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Unit Standard 19157

Sheep

Demonstrate knowledge of sheep genetics, and ram selection

Version 2 Level 3 Credit 5

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Learning objectives

People credited with this unit standard are able to demonstrate knowledge of:

- the principles of genetics as they affect sheep breeding
    - describe genetic gain in terms of its application to sheep breeding and production improvement
    - describe the role of genes and chromosomes in relation to sex determination, heredity, traits and cell division
    - differentiate heredity and environment and describe in terms of their influence on genetic improvement
    - describe the normal distribution curve in terms of its use in breeding programmes

- the identification and recording of traits for sheep breeding purposes
    - describe the identification of desirable traits in relation to productive value, ease of management, and visual and structural characteristics
    - Describe desirable traits in terms of measurement and recording

- ram selection
    - describe ideal physical features of rams in accordance with on-farm breeding procedures
    - describe breeding values for rams in terms of the important features
    - describe information required for ram purchase in terms of the sources available

- selection of sheep for culling and wastage
    - describe selection, culling, and wastage in terms of livestock farming practice
    - describe the effects of culling and wastage of sheep in terms of the way they influence livestock breeding
    - calculate the number of replacements needed from given culling and wastage figures

An introduction to genetic improvement

Combining sheep of superior genetic merit with good management and suitable environments is necessary to ensure sheep produce the type of products consumers want, while allowing farmers to make sustainable profits.

Genetic improvement requires breeders to accurately record information and details of their sheep for the traits they wish to improve. New Zealand's main sheep recording company is Sheep Improvement Ltd (SIL). It is administered by Beef + Lamb New Zealand Ltd. SIL maintains breeding records for stud flock breeders and other ram breeders, and produces estimates of genetic merit for recorded sheep.

There is no single trait to breed for that will determine farm income on its own. Animals with different characteristics can be of equal merit in an enterprise, but for different reasons.

The New Zealand sheep flock has around 24 million breeding ewes. Approximately 40% of the national flock is Romney, 12% Coopworth, 10% Perendale, 5% Merino, 3% Corriedale, and the balance Halfbred and other breeds. The 'other' breeds are fewer in number but are very important as they supply terminal sires to produce lambs for the export meat trade. Each breed has specific genetic traits or characteristics that are designed to meet a range of consumer and farmer requirements.

For example, Romneys have been bred to produce good all-round performance throughout New Zealand. They are generally good mothers, have medium lamb growth rates, average to good lambing percentages, reasonable carcass quality and good coarse wool fleece weights. In contrast, Merinos are best suited to dry areas of New Zealand such as Central Otago, they produce fine wool, often have below average lambing percentages (although this could be due to the environments they are farmed in rather than genetics) and relatively low lamb growth rates. Romneys are farmed for their meat and wool, whereas Merinos are mainly farmed for their fine wool. Each breed requires a different focus for genetic improvement depending on the products grown.

Before looking at the recording and selection of sheep to improve flocks some understanding about traits, genes and chromosomes is required. These terms will be referred to during the module and you will need to understand them.

Basic genetics

There are many websites that describe basic genetic principles. One good site can be found at learn.genetics.utah.edu. This website will take you through a tour of the terms and give you a simple introduction to genetics and hereditary traits. There are many similar websites that can be found by typing in the words 'gene', 'genetics' or 'chromosome' in the search box. Most of these sites refer to human genetics but all living things have genes, chromosomes and hereditary traits.

The major terms in genetics are:

- Cells: These are the small units that make up any living organism. Each cell has a nucleus, a cell wall or membrane and a jelly-like cytoplasm contained within the cell membrane.
- Germ cells: Germ cells become the reproductive cells in a body, i.e. germ cells develop into eggs or ova in a female and sperm in a male.
- Nucleus: The nucleus contains the information as to what the cell does. The instruction comes in the form of the DNA molecule (see below).
- Genes: Genes are the equivalent of the instruction manuals for the body. They are the directions for building all the proteins that make a body function, whether it is sheep, cattle or humans. The genes for particular traits are found in the same place on the same chromosome in any sheep.
- DNA: The full name of DNA is deoxyribonucleic acid and it is the main component of chromosomes. Genes are the sites along the length of the chromosome that control traits. One strand of DNA contains many genes and it is the mix of genes in the DNA that determine whether a leg grows, wool grows or there is more fat in the meat in a particular animal. DNA is constructed of two organic compounds called nucleotides - phosphate (P) and deoxyribose (D). The nucleotides form strands twisted into a double helix (see blue strands pictured right). A double helix means the strands coil around each other in a ladder-like arrangement. Each strand is made up of alternating phosphate (P) and deoxyribose (D) units (light and dark blue parts). The rungs (see yellow, pink, green and purple parts pictured right) are composed of the compounds adenine (A), guanine (G), cytosine (C), and thymine (T).

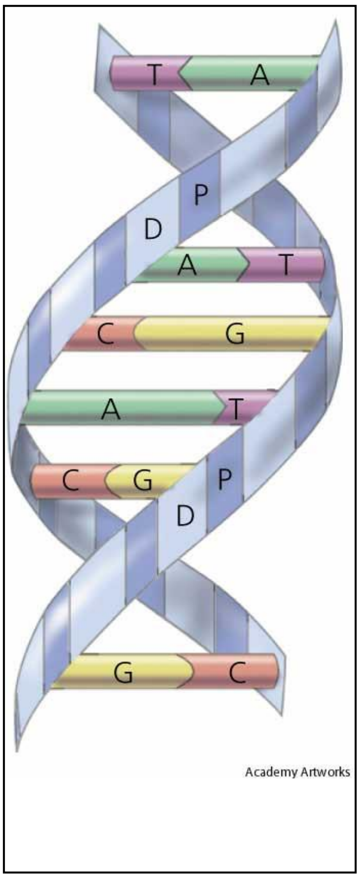


Figure 1 DNA structure an d components

- Chromosomes: Chromosomes are the storage units for DNA. In other words, DNA is packaged into compact units called chromosomes. Chromosomes come in pairs and each animal of a particular species has the same number. In humans each cell has 46 chromosomes that come in 23 paired sets. Sheep have 54 chromosomes in 27 paired sets, and cattle have 60 chromosomes in 30 paired sets.

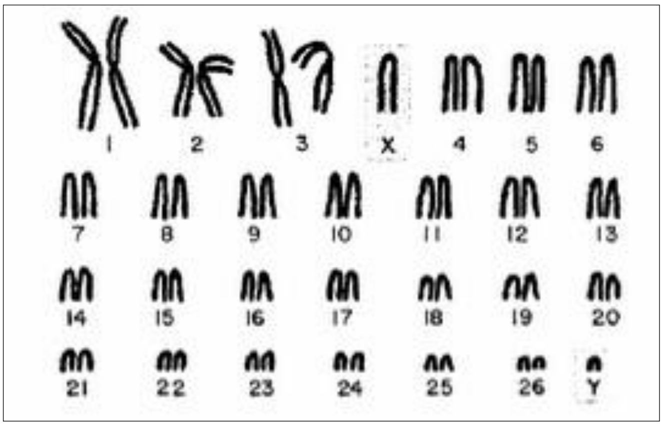


Figure 2 Ram chromosomes (note one y and one x chromosome)

Chromosomes are usually numbered from the largest to the smallest except for the sex-determining chromosomes which are denoted as being the "X" and "Y" chromosome. The "Y" chromosome is a lot smaller than the "X" chromosome.

- Allele: An allele is one member of a pair of genes occupying a specific spot on a chromosome (called a locus) that contributes to a trait. There can be more than one allele controlling a trait. For example, there are two main alleles controlling the trait for fleece colour in some sheep breeds - one allele for white and the other allele for black. There are seven alleles controlling the trait for blood type. Each sheep will have just one of the possible alleles on each chromosome. So a sheep may have one chromosome with an allele for white colour and the other chromosome in the pair may have an allele for black colour. The terms gene and allele often get confused. In the fleece colour example, a gene determines the trait of 'fleece colour'; the allele is the specific code for a particular colour such as white.
- Recessive genes: These are genes that are present in the DNA but not expressed because their features are suppressed by the allele of the dominant genes. If a recessive gene can join with another recessive gene then it can become the expressed trait. For example, with wool colour, white is dominant over black so black wool will only occur if there are two black alleles. White wool will occur if there is a black allele and a white allele as the white gene is the dominant gene.
- Dominant genes: These are the genes which are strongest in expressing their traits. They have a dominant allele that masks the recessive alternative if the recessive alternative is present in the DNA. We will look at several examples through the module.
- Traits: Traits are the characteristics of the animal. It is the combination of traits that make each individual unique. Inherited traits are passed from generation to generation and these must not be confused with the environmental influences. (See page 18 for more on genetic vs. environmental effects.)
- Hereditary traits: Hereditary traits are factors and features that can be transferred from one generation to another generation.
- Genotype: This is the total mix of genes carried by an individual. It is the genetic make up which sets the potential performance for the progeny.
- Phenotype: This refers to the appearance and/or the performance of the animal. Variations in the phenotype in a population result from the combined effect of environmental factors and the inherited genes. A combination of the environment and management are shown in actual performance of the animal.
- Fecundity: This term is also referred to as prolificacy. It is the ability of an animal to produce multiple offspring. In sheep it is the ability of the ewe to produce multiple lambs at each lambing.
- Purebred: The term refers to a flock or a bred that has not incorporated any other breed for several generations.
- Crossbred: Is a sheep or other animal produced by crossing two or more different breeds.
- F1: Is the progeny from the first cross of two purebreds.
- F2: The progeny produced from the mating of an F1 ewe and an F1 ram of the same breed composition.
- Hybrid vigour: This is also known as heterosis. Hybrid vigour occurs when the performance of the F1 animal is higher than that which is expected from the average of the two parent animal's performances. The difference in performance from the average (either higher or sometimes lower) is due to hybrid vigour.

- Composite breed: This is often referred to as a synthetic breed. The composite breed contains genes from more than one breed and is created by crossbreeding. In some cases the initial crossbreeding is followed by mating progeny to sheep of the same cross until a stable mix is produced e.g. Coopworth and Perendale.
- Cell biology: There are two types of cells in an animal. They are body cells and germ cells. The body cells form the body of the organism (organs and skin). The germ cells become the reproductive cells (sperm and egg).

Mitosis

Body cells each contain the full set of chromosomes. As chromosomes come in pairs, a body cell has 2n chromosomes where n = the number of pairs. For example, sheep have 27 pairs of chromosomes so n = 27 (2 x 27 = 54 = the full number of sheep chromosomes).

Before the body cells divide to create new cells their chromosomes replicate to create 4 pairs or 4n. One of each set of chromosomes is attracted to opposite ends of the cell which then narrows in the middle part of the cell. The cell divides at the narrow part and two new cells are created. Each new cell is an exact replica of the original parent cell and contains a full set of chromosome pairs (2n). This process of cell division of body cells is called mitosis and is illustrated on the left of the diagram on the next page.

Meiosis

When the germ cells (reproductive cells) first divide the original cell becomes like a body cell and it then undergoes a second cell division where the chromosomes number is halved. For example, after the first division of cells in a sheep the cells have 2n = 54 chromosomes but after the second division they have n or 27 chromosomes. The first division is therefore the same as mitosis as described previously. The second cell division takes place without replicating the DNA so only one strand of each chromosome is drawn to the cell (see diagram on the next page).

During the second cell division the paired chromosomes align in a tangle along the centre of the cell and some bits swap over and then rejoin. The rejoining can be different from the original. Two new cells then form containing one chromosome from each pair.

After the second division is complete there are four cells containing one of each pair or n chromosomes. In a male, each of the four cells develop into sperm and in a female the four cells create only one egg and the other three cells are wasted.

When a sperm and an egg combine the new individual has a full set of chromosomes (2n) with half from each parent. The recombined pairings which are different from the parent create the variations in the offspring.

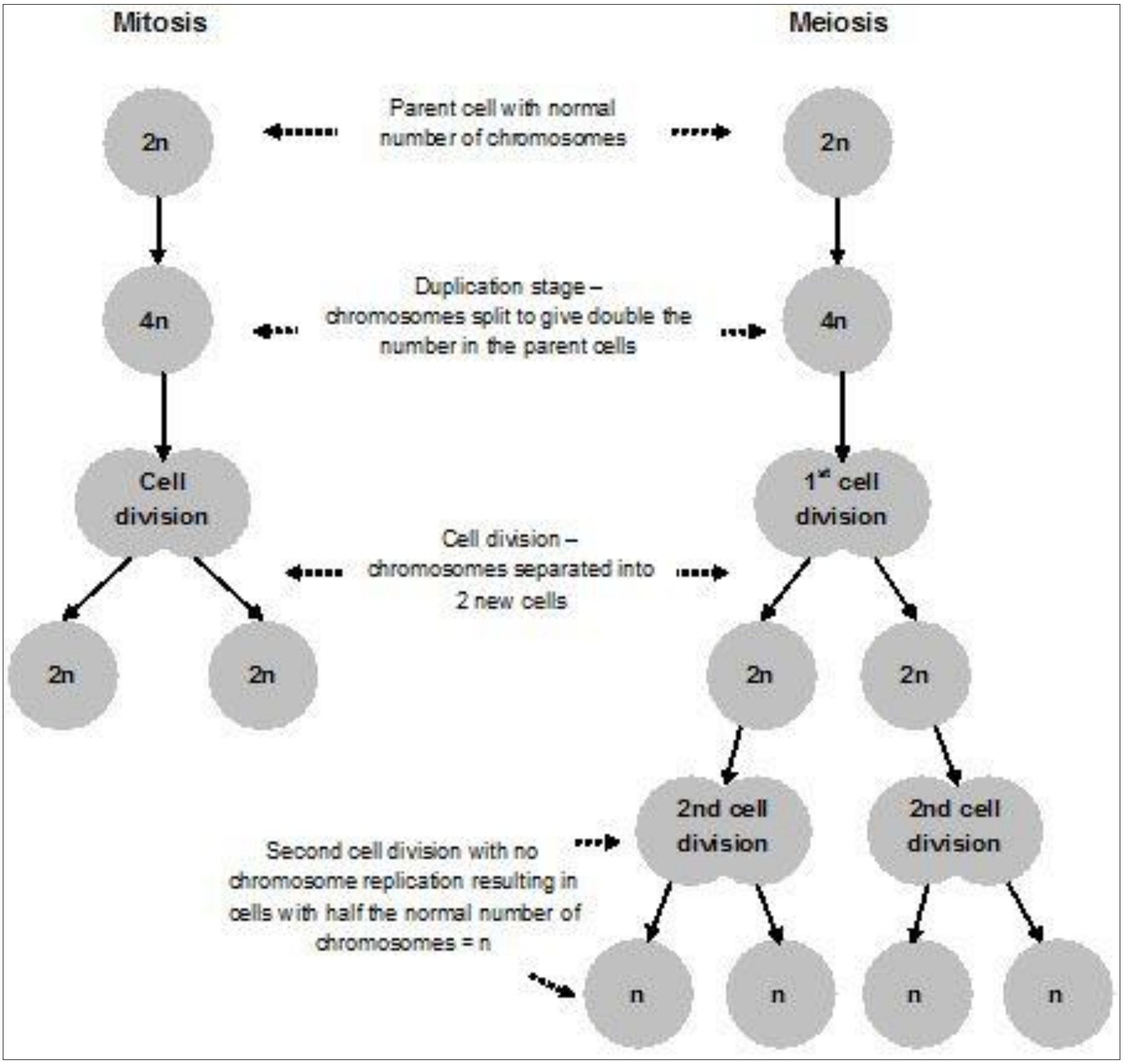


Figure 3 Mitosis and Meiosis

Gender and trait determination

Gender determination

Gender (whether an animal is male or female) is determined by one special pair of chromosomes. The chromosomes that determine the gender of an individual are referred to as the X and the Y chromosomes. Females carry two copies or a pair of the X chromosome while males carry one X and one Y chromosome. If during fertilisation an egg with an X chromosome joins with a sperm carrying a Y chromosome, then a male foetus develops. If the egg with an X chromosome joins with a sperm with an X chromosome then a female foetus develops. The shaded cells in box below below show the possible chromosome combinations. There is a 50:50 chance of male (XY) or female (XX) offspring. This process is the same for all animals.

		Male	
		X	**Y**
	X	XX	XY
Female	**X**	XX	XY

Figure 4 Gender determination from combinations of X and Y chromosomes

Trait determination

The combination of alleles of the many different genes in a sheep makes each individual unique.

An allele may be dominant or recessive. A dominant allele will always show its characteristics in an animal as long as it is present on at least one chromosome. A recessive allele always has to be present on *both* chromosomes before its characteristics will be displayed. There are some exceptions to this general rule. In some cases there can be varying degrees of allele dominance. (See www.suite101.com/content/incomplete-dominance-and-codominance-a173718 for a brief explanation of incomplete dominance and co-dominance.)

The main system of coding alleles is to use letters. Usually capital letters are given to dominant alleles and small letters to recessive alleles.

Example:

- P = polled allele (dominant) p = horned allele (recessive)
- W =white allele (dominant) w = black allele (recessive)

To show that there are always two alleles present (one on each chromosome), two letters are used.

Example:

- PP = polled sheep pp = horned horned Pp = polled sheep
- WW = white sheep ww =black sheep Ww = white sheep

If the two alleles are the same on each chromosome they are said to be homozygous. If the two alleles are different they are said to be heterozygous. This is shown in the following diagram where pairs of alleles are shown on a pair of chromosomes.

