to allow breeders to set an objective with a price – fibre diameter relationship appropriate to their situation, or else to use the targeted approach to define what changes in fleece weight and fibre diameter are desirable over the life of the breeding program. This capacity to allow breeders to develop customised breeding objectives with a sound economic basis is one of the strengths of *Object*.

SelectGene is a breeding objectives software package developed by CSIRO Livestock Industries, as part of the Fine Wool Project research program. It is similar in philosophy to *Object*, using a price premium approach for wool quality traits. Due to its origins, *SelectGene* targeted fine wool enterprises. *SelectGene* is no longer being developed and support is limited.

At the time of writing, a new software package named *Sheep Object* was under development by the Animal Genetics and Breeding Unit at the University of New England. This package will have the ability to develop objectives for a range of sheep enterprises, including non-Merino breeds.

Selection indexes commonly used

By 1998, there were around 50 ram breeding flocks that had used *Object* to set customised objectives, representing around 14% of ram sales nationally (Ponzoni et al. 1998). At that time, the average micron premium used was 6.1%, with a range of 2% to 15%.

Object has also been used to derive a range of industry standard objectives and associated selection indexes which are also widely used. These include:

- "Standard" 3%, 6%, 12% and 20% micron premium objectives.
- The standard micron premiums with extra emphasis on staple strength (+2 N/ktex improvement over 10 years).
- The standard micron premiums with extra emphasis on body weight (+2 Kg over 10 years).
- The standard micron premiums with 50% emphasis on parasite resistance (FEC)

Note that the staple strength, body weight and parasite resistance objectives are based on desired gains methodology.

A range of selection indexes have also been available through one of the industry's across flock genetic evaluation services, Merino Genetic Services. These are:

- Merino 8% micron premium
- Merino 8% micron premium dual purpose
- Merino 8% micron premium plus FEC
- Merino 15% micron premium

It is likely that there will soon be a rationalisation of the objectives / indexes used as "industry standards".

20.3 Genetic evaluation systems

Genetic evaluation in Merinos has developed in a unique way, due in no small part to the large number of studs and other ram breeding flocks in the industry, and the large differences in performance which are observed between these flocks. This has created an opportunity for breeders at all levels to capture the benefits of across flock selection through genetic benchmarking. In addition, the absence of full pedigree information in many situations has meant that sire progeny testing has been an important tool for genetic improvement. Genetic evaluation in the Merino industry has undergone major changes since the early 1990's, and is on the verge of a new breakthrough with the development of Sheep Genetics Australia (SGA). This and other genetic evaluation systems are discussed in this section.

