
Sam Gill, Stuart Warner (Vic DPI), Tom Bull, Neal Fogarty

Learning objectives

At the end of this topic you should:

- 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
- Understand and describe the way in which Sheep Genetics has improved sheepmeat production
- Understand the relevance of genetic correlation to ASBV
- Be able to separate environmental from genetic effects
- Understand the measures of accuracy for ASBV and FBUS

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.

21.1 Introduction to the topic

In this topic we explore genetic improvement programs in the Lamb industry. The history of this industry in Australia is interesting. While the Merino industry in Australia fared well and was wealthy a few decades ago, the lamb production was more or less seen as a poor cousin. This disadvantage was turned into an advantage in the early 1990s when an across flock genetic evaluation system was initiated by Meat and Livestock Australia: LAMBPLAN. Since then, the genetic trends achieved by Terminal Sire breeds have been significant and this has impacted on phenotypic progress and market share. The improvement in the meat sheep sector can be contrasted with the lack of improvement or trend in the wool sector. The terms of trade have improved strongly for sheepmeat over the last decade whereas they have deteriorated for wool, and these may well have to do with the rate of genetic improvement in both sectors.

Sheep Genetics (SG) is now the national genetic information and evaluation service for both the meat and wool sectors of the sheep industry. SG has been developed jointly by Meat & Livestock Australia (MLA) and Australian Wool Innovation Limited (AWI), together with industry.

Sheep Genetics has been developed to utilise the world’s most comprehensive sheep genetic database and evaluation service for the Australian sheep industry underpinned by a best practice quality assurance system. SG acts as a resource for sheep genetic information and improvement through which commercial producers, ram breeders and service providers can interact. It will supplement the skills of ram breeders and sheep classers by evaluating current measurements and providing further information, often on traits not assessable by the eye e.g. reproduction, carcase and internal parasite characteristics.

SG works with federal and state agencies, breed societies, livestock agents, sheep classers, agricultural advisors and veterinary consultants, fleece testing businesses and genetic service providers. It will function as Australia’s sheep genetic information database for all stakeholders to use. SG will also be an evolving data system, that is able to be upgraded to accommodate new, proven technologies as they arrive, including DNA parentage, gene markers, new traits, and electronic identification.
21.2 Overview of LAMBPLAN

LAMBPLAN supplies ram breeders and commercial lamb and sheep producers with an estimate of the value of an animal's genes to contribute to the productivity and profitability of their lamb and sheep enterprises. It provides flexibility enabling ram breeders to concentrate on the traits considered important to their breeding objective and the requirements of their clients. LAMBPLAN information assists ram buyers to choose rams that will produce slaughter lambs or 1st cross ewes that meet their breeding objectives.

For example, using LAMBPLAN, a lamb producer wanting to increase the weight and decrease fatness in his or her trade or export lambs can select rams that have genes that meet these criteria. Similarly a 1st cross breeder can select a ram that will produce daughters that have higher fertility and produce heavier lambs at weaning. If you consider that a ram contributes half of the total genetics of lambs and 1st cross ewes, you start to realise the potential of having such a high level of control over which rams are used.

LAMBPLAN currently performs two different forms of analysis for the meat industry:

**Terminal** - provides genetic information to aid selection of rams for use in prime lamb enterprises. It directly compares animals using an across-flock and across-breed analysis. It compares breeds such as the Poll Dorset, White Suffolk, Texel, Suffolk, Dorset and Dorper.

**Maternal** - provides genetic information to aid selection of rams for breeding 1st Cross ewes for use in a dual purpose production system. It compares animals within breed and across-flock. Animals compared within breed include Border Leicesters, Coopworths, Corriedales and Prime SAMMs.

LAMBPLAN is the brand that is used to identify information regarding terminal and maternal prime lamb breeds. LAMBPLAN offers producers information on the genetic merit of individual animals to perform for growth, carcase, reproduction, wool and disease resistance. Of key importance for sheep producers selecting terminal sires are the performance traits of GROWTH, FAT and MUSCLE with an increasing importance on birth weight and worm resistance.

The information provided by individual ram breeders to SG is used to calculate Australian Sheep Breeding Values (ASBVs) and Flock Breeding Values (FBVs). These are simple, practical performance measurements of key production traits. The breeding values can also be used to form indexes which enable producers to source animals with combinations of traits to match the requirements of their breeding plan. All major terminal and dual-purpose breeds in Australia use the services of SG and LAMPLAN. LAMBPLAN estimates the genetic (breeding) value of animals, in order to determine the value of genes for specific production traits (such as weight, fat, eye muscle depth and disease resistance). Breeding Values (BV) are calculated from the animal’s own measured performance and that of its relatives.

For each trait, the BV is shown as a positive or negative difference from the breed base, which is set at zero. The average BVs for different traits change over time as a breed makes genetic progress. Therefore, current breed average and top 20% BVs are more relevant for benchmarking than the zero base. BVs describe the genetic differences between animals in simple terms and explain the genetic value that can be passed onto progeny (adjusted for environmental effects and taking heritability into account).
21.3 Australian Sheep Breeding Values (ASBVs) and Flock Breeding Values (FBVs)

LAMBPLAN provides two forms of breeding values.

1. Australian Sheep Breeding Values
   - ASBVs enable genetic comparison:
     - across flock and across breed for the terminal sire group of breeds
     - across flocks within each of the maternal breeds
     - across flocks within the Merino and Poll Merino breeds.
   - ASBVs for all breeds other than merino are presented under the brand LAMBPLAN.

2. Flock Breeding Values

Across flock comparison requires a ram breeding flock to have adequate genetic linkage to other flocks undertaking evaluation. Flocks with inadequate across flock genetic linkages receive FBVs, which enable genetic comparison of animals within the flock only.

In most circumstances it makes more sense to select rams that have ASBVs. These rams will have breeding values of greater accuracy, and can be compared between different flocks.

Identifying an ASBV or an FBV. ASBVs and FBVs are readily identified because ASBVs are reported with an accuracy percentage and FBVs are reported without an accuracy percentage.

How are ASBVs calculated?

ASBVs are calculated by taking the raw measurements on the individual animal, combining known information regarding relative's importance, taking account for correlated traits (ie those that have an affect on the individual trait being measured) and ultimately adjusted for the environment. It is based on a multiple trait BLUP method.

Traits are usually expressed in the units that they are measured in. That is weight traits are expressed in kilograms of live weight and fat and muscle in millimeters. All of the individual raw measurements are entered into a single database. Here they are adjusted for variable confounding factors such as birth type, rearing type, age of dam and the influence of the lamb's pedigree is included. The result is an ASBV for each measured trait that compares that animal to the average of all animals in the year 2000. The year 2000 is set as a base year and is set as a constant so that you can track genetic change over time.

Figure 21.1: Relative contribution to an ASBV (MLA 2006)
What traits does LAMBPLAN evaluate?

LAMBPLAN is structured to allow ram breeders to measure and evaluate a wide range of commercially important production traits. ASBVs are available in the following core traits: wool, growth, carcase, reproduction, internal parasite resistance.

ASBVs are available from birth to adult ages. Ram breeders have the option of selecting the traits that best fit their breeding objectives.

Table 21.1: ASBVs by age available through SG.