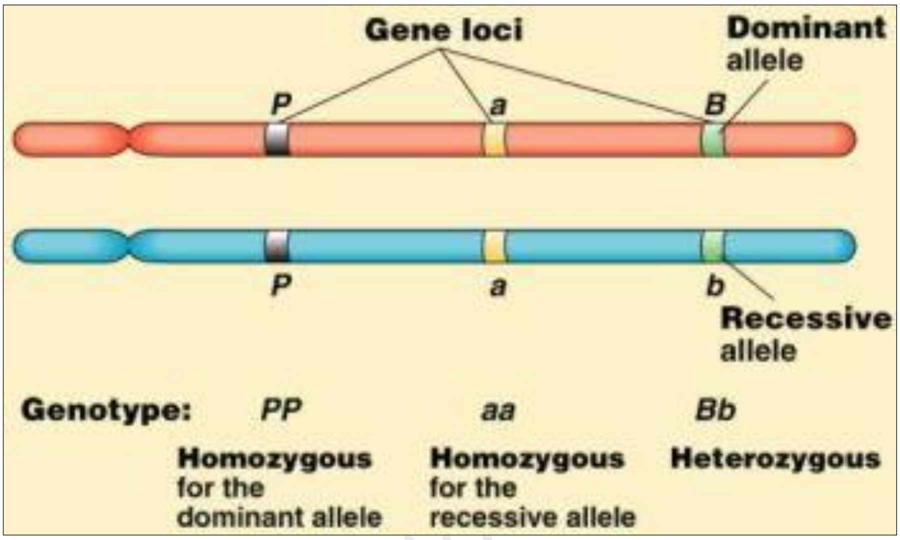


Figure 5 Allele

Source: www.teachnet.ie/lmclafferty/2004/allele.html

Exercise 1

Try this: Get a pack of cards and separate the red and the black cards, shuffle the two half decks then merge one half deck of each colour with a half deck of the other colour. After the decks have been merged, turn the cards face up and look at the different mix that has taken place between the hearts and spades, and the clubs and diamonds and the variations in the places of the numbers. The two piles will be very different each time you do the exercise. You will now have some idea as to the randomness of the how genes combine to determine traits.

Each gene site or locus for the trait is the same for all animals within the species and creates an address for the gene or the trait. New technology has allowed scientists to identify genes on a chromosome by mapping along the chromosome to identify the individual gene locations (gene mapping).

The use of gene mapping now allows the DNA to be tested prior to mating so some genes can be identified without the usual program of progeny testing which takes at least two years to obtain any measurement. To date this technology is in limited use with sheep breeding.

Gene manipulation

Over recent years the use of the word gene in breeding programs has become emotive as we hear about the negative features of terms relating to genetic modification (GM). Genetic modification is a general term that covers several gene management and altering processes. The processes require DNA to be introduced to a species from another species or altered within the species by means other than the normal combination of an egg and a sperm.

Sheep have been in the forefront of GM programmes with Dolly being the most famous cloned sheep. A flock of transgenic sheep in the central North Island provided a human protein for drug manufacturing. More detailed knowledge of genetic modification is part of further and more intensive studies and is not covered in this unit standard.

Single gene traits

A trait that is controlled by a gene with alleles located at a single locus is called a single gene trait. There may be just two alleles or several. Alleles may be dominant or recessive.

Some examples of single gene traits involving just two alleles are:

- polledness (no horns) is dominant to horns
- white fleece colour is dominant to black fleece colour (sheep colour is more complex than this suggests but is beyond the scope of this unit standard)
- the hairy allele in Drysdale sheep is dominant to the non hairy allele

In the simplest cases, a breeder can identify a particular gene (e.g. the 'hairiness' gene in Drysdale sheep) and then, by following a breeding plan based on dominant and recessive allele knowledge, establish an animal that displays the desired trait.

For example, suppose a *white* ram carries two dominant alleles of the 'colour' gene (WW) and a *black* ewe carries two recessive alleles of the 'colour' gene (ww). (Remember chromosomes come in pairs so you have two alleles present for each trait.) The sperm will only have the dominant W gene and the egg will have only the recessive w gene. If the ram and ewe mate, all of their lambs will be heterozygous (carry one W and one w) and all will be white because white (W) is dominant over black (w). See the figure on the next page.

		Ram (white) W	W
Ewe (black)	w	Ww	Ww
	w	Ww	Ww

Figure 6 Possible gene combinations
for progeny from a white ram with homozygous dominant colour genes (WW) and a black ewe with homozygous recessive colour genes (ww).

The progeny of this mating between the white ram and black ewe are called the F1 offspring or generation. F stands for filial, which means the generation after the parents.

Now look what happens if the F1 offspring are mated. Half the heterozygous ram's sperm will carry dominant W and half will carry recessive w, likewise, half the ewe's eggs will have W and half w.

		Ram (white) W	w
Ewe (white)	W	WW	Ww
	w	Ww	ww

Figure 7 Possible gene combinations
for progeny from a ram and ewe with heterozygous colour genes (Ww).

The progeny of this mating between the F1 heterozygous white ram and ewe are called the F2 offspring or generation. The F2 offspring would be:

- 1/4 homozygous WW and white
- 1/4 homozygous ww and black
- 2/4 heterozygous Ww and white in colour but carry the recessive black allele

Exercise 2

Make up a similar example for polled and horned sheep. Use “P” for polled which is the dominant gene and “p” for the horned gene which is the recessive gene. How many polled and horned lambs will be born when a horned ram (pp) is used as a sire with a heterozygous polled ewe (Pp)?

Answer:

		Ram (horned)	
		p	**p**
Ewe	**P**	Pp	Pp
(polled)	**p**	pp	pp

50% will be polled and 50% horned.

A breeding plan with known gene structures is shown in the following example:

- N^d = dominant Drysdale hairy gene
- n = recessive Romney woolly gene

Purebred offspring	Drysdale X Drysdale = homozygous parents which give Drysdale offspring. N^dN^d X N^dN^d = all offspring N^dN^d hairy
	Romney X Romney = homozygous parents which gives a Romney offspring. nn X nn = all offspring nn woolly
F1 offspring	Romney X Drysdale = heterozygous offspring. N^dN^d X nn = all are N^dn These animals are referred to as F1 and are hairy.
F2 offspring	F1 heterozygous mated to a Drysdale will give homozygous and heterozygous offspring but they will all be hairy. N^dN^d X N^dn = N^dN^d + N^dn
	F1 heterozygous mated together gives a mix of homozygous and heterozygous (¾ hairy and ¼ woolly) N^dn X N^dn = N^dN^d + N^dn + N^dn + nn

There have been two major genes identified in New Zealand that have a very large affect on the fecundity of sheep. There are likely to be other genes in some other flocks that will also have major affects on breeding programmes. Continual work is being undertaken to identify these.
The two major genes identified to date are:

Figure 8 Drysdale ram with hairy fleece

Booroola

The Booroola gene was discovered in prolific Merino sheep but has since been bred into a large number of breeds. The Booroola gene works like this: If a ewe sheds one egg (ovum) per ovulation then one copy of the Booroola gene will increase that to 2.5 eggs, two copies will increase it to four eggs per ovulation. For every extra 1.5 eggs there is an expected increase in litter size of one. So a sheep normally producing one lamb will have two lambs with one copy and about three lambs for two copies of the Booroola gene. The Booroola gene is commercially available and has been known for many years yet there has been little use of the Booroola gene in commercial flocks.

Inverdale

The Inverdale gene was discovered in the Invermay flock which was selected for its high level of fertility and originated from a ewe that had produced 40 offspring over thirteen productive years. The Inverdale gene is found on the X chromosome so a carrier ram (X^1Y) will pass it on to all his daughters and none of his sons. (The symbol X^1 indicates the gene is carried on the X chromosome.) A ewe with one copy (X^1X) will pass it on to half of her offspring of either sex. A single copy of the Inverdale gene increases the ovulation rate by about one egg per ovulation and the litter size by about 0.6. Ewes with two copies (X^1X^1) are infertile and will have non-functional ovaries. Gene markers can now identify animals that carry the genes. The Inverdale ram can be used to produce ewe lambs with one copy of the gene which are then mated to a terminal sire to avoid producing a barren female. The Inverdale gene is available in a variety of breeds.

Multi-gene traits

Where genes at more than one locus determine a trait it is called a muliti-gene trait. Multi-gene traits that involve measurement are called quantitative traits. Examples include sheep weight and fibre diameter. Weight is measured in kilograms and fibre diameter in microns. Note that these traits can not be grouped into distinct categories such as black or white, or horned or polled. Instead these traits represent a continuous gradient of variation within the flock. Your ewes prior to mating may vary from 50kg to 70kg, or the fibre diameter of your ewes fleeces may vary from 26 microns to 40 microns.

Quantitative traits are determined by the additive action of many genes. To oversimplify for the sake of explanation, assume that ewe weight is determined by five different genes called A, B, C, D, and E. Each gene has two alleles. The recessive alleles a, b, c, d, and e make no contribution to weight and the dominant alleles A, B, C, D, and E make equal contribution to weight. (To further simplify this exercise we will ignore any environmental influences on weight.)

A ewe that has the alleles aabbccddee would be of the lightest possible weight and a ewe that has the alleles AABBCCDDEE would have the heaviest possible weight. Ewes that have the alleles AaBbCcDdEe would be of average weight. Ewes that are AabbCCddEe and aaBBccDDEe would also be of average weight. Why? Because the effect of the dominant alleles is additive. All three allele combinations that result in average weight ewes contain exactly five dominant out of the possible ten dominant alleles. In this simplified explanation, it is not important which of the dominant alleles are present because they all contribute equally to the final expression of the trait. Other allele combinations could be Aabbccddee, aabbCcddee, and aabbccddEe. In this case all the ewes would be the same weight and just a bit heavier than aabbccddee ewes.

Many of the traits important to sheep breeding and production are multi-gene quantitative traits. They account for the large variation in production between individual sheep. They are also complicated by environmental affects on animals. For example, a ewe's genes may determine her potential weight but environmental factors over her lifetime will also affect her weight.

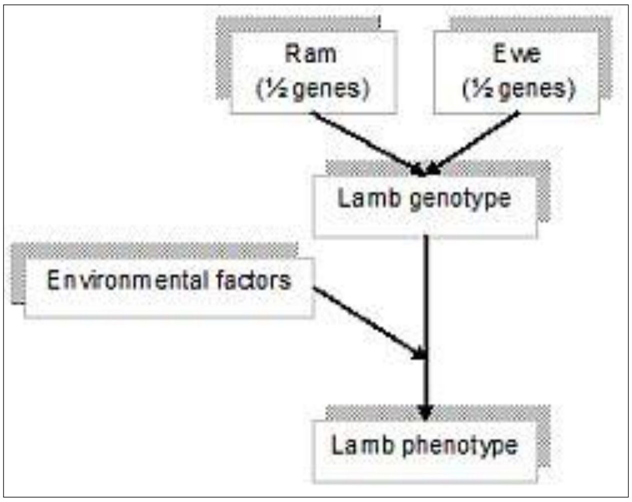
Population genetics is used to describe and measure the variability of multi-gene quantitative traits.

Genes are not the only influence on the expression of traits. The environment also plays a part.

Genotype and phenotype

The terms genotype and phenotype can be thought of as the internal and external composition of an animal.

- The genotype is the genetic, heritable information carried within an animal in its DNA.
- The phenotype is the displayed aspects of an animal; anything that is part of its observable form, function or behaviour.



The genotype interacts with the environment to produce the phenotype. Environmental factors do not change the genotype of the animal but they do affect the animal's ability to perform to its optimum genetic potential. For example, while genes play a role in determining a lamb's size, nutrition levels and other conditions it experiences after being conceived also have a large effect.

Some environmental factors that are important for ram and ewe selection include:

- birth date – important for traits measured early in life such as weaning weight
- birth/rearing rank – twin lambs are usually lighter than single reared lambs
- sex – ram lambs are typically heavier than ewe lambs
- age of dam – hoggets typically produce lighter lambs than older ewes

Heritability (h^2) tells us how much of the variation in phenotype is caused by genes. A high heritability means that the environment has a lesser effect on the phenotype. From the table below the h^2 of mean fibre diameter is 0.40 to 0.65. This means that 40% to 65% of the variation in fibre diameter comes from genes and 60% to 35% comes from the environment, which includes the management of the sheep. The h^2 of the number of lambs born is very low, i.e. 0.05 – 0.20. This means that management is the most important factor in improving the number of lambs born.

To assist in identifying the ability of a gene trait to influence a breeding program a range of heritability estimates have been established and the accepted ranges are listed in Table 1 on the following page.

Table 1 Traits and their heritability

Trait	Heritability
Number of lambs born	0.05 - 0.20
Number of lambs weaned	0.05 - 0.15
Weaning weight	0.10 – 0.35
10 month (hogget) weight	0.20 – 0.50
Hogget fertility	0.05 – 0.15
Greasy fleece weight	0.30 – 0.40
Staple length	0.35 - 0.45
Mean fibre diameter	0.40 - 0.65
Crimps per cm	0.30 – 0.50
Bulk	0.20 - 0.50
Medullation	0.40 – 0.70
Greasy colour	0.10 – 0.30
Face cover score	0.20 – 0.40
Live animal ultrasound scans	
EMD (eye muscle depth)	0.15 – 0.35
EMW (eye muscle width)	0.10 – 0.35
FDM (fat depth over eye muscle)	0.10 – 0.35
Carcass traits	
Fat depth (over eye muscle)	0.25 – 0.40
EMA (eye muscle area)	0.25 – 0.60
Lean weight	0.20 – 0.40
Fat weight	0.20 – 0.40

To convert the heritability (h^2) to a percentage multiply it by 100, e.g. h^2 for hogget fertility is 0.05 to 0.15 or 5% (0.05 x 100) to 15% (0.15 x 100).

Rate of genetic gain

Genetic gain or improvement is the selection and breeding of sheep with better production genes and/or genes that reduce costs.

The *rate* of genetic gain is the speed with which genetic improvement happens.

Rate of genetic gain (RGG) is controlled by three factors. They are:

1. heritability (h^2)
2. selection differential (SD)
3. generation interval (GI)

Heritability (h^2)

Heritability refers to the percentage of variation in a trait that can be explained by genetic variation. It is measured as a percentage (e.g. say, 10% or, the decimal version, 0.10). Traits with high heritability measure around 30% or higher, medium heritability around 10 to 30% and low heritability below 10%. In general growth traits tend to have relatively high heritability and fertility traits tend to have low heritability.

Selection differential (SD)

The selection differential is a measure of how good the parents of the next generation will be compared to the existing flock average. Rams and ewes should be considered separately as you can be much more selective among the rams as fewer are needed for mating. It is important to pick parents as far above the flock average as possible, because if you breed average males to average females you will get average offspring and no progress will be made.

To calculate the selection differential for an individual sheep, the flock average for the particular trait being measured is subtracted from the trait measured for the selected sheep. It is critical that on-farm trait measurements are corrected for environmental affects such as birth date, rearing rank, etc. so the selection differential reflects the genotype for each animal. In the following example assume measurements have been corrected to take into account environmental effects. To calculate SD:

Corrected average fleece weight of all weaned ram lambs	= 3.98 kg
Corrected average fleece weight of selected ram	= 4.30 kg
Selection differential	= 4.30 – 3.98
	= 0.32 kg

The higher the SD the greater the selection pressure for the particular trait. In other words, the higher above the flock average the selected animals are for a particular measured trait, the quicker genetic improvement can be made. Selection differentials for rams are typically higher than those of ewes, because you select a much smaller proportion of the rams.

The following example calculates the SD for a group of hoggets selected for fleece weight. Assume a small flock of ten ewe hoggets and you want to select seven of these as replacements based on fleece weight. Assume measurements have been corrected for environmental affects.

Hogget No	**Fleece weight (kg)**	**Fleece wgt of selected hoggets (kg)**
1	4.20	4.20
2	4.30	4.30
3	4.25	4.25
4	3.70	Culled
5	4.00	4.00
6	3.80	3.80
7	4.10	4.10
8	3.75	Culled
9	4.15	4.15
10	3.55	Culled
Total	39.80	28.80
Average	**3.98**	**4.11**

Selection Differential (SD) = 4.11 – 3.98 = 0.13 kg

If the measurements in the above example were raw, uncorrected data the fleece weights would include environmental effects. For example, if the hoggets had *not* been shorn as lambs then the older hoggets would have a heavier fleece weight than younger ones. This illustrates why environmental affects such as birth date need to be taken into account.

If the hoggets had been shorn as lambs then the growth of wool would have been constant from that time until they were shorn as hoggets. This would have reduced some of the environmental affects on fleece weight. Correcting for environmental affects is reasonably complicated. It is usually carried out by organisations that specialise in analysis and database services for sheep breeders such as SIL (Sheep Improvement Ltd.).

Note: The SD can be calculated for any of the selection features that a breeder uses as the basis for the selection and improvement of a flock.

Generation Interval (GI)

The generation interval is the time interval between generations. It's defined as the average age of the parents when the offspring are born. The shorter the GI the faster improvements can be made. For example, ewes first mated as hoggets reduce the GI compared to first mating as two-tooths.

The trait being measured may lengthen the GI as you may have to wait for offspring to display the trait before being able to make selections. For example, if you are selecting for adult fleece weight of progeny then you have to wait one season before making selections.

Calculating rate of genetic gain

RGG is on a per year basis and can be calculated from the following equation:

RGG = (heritability x selection differential) ÷ generation interval

To get the maximum RGG you need to breed for traits that have a high heritability, then maximize the selection differential by choosing top performing stock, and keep a low generation interval, i.e. breed as often as possible.

For example, if:

h^2 = 30% (heritability of fleece weight)

SD = 0.13 kg (for fleece weight)

GI = 2 (breeding as two-tooths)

RGG = (0.3 x 0.13) ÷ 2

= 0.019 kg fleece weight/year

If the SD = 0.2 and GI = 1 (mating as hoggets)

RGG = (0.3 x 0.2) ÷ 1

= 0.06 kg fleece weight/year

Increasing the SD and decreasing the GI results in an improvement in the rate of genetic gain.

Population genetics

Population genetics is based on measuring the variation within a population (e.g. a flock of sheep) around the mean or average of the population. From this population individual animals with superior economic traits are selected so they can become the parents of the next generation. Continual selection of parents from above the mean creates improvement.

Important traits and variation within a flock are measured with environmental corrections where possible. It is only the genes that are passed on so it is important to separate genetic merit from environmental influence (this is discussed further on page 18).

Population genetics requires the understanding of some basic statistics and mathematics. We will introduce you to the basic concepts to help you understand the principles of the standard or normal distribution curve (also called the bell curve) and how it is used in animal breeding.