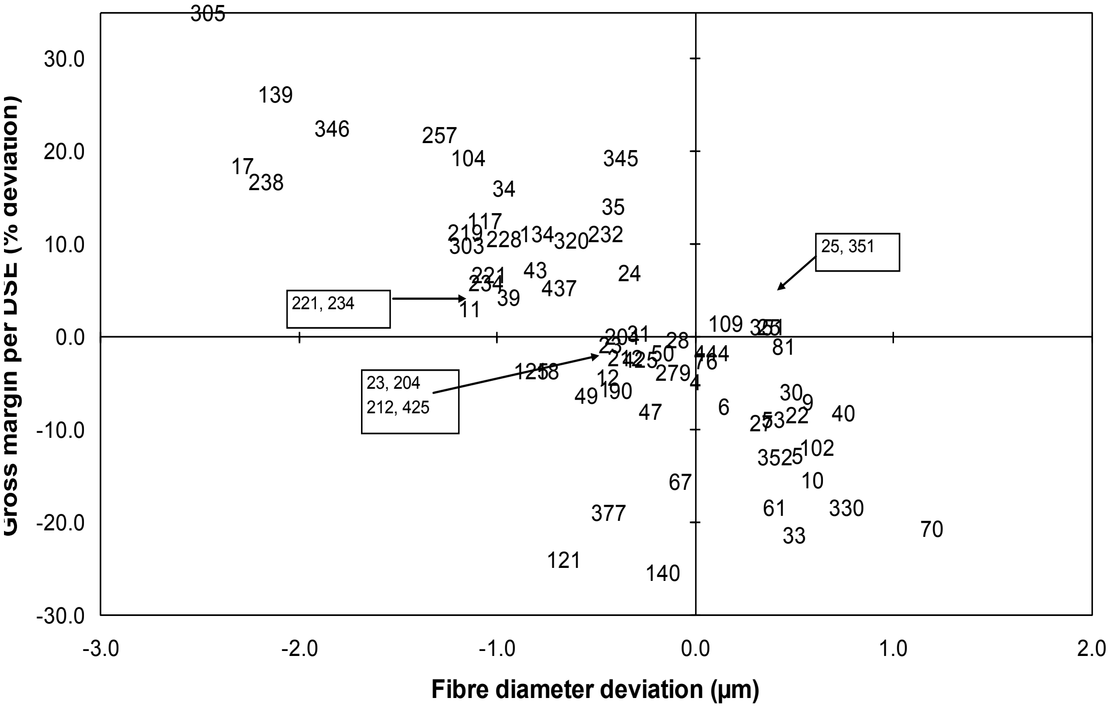
Wether trials

Wether trials have been used by commercial producers to compare the profitability of bloodlines. Many trials were conducted in all states of Australia through the 1980's and 1990's. The design of these trials involves the comparison of small teams of commercial wethers representing different bloodlines at a central site. The teams are typically entered by commercial producers who are ram buying clients of the bloodlines, and are made up of wethers selected at random.

The results from each individual trial are too imprecise to be confident about bloodline differences, so NSW Department of Primary Industries have merged the data from all available trials and performed across-site analyses. This is made possible by the use of the same bloodlines across trials, creating genetic linkages. In the most recent analyses (Coelli et al. 2000), there were 375 bloodlines included, of which 196 were sufficiently accurate for the purposes of comparison.

Across all bloodlines there is a considerable range in performance, with the difference between the top and bottom bloodlines equating to 50% of the mean for clean fleece weight (4.4 kg), and 6 microns for fibre diameter. These differences lead to considerable variation in profitability, with gross margins for bloodlines ranging from 32% above the average gross margin to 25% below the average. For the market period between 1995 and 1999, clean fleece weight and fibre diameter contributed 93% to the variation in gross margin, with body weight contributing 6%. Other wool quality traits explained the remaining variation. Figure 20.6 shows the relationship between fibre diameter and profitability. At the time of writing, the wether trial analyses were being updated with data from new trials and importantly, evaluated under more recent market scenarios.

Figure 20.6 The relationship between fibre diameter and profitability in wether trial data. Source: Coelli et al. (2000).



NSW DPI has developed an extension program to aid commercial breeders to use wether trials, which outlines a five step process:

1. Set the breeding objective of your flock, which may simply involve a statement such as “I wish to reduce fibre diameter in my flock by 2 microns while holding fleece weight constant”.
2. Benchmark the performance of your current bloodline relative to other bloodlines, particularly those which match the breeding objective defined in step 1. This step will identify alternative bloodlines which could be used as a ram source.
3. Consider all traits in the objective, including traits which are not evaluated in wether trials, such as reproduction and disease resistance.
4. Find out about the breeding objectives of the ram sources under consideration, and how they are progressing towards these objectives. Importantly, question whether or not the ram source’s objective matches your own.
5. Consider other constraints, such as the location of the ram source, and the price and availability of rams.

Although wether trials have their limitations (the main one being the long time lag between the selection decisions made in the studs and the flow of genes down to the commercial flocks from which the wether teams are chosen), they have been an important driver of genetic change in the Merino industry. Many commercial breeders have used wether trials to identify more profitable ram sources.