<table>
<thead>
<tr>
<th>Body weight</th>
<th>Birth</th>
<th>Weaning</th>
<th>Post-weaning</th>
<th>Yearling</th>
<th>Hogget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcase traits (GR Fat and EMD)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fleece weight – greasy and clean.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fibre Diameter</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>CV of diameter</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Curvature</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
</tr>
<tr>
<td>Staple length</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Staple strength</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Faecal Egg Count</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>No. of lambs born</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
</tr>
<tr>
<td>No. of lambs weaned</td>
<td>✓</td>
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<td>✓</td>
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</table>

One of the keys to successful results from LAMBPLAN is the accuracy of the information that is collected. Flexibility enables a breeder to collect information at regular intervals throughout the animal's development to maturity (including sire and dam, conception method, sex, date of birth, birth type, rear type and management group) within management constraints. Accurate and consistent animal identification, which is essential for genetic evaluation, is achieved through use of an industry standard format. To achieve the data quality required to maintain the integrity of LAMBPLAN ASBVs, an independent person must collect or conduct some of the trait measurements. This is an accredited ultrasound scanner for fat and muscle measurements or an accredited wool laboratory or in-shed equipment for wool characteristics.

Figure 21.2: Data collection age ranges
**Genetic Correlations**

In any animal selection program genetic correlations, or relationships, may exist between traits of interest. The effect is that when selecting for one trait another trait, or traits, may be influenced in the progeny of the selected animals. This occurs because some of the genes that influence the expression of a trait of interest also affect other traits. In many cases, one or more genes affect more than one trait and the traits are said to be genetically correlated. Measuring or observing a second trait can provide more information about the desired trait, than just a measure of the trait alone. Correlations are described as either positive or negative (or zero where no correlation exists). A positive correlation is when selection for one trait leads to an increase in another trait (eg. growth rate and birth weight). A negative correlation is when selection for one trait leads to a decrease in another trait (eg. growth rate and eye muscle depth at constant weight).

While the correlated effect is what happens on average in the population, there will be animals that do not conform to the expected correlation (eg. high growth with below average birth weight). Often these animals are referred to as curve benders, as the y break trait relationships. For seed stock and commercial breeders, these are often highly desirable animals. To identify these animals within the population requires all traits of interest to be measured and analysed.

Tables 21.2 and 21.3 illustrate genetic correlations and heritability for a range of traits. The heritability is shown in bold on the diagonal with genetic correlations given as positive (+) or negative (-). "0" represents no correlation between traits.

**Table 21.2: Indicative heritabilities and correlations for maternal breeds**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability</th>
<th>YFAT</th>
<th>YEMD</th>
<th>YGFW</th>
<th>YFD</th>
<th>YFDCV</th>
<th>YSS</th>
<th>YWEC</th>
<th>NLW</th>
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<tbody>
<tr>
<td>PWT</td>
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<tr>
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<tr>
<td>YEMD</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.04</td>
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</tbody>
</table>

- / + = low, - - / + + = moderate, - - - / + + + = high

**Table 21.3: Indicative heritabilities and correlations for terminal breeds**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability</th>
<th>WWT</th>
<th>PIWWT</th>
<th>YWT</th>
<th>PFAT</th>
<th>YFAT</th>
<th>PEMD</th>
<th>YEMD</th>
<th>BWT</th>
<th>WWT</th>
<th>PWT</th>
<th>YWT</th>
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<th>YFAT</th>
<th>PEMD</th>
<th>YEMD</th>
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<td>PIWWT</td>
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- or + = low, - - or + + = moderate, - - - or + + + = high

**Heritability** Only a proportion of the observed superiority or inferiority of an animal (after adjustment for known non-genetic effects) is actually passed onto progeny. The degree to which differences are passed on - or inherited - is known as the heritability of a trait. The heritability of the desired traits is used to produce sound genetic estimations of breeding values.

Typical heritability of performance traits is about 50-60% for fibre diameter, 30-40% for fleece weight 30% for weight and growth, about 25 - 35% for fat depth, about 25-35% for eye-muscle depth and about 5-10% for reproductive traits.
Environmental Effects
For all traits, there are factors other than the animal’s genes that influence the level of performance that is expressed. The effect of non-genetic or environmental factors on animal performance means that using a simple measure of performance alone will not give an accurate guide to the animals’ genetic merit. To make an ASBV as accurate as possible environmental factors need to be taken into account. Easily identified environmental effects include birth date, age of dam, birth type, rearing type, weaning group and post weaning management groups. Other, often forgotten, effects may be disease problems, structural faults or feeding differences between show and flock rams, for example.

21.4 Genetic Linkage
LAMBPLAN ASBVs use information from all relatives of each animal regardless of the flock or group. This Across-Flock feature of ASBVs means that all animals can be directly compared for their genetic value, allowing the benchmarking of the whole breed. One of the strengths of genetic evaluation is that it enables direct comparison of animals across studs, which are often run under vastly different management, climatic and nutritional regimes. To do this the LAMBPLAN or MERINOSELECT evaluation must be able to calculate an Australian Sheep Breeding Value (ASBV) that is free of non-genetic (environmental) effects on the animal’s performance. Genetic linkage is one of the tools that allow this to occur.

Figure 21.4: Criteria to be met before an ASBV will be reported

If there is no genetic linkage, ASBVs can not be calculated, and breeders will receive Flock Breeding Values (FBVs). FBVs allow comparison of animals within flock only. In addition to comparing across flocks, genetic linkage is required for comparison across management groups and years within a flock. To effectively achieve this linkage it is important not to change all sires from one year to the next. Small studs, in particular, need to be wary of this situation.

How is genetic linkage developed?
The most effective way to create genetic linkage is to have progeny from a sire pedigree and performance recorded in two or more studs. AI sires commonly perform this function due to their accessibility by all breeders. However, a sire used by natural mating in more than one stud performs the same function. It should be noted that sires need not be used in the same year in each stud. Purchasing new studs sires from other performance-recorded studs also plays a key role in developing genetic linkage.
Genetic evaluation uses the link sire as a reference point from which it looks at the relative performance of other sires. Essentially genetic evaluation systems are interested in the +2 kg, -3 kg, etc, deviations to calculate ASBVs, which are derived from the actual weights and measures submitted by breeders.

A point to note is that evaluation of sires is only effective when at least two sires are represented in a management group (same sex, similar age and same nutrition and management). When only one sire is represented in a management group, the performance of the lambs in that group contributes no information to their sire’s ASBVs.

Figure 21.5: Linkage occurs when progeny from a common (link) can be compared against progeny from sires in different groups, flocks or breeds

How to improve genetic linkage?
Genetic linkage is commonly developed from:
The pedigree links that exist between flocks simply because breeders sell rams and ewes to each other. If there is good pedigree information from the flocks involved, this provides a basis for across-flock evaluation.
The use of Artificial Insemination (AI). As AI becomes more widely used, this will establish more direct links between flocks.
Young sire programs. These are an excellent mechanism for ensuring continual flock linkage as well as testing new genetics.
Entering sires in Meat Sheep Central Progeny Testing, or Merino Superior Sires (run by the Australian Merino Sire Evaluation Association). In these centralised progeny tests, progeny of sires from different flocks are evaluated in a single, common environment.

Across breed ASBVs
Across breed ASBVs are currently available only for the terminal meat sheep breeds. For example, ASBVs for Poll Dorsets, Texels, White Suffolks can all compared with each other. ASBVs for maternal breeds are across flock but within breed breeding values. For example, ASBVs from Coopworth flock X can be compared with ASBVs from Coopworth flock Y, but not with ASBVs from Border Leicester flock W. Merino ASBVs are across flock within breed breeding values.