Normal distribution curve

The spread of performance variables or measures found in a population is known as the normal distribution curve. A normal distribution of data means that most of the individual measures in a set of data are close to the mean, while relatively few measures tend to be a lot bigger or a lot smaller.

For example, if you were interested in wool fibre diameter for a given sheep breed, you would expect most animals to have a similar fibre diameter but there will be some that will have much finer wool than the mean and some a lot coarser. The distribution of the measurements around the mean follows a normal distribution curve.

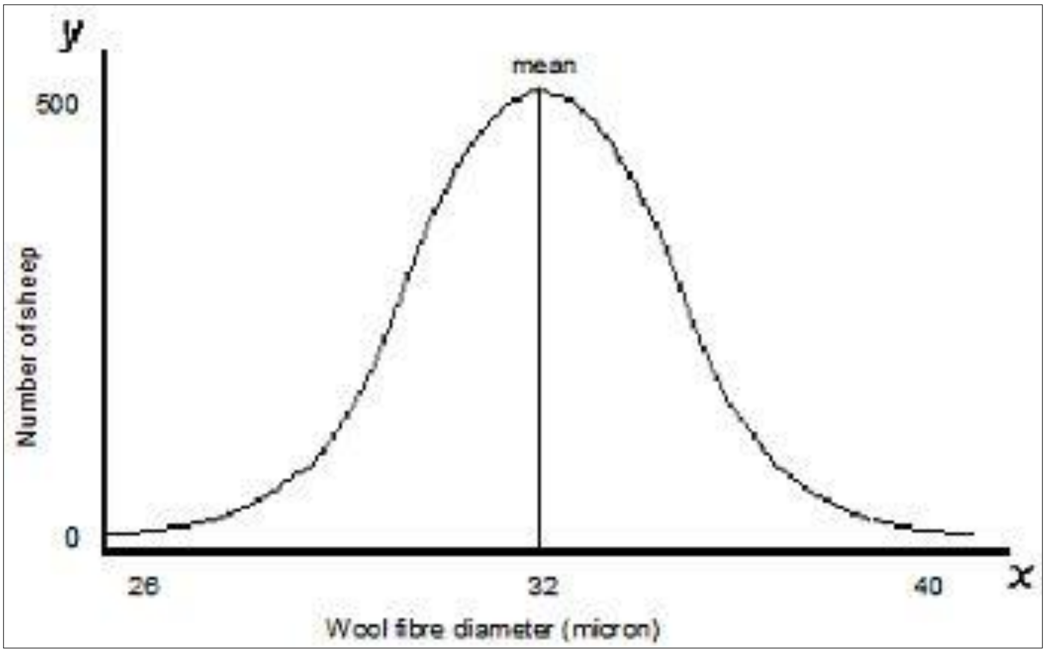


Figure 9 Normal distribution curve

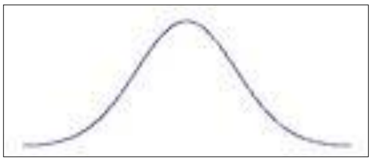
The x-axis (the horizontal one) is the measure of the trait of interest e.g. wool fibre diameter, lamb weaning weight or loin lean yield. The y-axis (the vertical one) is the number of data points for each value on the x-axis... in other words, the number of sheep with x fibre diameter, the number of lambs with x weaning weight or the number of lambs with x loin lean yield.

The interaction of many genes at many loci can produce a wide variety of offspring. The normal distribution curve is used to measure the change in the continuous variables as they are measured within a large population. The continuous variables are the traits such as fleece weight, growth rate or fat depth while traits such as survival and fertility do not have continuous variation. That is, a lamb either survives or it doesn't and ewe either becomes pregnant or it doesn't whereas fat depth could vary from 1mm to 20mm and growth rate may vary from 0.1 kg a day to 1.0 kg a day. Within the population there is a typical distribution pattern and the measurement of the changes within the pattern shows the rate of development or change.

Figure 10 mob of ewes

Each of these ewes will have a different liveweight which will form a range from light (e.g. 45kg) to heavy (e.g. 75kg). Many of the ewes' liveweight will be close to the average flock liveweight (e.g. 60kg).

The normal distribution curve is always 'bell-shaped', but how narrow (also called 'tight') or flat the curve is, is determined by how close to the mean each measure is. In other words, if most animals had a fibre diameter close to the mean of 32 micron we get a steep and tight curve (like the graph on the right below) or if a relatively high number of the sheep have lower and higher micron measures than the mean, the curve may be wider and flatter (like the graph on the left below).



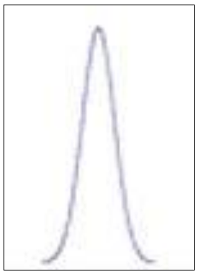


Figure 11 Left: Flat normal distribution curve
Right: Tight normal distribution curve

Standard deviation

The standard deviation is the statistical expression of how variable the results are. A large standard deviation means that the population is highly variable (a flat normal distribution curve), while a low standard deviation means that there is little difference between the best and the worst animal and that they are all very close to the mean (a tight normal distribution curve).

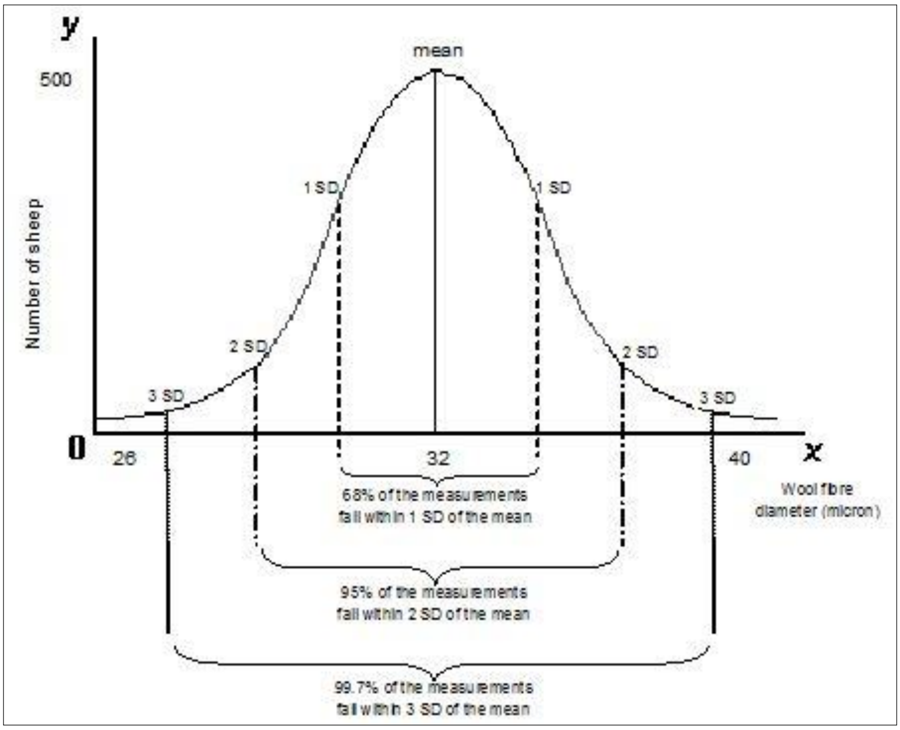
Computing the value of a standard deviation is complicated but the 'empirical rule' is a handy quick estimate of the spread of the data given the mean and standard deviation of a data set that follows the normal distribution.

The empirical rule states that for a normal distribution:

- 68% of the data will fall within 1 standard deviation of the mean i.e. 34% above and below the mean
- 95% of the data will fall within 2 standard deviations of the mean i.e. 47.5% above and below the mean
- almost all (99.7%) of the data will fall within 3 standard deviations of the mean i.e. 49.85% above and below the mean

Note that these values are approximations. For example, 95% of the data will actually fall within 1.96 standard deviations of the mean; 2 standard deviations is a convenient approximation.

The following graph (not to scale) shows a normal distribution curve for wool fibre diameter and the standard deviations (SD) around the mean. The solid line marks the mean diameter; the dashed line, 1 standard deviation; the dot and dashed line, 2 standard deviations and the fine dotted line 3 standard deviations.



If this curve were flatter and more spread out, the standard deviation would be larger in order to account for 68 percent of the fibre diameter measurements. So that's why the standard deviation can tell you how spread out the measurements in a set are from the mean.

If you are aiming to produce wool with a fibre diameter finer than the mean you would select animals that fall to the left of the mean. If you want coarser wool than the mean you would select animals with diameter measurements from the right side of the mean.

The aim in all breeding programmes is to continually move the mean line to the right and in some cases tighten up the curve so more animals have the mean measurement you are selecting for. The tightening of the curve will also result in less selection possibilities as the population gets closer to the mean.

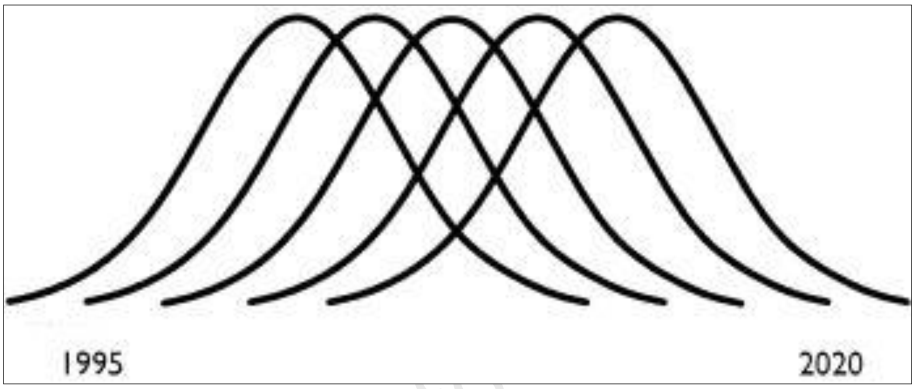


Figure 12 A curve moving to the right to show how a flock improves from the base year of 1995

Test Yourself #1

How do genes determine the sex of an animal? Include a diagram to show the combination of genes.

1. What is a trait?

2. How many pairs of chromosomes does a sheep have?

3. Describe the difference between meiosis and mitosis.

4. Describe an F1 cross and how it is created.

5. Describe the main difference between dominant and recessive genes for single gene traits.

6. What does the term heritability describe?

7. What is the heritability of:
    - fleece weight
    - weaning weight
    - lean weight

8. Draw a typical normal distribution curve.

9. Draw a narrow and flat normal distribution curve and explain what information the shape of the curve gives you.

10. Using a normal distribution curve, show the general area of the curve you would ideally use to select rams from as part of a breeding programme. Use wool fibre diameter as an example.

11. Define phenotype.

12. Define genotype.

Identification and recording of traits

When developing a breeding programme you need to decide what traits to use as the criteria for selecting and culling rams and ewes. Traits can be considered in terms of production and ease of management.

Importance of common selection traits:

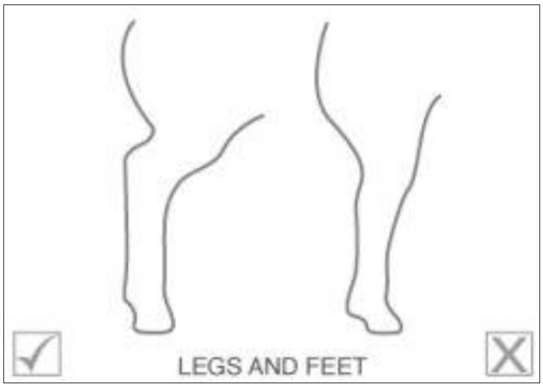
Trait	Importance
Survival rate	Important in all breeds as there is no point in having a high lambing percentage if lambs do not survive.
Growth rate (weaning weight)	An important selection trait in meat producing breeds because the faster lambs grow the less time to slaughter and, for dual-purpose breeds, the less time to meet target liveweights.
Carcass composition (meat yield)	An important selection trait in meat producing breeds recording fat and lean meat yield.
Milking ability	An important trait in all ewes having multiple births to ensure each lamb is adequately fed to survive and grow. This trait is usually indicated by lamb growth to weaning. Milk production is also particularly important for dairy sheep farmed for milk.
Facial eczema and parasite susceptibility	Low susceptibility is important for easy-care management and lower production costs.
Fecundity (litter size)	An important trait in all breeds provided it does not compromise production in other areas.
Fleece weight Fibre diameter Staple length Wool colour	Important selection traits for fine wool breeds such as Merino and for specialist carpet wool breeds.

If you are to select animals using any of the above traits you need to measure the traits. For example:

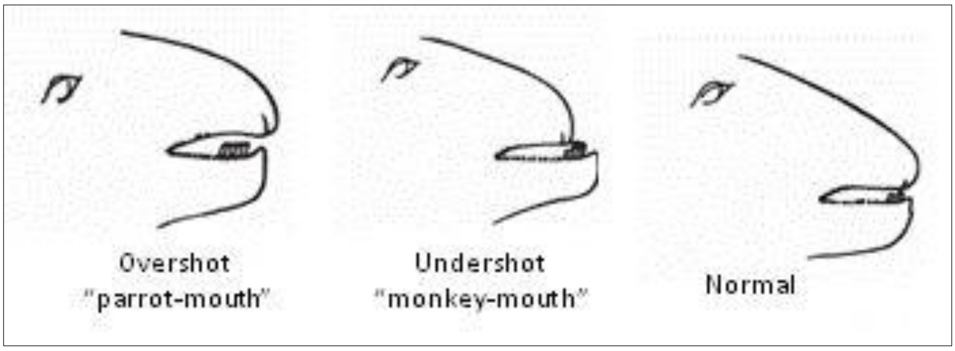
Trait	When measured	Measurement units	Method of measuring
Weaning weight	At weaning	Kilograms (kg)	Using sheep scales
Fleece weight	Usually at hogget shearing	Kilograms (kg)	Using scales
Fibre diameter	Usually at hogget shearing (before hoggets shorn)	Microns (μ) – measured by wool testing laboratory	Mid-side sample taken just before shearing
Fecundity	At birth	Number of lambs/ewe	Counting lambs born for each ewe
Meat yield	At slaughter	Kilograms (kg) – measured by meat processor	No on-farm measurements taken

Environmental effects need to be considered when measuring traits. For example, if you want to compare weaning weights of lambs ideally they should be run as one mob, and ram and ewe lambs compared separately. Stud farmers need to correct for date of birth, birth/rearing rank and age of dam, usually analysing ewe and ram lams separately. Feeding has significant effects on fleece weight also so comparisons should ideally be made within a single mob. Fibre diameter of wool is affected by ewe age and feeding so, again, measurement comparisons need to take this into account.

In addition to the above traits that can be measured, structural and visual characteristics can also be assessed.



- Sheep need sound feet with low susceptibility to foot scald and foot rot. Sore feet can lead to reduced feed intake and result in lower overall performance. Ability to mate may also be affected.
- Legs should be set squarely under the corners of the body. They should not be too close at the knees. The pasterns (the angled part just above the hoof) should not be too straight or too angled (see diagram). The back of the legs and the rump should be in line (compare diagram on right with rams in picture above). Sound legs, free of defects ensure ease of movement. This is particularly important in New Zealand's free range grazing systems where sheep may travel long distances over their lifetime.
- The mouth should be correctly formed. In a correct mouth, both the top and bottom jaws are lined up so the incisor teeth (the front



teeth) are flush with the pad on the upper jaw (see diagram on right below). Sheep with severe mouth defects (overshot or undershot jaws) may have difficulty grazing short pastures.

- Teeth should be in good condition with no breaks. Broken or rotten teeth will affect feed intake.
- Skeletal size (hip height) should be assessed within breed or breed type. Large-framed sheep tend to grow faster and finish at heavier weights than small-framed animals. This should be backed up by growth rate and carcass records where possible. Large framed ewes may not always be desirable as more food will be needed to maintain a large animal.
- A ewe with a sound udder is essential for lamb survival and growth. The size of the udder will depend on the ewe's age and stage of lactation. Udders should be palpated (felt) to determine that they are healthy and functional. Ewes with hard, lumpy udders should not be considered for breeding purposes. The udder should have two teats that are free from defects. Ewes with pendulous udders and bulbous or oversized teats should be avoided.
- Rams' scrotal size and health are vital for successful mating. Larger scrotums mean larger testes and generally greater sperm production. Scrotums should be checked for size and feel firm and free from lumps when palpated.

Breeding values and selection indexes

Most selection programmes are based on breeding values and selection indexes. Breeding values indicate the genetic potential of a sheep for a specific trait, whereas selection indexes indicate the genetic potential of a sheep by combining a number of traits into a single figure.

Breeding values

Breeding values (BV) are an assessment of the genetic potential of a sheep for a specific trait. They are calculated from the corrected performance and heritability of each trait to create an estimate of the genetic merit of an individual. The BV is expressed as a genetic deviation above or below the average genetic value of the flock. Each individual will have BVs for each trait recorded.

A positive BV usually indicates that the particular animal is better than the average of the flock and those with negative BV's are below the average of the flock. The exceptions are for fat and faecal egg count where negative numbers are more desirable because we want these things to go down, not up.