Central test sire evaluation

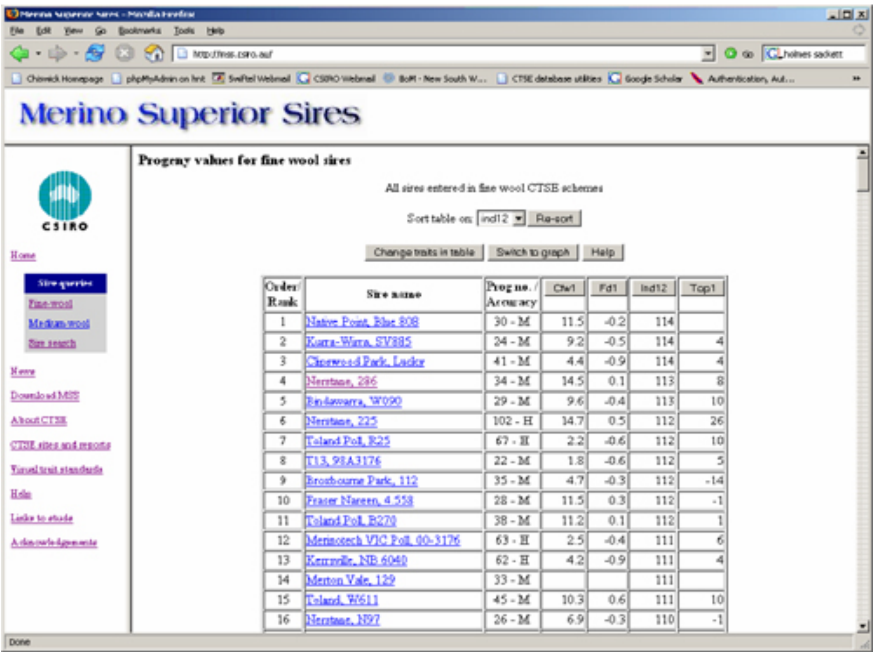
Central test sire evaluation (CTSE) in Australia involves independent progeny testing of Merino sires. The first site was established in 1987 in the Riverina region of NSW, closely followed by a site in the New England region of northern NSW. Since then, there have been 13 sites in operation at different times around Australia.

There are typically 10 to 16 rams entered annually at a site, with up to 50 ewes inseminated per sire. Ewes are allocated at random, as only sire pedigree is recorded on the lambs. The sires are compared for a wide range of traits measured on their progeny, with between one and three assessments of performance made, depending on the site.

Two of the sires each year are chosen as link sires, one to link with other sites, and one to link with previous drops within the site. This designed system of linkage has allowed combined across site analyses to be performed, and two analyses are performed, one for fine and one for medium wool sites. These analyses are made available through Merino Superior Sires (MSS), which is accessible via a hard copy report (Swan et al., 2005) and a website (http://mss.csiro.au), shown in Figure 20.7.

The range of traits available in the MSS reports includes clean and greasy fleece weight, mean fibre diameter, CV of fibre diameter, body weight, index performance, and percentage of tops and culls from visual classing. Sites also produce reports on each drop, and there is greater detail on traits in these reports than in MSS, particularly for visual traits. This means that users of CTSE information can identify top performing sires from the MSS report, and then go to the site reports for a greater level of detail. Site reports are available for download from the MSS web site.

Figure 20.7 The Merino Superior Sires website. Source: CSIRO, (2005).



The CTSE system has been a very successful means of across flock evaluation. Although only a limited number of sires can be compared at any one time, in excess of 900 leading sires have been entered between 1989 and 2003. The leading sires have been used widely throughout the industry, impacting on genetic progress.

Importantly, the system has been managed by ram breeders, currently through the Australian Merino Sire Evaluation Association (AMSEA). Because the evaluations are run independently, breeders have confidence in the results. CTSE has also had an impact on education, with the breeders involved learning the principles of designing pedigree and measurement recording programs, and applying these in their own flocks.

One of the drawbacks of CTSE is the progeny testing time lag. For example, if the breeder progeny tests in the home flock, a sire may be 3 or 4 years old on entry in an evaluation, and 5 to 6 years old before CTSE results become available. Along with the ability to compare many more sires, this is one reason why across flock evaluation has expanded to include on-farm data as discussed in the next section. Nevertheless, the CTSE system can continue to make an important contribution to across flock evaluation, both through strengthening genetic linkages between on-farm data sets, and in evaluating sires for traits which are otherwise costly to measure on farm.

On-farm evaluation and the development of sheep genetics Australia

The most recent development in across flock evaluation in Merinos has been the introduction of analyses which include on-farm data. The ability to compare animals accurately across a large number of flocks has the potential to dramatically increase rates of genetic gain across the industry, and would be beneficial for both ram and commercial breeders. While wether trials helped breeders to identify the most profitable bloodlines, the ideal is to be able to identify the most profitable rams, irrespective of their origin.