As the terminal meat sheep industry becomes more focused on commercial performance (eg. faster growth, superior carcasses, high weaning rates, good milking ability, and worm resistance,) more breeders will use the best genetics they can find, regardless of source. Across-breed ASBVs have simplified this selection in the same way that ASBVs do within breeds. As this process continues, breeders will put together packages of the best genes available for the range of industry requirements. New combinations of genes will be continually evolved drawing on the entire gene pool. Where appropriate data is available, SG is able to evaluate animals across a range of breeds. The calculation of across-breed ASBVs is, in principle, no different to calculating across-flock ASBVs. It requires across-breed genetic linkage in addition to across flock genetic linkage. SG currently produces across-breed ASBVs for the terminal sire ram breeds.
There are two key forms of across breed genetic linkage available for the sheep industry:

Central Progeny Tests  where sires of different breeds are compared on the basis of their crossbred progeny in a common location.

Pedigree connections  where sires of one breed are used over ewes of another and the resulting progeny are compared to purebred progeny.

Commercial producers are now able to compare the performance of terminal sire rams from different breeds. This ensures that the best ram can be selected for a specific market target, regardless of which flock it is from.

21.5 ASBV and FBV Accuracy

By definition, ASBVs are an estimate. Accuracy, published as a percentage, is a reflection of the amount of effective information that is available to calculate the ASBVs for an animal. Accuracy is influenced by:

- heritability of the trait;
- size of the group in which the animal is compared;
- correlation between the trait reported and other records available;
- accuracy of parents' ASBVs; and
- amount of performance information available on the animal itself and its relatives.

Accuracies are calculated for both ASBVs and FBVs. This is reported as individual trait accuracy. A minimum level of accuracy must be achieved before ASBVs and FBVs can be reported. FBVs have to meet the same minimum standards of accuracy as ASBVs, but FBVs do not have accuracies published with them. Whole flock recording for the appropriate range of traits will improve accuracy of ASBVs.

Figure 21.6: Accuracy reporting thresholds for ASBVs and FBVs

Accuracy cannot account for some breeder influenced data quality issues, for example, how well management groups are defined.

Table 21.4: Major factors to ensure accuracy

<table>
<thead>
<tr>
<th>Increased accuracy</th>
<th>Reduced accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>accurate management groups</td>
<td>poor identification of management groups</td>
</tr>
<tr>
<td>two or more sires’ progeny in each management group</td>
<td>all progeny in a management group by one sire</td>
</tr>
<tr>
<td>even mating group sizes</td>
<td>some sires get many progeny, others few progeny</td>
</tr>
<tr>
<td>animals get similar amounts of performance information</td>
<td>some animals get many records, others very few</td>
</tr>
<tr>
<td>accurate pedigree records</td>
<td>poor pedigree data</td>
</tr>
</tbody>
</table>
Good records, even-sized mating groups, and similar amounts of performance data for similar groups of animals, all contribute to ensuring that ASBVs are as accurate as possible.

The Impact of Accuracy on Genetic Progress

It is important to keep accuracy in perspective. Accuracy and genetic merit are not the same. It is quite possible to have animals that have very low ASBVs, but for those ASBVs to be very accurate. Conversely, animals may have high ASBVs with low accuracy. The ability to make genetic gain is strongly influenced by:

- having accurate information about animals’ genetic merit, plus
- finding plenty of animals with high genetic merit.

The most accurate information will come from whole flock pedigree and performance recording with good data structure and accurate management grouping. From this foundation, the main challenge is then to identify better and better animals each year. The way to do this is to select the animals with the best ASBVs and Index Values for the particular production system that:
  - have performed well themselves; and
  - have a reasonable number of well-performed relatives.

Typically, for studs that are making genetic progress, this will mean using 7-8 young sires for every 2-3 older sires. This might seem risky - after all, the older sires have higher accuracy. However, remember that the ASBVs and Index Values have used all available information, and taken account of how much information is available on each animal, young or old. This means that animals with the best ASBVs and Index Values will be the best bets for breeding.

While the ASBVs and Index Values may change for individual young animals as they get progeny, a team of young animals (sires for example), will breed very close to their average ASBV or Index value. This occurs through an averaging effect because ASBVs and Index values have equal chance of moving up or down. Several elite breeding schemes use such an approach.

Exactly the same principle can be applied for any trait (including the Selection Index) and for any mating group, (eg a larger team of rams or a mating set of rams and ewes). In all cases, the larger the number of animals being considered, the closer they will breed to their average ASBV or Index.

Are all LAMBPLAN studs equal?

No not all studs are equal. Some collect more information than others either resulting from having more animals to measure, the size of the stud, or from collecting more information on those animals that are available. It should be pointed out that just because a stud is large, it doesn’t mean that it is superior to a smaller stud. It’s the amount of information that is collected on the individual animal as well as its relatives that determines the quality of the data.

Accuracy of an ASBV depends on the amount of information on relatives and the data quality grade. Data quality depends on the percentage of individuals that are recorded from the flock. The greater the percentage of animals recorded the higher the quality of the information.
Table 21.5: Data quality grades of Sheep Genetics Australia participating studs (MLA 2006)

<table>
<thead>
<tr>
<th></th>
<th>Bronze</th>
<th>Silver</th>
<th>Gold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedigree</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Sire</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dam</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Birth</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Date</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Weight</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Weaning</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Weight</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Post weaning OR Yearling weight and fat and eye muscle depth

<table>
<thead>
<tr>
<th></th>
<th>Rams</th>
<th>Ewes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rams</td>
<td>&gt; 50% of lambs with a WWT</td>
<td>&gt; 50% of lambs with a WWT</td>
</tr>
<tr>
<td>Ewes</td>
<td>&gt; 50% of lambs with a WWT (wt only)</td>
<td>&gt; 50% of lambs with a WWT</td>
</tr>
</tbody>
</table>

Wool traits (maternal breeds only)

<table>
<thead>
<tr>
<th></th>
<th>Rams</th>
<th>Ewes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rams</td>
<td>&gt; 50% of lambs with a WWT</td>
<td>&gt; 50% of lambs with a WWT</td>
</tr>
<tr>
<td>Ewes</td>
<td>&gt; 50% of lambs with a WWT</td>
<td>&gt; 75% of lambs with a WWT</td>
</tr>
</tbody>
</table>

Criteria for consideration when selecting a stud include:

- Does the stud participate in Sheep Genetics Australia and LAMBPLAN. This should be the first criteria. SG is the leading tool for performance recording of sheep in Australia, indeed the world, and it should be your number one priority when selecting a stud.
- Does the seed stock producer have an understanding of your breeding objective. Setting a breeding objective will be discussed later, however it's important that you can communicate this objective to the seed stock producer so they can assist you in selecting rams.
- What is the data quality grade of the stud. Where comparable studs have different data quality grades, all other factors being equal it makes good business sense to purchase rams from the stud with the higher standard, ie gold over silver, and silver over bronze. The higher the data quality standard the greater the accuracies of the ASBVs and the more useful the information.

Don’t choose your ram supplier based on breed!

A major advantage of the Terminal Sire Data base within LAMBPLAN is that it compares rams from all terminal breeds. As a result of this fact the decision around which breed to choose will be a purely personal one. Research has shown that there is AS MUCH VARIATION WITHIN A BREED AS THERE IS BETWEEN BREEDS. In other words there are good rams and poor rams in every breed. The advantage of LAMBPLAN is that it allows direct comparison of one terminal breed with another and therefore selects the best ram regardless of breed.