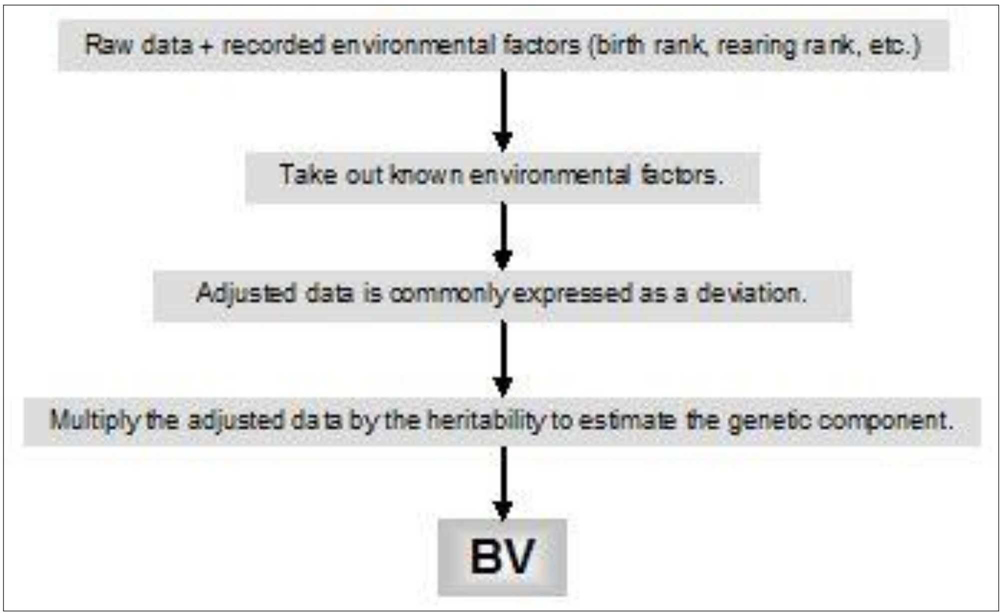
The BVs of the flock will follow a normal distribution curve (see page 23 for an explanation of a normal distribution curve). For example, a flock of rams will contain many rams with or near the mean BV for lamb weaning weight (WWT) but some will also have WWT BVs above and below the mean. Those with higher BVs are likely to produce lambs that have a higher weaning weight than the mean. Those with lower WWT BVs are likely to produce lambs that have a lower weaning weight than the mean. If you want to improve the lamb weaning weight of your flock you need to choose a ram with a WWT BV higher than the mean WWT BV.

All BVs are corrected for known environmental factors so the animals are truly compared on their genetic merit. The environmental adjustments include:

- the age of the ewe as this affects her milking ability
- the birth date of the lamb as this alters the age at weaning
- birth and rearing rank of the lamb
- the sex of the lamb

An example of a distorted BV where environmental effects are not corrected for could be the recorded weaning weight of the season's first born, single reared lamb from a mature ewe. This lamb would be far heavier than its counterparts. Non-adjusted data is misleading.

The recording of data to create BVs follows the process outlined below:



As more information becomes available for an animal, the more accurate the BV. It is an on-going calculation that is continually updated.

To work through an example, assume the following:

- Ram 1 has an adjusted fleece weight of +0.8 kg above the flock average.
- Ram 2 has an adjusted fleece weight of -0.6 kg below the flock average.

Fleece weight heritability is 0.3 (30%).

The calculations are:

- Ram 1 = +0.8 kg X 0.3 = +0.24 FWTBV
- Ram 2 = -0.6 kg X 0.3 = -0.18 FWTBV

Ram 1 has a BV for fleece weight of +0.24. Because he supplies only half the genes of his progeny (their dams supply the other half), his progeny will get half his genetic improvement i.e. an average increase of 0.12 kg (0.24 ÷ 2 = 0.12) in fleece weight if mated to average ewes.

Ram 2 has a BV for fleece weight of -0.18. His progeny will get half his genetic loss, being an average decrease of 0.09 kg (0.18 ÷ 2 = 0.09) in fleece weight if mated to average ewes.

Exercise 4

Ram A is mated with ewe B. Calculate the change in the progeny for fleece weight (FWTBV) and weigh at weaning (WWTBV).

Ram A = + 0.16 FWTBV and +2.30 WWTBV

Ewe B = +0.10 FWTBV and +1.75 WWTBV

The challenge of any breeder is to choose superior parents to breed the next generation. The choices must maximise the important traits to the flock. Breeders must understand genetics and the ranking of the individuals from the best to the worst for each trait so they can make the best selection decisions.

There are registered breeders for all of the sheep breeds in New Zealand. The sheep breeders are at the forefront of the recording programmes promoting genetic gain and working to improve the New Zealand flock.

Selection indexes

Selection indexes are mathematical factors given to various traits that a breeder might wish to select to improve their flock. They convert genetic merit for several traits into a single number that expresses the economic gain if that animal is used. An assessment of the indexes is essential in any breeding and genetic improvement program. Sheep Improvement Ltd (SIL) is the main organisation in New Zealand that produce selection indexes based on information supplied by breeders.

Selection indexes are (with the use of well-designed computer selection and recording programs) readily customised for any sheep breeder or sheep breeding group. SIL have identified the most common breeding requirements and have structured standard reports to suit most farmers and common farming situations.

A dual purpose flock might have the following performance results recorded:

- number of lambs born, recorded as NLB
- weaning weight, recorded as WWT
- hogget fleece weight at 12 months recorded as FW12

From these results breeding values are calculated. BVs are then multiplied by a weighting (a value that reflects their relative importance). The weightings are based on the net financial worth of the trait, commonly called the relative economic value or REV.

SIL standard indexes will give near optimal genetic gains for most farming conditions in New Zealand. The indexes have been derived using technical and economic information relevant to the average flock in New Zealand. The recording of the traits recognises that the breeders target specific commercial farming *conditions. The standard indexes suit a large number of breeding programmes and lead to a more uniform understanding of evaluations for genetic merit by both ram buyers and ram breeders. SIL are able to generate custom indexes and reports for individual farmers where it is relevant, but the standard reports are recommended as they reflect the industry needs.*

Tables on the following pages summarise traits used and their economic weightings for standard SIL indexes (as of May 2010). The economic weightings take into account the actual industry returns, the proportion of progeny that will express the trait and the time it will take until income is earned from the trait (e.g. income from weaning weight is earned sooner than daughters' lambing performance).

The economic weighting is the value in dollar terms that is achieved from each successfully mated ewe. From the table below we can see the returns being achieved – e.g. for NLB (number of lambs born) the return is 2430 cents (or $24.30) per ewe mated. This means that for every 1 point increase in NLB breeding value there will be a return of $24.30. The lamb dag score has an economic weight of -254 which means that for every 1 point increase in LDAG breeding value it will cost the farmer $2.54 per ewe mated.

Table 2 Dual-Purpose Overall (DPO) sub-indexes, breeding values and weightings as at May 2010

Sub-index	Sub-index short name	Goal trait breeding value	Breeding value short name	Economic weighting (cents per ewe lambing)
Lamb growth[1]	DPG	Weaning weight – direct	WWT	116
		Weaning weight – maternal	WWTM	97
		Carcass weight	CW	220
Adult size	DPA	Ewe weight	EWT	-72
Meat yield	DPM	Hindquarter lean yield	HQLY	402
		Loin lean yield	LNLY	602
		Shoulder lean yield	SHLY	201
		Fat yield[2]	FATY	
Wool[3]	DPW	Lamb fleece weight	LFW	416
		Hogget fleece weight	FW12	102
		Adult fleece weight	EFW	300
Reproduction	DPR	Number of lambs born (litter size)	NLB	2430
Twinning rate	DPT	Twinning rate adjusted for NLB	TWIN	3000
Hogget lambing	DPH	Hogget fertility	HFER	880
		Hogget litter size	HNLB	302
Survival	DPS	Survival to weaning – direct	SUR	6329
		Survival to weaning – maternal	SURM	6371

[1] WWT refers to lamb growth and WWTM refers to milking ability of the dam.

[2] Previous dual purpose indexes had a negative weighting on fat. There is now no (zero) weighting on FATY.

[3] Wool diameter and quality traits are not included in the DPO but are included in indexes used for wool breeders such as the 'Medium-fine' fine wool index.

Table 3 Terminal Sire Overall (TSO) sub-indexes, breeding values and weightings as at May 2010

Sub-index	Sub-index short name	Goal trait breeding value	Breeding value short name	Economic weighting (cents per ewe lambing)
WormFEC[4]	DPF	FEC1%	FEC1	-2.9
		FEC2%	FEC2	-2.9
		Adult FEC%	AFEC	-2.5
Resilience	DPZ	Age when first drenched	DRAGE	*Not available*
		Liveweight gain under parasite challenge	RGAIN	*Not available*
Dag score	DPD	Lamb dag score	LDAG	-254
		Adult dag score	ADAG	-687
Facial eczema	DPX	GGT21 (indicates liver damage)	GGT21	-903

Sub-index	Sub-index short name	Goal trait breeding value	Breeding value short name	Economic weighting (cents per ewe lambing)
Lamb growth	TSG	Weaning weight – direct	WWT	66
		Weaning weight – maternal	WWTM	
		Carcass weight	CW	158
Adult size		Ewe weight	EWT	
Meat yield	TSM	Hindquarter lean yield	HQLY	462
		Loin lean yield	LNLY	693
		Shoulder lean yield	SHLY	231
		Fat yield	FATY	-280
Wool		Lamb fleece weight		
		Hogget fleece weight (FW12)		
		Adult fleece weight		
Reproduction		Number of lambs born		
Twinning rate		Twinning rate adjusted for NLB	TWIN	
Hogget lambing		Hogget fertility	HFER	
		Hogget litter size	HNLB	
Survival	TSS	Survival to weaning – direct	SUR	4110
		Survival to weaning – maternal	SURM	
WormFEC	TSF	FEC1%	FEC1	-1.56
		FEC2%	FEC2	-1.56
		Adult FEC%	AFEC	
Resilience		Age when first drenched	DRAGE	*Not available*
		Liveweight gain under parasite challenge	RGAIN	*Not available*
Dag score	TSD	Lamb dag score	LDAG	-254
		Adult dag score	ADAG	
Facial eczema		GGT21	GGT21	

* Traits in gray print are not included in the TSO index but *are* included in the DPO index.

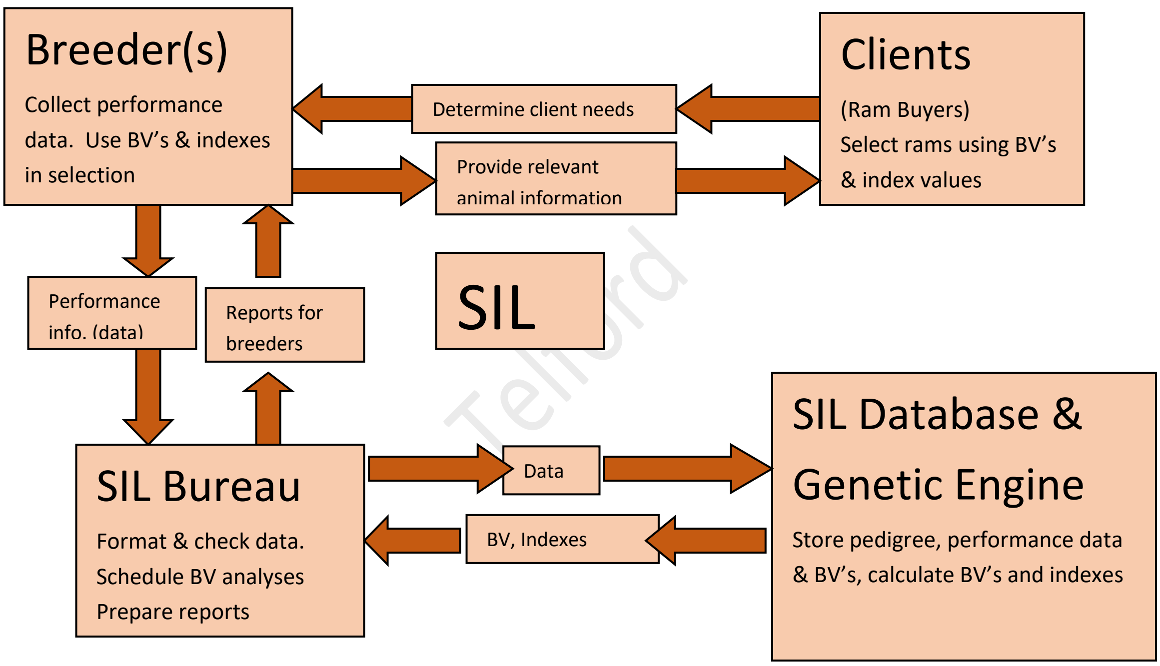
[4] FEC1 = Faecal egg count before 1st March, FEC2 = faecal egg count after 1st March and AFEC = Adult faecal egg count

Sheep recording systems

Sheep Improvement Ltd (SIL) manages a sheep recording program and analyses for breeding values (BV), indexes and sub-indexes across the national flock. It was established by the New Zealand Meat and Wool Boards in the late 1990s.

Pedigree and performance information is collected on farm and SIL analyses these to predict genetic merit for individual sheep. These predictions help breeders and ram buyers make selection decisions. Breeders gather performance, pedigree and other information and send it to one of eight SIL bureaus. Data is checked and entered onto the SIL system, then a genetic analysis is scheduled and report formats are specified. This is summarised in the following diagram.

How the SIL recording system operates in New Zealand



The system operated by SIL has been formulated to summarise the key areas of productivity and provide breeders with a more simplified interpretation of overall genetic merit. Individual breeders and commercial flock operators may have their own specific criteria and requirements.

There are many different factors that create the BVs and a computer is required to bring together the information. The SIL BVs also incorporate the performance of related animals. This means an animal with extraordinary individual performance but low performance relatives gets a lower BV than you would otherwise expect. The use of relatives' information is an important strength of the SIL sheep recording system.

Sub-indexes are the focus of the SIL recording program (see Tables). Sub-indexes are also called Goal Trait Groups (GTG) as they include 'goal traits', i.e. those that are considered important in improving farm profitability by improving flock performance where measurable indicators are available.

Managing genetic gain

As we can saw in the section on 'Population Genetics' on page 39 it is important that the sheep selected are above the mean (average) of the flock. The first thing a farmer should do is identify traits important to the farm, then seek the best rams that will help meet these requirements.

Breeding values (BVs) and selection indexes are a function of the flock in which they are calculated. In most cases they are only comparable within a single flock, although across flock analysis can allow values to be compared between several flocks provided there are good genetic connections between the flocks. It is not possible to compare the genetic merit of rams from different flocks unless the flocks have conducted an across-flock analysis AND there are good genetic connections between the flocks.

For every flock analysis SIL sets 1995 as the benchmark year and the average genetic merit of lambs born in 1995 is set to zero. The BVs are therefore a measure of the merit of a ram compared to the 1995 average for that flock.

Studies of commercial flocks have shown an average 2% per annum genetic gain. Ram breeders must ensure that the rate of gain that they achieve must at least equal or exceed the rate of gain of commercial farmers.

An annual 2% gain is significant as shown below in the lambing percentage example. Assume we have 120% lambing in year 1:

Year 1	120% lambing	+ 2% gain	(120 x 0.02) + 120	= 122.4%
Year 2	122.4% lambing	+ 2% gain	(122.4 x 0.02) + 122.4	= 124.9%
Year 3	124.9% lambing	+ 2% gain	(124.9 x 0.02) + 124.9	= 127.4%
Year 4	127.4% lambing	+ 2% gain	(127.4 x 0.02) + 127.4	= 129.9%
Year 5	129.9% lambing	+ 2% gain	(129.9 x 0.02) + 129.9	= 132.5%
Year 6	132.5% lambing			

For a flock of 2000 ewes the lambing percentage would increase from 120% in year 1 (2400 lambs) to 132.5% in year 6 (2650 lambs). Assuming lamb and ewe survival remain the same, 250 more lambs would be born due to genetic gain ((132.5% - 120%) X 2000 = 250). If lamb prices stayed the same over the six years at $75 per head, the increased income would be $18,750 per year.

With the flock maintained at 2000 ewes the additional lambs could be available for sale, but there will need to be changes in management as extra lambs require extra feed.

Alternatively, if the farmer wants to have only 2,400 lambs born each year then the ewe flock could be reduced from 2,000 to 1,811 ewes. This option can have the following benefits:

- less ewes to winter to maintain the same number of lambs for sale
- less ewes to mate could mean less rams to buy and so more money available to buy better rams
- reduced animal health and shearing costs

It is usually not possible to make maximum genetic gain on more than one trait at a time (unless the traits are genetically related) and in some instances performance in one trait might go backwards when performance in another trait improves – e.g. wool weights might decline with increasing lambing percentage.

Test Yourself #2

1. What does SIL do?

2. Are the following statements true or false?
   a) Breeding values assess the genetic potential of a sheep for a specific trait.
   b) You should always choose sheep with positive breeding values for traits.
   c) Selection indexes convert genetic merit for several traits into a single number that expresses the economic gain if that animal is used.
   d) A BV is calculated by multiplying the selection index for a trait by its REV.
   e) It is usually not possible to make maximum genetic gain on more than one trait at a time.

3. Give an example of a desirable negative breeding value and explain why it is desirable.

4. What do the following abbreviations stand for: DPO, TSO, DPX, DPS, WWT, NLB and FEC1?

5. For the May 2010 DPO index, list the economic weighting for DPX, DPS, WWT, NLB and FEC1.

Ram selection and culling

Most flock improvement comes from the ram. This is because on a commercial farm one ram is mated to around 150 – 200 ewes therefore rams with BVs higher than the average BVs of the ewe flock have a greater influence on the flock than individual ewes. The improvement occurs even though only half of the genes come from each parent.

The challenge of the ram breeder is to choose superior parents to breed the next generation better than the current generation. A ram breeder must therefore know the genetic merit of the potential parents and the industry's requirement for particular traits. The ram breeder records all the information to provide the best possible ram for the industry but there are still risks. Some of the superior performance recorded may still be due to the environment or management rather than genetics, or a particular ram's progeny may not perform as well as expected under a particular environment or management style. However, recording significantly lowers the chance of poor performing progeny.

Have a discussion with the decision makers on your property or another local sheep farmer to find out about the ram buying policy or the sheep breeding programme on the farm.

There is a large amount of ram information from recorded flocks on which rams can be ranked. The information can be adapted by the breeder and buyer to focus on the particular traits considered right for the buyer.

Key points to consider when purchasing a ram are:

- Decide what production traits are important for genetic gain in your flock.
- Remember the more traits selected for, the less progress made in individual traits.
- Selecting the right ram breeder is the most important step in the process.
- The ram breeder's flock must show genetic gain in the production traits important to your own flock.
- The ram breeder's flock must be genetically superior to your own flock.
- Understand that your flock's production will track the genetic improvement of your ram breeder's flock.
- Spend time reading the records and select rams from their genetic production records before making your final choice by inspecting each animal.

- The ram breeder should have the rams ranked from best to worst for each trait, or ranked on breeding value or overall breeding index.
- Make sure the productive traits you are interested in are in the index.
- SIL index information is a big advantage in ram selection.