The first on-farm evaluation was Merino Benchmark (Casey and Atkins 1999), which began in 1996 with 8 breeders, and has subsequently grown to include 46 breeders in 2005. Merino Benchmark has high standards of quality assurance, and data which does not meet those standards is excluded from the analysis. Importantly, Merino Benchmark uses CTSE data to strengthen genetic linkages between on-farm data sets.

The next on-farm evaluation to develop was Merino Genetic Services (MGS), which has been funded by MLA, partially through the Merino Validation Project where breeders were supported to collect growth, carcase, and FEC data.

A breakthrough occurred in 2002, when key industry stakeholders agreed to work towards aggregating data from Merino Benchmark, MGS, and CTSE to form a single system of genetic evaluation, to be known as Sheep Genetics Australia (SGA). The benefits of this are clear: firstly, it will be possible to compare many more animals; secondly, sires which are in common across the three evaluations will now have one set of performance results instead of the current three; and thirdly, a common language will be used to describe the results.

From 2002 to the time of writing (2005), considerable effort has gone into solving technical and business issues which must be resolved prior to the launch of SGA. The main technical issues have been:

- The wide range in mean performance across flocks for traits such as fleece weight, fibre diameter, and body weight. There is an environmental component to this effect, which has been addressed by converting the data to a percentage scale with management groups, as well as a genetic component, which has been addressed by treating flocks as different “genetic groups”.
- The sparse pedigree structures present in Merino data, with sire pedigrees only recorded. It is necessary to allocate animals with unknown pedigree to genetic groups, which to date has been problematic.
- The need to develop a database to support the genetic evaluation software.

Current plans are to launch the system in the second half of 2005.

20.4 Breeding programs

As discussed previously, many Merino breeders have similar breeding objectives, but there is a diversity of opinion on how to realise those objectives. Perhaps simplistically, the breeding philosophies used by breeders can be categorised as traditional visual classing, measurement based programs, and skin based programs such as Soft Rolling Skin® (http://www.srswool.com). Realistically, many breeders use a combination of approaches.

The South Australian Research and Development Institute (SARDI) began a trial in 1996 to compare these different breeding philosophies. In collaboration with ram breeders and sheep classers, they established three selection flocks:

1. A flock selected primarily using objective measurements, known as the MPR flock.
2. A flock mainly selected on visual appraisal by sheep classers, known as the PCA flock.
3. A flock based on the Soft Rolling Skin® / Elite Wool approach, known as the EWF flock.

The flocks adopted a common breeding objective, which was to maintain or slightly improve fleece weight and body weight, and to significantly reduce mean fibre diameter and improve other wool quality attributes.

An unselected control flock was also included to provide a benchmark for the genetic improvement in the selection lines. Subsequently two more lines have been added, the FM+ line which aims to improve carcase traits while reducing fibre diameter, and the FWF line which is a fine wool selection line.

With seven drops currently evaluated (1997 to 2003), the main findings reported by Brien et al. (2005a) are:

- All selection lines are more profitable than the randomly bred control line.
- The three original lines are meeting the objective to maintain fleece weight relative to the control.
- There have been significant reductions in fibre diameter, most of which occurred during the early years of the program, and can mainly be attributed to the rams brought in to each flock.
- All lines are meeting their body weight objectives except the MPR line which has shown a reduction in body weight.
- The FM+ line has demonstrated that it is possible to combine selection for wool and meat traits.
- Visually assessed wool and skin traits have improved, but conformation traits are poorer than in the control line.

The selection responses for fleece weight and fibre diameter relative to the control are shown in the charts below (Figure 20.8, 20.9).

Figure 20.8 Selection responses for fleece weight relative to the control Source: Brien et al. (2005b).