21.6 What ASBVs are important when selecting a terminal sire?

The following traits are available for all animals that are in LAMBPLAN’s national database. The emphasis placed on each of the traits will vary depending on the purpose for which the animal is selected.

Liveweight traits

Weight breeding values describe the animal’s genetic merit for growth rate. The higher the ASBV, the greater the potential of that animal to grow quickly. This will mean that animals with a higher ASBV will be heavier at a constant age. Measurements are calculated for animals at: birth, weaning, post-weaning, yearling, hogget and adult weights. The reason that measurements are taken at different times is that it allows producers to select the measurement that best reflects the age that they are selling lambs at.

Birth weight (kg) BWT

Lamb weights are collected within 24 hours of birth. Moderate birth weights are desirable, as high or low weights may compromise survival of either the lamb or ewe.
Weaning weight (kg) WWT
Weaning weight estimates the genetic difference between animals in live weight at 100 days of age. For producers looking to turnoff young lambs, the rate of growth to this point is very important.

Post-weaning weight (kg) PWWT
Post-weaning weight is generally measured when the animals are 5 -8 months (usually 225 days) old. This measurement is usually taken at the same time as scanning and is the most commonly reported measurement on sale catalogues. It is used in the calculation of the Carcase Plus index.

Yearling weight (kg) YWT
Data is recorded at about 300 days from birth. Yearling weight ASBVs provide valuable information for producers growing lambs out to extra heavy weights, or in areas where lambs may take additional time to finish.

Carcase traits
These describe the animal’s genetic merit for leanness and muscle. The lower the ASBV value for fat ASBVs the leaner the animal is. The greater the ASBV for muscle, the more muscle the animal has.

Fat depth ASBVs
Fat depth ASBVs estimate the genetic difference between animals in fat depth at the GR site (see Figure 21.7). The lower or ‘more negative’ the ASBV, the leaner the animal is at a given weight. Accredited LAMBPLAN scanners take the measurements using ultrasound technology, at the C site. The results are then converted to a fat depth measurement (mm) at the GR site for post-weaning (PFAT) at 45kg live weight, yearlings (YFAT) at 60kg live weight and hoggets (HFAT) at 70kg live weight.

Eye muscle depth ASBVs
Eye muscle depth ASBVs estimate the genetic difference in eye muscle depth at the C site. A positive ASBV means a genetically thicker muscled animal, and one that will have slightly more of its lean tissue in higher priced cuts. Measurements are taken by accredited LAMBPLAN scanners using ultrasound technology and are measured in millimeters for post-weaning (PEMD) at 45kg live weight, yearlings (YEMD) at 60kg live weight and hoggets (HEMD) at 70kg live weight.

Figure 21.7 – Location of GR site on lambs

Worm resistance
Increasingly worm resistance is becoming important. This is the result of producers seeking out alternative worm control measures to drenching. As part of the control measures producers are seeking to breed sheep that are more resistant to the effects of worms.
Worm egg count (WEC)

Worm egg count ASBVs describe the value of animals’ genes for carrying worm burdens – a combination of being genetically less predisposed to pick up worms and being able to cope immunologically with the worm burden. Worm egg counts can be taken around 100 days for weaners (WWEC), 225 days for post-weaning (PWEC) or 360 days for yearlings (YWEC). The best time to take worm egg counts (WEC) will depend on local climatic conditions and worm burden patterns. Lambs being sampled need to have been weaned for long enough to ensure their own immunity is assessed, rather than that of their dams. ASBVs for WEC are expressed as a percentage. Those with more negative percentages are more resistant to worms than those with positive percentage figures.

21.7 Terminal Sire Indexes

In addition to ASBVs for individual traits, LAMBPLAN produces indexes. An index is calculated by combining a number of ASBVs based on their relative economic value to rank animals based on that combined criteria. The most common terminal sire indexes available are Carcase Plus, Trade $ Index and Export$ index.

Carcase Plus Index

The Carcase Plus index places 60% of emphasis on weight or increasing growth rate, 20% on reducing fatness and 20% on greater muscling. The Carcase Plus index is calculated using post-weaning information as this is the age where most lambs are turned off. The selection index rates animals on their ability to breed heavy, lean and well-muscled progeny suitable for export weight and fat specifications. The base of the Carcase Plus index (as with all LAMBPLAN indexes) is set at 100, which is the mean index figure for 2000.

Dollar Indexes - Trade $ Index and Export $ Index

Two “Dollar Index’s” exist for use by commercial lamb producers to select rams for use. The “Trade $ Index” and the “Export $ Index. Dollar indexes attempt to show the relative value of a ram expressed as dollars return per ewe joined per year. Currently both indexes assume 100% weaning and a lamb value of $3.50 per kg carcass weight at slaughter.

The trade $ Index is designed to target production of 22kg carcase weight lambs. It combines post-weaning age ASBVs for growth, fat and eye muscle depth into a $ index value. The Trade $ Index is expressed as dollars/ewe joined/year/ In estimating the dollar variation the index assumes a weaning rate of 100% and lamb at $3.50 cwt. The Trade $ Index rewards animals with a post-weaning (PWWT) +6 or greater. The greater the PWWT ASBV is above 6, the more points allocated to the index.

Production of trade weight lambs requires appropriate leanness. But excessive leanness is undesirable due to difficulties in finishing lambs at this weight. For this reason the Trade $ Index optimises the Post-Weaning (PFAT) ASBV at -0.5. The further an animals PFAT ASBV is from -0.5, the fewer points allocated. The index also rewards animals with more positive post weaning eye muscle depth ASBVs, which are desirable for carcase conformation and yield. The more positive the PEMD ASBV, the more points awarded in the index.

Table 21.6: Comparison of Trade $ Index and Export $ Index

| Index    | Target market for lambs | Emphasis placed upon each trait |  |
|----------|-------------------------|---------------------------------|  |
|          |                         | Growth (PWWT)                  | Fat (PFAT) | Muscle (PEMD) |
| Trade $  | 22kg carcase weight lambs at 7.5 months of age | Rewards animals with a PWWT ASBV of +6 or greater | Optimises fat (PFAT) at -0.5. The further an animals PFAT is | Rewards animals with a PEMD of 0 or greater | The more positive |

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The higher the PWWT is above +6 the more points that are allocated to the index. The higher the PWWT is above +10 the more points that are allocated to the index. The further an animal is from -1.0 the less points that are allocated towards the index. The more positive the PEMD ASBV the more points are allocated to the ASBV.

<table>
<thead>
<tr>
<th>Export $</th>
<th>24kg carcase weight lambs at 7.5 months of age</th>
<th>Rewards animals with a PWWT of +10 or greater.</th>
<th>Optimises PFAT at -1.0.</th>
<th>Rewards animals with a PEMD of 0 or greater.</th>
</tr>
</thead>
</table>

21.8 Estimating ram value – Dollars and Sense

It’s possible to perform a quick analysis of two rams that shows the value of extra growth by comparing the ASBVs for PWWT for two rams. An example is given below.