The most important point when buying rams is to choose a ram breeder showing genetic gain in the traits important to your flock. Then take your time and ensure you ask the right questions of the seller.

Where to buy rams

Rams should be bought from specialised ram breeders. If you know very little about the ram you buy, at best, you may end up with an average ram and at worst, introduce disease or traits that could significantly reduce the productivity of your flock. There are many ram breeders in New Zealand and sourcing the right rams to suit your property, management style and farm goals requires some research.

Information on ram breeders and their stock can be got from:

- stock agents
- SIL across flock analysis results, e.g. SIL ACE
- SIL FlockFinder
- breeders websites
- publications such as rural magazines and newspapers

Stock agents may have the advantage of knowing your property and that of the breeders and can therefore advise which breeder may meet the ram requirements you are looking for.

SIL ACE ranks commercially important traits and identifies leading rams that can be bought from their source flocks (or buy the sons of these rams). FlockFinder is a new SIL service that helps farmers find ram breeders that might interest them (i.e. share their goals and breed preferences).

Many ram breeders now have websites to inform you about their stock. As well as rams for sale they typically publish information about their farm and their breeding objectives. Some breeders now sell online, with selection index information provided for farmers to assess.

Breed association websites usually have links to breeders specialising in the associations breed. They usually present general information on the breeds and may publish upcoming breeders' sale dates.

Farming newspapers and magazines (many of which also have content online) often publish when ram sales are on, run advertisements by breeders and may have feature articles on particular breeders from time to time.

Ram purchases can be made:

- direct from breeders
- a stock agent
- ram auctions

Ram auctions are typically held by breeders to sell off their lower performing rams. These rams may still have better genetics than your existing flock so can be suitable to buy and you may get them for a good price. Where demand is high for top performing rams, auctions may also be held by a breeder in the hope of achieving a higher price than they may have otherwise set. Some breeders sell all their rams by auction.

Questions to ask when choosing a ram breeder and buying a ram

Questions to ask the breeder will include the environment, management and breeding policies. In asking the right questions you will receive most of the answers to the ten key points that are noted above. You need to understand the reasons behind these so you can make your inquiry with knowledge.

The choice of ram breeder is more important than the selection of the ram as it is the breeder's trait selection and genetic gain in those traits that is important to you as the buyer. You need to know that the breeder is continuing to improve their rams in areas useful to you and in an environment that is compatible with your property.

Suggested questions and reasons for asking the questions are listed below.

1. **What traits are the focus of the breeding programme?**
   These are the traits that the ram breeder has considered in the breeding programme. They need to match your on-farm breeding programme priorities.
2. **What is the ram breeder's management programme and stud stocking rate?**

   Some stud stock breeders have very low stocking rates and the animals are farmed in semi-artificial situations. You need to have a good understanding about where they come from and what type of country the rams were bred on, so you can gauge the likely performance under your farming conditions. BVs generated in a farming environment very different from your farm might not translate into expected gains on your farm; similarly some animal health matters might be masked with heavy use of animal health treatments or the non recording of such matters as facial eczema if the breeder is outside a facial eczema prone area.

   If a ram has been farmed in a totally different environment to your own, i.e. perhaps under an extensive farming model and is then put into an intensive situation, he may not perform as expected. All BV's are adjusted for environmental factors (such as rearing rank and age) and as many of the management factors as possible but do not indicate differences between ram breeding environments.

   It is preferable to buy rams from a farm with similar farming practices and with similar environmental conditions.

3. **Are the SIL records available for inspection?**

   Any breeder who is prepared to offer rams for sale should make all the records available for inspection. Anyone who does not provide these records cannot show you the relative genetic merit of the rams on offer.

4. **Is the flock part of a larger sire referencing scheme or group breeding scheme?**

   The greater the number of progeny, the more accurate the data. Sire referencing or group breeding schemes involve large pools or groups of rams and ewes used to progeny test large numbers of rams over a number of similar flocks. Recording in a large group provides a greater degree of accuracy and therefore there is a greater chance of showing any deficiencies in the breeding programme.

5. **What has been the genetic progress from the original base or start point?**

   Can your breeder show you how much they have increased performance? This information will assist you in determining the progress the particular breeder has made over a period of years. It will show the strength of the breeding programme.

6. **Are there any breeder references available?**

   Do not be afraid to ask for references and follow them up. When checking, ensure that these farmers use similar management in an environment similar to your own.

7. **Where does the stud buy rams?**

   Most commercial breeders require someone to provide them with the stud rams for improving the commercial flock. Similarly, the stud stock breeder also requires other farmers to provide them with stud stock which will also improve their flock. Some knowledge of their supply sources is useful for your own information when buying rams so you can determine if the breeding programmes and flock management of all the breeders involved focus on the factors important to your farm.

8. **What proportion of ram lambs born are on the selection list?**

   Again we need to go back to the population genetics and remember that it is only those in the top half that are above the average in the flock. A good breeder will not offer lower end rams.

9. **How many rams have been sold on the selection list?**

   You need to ensure you have good access to the records and that you are not just taking the tail-end rams from a flock unless you are well satisfied that even their genetic ability is still well above that of your existing flock.

10. **What was the breeder's average lamb slaughter date (or age) and the average carcass weight?**
    This can provide some growth rate details and perhaps some anticipated potential returns. This information should be cross referenced with the average lamb weight at weaning. The buyer must identify the effect of good or bad seasons and the many management factors. Using the SIL information takes into account environmental as well as genetic factors.

SIL ram selection list

Please note you will need to check out the SIL website for a more up-to-date form. Please note that the following websites are recommended for students to view and research.

https://www.sil.co.nz/files/1510696889_Guide%20to%20RamFinder.pdf
http://tools.sil.co.nz/eSearch/RamFinder/Search.aspx
http://www.blnzgenetics.com/files/1507488803_Ram%20buyers%20guide%202017.pdf

Set out below is an example of a SIL ram selection list that will enable you to read the information relating to the individual rams and their potential performance. The ram selection list (a made-up example) shows the pedigree details, the reproductive performance, the birth and rearing rank of the animals, and the lifetime identification. There are also the breeding values calculated using all the available information about the individuals and their relatives. There may also be a comment column for any remarks about individual animals.

The breeder of the rams will have their own SIL selection lists available. The following simplified example shows the information on the front one or two pages of a ram selection list report.

Ram Selection List

Front page of report

Report flock number, prefix and owner details

Report flocks... Numbers of rams....

Flock prefix ... Date report run....

Goal trait groups selected for analysis. Varies with breed, objectives etc.

Goal trait group selected - Growth Reproduction Survival Wool Meat

Indicates the birth years of all the animals included in the analysis. Analysis includes all progeny, siblings, sire, dams, and relatives born

Analysis Birth Period...........

Base Year: 1995

Base year is 1995. The base year can be changed.

Report Birth Period...............

This report list the rams born this year.

Report Sorted By...... Index SIL, Dual Purpose Overall, Flock, Birth

Animals here are sorted on index

SIL: DPO= SIL Dual Purpose Growth (with meat) + SIL Dual Purpose Meat + SH Dual Purpose Reproduction + SIL Dual Purpose Survival + SIL Dual Purpose Wool.

SIL: Dual Purpose Growth (with meat) (DPGM)+36WWTBV+106CWBV-

Abbreviations of all breeding values are explained.

List of Flock Numbers and Prefixes.

All the flocks referred to in the report and their prefixes are listed.

NOTE: Comments and descriptions in the shaded boxes are for information. They are not part of the report.

The following copies of report pages are too small to read clearly but they give you an idea of the information they contain. Below is a copy of the ram selection list report first page. The first section covers report details and explanations of the indexes used as outlined on the previous page.

November 2009 Ram Selection List - Top 500

Report Flocks	233, 912, 1138, 2077, 2415, 2522, 2747, 2749, 2776, 4474, 4479, 4482, 4564, 4705
Flock Prefix	**Multiple Flocks**
Flock Owner	
Report Sorted By	**Rk1**
Number of Rams	**500 / 4013**
Date Report Run	
Report No.	
Report Birth Period	**2008** to **2008**
Genetic Analysis No.	**19658**
Analysis Birth Period	**1988** to **2009**
Analysis Flocks	**233, 912, 1138, 2077, 2281, 2415, 2522, 2638, 2747, 2748, 2749, 2776, 4334, 4474, 4479, 4482, 4525, 4564, 4640, 4705**
Goal Trait Groups	**Growth; Meat; Reproduction; Survival; Wool; WormFEC**
Genetic Analysis Codes	**Reproduction excludes LW8; Outside sire BVs from ACE; Best DNA BV Analysis**
Data Exclusion Set	**None**
Date Breeding Values Created	**29-Nov-2009 16:36**
Base Year	**1995**

WormFEC™ Pfizer Animal Health Animal Genetics

Explanation of Indexes

High Performance Overall	**(HPO) ¢ = (HPGm) + (HPMg) + (HPR) + (HPS) + (HPW) + (HPF)**
SIL Dual Purpose Overall	**(* DPO) ¢ = (* DPGm) + (* DPMg) + (* DPR) + (* DPS) + (* DPW) + (* DPF)**
SIL Dual Purpose Production	**(* DPP) ¢ = (* DPGm) + (* DPMg) + (* DPR) + (* DPS) + (* DPW)**
High Performance Growth (with Meat)	(HPGm) ¢ = 116 x WWTBV + 97 x WWTMBV + 140 x CWBV - 72 x EWTBV
High Performance Meat (with Growth)	(HPMg) ¢ = 293 x LEANBV - 183 x FATBV
High Performance Reproduction	(HPR) ¢ = 1020 x NLBBV
High Performance Survival	(HPS) ¢ = 6329 x SURBV + 6371 x SURMBV
High Performance Wool	(HPW) ¢ = 102 x FW12BV + 416 x LFWBV + 300 x EFWBV
High Performance WormFEC	(HPF) ¢ = - 2.90 x FEC1BV - 2.90 x FEC2BV - 2.50 x AFECBV
SIL Dual Purpose Growth (with Meat)	(* DPGm) ¢ = 116 x WWTBV + 97 x WWTMBV + 140 x CWBV - 72 x EWTBV
SIL Dual Purpose Meat (with Growth)	(* DPMg) ¢ = 293 x LEANBV - 183 x FATBV
SIL Dual Purpose Reproduction	(* DPR) ¢ = 2430 x NLBBV
SIL Dual Purpose Survival	(* DPS) ¢ = 6329 x SURBV + 6371 x SURMBV
SIL Dual Purpose Wool	(* DPW) ¢ = 102 x FW12BV + 416 x LFWBV + 300 x EFWBV
SIL Dual Purpose WormFEC	(* DPF) ¢ = - 2.90 x FEC1BV - 2.90 x FEC2BV - 2.50 x AFECBV
ggaf Early Growth with Meat	(eGm) ¢ = 116 x WWTBV + 97 x WWTMBV + 140 x CWBV
ggaf Late Growth with Meat	(lGm) ¢ = - 72 x EWTBV

The information below follows on the second page of the report and explains the abbreviations, the birth flock numbers and prefixes for report animals.

Explanation of Breeding Values

AFECBV = Adult FEC BV
EMABV = Eye muscle area BV
FEC1BV = FEC1 BV
LEANBV = Lean weight BV
SURBV = Lamb survival BV
WWTMBV = Weaning weight maternal BV
CWBV = Carcass weight BV
EWTBV = Ewe live weight BV
FEC2BV = FEC2 BV
LFWBV = Lamb fleece weight BV
SURMBV (SURmBV) = Survival maternal BV
EFWBV = Ewe fleece weight BV
FATBV = Fat weight BV
FW12BV = Fleece weight 12 BV
NLBBV = Number of lambs born BV
WWTBV = Weaning weight BV

List of birth flock numbers and prefixes for report animals, including sires and dams

94	View Hill	168	Little Bush	228	Wheeler	233	Tamlet
271	Douglas Downs	446	Growbulk	452	Wairaki	489	Longview
603	Cairnlea	712	Marlow	825	Oakfield	845	Avalon
904	Coryston	912	Shoreford	1008	Tan Bar	1138	Tamlet
1194	MNCC	1568	Blue Willow	1735	Glenrae	1983	Rosemains
2077	Rosedale	2415	Colhoun	2522	Waikaka	2595	Nithdale
2608	Esselmont	2658	Brandes Burton	2672	Blackdale	2695	Blythburn
2747	Mount Linton	2749	Mount Linton	2766	Meba	2776	Tamlet
2862	Hemingford	2937	Ohio	2960	W.T.D.	2975	Laneside
3004	Kepler Supreme	3007	Waikite Texel	3704	Robertson	4474	Twin Farm TEFRom
4479	Rosedale Growbulk	4482	Waikaka Texels	4525	Rosedale Elite	4564	Colhoun
4626	Avalon Texel	4648	Strathconon	4669	Blackdale Textra	4705	Twin Farm
4862	Rosedale Inverdale						

DISCLAIMER: While all reasonable care has been taken to ensure the accuracy of information in this report, SIL expressly disclaims any and all liabilities that may arise from its use

The third page shows the actual ranking of rams for each of the indexes used and breeding values.

November 2009 Ram Selection List - Top 500

Report Flocks **233, 912, 1138, 2077, 2415, 2522, 2747, 2749, 2776, 4474, 4479, 4482, 4564, 4705**

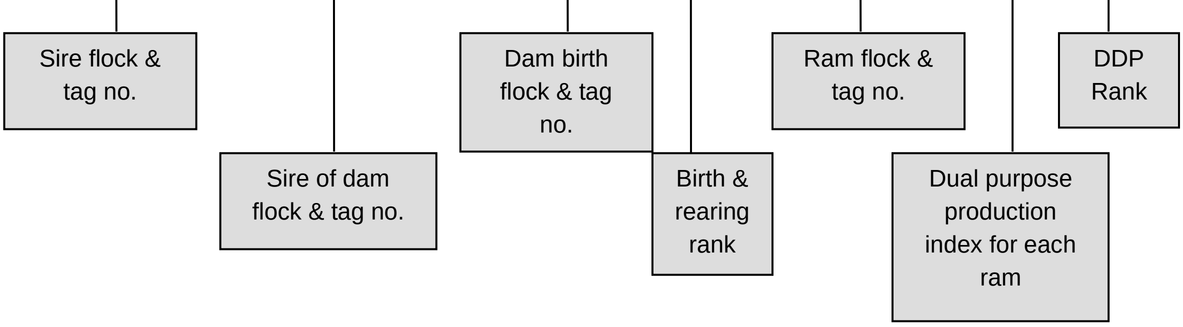
Flock Prefix **Multiple Flocks**

Flock Owner

Period **2008**

Sire Flk	Sire Tag	SoD Flk	SoD Tag	Dam BFlk	Dam Tag	BB/ RR	Flock	Ram Tag	DPP	Rk1	DPR	DPS	eGm	lGm	DPM	DPW	HPO	Rk2	DPO	Rk3	NLB BV	SUR BV	SURm BV	EMA BV	Breed
4474	1165/05	4474	982/03	4474	802/04	2/2	**4474**	**982/08**	1853	1	508	385	861	-293	470	-77	1502	3	1797	1	0.209	0.040	0.02	1.56	45 Rom
4474	1165/05			4474	1053/03	2/2	**4474**	**859/08**	1806	2	521	389	816	-320	348	52	1446	8	1749	2	0.215	0.037	0.02	0.78	45 Rom
4474	1165/05	4474	169/03	4474	289/04	3/2	**4474**	**1049/08**	1721	3	385	298	892	-293	400	38	1405	11	1629	5	0.159	0.029	0.02	1.05	45 Rom
4479	2247/04	4479	9001/03	4479	3152/04	2/2	**4479**	**3846/08**	1669	4	386	401	625	-233	427	64		1654		1654	0.159	0.029	0.03	0.34	55 Rom
4474	982/07	4474	1165/05	4474	326/07	1/1	**4474**	**1791/08**	1668	5	226	185	986	-287	560	-2	1539	2	1670	3	0.093	0.008	0.02	1.56	41 Rom
4474	718/06	4474	430/04	4474	712/06	2/2	**4474**	**13/08**	1644	6	375	233	797	-151	333	57	1258	31	1476	22	0.154	0.029	0.01	0.85	42 Rom
4474	1285/06	4474	1165/05	4474	1403/06	2/2	**4474**	**25/08**	1641	7	226	283	903	-268	461	37	1482	5	1613	7	0.093	0.033	0.01	1.39	47 Rom
233	379/06	3007	488/00	233	573/05	2/2	**233**	**23/08**	1621	8	407	289	699	-380	405	201	1316	18	1552	11	0.168	0.030	0.02	2.48	50 Rom
4474	718/06	4474	1607/05	4474	745/06	2/2	**4474**	**340/08**	1611	9	178	358	872	-288	429	62	1558	1	1661	4	0.073	0.037	0.02	1.34	36 Rom
1138	31/07	1138	266/04	1138	716/05	2/2	**1138**	**326/08**	1611	9	292	244	776	-324	345	278	1274	26	1444	27	0.120	0.019	0.02	2.06	81 Coo
233	379/06	4479	3154/02	233	227/04	2/1	**233**	**5/08**	1586	11	507	325	683	-314	260	124	1334	16	1628	6	0.209	0.036	0.02	1.74	59 Rom
2747	78/06	35	140/03	2749	618/06	1/1	**2747**	**500/08**	1566	12	76	-150	1613	-869	720	175		1654		1654	0.031	-0.026	0.00	2.35	47 Texe
4474	1699/07	4474	1165/05	4474	390/07	2/1	**4474**	**1648/08**	1548	13	295	150	1183	-292	306	-93	1388	12	1559	10	0.121	0.023	0.00	1.26	45 Rom
2747	503/07	3003	716/01	2747	158/03	2/2	**2747**	**311/08**	1536	14	-11	209	1178	-487	499	148		1654		1654	-0.005	0.021	0.01	1.67	41 Suff
2747	78/06	35	165/00	2747	249/04	2/2	**2747**	**401/08**	1533	15	343	-15	1165	-728	624	144		1654		1654	0.141	-0.027	0.02	2.90	39 Suff
233	629/05	3007	348/03	233	138/06	2/2	**233**	**563/08**	1529	16	302	148	1177	-562	394	69	1025	97	1201	81	0.124	0.014	0.01	3.16	50 Rom
2747	78/06	35	165/00	2747	249/04	2/2	**2747**	**400/08**	1526	17	343	109	1010	-605	544	125		1654		1654	0.141	-0.007	0.02	2.39	39 Suff
603	279/07	2672	426/04	2415	949/06	2/2	**2415**	**973/08**	1526	17	355	114	1021	-504	357	183	1172	48	1377	42	*0.146	0.015	0.00	1.81	70 Coo
4474	1165/05	3889	104/04	4474	1149/05	2/2	**4474**	**653/08**	1523	19	433	417	598	-132	222	-15	1294	22	1545	12	0.178	0.042	0.02	0.69	45 Rom
4474	718/06	4474	1021/00	4474	395/02	2/2	**4474**	**9/08**	1518	20	363	201	634	-129	328	121	1327	17	1537	15	0.149	0.025	0.01	0.62	53 Rom
4474	1165/05	4474	31/05	4474	486/06	2/2	**4474**	**52/08**	1516	21	348	352	1061	-344	243	-145	1275	25	1477	21	0.143	0.034	0.02	1.51	38 Rom
233	629/05	3007	348/03	233	168/06	2/1	**233**	**218/08**	1507	22	222	173	1142	-476	359	87	1259	30	1388	40	0.091	0.014	0.01	2.18	47 Rom
4479	2229/04	446	134/03	4479	3197/05	3/3	**4479**	**3376/08**	1500	23	361	245	892	-524	399	127		1654		1654	0.149	0.012	0.03	1.63	75 Rom
4479	2229/04	4479	2247/04	4479	2840/06	3/3	**4479**	**3751/08**	1499	24	361	245	695	-292	381	109		1654		1654	0.149	0.014	0.02	0.80	75 Rom