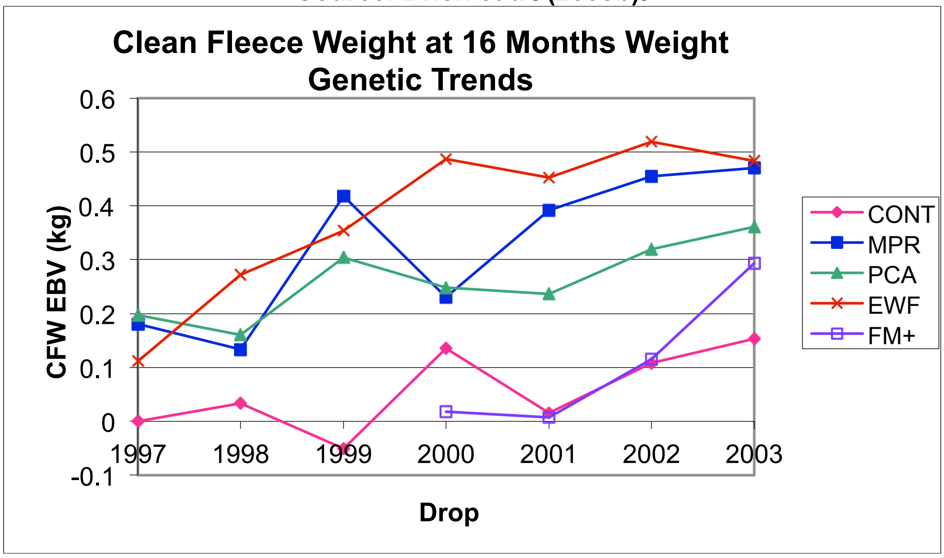
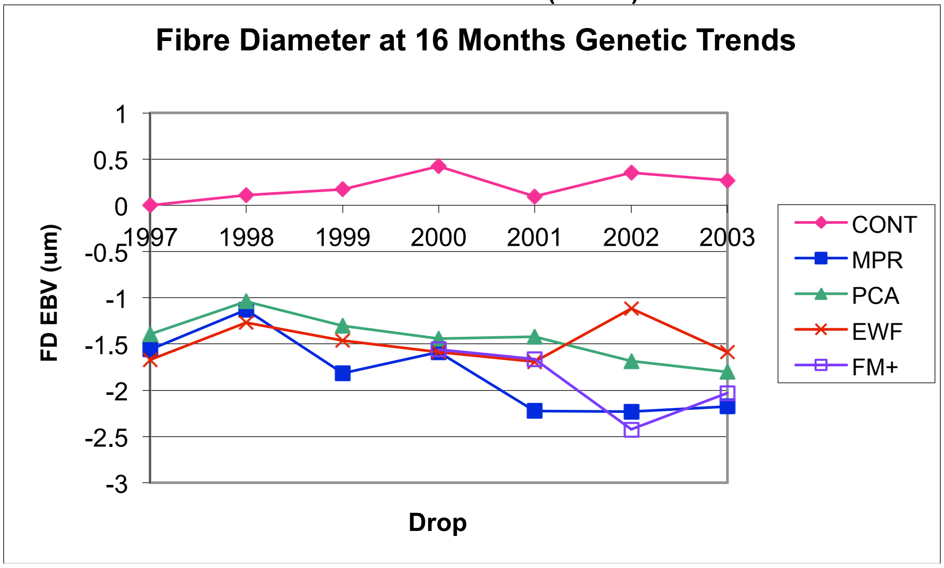


Figure 20.9 Selection responses for fibre diameter relative to the control
Source: Brien et al. (2005b).



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Readings

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Activities

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Submit answers via WebCT

Useful Web Links

Available on WebCT

Assignment Questions

Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCt

Summary

Summary Slides are available on CD

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Glossary of terms

Breeding objective[1]	A description of the characteristic(s) which selection is intended to improve
Closed nucleus breeding scheme	A traditional breeding scheme where genes are transferred from the parent studs through to multiplier or daughter studs and through to commercial flocks but no genes are transferred in the opposite direction
Commercial sector	Sector of the Merino industry where profit is made from meat and wool, not through the selling of genetic services and products
Correlation[1]	A measure of the direction and strength of the association between breeding values for two characters eg liveweight and fat depth
Heritability[1]	The proportion of superiority of parents in a trait which is, on average, passed on to offspring
Micron premium	The percentage change in price associated with a one micron reduction in fibre diameter
Open nucleus breeding scheme	A breeding scheme where genes from the commercial and multiplier tiers of the industry can be transferred into the parent stud tier
Ram breeding sector	Sector of the Merino industry that makes profits from the sale of genetic products and services eg ram sales. This sector drives the rate of genetic progress within the commercial sector
Selection index[1]	An overall score of genetic merit which combines information on several measured traits, with an emphasis on strength of association with traits in the breeding objective and their relative economic value

[1] Glossary terms taken from Simm (2000).