<table>
<thead>
<tr>
<th>ID</th>
<th>PWWT</th>
<th>PFAT</th>
<th>PEMD</th>
<th>Carcase Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12.3</td>
<td>-0.7</td>
<td>0.8</td>
<td>182</td>
</tr>
<tr>
<td>B</td>
<td>8.2</td>
<td>-0.4</td>
<td>0.2</td>
<td>152</td>
</tr>
</tbody>
</table>

**How much more can you afford to pay for Ram A?**

Ram A’s ASBV post-weaning weight (PWWT) = 12.3kg
Ram B’s ASBV post-weaning weight (PWWT) = 8.2kg

\[
\text{Difference in post-weaning weight} = +4.1kg
\]

Predicted difference in the actual weight of progeny at time of sale (half the difference in post-weaning weight (PWT) ASBV) ie \( 4.1 \div 2 \) = +2.05kg

Predicted difference in actual carcase (CWT) weight at 46% dressing ie \( 0.46 \times 2.05 \) = +0.94kg

Assume your rams are joined at 2%, producing a 100% lambing rate each year for four years. Use these example figures to calculate the total number of lambs produced using the following formula:

i) 50 ewes joined /year x 100% lambing x 4 years of service: \( 50 \times (100 \div 100) \times 4 = 200 \) lambs

ii) No. of lambs produced by the predicted difference in CWT at 46% dressing \( (200 \times 0.94) \)

iii) Total predicted gain in carcase weight (CWT) = 188kg

iv) Average price received (¢/kg cwt) = 300¢/kg

\[
\text{Finally, multiply the average price received by the total predicted gain in CWT} \ (3.00 \times 188): \text{Value of total predicted gain in carcase weight} = $565
\]

Thus, Ram A will provide an additional 188kg carcase weight if joined to 50 ewes with a conception rate of 100%. If you use Ram A for four years and receive on average 300¢/kg CWT, you will gain an additional $565 in value compared to Ram B.
21.9 Putting it all together – comparing rams

The terminal breed group, as do all other breeds within the SG system, has a percentile band table that shows how well an animal performs relative to the current year drop. Remembering that all terminal sires are recorded in the one data set within SG, the percentile band for terminal sires is across breed. Percentile bands are available from the SG website and are normally published twice a month. It’s important that you have the right percentile report to compare the ASBVs to.

When you attend a ram auction, the seed stock producer will provide you with the sale catalogue. In the catalogue rams will be listed, along with ASBVs for key traits. Usually BWT, PWWT, YWWT, PFAT, YFAT, PEMD and YEMD as well as a Carcase Plus index and possibly a Trade $ Index and an Export $ Index. You should ask the seed stock producer to supply you also the percentile report that is relevant to the presented ASBVs. By using the percentile report you can determine how well the animal performs relative to other animals in the current drop.

Note from the percentile report that the average value for many ASBVs is no longer zero. This is because the average is set as the average of all rams in the year 2000 and genetic selection has moved traits in commercially desirable directions. The average for PWWT on the 1st of March 2006 was 8.1kg. Therefore a ram with a PWWT of 7.1 is 7.1kg heavier at PWWT than the average for all rams in the year 2000 but is 1.1 kg below the average of all rams on the 1st of March 2006.

This gives a stark picture of the performance gains possible through using objective measurement and SG and LAMBPLAN.

21.10 Maternal Traits affecting Profit

Many factors can affect the profitability of the prime lamb enterprise, with three key factors being: production, price and costs.

- Production is the factor that usually offers the most potential to increase profitability. Management and stocking rate are very important however genetics sets the potential productivity of an enterprise.
- Price received is affected by marketing although the important aspect is to ensure that the product meets the market specifications eg. carcase weight and fat level.
- It is difficult to decrease variable costs without decreasing flock size so increasing gross margin requires increasing production per ewe and/or increasing price received. It is also difficult to decrease fixed costs and the most effective way to do so is often to spread these costs over more sheep by increasing the production per ha.

Most of the production traits are influenced by both management and genetics. The important traits to consider are:

- Reproduction - drives weaning percentage and the number of lambs turned-off
- Growth - influences time to turnoff, carcase weight and possible joining age of ewes
- Carcase traits - influence carcase weight, fat cover and lean meat yield which can affect the price received
- Parasite resistance - influences production costs eg resistance to worms and flystrike

The lamb turnoff rate was the major driver for the differences in $Gross Margin between sire groups of crossbred ewes in the MCPT. Over 80% of income was from lamb sales and less than 20% from ewe wool. While the number of lambs turned off (which is a combination of lambs born per ewe joined and lamb survival) was the major profit driver, lamb growth rate and fat level (which affect carcase weight and price) also affected profit. Lamb carcase price was determined by
carcase weight and fat level which affected the proportion of lambs meeting the market specifications.

The number of lambs weaned in a ewe’s reproductive life is influenced by several components including:

- Ovulation rate.
- Litter size.
- Prenatal and postnatal survival, and
- Interval between lambings.

ASBVs have three traits that describe reproductive performance. They are the number of lambs born (NLB) and the number of lambs weaned (NLW), expressed as the ratios to the number of the ewe’s lambing opportunities. Scrotal circumference in the ram is also an indicator of reproductive performance of female relatives and ASBVs may also be reported. The NLB and NLW per lambing opportunity are female reproduction traits, but information from male animals can contribute to the ASBVs. Male animals have genes for female reproduction traits, which they pass on to their daughters.

The ability of the ewe to provide genes for milk production and maternal nurturing is expressed by the ASBV for maternal weaning weight, separate from the genes passed on for direct growth. For the growth traits (or weights at different ages) we know that the performance of the lamb is affected by the value of its own genes for growth and how much milk the mother provides and how good a mother she is. The mothers’ maternal ability affected by how good or bad the genes of the mother are for producing milk and for her general maternal performance. So, there are two sets of genes affecting the growth of the lamb.

- direct genes for growth - the genes of the lamb itself for taking in food and converting that food to body tissues.
- maternal genes for growth - the genes of the dam for providing milk and generally assisting the lamb to grow.

Where records are available for weaning weights and the sire and dam pedigree, the growth of the lamb to weaning can be split into its ‘direct’ and ‘maternal’ components – providing both direct and maternal weaning weight ASBVs.

This separation between direct and maternal genes for growth means breeders can:

- Identify animals with the best genes for early growth – those with superior direct weaning weight ASBVs.
- Identify dams that will give their lambs the better start – higher milk and better mothering or maternal performance – those with superior maternal weaning weight ASBVs.

Animals with better than average maternal weaning weight ASBVs will breed daughters that rear heavier progeny. While animals with poorer than average maternal weaning weight ASBVs will breed daughters that rear lighter progeny. Selecting for high milking or mothering alone would seriously limit improvement in other traits. This is because the correlation between maternal weaning weight, and weaning weight direct, is negative, so both traits need to be included in an index.

**Genetic variation**

There is considerable genetic variation for most production traits and significant response can be achieved from selection. The rate of change that can be achieved is determined by the amount of genetic variation in the trait (heritability) and the breeding program implemented (how much better the selected animals are than the average and how rapidly the generations are turned over).
Estimates of genetic parameters for sheep from data published in the world literature over the last decade have been compiled (Safari and Fogarty 2003) and summarised in a recent review (Safari et al. 2005). The results show there is significant genetic variation and considerable potential response to selection for all the major production traits and disease traits such as worm resistance (Greeff and Karlsson 2006). Response to selection is a function of the heritability and phenotypic variation of the trait as well as the selection intensity imposed and generation interval. Table 21.9 shows the average heritability and phenotypic variation for various sheep production traits. The response to selection (given the same selection intensity and generation interval) relative to that which can be achieved for clean fleece weight (100) is also shown in Table 7.1. Even though the heritability of reproduction is lower than that of other traits, it has high variation, which means that a moderate response can be achieved with an effective selection program (Fogarty et al. 2006).