Enlarged section of report

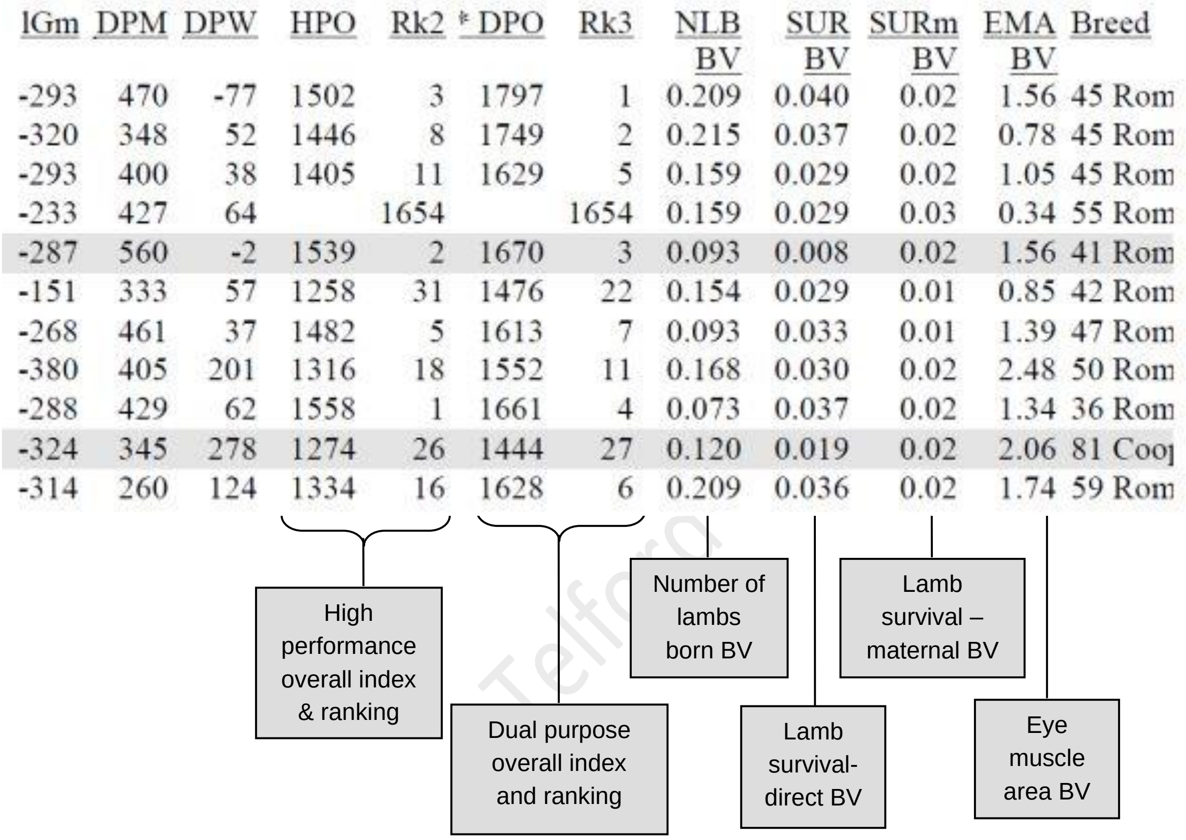


Sire Flk	Sire Tag	SoD Flk	SoD Tag	Dam BFlk	Dam Tag	BB/ RR	Flock	Ram Tag	DPP	Rk1	DPR
4474	1165/05	4474	982/03	4474	802/04	2/2	**4474**	**982/08**	1853	1	508
4474	1165/05			4474	1053/03	2/2	**4474**	**859/08**	1806	2	521
4474	1165/05	4474	169/03	4474	289/04	3/2	**4474**	**1049/08**	1721	3	385
4479	2247/04	4479	9001/03	4479	3152/04	2/2	**4479**	**3846/08**	1669	4	386
4474	982/07	4474	1165/05	4474	326/07	1/1	**4474**	**1791/08**	1668	5	226
4474	718/06	4474	430/04	4474	712/06	2/2	**4474**	**13/08**	1644	6	375
4474	1285/06	4474	1165/05	4474	1403/06	2/2	**4474**	**25/08**	1641	7	226
233	379/06	3007	488/00	233	573/05	2/2	**233**	**23/08**	1621	8	407
4474	718/06	4474	1607/05	4474	745/06	2/2	**4474**	**340/08**	1611	9	178
1138	31/07	1138	266/04	1138	716/05	2/2	**1138**	**326/08**	1611	9	292
233	379/06	4479	3154/02	233	227/04	2/1	**233**	**5/08**	1586	11	507

PLEASE NOTE: These reports are from 2009 and the layout will be different now.

The rest of the report gives the rankings for other production indexes (e.g. DPR = Dual purpose reproduction, DPS = Dual purpose survival, etc.). On the far right the very last column gives the breed of the ram and the four columns before that give breeding values for NLB (number of lambs born), SUR (lamb survival), SURM (maternal contribution to lamb survival) and EMA (eye muscle area).

Below is an enlarged section of the third page of the report showing the far right hand columns.



IGm	DPM	DPW	HPO	Rk2	DPO	Rk3	NLB BV	SUR BV	SURm BV	EMA BV	Breed
-293	470	-77	1502	3	1797	1	0.209	0.040	0.02	1.56	45 Rom
-320	348	52	1446	8	1749	2	0.215	0.037	0.02	0.78	45 Rom
-293	400	38	1405	11	1629	5	0.159	0.029	0.02	1.05	45 Rom
-233	427	64		1654		1654	0.159	0.029	0.03	0.34	55 Rom
-287	560	-2	1539	2	1670	3	0.093	0.008	0.02	1.56	41 Rom
-151	333	57	1258	31	1476	22	0.154	0.029	0.01	0.85	42 Rom
-268	461	37	1482	5	1613	7	0.093	0.033	0.01	1.39	47 Rom
-380	405	201	1316	18	1552	11	0.168	0.030	0.02	2.48	50 Rom
-288	429	62	1558	1	1661	4	0.073	0.037	0.02	1.34	36 Rom
-324	345	278	1274	26	1444	27	0.120	0.019	0.02	2.06	81 Coo
-314	260	124	1334	16	1628	6	0.209	0.036	0.02	1.74	59 Rom

So for this ram selection list, ram 982/08 from flock 4474 was ranked number 1 for the dual purpose production (DPP) index with an index value of 1853. It was also ranked number 1 for the dual purpose overall (DPO) index with an index value of 1797. The breeding values for this ram were:

- NLB = 0.209
- SUR = 0.040
- SURM = 0.02
- EMA = 1.56

Exercise 3

Obtain a ram selection list from a sheep breeder and identify the important details.

It is essential that you are able to read a ram selection list if flock improvement is to be part of your farm business.

Using BVs rather than indexes for selection

In some cases indexes may not be the ideal selection criteria to use. Breeding values alone may be more appropriate if general indexes do not suit the breeding programme for a farm.

For example, on farms that regularly experience summer droughts liveweight gain (WWT) may be more important than muscling (HQLY, LNLY, SHLY). Although the latter is valuable, getting lambs to slaughter weight before the summer dry period is more important.

In some cases a farmer may not wish to increase their lambing percentage further. The DPO puts a high emphasis on fecundity, so a farmer may wish to put more emphasis on rams with high BVs for weaning weight (WWT), carcass weight (CW) and possibly wool traits (LFW, EFW) rather than rams with high reproduction (NLB) BVs.

Each farmer needs to select rams based on traits important to their own farming system and gaols.

The following sections look at selecting rams using the TSO and DPO selection indexes. These are a good starting point for general flock improvement.

Buying a terminal sire

A terminal sire is a ram that is mated to ewes to produce lambs for slaughter. Ewe lambs from terminal sires are not used as replacements for the ewe flock. Examples of terminal sire breeds are Suffolk, Poll Dorset and Texel.

Terminal sires must produce lambs that survive, grow fast and yield a quality carcass. As all lambs are slaughtered, reproductive performance, wool and disease resistance have little or no value in the selection of a terminal sire. The three most important factors to consider when selecting a terminal sire are:

1. Lamb survival (SUR)
2. Lamb growth (WWT)
3. Carcass quality (CW, HQLY, LNLY, SHLY, FATY)
4. Ram structural soundness (feet, legs, testicles and mouth – see page 28) – the best genetics in the world has no value if the ram is not capable of producing any progeny

Identify the ram's TSO index (Terminal Sire Overall index) - the higher the TSO the better the ram. The TSO index is important as ram buyers are typically price-sensitive and as the index is expressed in cents it makes it straight-forward to convert into expected value on the farm.

Calculations show the value of individual rams.

Ram A has a TSO index of 300 cents

Ram B with a TSO index of 200 cents

Ram A will be expected to return an extra 50 cents per ewe lambing

(300 cents – 200 cents) ÷ 2 (supplying half of the genetic makeup and improvement of the lamb with the other half coming from the ewe) = 50 cents.

If ram A is mated to 100 ewes with a 100% lambing, the expected return will be $150 more than a ram with a TSO of zero.

(300 cents x 100 lambs) ÷ 2 (supplying half of the genetic makeup and improvement of the lamb with the other half coming from the ewe) = $150

If ram B is mated to 100 ewes with a 100% lambing, it will return $100 more than a ram with a TSO of zero.

(200 cents x 100 lambs) ÷ 2 = $100

So ram A is expected to return an extra $50 per 100 ewes compared to ram B.

After selecting a group of potential rams for purchase, reject any rams with structural soundness and faults. A good breeder should not offer rams with faults.

Comparing the value of rams

The value of a ram depends on:

- its genetic superiority over another ram
- the number of years it is used
- the ewes mated per year
- litter size per 100 ewes mated

The following calculation shows how ram buyers can calculate the difference in value between two rams within the same ram selection list.

$$\text{Extra ram value} = \frac{\text{years used x tailing percentage x ewes mated per year x TSO margin}}{210}$$

210 is a constant number that takes into account:

- a discount factor (to reflect the time taken until income is earned)
- ram gene contribution (always 0.50 with the other 0.50 coming from the ewe)
- a factor that reflects the average survival rate of lambs born
- a multiplication factor to convert cents to dollars

The difference between rams is measured as the 'margin of superiority'. To calculate the margin of superiority consider the following data:

Ram A with TSO 300
Ram B with TSO 200
TSO margin = 300 – 200 = 100 cents ($1.00)
Tailing litter size = 150%
The rams are used for four years
The mating rate is 200 ewes per ram

The extra value of Ram A over Ram B is:

$$\frac{4 \times 150 \times 200 \times \$1.00}{210} = \$571.43$$

This shows that a buyer could pay $571.43 more for Ram A than Ram B. If the seller is asking more than this margin for Ram A over Ram B then Ram A becomes relatively expensive.

Buying a dual-purpose sire

A dual purpose sire is a ram that produces progeny that are suitable for producing lambs for slaughter **and** ewe lambs that can be retained for breeding. In addition to selection indexes and breeding values rams should be assessed for structural soundness (feet, legs, testicles and mouth – see earlier in the module).

The following calculation shows how ram buyers can calculate the difference in value between two dual-purpose rams. You may find it difficult to understand. The formula is given for those interested in how the difference in value is calculated. Even if you do not follow the calculations completely you should understand that the indexes do allow buyers to assess the difference between rams.

Dual-purpose sires are assessed mainly on the performance of their daughters and the comparison is therefore on the basis of the daughters' production. It is important to assess the proportion of ewes born and retained, and how many times they lamb over their lifetime. This allows you to estimate the ram value in a similar way to the terminal sire calculation but there are a few more terms within the calculation.

$$\textit{Proportion of ewe lambs retained} = \frac{\textit{replacement proportion}}{\textit{(litter size x proportion of ewes to replacement sire x proportion of progeny that are female)}}$$

Example

- 25% replacements or (as a proportion) 25 ÷ 100 = 0.25
- 150% lambing or (as a proportion) 150 ÷ 100 = 1.5 lambs per ewe
- 60% of flock mated to the replacement sire or (as a proportion) 60 ÷ 100 = 0.60
- 50% of progeny are ewes or (as a proportion) 50 ÷ 100 = 0.50

$$\text{Proportion of daughters retained} = \frac{0.25}{1.5 \times 0.60 \times 0.50}$$

$$= 0.56$$

$$= \text{or } 56\%$$

(0.56 x 100 = 56%)

This information can then be used to calculate the margin of superiority of dual-purpose rams.

Margin of superiority of dual-purpose rams is calculated using the following equation:

$$\textit{Extra ram value} = \frac{\textit{years used} \times \textit{tailing litter size} \times \textit{ewes mated per year} \times \textit{ewe lambs retained} \times \textit{DPO margin}}{100}$$

> 100 is a constant number that is calculated taking into account:
>
> - a discount factor (to reflect the time taken until income is earned)
> - ram gene contribution (always 0.50 with the other 0.50 coming from the ewe)
> - the proportion of female progeny (0.50)
> - a factor that reflects the average survival rate of lambs born
> - the number of times daughters have lambs (based on average lifetime of 4.2 years)

Example:

Ram A with DPO 575
Ram B with DPO 285
DPO margin = 575 – 285 = 290 cents ($2.90)
Tailing litter size = 1.5
150 ewes mated per year
Keep 56% or 0.56 of the daughters (see ‘Proportion of daughters retained’ calculation above)

The extra value of Ram A over Ram B is:

$$\frac{4 \times 1.5 \times 150 \times 0.56 \times 290}{100} = \$1,461.60$$

This shows that a buyer could pay $1,461.60 more for Ram A than Ram B. If the seller is asking more than this margin for Ram A over Ram B then Ram A becomes relatively expensive.

When purchasing a ram, a buyer estimates the genetic merit of a particular ram against another ram in relation to farm returns.

Test Yourself #3

1. Describe the most important point to consider when buying a ram.

2. List sources of information you could use to find out about rams for sale.

3. Describe why is it important to find out from a ram breeder what genetic progress has been made from the original base or start point.

4. Describe why it is important to know how many rams have been sold on the breeder's ram selection list.

5. Describe the main difference between the key factors considered when buying a terminal sire compared to a buying a dual-purpose sire.

Culling rams

Once a ram reaches six years of age (four to five matings) its fertility, libido and serving capacity often decline significantly. Older rams are also likely to have poorer genetic merit than younger rams (assuming breeders are making genetic progress with their flocks). Culling rams by age is therefore a sound policy. It is considered to be a compromise between practicality, maximising genetic gain and economics.

All rams should be examined annually for reproductive and physical soundness. Any with testicular abnormalities or permanent physical disabilities should be culled. Rams should be examined before replacements are ordered so that actual replacement numbers are known.

Stress of any description can render rams temporarily infertile. Rams that are not locally bred will need extra time before mating to acclimatise to their new environment.

Culling for age

Most rams are purchased at 12-18 months of age (hogget or two-tooth). They should ideally be culled and replaced after a maximum of four years of use.

Culling by age has the following benefits:

- Age is a good indicator of reproductive ability.
- Culling for age and purchasing replacement rams each year means that a good balance of mixed aged rams is maintained.
- Studs can plan to supply the quantity and type of ram required if annual replacement numbers are relatively constant.
- Annual replacement of 20-25% of the ram flock will allow for more accurate budgeting and place less strain on finances than would less frequent purchases of large numbers of rams.
- The rate of genetic gain can be high because the more rapidly that rams are replaced the closer the commercial flock will be in genetic merit to the stud flock from which rams are purchased. That is, if the stud supplying rams is making genetic gain, then each year's ram lambs will be an improvement on the one before and this will be passed on to the commercial flock over the on-farm lifetime of the ram.

Culling for other factors

Rams should be physically examined and the testes palpated (examined by touch) each year before replacements are ordered. This should be done well before mating to allow the replacements a minimum of eight weeks to arrive and settle on a property.

For acceptable sperm production, the scrotum should be greater than 28 cm in circumference (measuring around the widest part of the scrotum). Small scrotal circumferences can have a number of causes, including immaturity (very young rams), poor nutrition and developmental defects. Small testes in well grown young rams should be viewed with suspicion.

Testes should be firm and springy with no abnormal lumps on palpation. Common testicular faults detected by palpation include:

- small, undescended (tucked up in the abdominal cavity rather than in the scrotum), single testes
- abscesses
- atrophy (shrinking)
- epididymitis (inflammation of the tubes through which the semen is transported)

Epididymitis can be caused by *Brucella ovis* or other bacteria. All of the conditions above can severely reduce sperm numbers and vitality so rams showing these conditions should be culled.

Rams with permanent disabilities such as poor mouths and feet should be culled. Young or very good rams that have a temporary disability should be spelled for a year.

Ram replacements

Get replacements early, at least eight weeks prior to the start of mating. Sperm production takes seven weeks so rams need to be unstressed and acclimatised to an environment well in advance of the breeding season to maximise sperm levels.

Even slight rises in body temperature over a short period of time can severely disrupt the formation of viable sperm. Stress increases body temperature, leading to ram infertility. Factors that can increase stress include mustering, drench/pour-on treatments, yarding, transportation, shearing and introduction to new rams. Rams suffering from temporary infertility will often appear quite normal and their ability to serve may not be affected but the effectiveness of the service can be low.

Calculating ram replacements needed

If a farmer has 20 rams and he/she chooses to replace 25% each year they will need to cull 5 rams:

20 x 25% = 5

Ram deaths during the year need to be taken into account when calculating replacement numbers. For example, if one six year old ram dies from the group of twenty then only four rams may need to be culled to meet the 25% replacement rate. However if the dead ram is a young ram of high genetic merit you may still need to cull five older rams, leaving a total of six to replace.

Ideally ram deaths should be zero if they are well managed. A farmer typically has only a relatively small number of rams and for most of the year they are run as one mob which should be easy to monitor and any problems dealt with promptly. However the occasional death from misadventure or injury may occur.

Ram management

Rams are a capital investment and therefore deserve special consideration in any farming enterprise. It is important to ensure they are in good working order as the success of the mating programme is reflected in the final dollars returned.

Key points to consider:

- Examine rams for testicular defects and abnormalities.
- Check for blowflies, lice and worms and treat if necessary.
- Ensure the rams receive treatment for any health problems.
- Supplement with minerals and vitamins if necessary – e.g. selenium, vitamin B12.
- Ram paddocks should be securely fenced and there should be ample feed, shade and water.
- Rams should be fit and have a body condition score of 3.5 – 4.0 at mating.

Ewe flock selection and culling

Stud breeders record their ewe flock performance as well their rams so breeding values are available for ewe selection. However, the greatest gains in genetic merit of commercial ewe flocks are through selection of rams purchased. Less genetic gain comes from selection of ewe replacements or culling from the commercial ewe flock. The following information on ewe selection relates to commercial flocks.

Ewe replacement selection

It is better to consider the selection of ewe replacements, and culling from the ewe flock, as a way to maximise production rather than genetic merit of the ewe flock. Why is this?

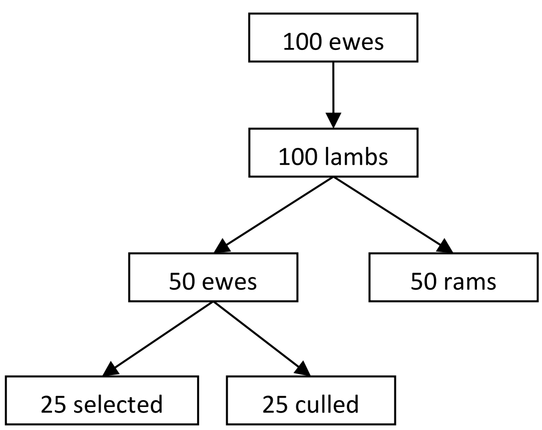
You use relatively few rams to mate to a large number of ewes (typically 1 ram to 100 – 200 ewes) so the genes of one ram quickly enter the flock. A ewe usually has one or two (maybe up to four) lambs at a time so only a small amount of an individual ewe's genes enter the flock each year.

Also, breeders using performance recording systems, such as that from SIL, can show you estimates of genetic merit for key traits which are typically far more accurate than those from commercial flocks. Breeders collect detailed measurements of performance and pedigree for individual animals to produce overall selection indexes that estimate the genetic merit for traits they record.

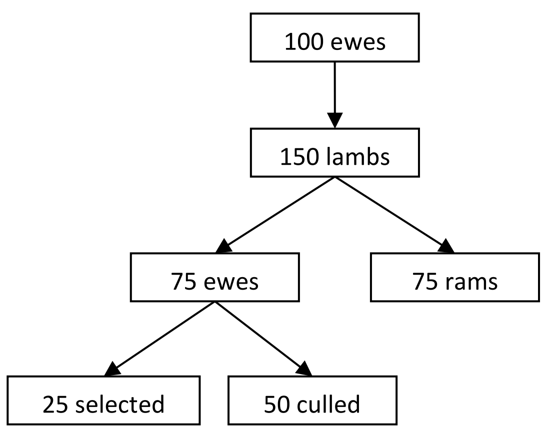
When you select ewe replacements, selection pressure (the ability to improve traits by selection) is much weaker since you must select a large proportion of those available. Increasing the lambing percentage for a particular flock can improve the selection pressure.

For example, compare 100% and 150% lambing percentage where 25% replacements are needed:

100% lambing percentage

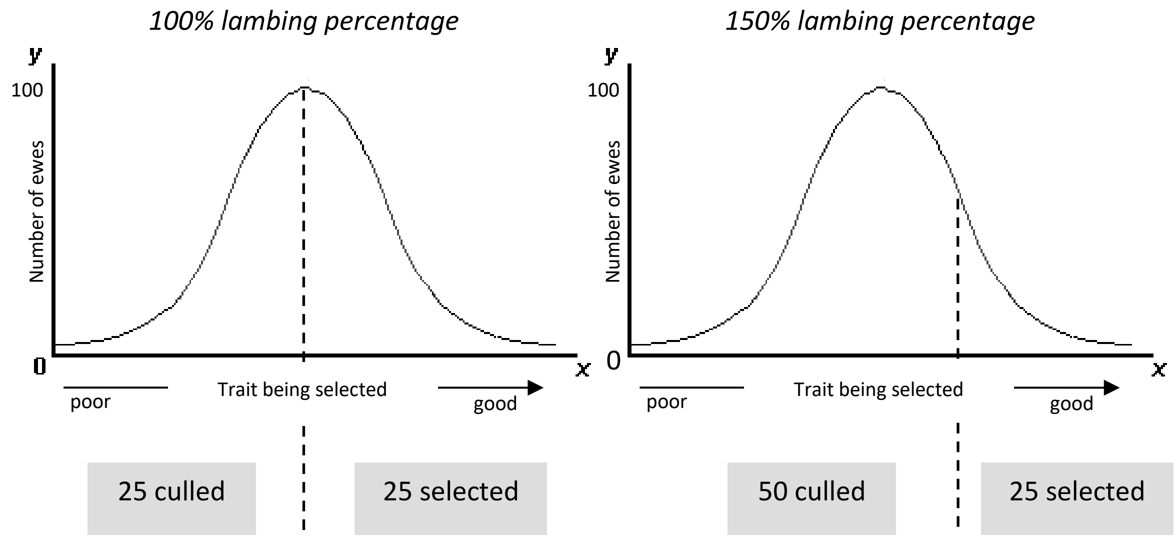


150% lambing percentage



Selection pressure can also be illustrated using a normal distribution curve (see page 23 for explanation of normal distribution curve). The curves below show that with 150% lambing percentage ewe hoggets selected are the top third of the hogget flock instead of the top half, as with 100% lambing percentage. This means, for the higher lambing percentage, ewes selected are likely to be superior in performance than ewes selected at the lower lambing percentage.

Effect of lambing percentage on selection pressure



Selecting heavier ewe hoggets as replacements will not significantly increase genetic merit for growth of their lambs. It is more likely to affect future productivity. Well fed, bigger ewes tend to have more lambs, are better able to feed lambs and have a heavier fleece weight. They may also cope better with other challenges they face. This is because there are non-genetic factors, such as environment and management that affect performance throughout an animal’s life.

Selecting twin-born ewe lambs as replacements does not noticeably increase genetic merit for lambing percentage. Number of lambs born is not very heritable so other factors are more likely to account for why a lamb is a twin, such as her mother was in good body condition and health at mating. Continually selecting ewes that produce twin lambs may, over time, improve the twinning ability of the flock but quicker progress could be made by crossbreeding with breeds known for their twinning ability (such as Finn and East Friesians) or using rams whose progeny have proven (through recording systems) to have high twinning rates.

Selecting ewe replacements on commercial farms should focus on selecting ewe hoggets that will have better actual production. For example, selecting based on fleece weight, fibre diameter, liveweight and/or body size. The overall genetic merit of the ewe flock will improve over time mainly from the influence of ram genes on their progeny.

Ewe culling

In a large commercial sheep flock it is not usually possible to tell which lamb(s) a ewe has actually produced therefore ewe culling should be for characteristics likely to affect future production. These may be physical faults she has developed (e.g. worn teeth, bearings), injuries or obvious signs of disease (e.g. hard udder from mastitis damage, wasting).

Body condition score alone should not be used as a criterion for culling. For example, a ewe that produced two well grown twin lambs may be in lower condition than a ewe that lost one of her two lambs and didn't do that lamb that well. However, if ewes have had the opportunity to recover condition, poor condition may indicate another problem (e.g. disease or she just doesn't carry condition).

In summary:

- Selection of rams is the main route to genetic improvement of your ewe flock.
- Selection of ewe replacements and culling of ewes affects productivity more than genetic merit of your ewe flock.

How many ewe replacements do you require?

Replacement numbers depend on farm management policies and properties. They are commonly 20% – 25%.

Some of the factors to consider when deciding on ewe replacement numbers are:

- **rate of genetic gain**
  The greater the proportion of replacements, the faster the rate of genetic gain. However this needs to be balanced against lambing percentage. Hoggets and, to a lesser degree, two-tooths typically have lower fecundidty than older ewes. Therefore, too many young ewes in the flock could reduce the overall lambing percentage.

- **deaths**
  Dead ewes need to be replaced. The death rate depends on farm management, physical features of the farm (e.g. rocky outcrops, holes, contours, aspect, etc.) and the age structure of the flock. A large proportion of young ewes may result in relatively more ewe deaths due to lambing difficulties. Older ewes that have already successfully lambed once are more likely to successfully lamb again so a greater proportion of older ewes may result in lower overall ewe deaths. Farming areas susceptible to flystrike and facial eczema can have high levels of deaths and wastage if outbreaks occur. Diseases such as Johnes (an incurable wasting disease) also contribute to deaths.

- **dry ewes**
  Dry dry ewes (those that are not pregnant at scanning), dry ewes (those pregnant at scanning but do not bear a lamb) and wet dry ewes (those that lamb but fail to rear a lamb) are commonly culled. A ewe that does not produce a marketable lamb is not contributing to the farms profits. Unless there is a very good reason for the loss of a lamb (e.g. severe weather conditions at lambing) or for not getting pregnant (e.g. an infertile ram) then the ewe should be culled.

- **teeth**
  Ewes with poor or worn teeth find it more difficult to harvest feed, especially when pasture is short or tough (e.g. stalky summer grass). Ewes grazing in areas of sandy soils will wear out teeth faster than those on silt loam soils. Also, eating winter crops or grain off the ground often means sheep take in soil which gets chewed along with the feed so may add to teeth wear.

- **feet**
  Ewes susceptible to scald and foot rot should be culled.

- **udder**
  Ewes that have had mastitis, or have hard or lumpy udders are unlikely to produce adequate quantities of milk for good lamb growth rates. Teats should be free of abnormalities and functioning properly.

- **age**
  You should not automatically cull a ewe that is six years of age, but you should consider if she is likely to perform well. Consider things such as maintenance requirements, genetic merit, fecundity and lactation performance. Ewes need to be culled while they still have a cull value because dead ewes have no value. As with rams, the genetic merit of new young ewes coming into the flock should be better than older ewes so, in general, older ewes have lower performance than young ewes.

- **sale of breeding stock due to drought**
  In some seasons lack of feed due to severe drought may mean breeding stock have to be sold. These will then need to be replaced the following season (assuming feed levels have recovered and finance is available).

Calculating ewe replacements needed

The following example calculates the number of ewe replacements needed for a flock of 2000 ewes.

Assume the following:

- Number of ewes 2000
- Number of ewe deaths 20

- Percentage of ewes culled for production 5%
- Percentage of ewes culled for age 15%
- Lambing percentage 150%
- Lamb losses from tailing to weaning 5%

Number of ewes dead and culled	= 20 + (2000 x 5%) + (2000 x 15%)
	= 20 + 100 + 400
	= 520 or 26% ((520 ÷ 2000) x 100)
Number of ewe lambs available for replacements*	= ((2000 x 150%) – ((2000 x 150%) x 5%)) ÷ 2
	= (3000 – 150) ÷ 2
	= 2850 ÷ 2
	= 1425 ewe lambs

*You need to divide by 2 because only half the lambs will be ewes.

So you need to select 520 of your 1425 ewe lambs (36%) to replace dead or culled ewes to maintain your flock number at 2000 ewes. The remaining 905 ewe lambs can be sold.

Reducing ewe deaths could decrease the number of replacements needed. Reducing lamb losses between tailing and weaning could increase the number of ewe lambs available to select from for replacements and increase the number available to sell.

Test Yourself #4

1. List three benefits of culling rams by age.

2. List four reasons why you would cull a ram.

3. What is the minimum time before mating that you should purchase replacement rams? Explain why.

4. Describe how lambing percentage increases selection pressure when selecting replacement ewe hoggets.

5. How many ewe hoggets would be available for selection from a flock of 2000 breeding ewes with 145% lambing if 21 were culled as lambs?

6. What are three factors that affect the number of ewe replacements required?

7. On commercial sheep farms, explain what basis ewe replacement selection should focus on.

Glossary of animal breeding terms

Allele:	Any one of the alternative forms of a gene occupying the same place on a chromosome.
Artificial insemination (AI):	The insertion of collected male sperm via a pipette into the female reproductive tract. Sperm collection is part of the AI process.
Artificial selection:	Selection made by human decisions. Opposite to natural selection caused solely by nature.
Back-cross:	A cross between an F1 (first cross) and either of its parent breeds.
BLUP:	Best linear unbiased prediction (BLUP), a statistical technique to compare genetic merit between years and between flocks, used internationally across all species of live stock.
Breeding Value: (BV)	An assessment of the genetic potential of an animal.
Chromosome:	The thread-like structure in the cell nucleus that carries the genes.
Common environment:	An environment in which all the animals in a group or population are run. It is an environment they all experience “in common”.
Contemporaries:	Animals born at the same time and similarly reared and treated.
Controls:	Populations or groups of animals that are unselected and against which other selected populations are compared.
Correlations:	A statistical term to describe the relationship or association between traits.
Crossbred:	The progeny from crossing two breeds, lines or strains.
Culling:	Removal of poor or old animals from a population for a range of reasons.
Deviation:	A statistical measure of the difference of a particular observation from the mean of the group of observations in which it is found.
DNA (deoxyribonucleic acid):	The chemical compound that makes up the basic structure of the chromosomes carrying the genetic code. The DNA of each animal is unique.
DNA parentage:	The use of DNA profiles identifies the DNA at various sites against the same sites for the sire and the dam. The closest match identifies the most likely parents.
Distribution:	A statistical term that describes the variation or spread of a series of observations.
Dominant:	The condition where one allele masks the effect of the other (recessive) allele.
Embryo:	An organism in the early stages of development in the uterus.
Fecundity:	A measure of the number of offspring born and reared by the dam.

Fertility: A measure of the ability of the female to conceive and produce offspring, or of the male to fertilise the female.

F1: The first generation of first cross bred animals.

F2, F3 etc.: Are subsequent generations or the second and third crosses of offspring from F1 x F1 parents or F1 x unrelated parent.

Frequency: A statistical term to describe the number of times an observation or a gene occurs in a population.

Gamete: The reproductive cell (either male sperm or female egg) that unite to produce the offspring or zygote.

Generation interval: The average age of the parents when the offspring are born.

Genes: The basic units of inheritance.

Genetic drift: The change in genotypes that occurs under the influence of random effects in the environment.

Genetic engineering: The science of modifying the genetic constitution of the animal directly through manipulation of genes.

Genotype: The genetic make-up of the animal.

Heritability: The strength of inheritance of the trait. Denoted by h^2.

Heterosis: Lift in production that occurs when animals of different genetic make up are crossed.

Heterozygote: An organism that received unlike alleles for a specific gene from each of its parents.

Homozygote: An organism that received like alleles for a given gene from its parents.

Inbreeding coefficient: The rate at which heterozygosity is reduced (or homozygosity is increased) per generation in the population. Inbreeding occurs when related animals are mated.

Inbreeding depression: The lowered performance that sometimes arises through increased inbreeding.

Index: A computed assessment or estimate of an animal's genetic value based on a number of different traits with economic weightings applied.

Interbred: F1 male and female crosses mated to each other repeatedly.

Joined: The term used to describe putting males and females together. Mating is used to describe which females are actually served by the males.

Linkage: An association of genes so that they are inherited together.

Locus: The point that a gene occupies on a chromosome. The plural is loci.

Mean (or average): Calculated as the total divided by the number of observations.