Table 21.9 Heritability, variation and relative response to selection for various traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability</th>
<th>Coefficient of variation (%)</th>
<th>Relative response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean fleece weight</td>
<td>0.36</td>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>Fibre diameter</td>
<td>0.59</td>
<td>7</td>
<td>75</td>
</tr>
<tr>
<td>Lambs weaned (/ewe joined)</td>
<td>0.07</td>
<td>64</td>
<td>76</td>
</tr>
<tr>
<td>Lambs born (/ewe joined)</td>
<td>0.10</td>
<td>53</td>
<td>90</td>
</tr>
<tr>
<td>Weight weaned (/ewe joined)</td>
<td>0.13</td>
<td>48</td>
<td>108</td>
</tr>
<tr>
<td>Ewe rearing ability</td>
<td>0.06</td>
<td>40</td>
<td>41</td>
</tr>
<tr>
<td>Scrotal circumference</td>
<td>0.21</td>
<td>9</td>
<td>31</td>
</tr>
<tr>
<td>Worm resistance</td>
<td>0.27</td>
<td>31</td>
<td>142</td>
</tr>
<tr>
<td>Post weaning weight</td>
<td>0.33</td>
<td>13</td>
<td>72</td>
</tr>
<tr>
<td>Fat depth</td>
<td>0.25</td>
<td>13</td>
<td>54</td>
</tr>
<tr>
<td>Eye muscle depth</td>
<td>0.24</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Lean meat yield</td>
<td>0.35</td>
<td>9</td>
<td>54</td>
</tr>
</tbody>
</table>

^ Source: Safari et al. 2005

There are several examples of realised responses to selection in sheep flocks that clearly demonstrate genetic selection is effective. Divergent selection for lambs weaned per ewe joined (LW/EJ) in Merinos over 16 years resulted in large, significant differences between the high and low lines in lambs born (1.50 v. 1.32), LW/EJ (1.16 v. 0.91) and litter weight weaned (23.9 v. 18.0 kg), with no differences between lines in fleece weight or ewe liveweight (Cloete et al. 2004). Figure 21.8 shows genetic trends in average predicted breeding values for the high and low lines.

Figure 21.8 Genetic trends for lines of Merinos selected for high and low reproduction

The average annual response to selection for litter weight of lamb weaned per ewe joined over 12 years was 0.692 kg for nine lines of sheep in a study conducted in the USA (Ercanbrack and Knight...
1998). The traits contributing to the annual response included LW/EJ (1.81%, P < 0.01), fertility (0.23%, ns), prolificacy (1.44%, P < 0.01) and lamb survival (0.45%, P < 0.05).

21.11 Defining the production system

It is important to define the lamb production system and the target market for products. The environment and infrastructure of the enterprise as well as financial and management constraints may limit some types of production. It is only then that the appropriate genetics can be selected for the production system. Some of the factors to consider include:

- Type of enterprise eg. self-replacing flock, crossbreeding
- Type of products eg. breeding store lambs for others to finish, breeding and finishing
- Lamb market eg. trade weight, heavy export
- Lambing season – ewes joined in spring and early summer need genes for out-of-season breeding

Two examples of the effect of the production system on results from the MCPT are discussed below to illustrate some of the points that need to be considered. These are the joining and subsequent lambing season and the practice of first joining ewes as lambs at 7-9 months of age.

Lambing season

The ranking of the sire breeds (and some sires) progeny tested in the MCPT varied with the production system and environment in which their first cross daughters were evaluated. In particular, the first cross daughters of the Finnsheep and Booroola Leicester sires had a relatively higher ranking than other breed crosses from the spring than the autumn joining (Figure 21.9). These breed cross ewes generally had high lambing rates with a high proportion of twin, triplet and higher order births. Lamb survival tended to be low for these from the autumn joining (lambing in late winter), whereas the out of season spring joining, resulted in fewer higher order births and lambing occurred in autumn with better weather conditions and higher lamb survival. The annual $ gross margin increased with age of the ewes from autumn ($45, $93, $102) and spring ($81, $104, $118) joinings. It almost doubled from the first autumn joining where the ewes were lambing at 12 months of age compared to the second. The differences between the autumn and spring joinings were due to both the season and age of ewe effects which are confounded, at least for the first and second joinings.

Figure 21.9 Annual $ gross margin ($/ewe) returns for crossbred ewes by various sire breeds when joined in autumn or spring

(Sire breed codes: BL Border Leicester, EF East Friesian, Fi Finnsheep, Cp Coopworth, WS White Suffolk, Cr Corriedale, BoL Booroola Leicester)
Joining ewe lambs

Producers can improve the productivity and profitability of their lamb enterprise by joining crossbred ewe lambs at 7-9 months of age. Joining ewe lambs considerably reduces the effective cost of growing out replacement ewes in the flock. Ewes that successfully rear lambs from an early joining also have improved subsequent lambing rates. The benefits of joining ewe lambs can accrue to both producers who breed their own replacements and those who buy in ewes.

Joining young ewes in the autumn will be much more successful than in other seasons. Sheep, like many animals are seasonal breeders and the peak of reproductive activity is in the autumn. Their breeding season is under hormonal control and is triggered by decreasing daylength. Breeds and individual ewes vary greatly in their breeding season and many are less sensitive to daylength and can be joined successfully at other times of the year after they have reached puberty. Few young ewes, less than 12 months of age will cycle naturally before January/February. The later into autumn ie March/April the more successful will be a joining for young ewes. This is because more ewes will reach puberty and ovulation rates will also increase.

The overriding factors for successful joining of young ewes are season and live weight. Crossbred ewes generally attain puberty in their first autumn if they reach 40-45 kg live weight. The heavier young ewes are in the autumn the greater proportion successfully join and lamb. This is illustrated in results from the MCPT (Figure 21.10). Age of ewe lambs also has some affect on the success of joining, all other factors being equal. That is older ewes of the same live weight and joined at the same time will generally have more ewes lambing with a higher proportion of twins than younger ewes.

Figure 21.10 Lambs born (% of ewes joined) from crossbred ewes by various sire breeds joined at 7 months of age
(Sire breed codes: BL Border Leicester, EF East Friesian, Fi Finnsheep, Cp Coopworth, WS White Suffolk, Cr Corriedale, BoL Booroola Leicester)

The results of the MCPT clearly demonstrate the considerable genetic variation among maternal genotypes that can be exploited to improve productivity and profitability of lamb enterprises. While there were some significant differences between the maternal sire breeds in performance of their progeny, the variation among individual sires within the breeds was far greater for most production traits. Lamb producers need to breed or purchase crossbred ewes that are by rams with high LAMBPLAN ASBVs for the traits that match the lamb enterprise and ensure they are bred from high performing base ewe flocks.
Selecting maternal sires

Figure 21.11 Terminal sire genetic trend for post weaning weight (Pwwt) (Source: Sheep Genetics Australia)

To make it simpler for breeders and buyers of rams, SG calculates several standard indexes for maternal breeds as well as terminal and Merino breeds. The standard indexes have different relative emphasis on the various traits to correspond to different breeding objectives. Each breeder should ensure that the index they use when selecting rams matches their flock breeding objective. Each breed has decided on the relative emphasis to place on each ASBV to calculate a breed index. However there is an opportunity for ram breeders to calculate a number of different indexes to allow ram buyers to select for their own breeding objective. The ASBVs for the various maternal breeds can only be compared within their own breed and not across breeds. Whereas the terminal ASBVs are calculated across the various terminal sire breeds and are comparable in different terminal sire breeds.

A selection index can be used to select effectively for two or more traits that may be have antagonistic genetic relationships. For example selecting to increase fleece weight alone will result in an increase in fibre diameter because there is a positive genetic correlation between the traits. However a selection index takes this genetic correlation into account and puts appropriate weightings on the traits which can result in improvement of both traits together. This was tested in the QPLUS selection lines in which various indexes were used to increase fleece weight and reduce fibre diameter in 3 bloodlines of Merinos. The realised responses after 8 years of selection are shown in Figure 21.12 along with the target points for the 10 years of selection predicted at the start of the project.

Maternal sire value

Maternal sires such as Border Leicester rams that have been tested through LAMBPLAN have ASBVs available at sale. Some questions for ram buyers are:

- how much more is a ram with superior ASBVs worth?
- how can rams with varying ASBVs for different traits be compared?
To help in making these decisions a computer program (EBV $ Calculator for Maternal Sires©) has been developed that calculates the additional $s generated over the lifetime of the ram (and his first cross and second cross progeny) compared to a ram with all ASBVs = 0. Maternal sires have ASBVs for several traits including:

- maternal weaning weight (ASBVmwwt)
- live weight (ASBVwt)
- fat GR (ASBVfat)
- eye muscle depth (ASBVemd)
- number of lambs weaned (ASBVnlw)
- greasy fleece weight (ASBVgfw)

Use of rams with superior ASBVs for these traits will result in progeny (first cross and second cross) that have higher performance and have higher returns. Each of the traits will contribute different amounts of $ because they contribute to different products from first cross and/or second cross progeny. For example, rams with positive ASBVwt will have heavier progeny which will have higher returns from both first cross and second cross lambs, whereas positive ASBVnlw means better lambing rate from the first cross ewes and more second cross lambs sold.

The returns will be different for the first cross and second cross enterprises. They will also vary with the breeding structure, production system and prices in each enterprise. Where maternal sires are mated to Merino or other base ewes in the first cross enterprise, the wether progeny are sold for slaughter and the ewe progeny are sold for breeding. In the second cross enterprise the first cross ewes are mated to terminal sires and all second cross lambs are sold for slaughter with additional returns from the first cross wool.

Total returns from better production of the progeny of the ram depends on the superiority of the ASBVs as well as several other factors relating to the production system and prices. These factors include the number of years the ram is mated, the number of base ewes, their lambing rate, the carcase weight of progeny, price of lambs, carcases and wool, fat discounts and the discount rate that reduces the value of income in future years. The computer program allows all of these factors in the breeding structure, production system and prices to be varied to suit individual situations.

The additional $ returns for a Border Leicester ram using the standard breeding structure, production system and prices (see box) are shown in Table 21.10. The ASBVs used are for the Band 10 of the Border Leicester LAMBPLAN analysis (ie a ram in the top 10% of Border Leicesters). The $ values shown are the additional $ contributed for each trait in both the first cross and second cross enterprises compared with using a ram with all ASBVs = 0. In this breeding structure the ram produces 60 first cross wethers and 60 first cross ewes over 3 years and his 60 first cross daughters produce 330 second cross lambs plus wool over 5 years.
Table 21.10 Additional value for Band 10 Border Leicester sire ASBVs

<table>
<thead>
<tr>
<th>enterprise</th>
<th>ASBV wt</th>
<th>ASBV umw</th>
<th>ASBV umf</th>
<th>ASBV umd</th>
<th>ASBV umw</th>
<th>ASBV umf</th>
<th>ASBV umd</th>
<th>Total $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>first cross wethers</td>
<td>Maternal weaning weight</td>
<td>416</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>first cross weight</td>
<td>second cross weight</td>
<td>366</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>first cross weight</td>
<td>second cross fat</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>first cross fat</td>
<td>first cross ewe lambing rate</td>
<td>928</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>first cross ewes</td>
<td>first cross ewe wool</td>
<td>141</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total first cross</td>
<td>Total second cross</td>
<td>1884</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the first cross enterprise the 60 first cross wethers from this ram would be heavier and slightly leaner (less carcasses discounted for fat score 5) and the 60 first cross ewes would be heavier when sold. This would result in $288 more returns than if a ram with ASBVs = 0 was used.

In the second cross enterprise there are gains in carcase weight of the 330 second cross lambs from maternal weaning weight (additional milk and nurturing) and weight as well as leanness (less carcasses discounted for fat score 5). The 60 first cross ewes also produce more lambs (from ASBV/umw) and wool (from ASBV/gfw) over their 5 years in the flock. The total additional value in the second cross enterprise is $1884.

The results highlight that the great majority (87%) of the additional returns from maternal sires with superior ASBVs are in the second cross enterprise. This is because many of the economically important maternal traits (maternal weaning weight, lambing rate and wool) are only expressed in the second cross enterprise and there are also a lot more expressions of performance (60 first cross ewes x 5 years). The important contribution of increased lambing rate is also highlighted.

The ASBVs for animals in the various bands of the Border Leicester LAMBPLAN analysis are shown in Table 7.3, along with the additional $ returns in the first cross and second cross enterprises for use of a Border Leicester ram with these ASBVs under the standard breeding structure and prices. The additional value from the first cross and second cross progeny of a Border Leicester ram with Band 10 ASBVs (i.e. top 10%) is $1508 (i.e. 2172-664) more than if a ram with Band 50 ASBVs (ie top 50% or current average for the breed) was used.

Table 21.11 Additional value of Border Leicester sire EBVs in first cross and second cross enterprises

<table>
<thead>
<tr>
<th>BL sire</th>
<th>EBV mwwt</th>
<th>EBV pwwt</th>
<th>EBV pfat</th>
<th>EBV pemd</th>
<th>EBV umw</th>
<th>EBV umf</th>
<th>EBV umd</th>
<th>Total $</th>
<th>Total $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band10</td>
<td>1.92</td>
<td>3.38</td>
<td>-0.40</td>
<td>0.59</td>
<td>0.08</td>
<td>0.23</td>
<td>288</td>
<td>1884</td>
<td>2172</td>
<td></td>
</tr>
<tr>
<td>Band 20</td>
<td>1.45</td>
<td>2.72</td>
<td>-0.31</td>
<td>0.37</td>
<td>0.06</td>
<td>0.15</td>
<td>231</td>
<td>1416</td>
<td>1647</td>
<td></td>
</tr>
<tr>
<td>Band 50</td>
<td>0.53</td>
<td>1.55</td>
<td>-0.06</td>
<td>0.00</td>
<td>0.02</td>
<td>0.04</td>
<td>128</td>
<td>536</td>
<td>664</td>
<td></td>
</tr>
<tr>
<td>Band 75</td>
<td>-0.16</td>
<td>0.56</td>
<td>0.12</td>
<td>-0.26</td>
<td>0.00</td>
<td>-0.03</td>
<td>42</td>
<td>-3</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>
There is real potential to make significant profitability gains from using improved maternal genetics:

- The MCPT has shown a range of up to $40/year in gross margin between first cross ewes breed using different maternal sires. This provides scope to source first cross ewes by sires with high genetic merit. There is a large variability in maternal sire performance and the tools are available to identify these superior rams.
- Both the first cross breeders and second cross producers can benefit from the selection of these superior rams.
- The main recipient of these gains is the second cross producer. If this producer is buying in first cross ewes, to capture the benefit of these genetics, they will need to either identify a reliable source or contract a first cross breeder to producer these high genetic merit ewes.
- There is real scope for first cross ewe lambs to be joined at 7-9 months of age provided they reach 45kg liveweight at that age.
- The first cross breeder can directly benefit by being able to market wether lambs heavier and earlier and by having greater flexibility in marketing first cross ewe lambs.

21.12 Hybrid vigour
Cross breeding has been an integral part of prime lamb production. Cross breeding can be used to produce lambs for slaughter or to be used as prime lamb mothers. Crossbreeding allows you to exploit all of the genetic differences both within and between breed differences as well as hybrid vigour. As with straight breeding, continued improvement depends on improving the average genetic merit of the foundation breeds used in the cross. Straight breeding utilizes within breed differences.

In a cross breeding system where all progeny are slaughtered and none are retained for breeding, the system is called ‘terminal crossing’. The ram used in this case is known as the ‘terminal sire’. Breeds such as Poll Dorsets, White Suffolks and Texels can be used as a terminal sire over Merinos to produce first-cross lambs for slaughter, or over first-cross ewes to produce second-cross lambs. Where crossbreeding involves the ewe portion being retained for subsequent breeding, this breeding system is called ‘maternal crossing’. The ram in this case is known as the ‘maternal sire’. Breeds such as Border Leicester, East Friesian, Finnsheep, Coopworth and other composites can be used as maternal sires over Merinos to produce first-cross ewes for breeding. However the sale of male progeny for slaughter is an important part of such an enterprise. The Merino ewe is used extensively in the prime lamb industry, with over half of the lambs slaughtered in Australia being bred from Merino ewes.
Hybrid vigour occurs when two different breeds are crossed. The greater the genetic difference between two breeds, the greater the hybrid vigour in crosses between them. For example crosses between Merinos and long wool breeds give more hybrid vigour than crosses of two long wool breeds. Hybrid vigour is seen when the average performance of crossbred progeny is better than the average performance of the two parent breeds. Hybrid vigour is the ‘free lunch’ that you get in crossbreds. However it is non-additive and is not be passed onto future generations. Unlike gains in the genetic merit of animals from selection within breeds, which are cumulative and are passed onto future generations. Using genetically superior animals in a crossbreeding program will result in higher performance from the progeny, regardless of the level of hybrid vigour.

The amount of hybrid vigour for any one production trait is often small. However, in the case of a composite trait, the hybrid vigour from each trait has a compounding effect, and the impact on production can be quite large. For example, the number of lambs weaned is a composite trait that expresses three other traits: fertility (the proportion of ewes lambing); proportion of multiple births; and lamb survival to weaning.

Traits that express the most hybrid vigour tend to have low heritability. Highly heritable traits like growth rate, wool production and carcase traits tend to express less hybrid vigour. Therefore hybrid vigour shows up most in traits associated with the ability to survive and reproduce. These ‘fitness’ traits can be repressed when close relatives are mated (inbreeding – which is the opposite of hybrid vigour).

A composite (or synthetic) breed contains a mixture of genes from two or more different straight breeds. A disadvantage of forming a composite breed is that you will lose some of the benefits of hybrid vigour in later generations. The more breeds used to form the composites, the more hybrid vigour that is retained.

21.13 Conclusion

The most appropriate production system for the environment and target markets for products need to be carefully defined in any sheep enterprise. There is considerable genetic variation between and within breeds that can be exploited. However breed substitution needs to be approached with caution. A new breed may excel in a desirable trait but it may be inferior in other characteristics that contribute to overall merit for the sheep enterprise. There is generally little objective data available to compare breeds and it often has limited genetic sampling and information on the merit of the tested animals relative to their average breed performance. The development of national genetic evaluation programs that have sufficient linkage to use across-breed procedures is addressing this issue. From a genetic improvement perspective this is negating some of the need for breeds within broad production types. There is considerable genetic variation for the major production traits and also those traits associated with product quality and adaptation. The availability of accurate genetic parameters (especially genetic correlations) allows seedstock breeders to develop more complex breeding objectives that combine wool, meat and disease traits and to be confident of the predicted outcomes of breeding programs. In addition, commercial breeders can use the information provided by the ASBVs and the various indexes to select rams that will make predictable changes to improve profitability and better meet the target market requirements for their products.
Readings


(Can also get to this site through the MLA web site – [http://www.mla.com.au](http://www.mla.com.au))

## Glossary of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across breed ASBV</td>
<td>ASBV that compare animals both across flocks within a breed and between breeds. All terminal ASBVs are ‘across breed’.</td>
</tr>
<tr>
<td>Across-flock</td>
<td>Animals in different flocks can be compared genetically as the analysis uses pedigree links to assess deviations in performance from common or related animals.</td>
</tr>
<tr>
<td>ASBV</td>
<td>Australian Sheep Breeding Value - between flocks and in the case of terminal sire breeds, between breeds.</td>
</tr>
<tr>
<td>Breeding Objective</td>
<td>The goal of the breeding program. Usually represented as a combination of traits to be improved in a desired direction.</td>
</tr>
<tr>
<td>C site</td>
<td>45 mm from the centre of the spine at the 12th and 13th rib. Site at which fat and muscle is measured by ultrasound scanning.</td>
</tr>
<tr>
<td>FBV</td>
<td>Flock Breeding Value – only within that individual flock. These are of lesser value to a commercial producer than ASBVs.</td>
</tr>
<tr>
<td>Fat Depth</td>
<td>The depth of subcutaneous fat measured at the C site.</td>
</tr>
<tr>
<td>Genetic Correlation</td>
<td>The genetic relationship that exist between traits.</td>
</tr>
<tr>
<td>Genetic Linkage</td>
<td>When two or more flocks share common genes.</td>
</tr>
<tr>
<td>GR site</td>
<td>110mm from the centre of the spine on the 12th rib.</td>
</tr>
<tr>
<td>Management Group</td>
<td>A group of animals that have been run under equal management and nutritional conditions.</td>
</tr>
<tr>
<td>Selection Index</td>
<td>A multiple score system, based on a number of component criteria, to give an overall selection criterion (an index) which can be used to rank animals for selection purposes. Used to combine various ASBVs into one measurement of performance that meets a market specification or a desired breeding goal.</td>
</tr>
<tr>
<td>Terminal Sire</td>
<td>A sire that is used to produce lambs which are all slaughtered.</td>
</tr>
<tr>
<td>Genotype</td>
<td>The genetic component of performance for an animal that can be passed on to progeny.</td>
</tr>
<tr>
<td>Heritability</td>
<td>The proportion of variation in a trait that is genetic and can be passed on to progeny.</td>
</tr>
<tr>
<td>Hybrid vigour</td>
<td>Is present when the average performance of crossbred progeny is better than the average performance of the two parent breeds.</td>
</tr>
<tr>
<td>LAMBPLAN</td>
<td>A component of the genetic evaluation program that is operated by Sheep Genetics (SG) to provide breeding values and other genetic evaluation information on meatsheep and maternal sheep.</td>
</tr>
<tr>
<td>Maternal breeds</td>
<td>Breeds used in the maternal sector of the sheep industry for crossbreeding e.g. Border Leicester which is crossed with the Merino to produce crossbred ewes as dams for lamb production.</td>
</tr>
<tr>
<td>Maternal weaning weight ASBV</td>
<td>The ASBV for the additional weaning weight of progeny from daughters of the animal e.g. Border Leicester ram with ASBVmwwt=+5 will have crossbred daughters that will produce second cross lambs that are 2.5 kg heavier (half ASBV passed on from the sire) at weaning than a Border Leicester ram with ASBVmwwt=0.</td>
</tr>
</tbody>
</table>