Meiosis:	Cell division in the reproductive (germ) cells in which the chromosomes are reduced from the paired (diploid) state to single (haploid) state.
Mitosis:	Cell division of body cells where each new daughter cell receives the normal diploid (double) set of chromosomes.
Monozygous:	Originating from one egg. Identical twins.
Mutation:	A change in the genetic material (germ plasma) of the organism.
Natural selection:	Selection which has not been influenced by people.
Normal distribution:	The bell-shaped distribution that describes the variation in traits in an unselected population.
Nucleus:	The central part of the cell in which the genetic material – chromosomes and genes – are found. The plural is nuclei.
Objective trait:	One that can be defined and measured in a precise way.
Parameter:	A statistical term for a measure or estimate.
Performance test:	A method of evaluating an animal based on its own performance.
Phenotype:	The displayed performance and appearance of the animal's genetic make-up (genotype) including environmental influences (genotype + environment = phenotype).
Polygenic:	Concerned with many genes.
Population:	A group of individual animals.
Progeny test:	The evaluation of an animal by examining the performance of its progeny.
Random, randomisation:	To arrange according to chance and remove any observed bias caused by any other factors.
Random breeding:	Where each male has an equal chance of mating with each female.
Recessive:	An allele that is masked by another (dominant) one.
Reciprocal cross:	A cross where the previous parent breeds, strains or individuals have been reversed from male A x female B to female A x male B.
Reference animal:	An animal (usually a sire) against which others can be compared, often in different environments.
Relative economic value (REV):	An estimate of the relative value (in money terms) of each trait – sometimes called economic weighting.
Selection differential:	The difference between the mean of the selected parents and the mean of the population from which they came.
Sex chromosomes:	Chromosomes that are concerned specifically with the inheritance of sex.
Sex limited:	Traits that are limited by the sex of the animal, i.e. can only be expressed in one sex.
Sex linked:	Traits that are carried on the sex chromosomes.

Sibling (sib):	Offspring of the same parents, but not necessarily born at the same time. Full sibs have both parents in common while half-sibs have only one parent in common.
Skewed:	A distribution that is distorted and has only one tail.
Standard deviation:	A statistical term that describes the variation in a trait around a mean value.
Stud:	A term used to describe a breeder or his or her flock or herd that is registered (pedigree) with an official breed association.
Subjective or qualitative trait:	One that cannot be defined or expressed in a precise way. A scoring system is often used.
Teaser:	A vasectomised male that acts as a normal male but cannot pass viable sperm.
Threshold:	A base above which expression of the gene will be seen and below which it will not.
Top-cross:	A cross by a sire from a new blood-line of the same breed.
Trait:	Character or characteristic that can be measured or assessed.
Translocation:	Transfer of part of a chromosome to another part of the same chromosome.
Two-tooth:	A sheep showing two permanent incisors.
Variation:	What is measured in a group or population of animals that differ from others.
Zygote:	The product of a union of two gametes.

Useful references and additional reading

A Guide to Genetic Improvement in Sheep	Sheep Improvement Ltd/Woolpro
A Guide to Improved Lambing Percentages	Edited by K. G. Geenty. Wools of NZ and the NZ Meat Producers Board (1997)
100 More, A Guide to Hogget Mating	Edited by, Richard Gavigan and Peter Rattray. Meat and Wool Innovation and Sheep Council
Sheep Genetics Study Workbook	Woolpro
NZ Society of Animal Production	Various conference proceedings
Pocket Guide to Sheep Breeds of New Zealand	Graham Meadows, 2008, New Holland Publishers Ltd

Websites

www.sil.co.nz	Sheep Improvement Ltd – information on their analyses and services
www.nzsheep.co.nz/breeds	Information on sheep breeds and links to breeders web sites
www.beeflambnz.com	Beef + Lamb New Zealand – range of information on sheep and sheep breeding
www.lifestyleblock.co.nz	Basic animal breeding information
learn.genetics.utah.edu	General information on genetic principles
stattrek.com/Lesson2/Normal.aspx	Tutorial on the normal distribution

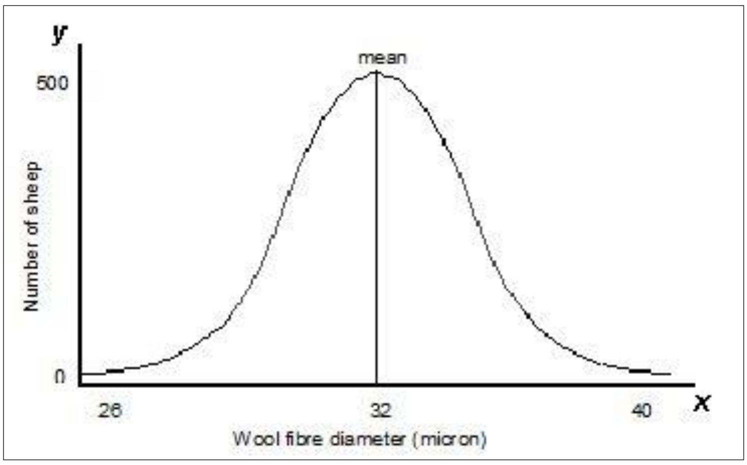
Test Yourself Answers

Test Yourself #1

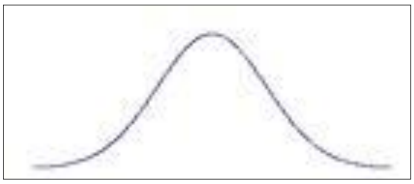
1. *Each lamb receives half its genes from each parent. The ram has X+Y chromosomes and the ewe has X+X. All eggs are X but a sperm may be X or Y. If an X joins with the Y then we get a male and if two Xs join we get a female.*

		Male	
		X	**Y**
Female	**X**	XX	XY
	X	XX	XY

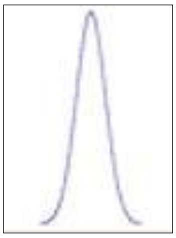
2. *A trait is a characteristic or feature of an animal.*
3. *Sheep have 27 pairs of chromosomes.*
4. *Meiosis is the division of sex cells with one chromosome in each cell. Mitosis is the division of other body cells with a pair of chromosomes in each cell.*
5. *F1 is the first cross offspring created by the mating of two different breeds.*
6. *Dominant single trait genes are always expressed in an animal if they are present, whether both alleles are dominant (homozygous) or one is dominant and one recessive (heterozygous). Recessive genes have to be homozygous (both alleles recessive) to be expressed in the animal.*
7. *Heritability tells you how much of the variation in phenotype is caused by genes.*
8.
   - *fleece weight 0.30 – 0.40*
   - *weaning weight 0.10 – 0.35*
   - *lean weight 0.20 – 0.40*
9.



10.



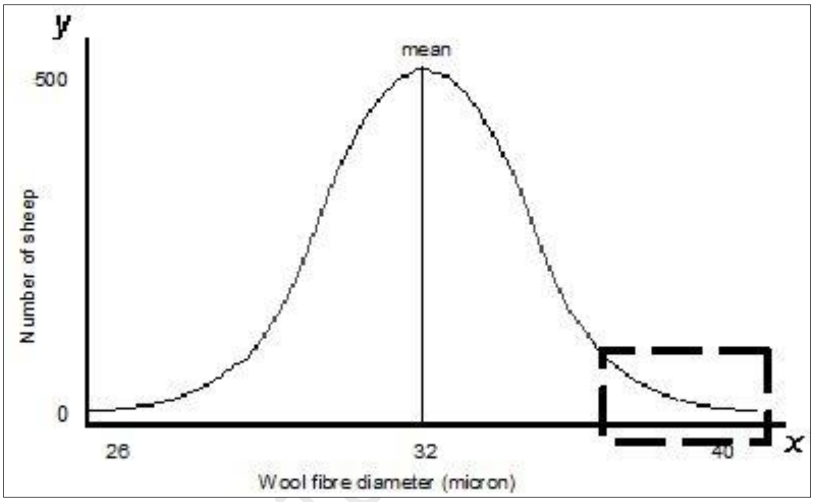
Flat normal distribution curve



Tight normal distribution curve

A narrow or tight distribution curve shows that most measurements are close to the mean measurement and a flat the curve means many of the measurements are lower and higher than the mean.

11.



In the area greater than 2 standard deviations from the mean.

12. *Phenotype is the displayed aspects of an animal; anything that is part of its observable structure, function or behaviour. Phenotype = genotype + environment.*
13. *Genotype is an animal's individual genetic makeup.*

Test Yourself #2

1. *SIL oversees the management of the national sheep breeding and recording systems. It calculates breeding values and indexes for breeders and farmers to use for selecting sheep.*
2.
   a) *True*
   b) *False*
   c) *True*
   d) *False*
   e) *True*
3. *Worm FEC*
   Fat yield (FATY – on TSO only)

A negative BV for these traits means fewer worms and lower fat levels, both of which are usually desirable traits in sheep.

4. *DPO Dual-purpose overall index*
   TSO Terminal sire overall index
   DPX Dual purpose facial eczema measure
   DPS Dual purpose survival
   WWT Weaning weight
   NLB Number of lambs born
   FEC1 Faecal egg count at 1 month

5. *Economic weighting*
   DPX -903
   DPS direct 6329
   WWT direct 116
   NLB 2430
   FEC1 -2.9

Test Yourself #3

1. *The most important point when buying rams is to choose a ram breeder showing genetic gain in the traits important to your flock.*
2.
   - *stock agents*
   - *SIL*
   - *publications such as rural magazines and newspapers*
   - *breeders websites*
3. *This information will assist you in determining the progress the particular breeder has made over a period of years. It will show the strength of the breeding programme.*
4. *You need to ensure that you are not just taking the tail-end ram from a flock unless you are well satisfied that even their genetic ability is still well above that of your existing flock.*
5. *Terminal sires must produce lambs that survive, grow fast and yield a quality carcass. As all lambs are slaughtered, reproductive performance, wool and disease resistance have little or no value in the selection of a terminal sire. A dual purpose sire is a ram that produces progeny that are suitable for producing lambs for slaughter* ***and*** *ewe lambs that can be retained for breeding so they are assessed mainly on the performance of their daughters and the comparison is therefore on the basis of the daughters' production.*

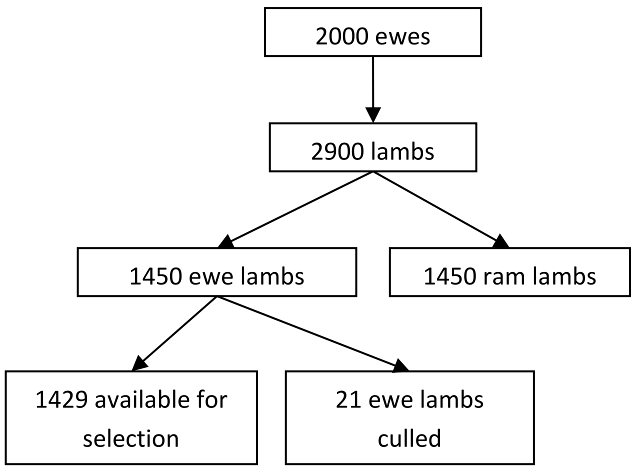
Test Yourself #4

1. *Any three of the following:*
   - *Age is a good indicator of reproductive ability.*
   - *Culling for age and purchasing replacement rams each year means that a good balance of mixed aged rams is maintained.*

- *Studs can plan to supply the quantity and type of ram required if annual replacement numbers are relatively constant.*
- *Annual replacement of 20-25% of the ram flock will allow for more accurate budgeting and place less strain on finances than would less frequent purchases of large numbers of rams.*
- *The rate of genetic gain can be high because the more rapidly that rams are replaced the closer the commercial flock will be in genetic merit to the stud flock from which rams are purchased. That is, if the stud supplying rams is making genetic gain, then each year's ram lambs will be an improvement on the one before and this will be passed on to the commercial flock over the on-farm lifetime of the ram.*

2. *Feet, fertility, fitness, disease, flystrike, FE, testicular abnormalities, other reproductive abnormalities or injuries*
3. *At least eight weeks before mating because it takes seven weeks to produce sperm and rams need to be settled into their new environment and stress free to maximise sperm production.*
4. *A higher lambing percentage means you have more hoggets to select from so you are more likely to be able to select hoggets with traits that measure better than the flock mean.*
5. *1429 ewe hoggets would be available for selection*

145% lambing percentage



6. *Any three of the following:*
   - *rate of genetic gain*
   - *deaths*
   - *teeth, feet, udder*
   - *sale of breeding stock*
   - *failure to get pregnant, failure to rear a lamb*
7. *Ewe replacement selection should focus on production factors of the ewes rather than genetic merit. The overall genetic merit of the ewe flock will improve over time mainly from the influence of ram genes on their progeny.*

Appendix

Sheep breeds

Each breed of sheep has particular traits suited to the productive purpose of the breed. The following information gives some idea of the range of performance for varying traits of the main dual-purpose and terminal sire breeds. The performance figures are a guide only.

Dual-purpose breeds

Romney

The Romney is the main sheep breed in New Zealand and accounts for approximately 40% of the national flock. It was developed from the Romney Marsh, a sheep that evolved in the wet marshes in East England. The Romney Marsh was first introduced to New Zealand in 1853. In 1956 the breed name was officially changed to New Zealand Romney to reflect the changes in the breed that had occurred to better suit the New Zealand environment.

As well as its significance as a pure breed, the Romney has been the basis of cross-breeding with the Cheviot to create the Perendale, and the Border Leicester to create the Coopworth.

Romneys perform well in high rainfall areas, as well as most other farming environments found throughout New Zealand. It is a medium size, white sheep with a white face and woolly legs. It is polled (doesn't have horns).

Features

Body weight	Ewes 45-75 kg and rams 60-85 kg
Meat	Average lamb carcass weight 15-22 kg
Breeding/lambing	Lambing percentage is typically 90-150%; good mothering ability and fairly easy care at lambing
Wool	Fibre diameter around 33-40+ microns, staple length of 125-175mm and fleece weight 4.5-6.0 kg
Use	The Romney is a dual purpose breed with an equal emphasis on meat and wool production. It has a heavy fleece of medium lustre wool and is crossed with a wide range of terminal sires for meat production.

Romney ewe with triplets

Coopworth

The Coopworth was developed in New Zealand in the 1960s from the Border Leicester and Romney breeds, by Professor Ian Coop of Lincoln College, Canterbury. It is the second most popular breed in New Zealand, making up 12% of the national flock. It is mostly farmed in lowland areas and improved hill country (i.e. hill country with applied fertiliser and ryegrass/white clover pastures).

The Coopworth is a polled, medium sized white sheep with a white face, a slight Roman nose and black nostrils. Its legs are clear of wool and it has black hooves.

Features

Body weight	Ewes 55-65 kg and rams 75-85 kg
Breeding/lambing	Lambing percentages are typically 110-160%. Easy lambing due to narrow shoulders and wide pelvis. Good mothering and milking ability.
Wool	Fibre diameter around 35-39+ microns, staple length of 125-175mm and fleece weight 4.5-6.0 kilograms.
Use	Used for meat and wool production. Wool used for carpet and heavy clothing.

Coopworth ewes

Source: www.ashtonglen.co.nz

Perendale

Bred in New Zealand, this is a dual-purpose meat and wool breed that was developed at Massey University by inter-breeding the Cheviot and Romney. It was first registered as a breed in the early 1960s. It is now makes up 10% of the national flock and is farmed on hill country throughout New Zealand.

The Perendale is a medium sized sheep that is active, hardy and a good forager. Both the face and legs are clear of wool. It is an easy care breed with few lambing problems but requires quiet handling. It has above-average resistance to internal parasites.

Features

Body weight	Ewes 50-65 kilograms and rams 65-80 kg.
Breeding/lambing	Lambing percentage is typically 100-140%.

Wool	Fibre diameter around 31-35 microns, staple length 100-150mm and fleece weight 3.5-5.0 kg.
Use	Used for meat and wool production. Wool used for knitting yarn and some garments.

Merino

The Merino is the oldest established breed in the world and was first introduced to New Zealand in 1773 by Captain Cook. These sheep did not survive and the breed was re-introduced in 1834. The Merino remained the major breed in New Zealand for many years but, as meat production became more important with the development of refrigerated shipping in 1882, it now only makes up 5% of the national flock.

Merinos do not usually perform well in wetter regions and today are mainly farmed in the drier, high country, lower hill country and Canterbury Plains in the South Island.

The Merino is a white fleeced sheep, with white face and legs. They are relatively light in weight but medium to large in body frame. This reflects their use for wool production rather than meat. Rams and ewes have folds of skin at the neck. They have wool on their cheeks and legs, and have white hooves. All rams and some ewes are horned. There is a polled strain, called a Poll Merino, which is otherwise very similar to a Merino.

Features

Body weight	Ewes 40-55 kg and rams 53-73 kg
Breeding/lambing	Lambing percentage is typically 75-110%.
Wool	Fibre diameter around 15-24 microns, staple length 65-100mm and fleece weight 3.0-6.0 kg.
Use	Making quality woollen and worsted fabrics.

Weaned Merino lambs grazing.

Corriedale

The Corriedale sheep was the first sheep breed to be created in New Zealand. It was established in the early 1900s from crosses of Merino, English Leicester, Lincoln, and some Romney and Border Leicester. It was initially developed in the Corriedale locality in North Otago and now is a prominent breed in the dry regions of New Zealand, making up 3% of the national flock. However, as a result of exports to many regions of the world, the Corriedale now almost outnumbers the Merino as the most popular breed in the world.

Corriedale rams are used for crossing with Romney or Perendale flocks to increase their body size and improve the fineness of their wool.

The Corriedale sheep is a medium sized, polled breed, well suited to a dry environment. It is white, with white face and dark nostrils. It has wool on its legs and dark hooves.

Features

Body weight	Ewe 65-80 kg and rams 85-105 kg
Breeding/lambing	Lambing percentage is typically 90-130%
Wool	Fibre diameter is around 24-33 microns, staple length75-125mm and fleece weight 4.5-6.5 kg
Use	Lean meat and medium to fine wool. Wool has many uses including for medium-weight outer garments, light tweeds and hand knitting yarn

New Zealand Halfbred

The New Zealand Halfbred was developed in the late 1800s by crossing Merino with some longer woolled breeds, typically the Leicester, Lincoln or Romney. The Halfbred has improved the meat and fecundity characteristics of the Merino. They are mainly farmed in the foothills throughout the South Island and in dry areas.

Halfbreds are white, with a white face and pink or black nostrils. Legs are typically covered with wool and hooves are white or black. They are medium sized and easy care.

Features

Body weight	Ewes 40-55 kg and rams 53-73 kg
Breeding/lambing	Lambing percentage typically 85-110%
Wool	Fibre diameter around 25-31 microns, staple length 75-125mm and fleece weight 4.0-6.0 kg
Use	Dual purpose meat and wool but with an emphasis on wool production. Wool is used in worsted fabrics and fine knitwear

Terminal sire breeds

Suffolk

The Suffolk was developed from crossing Southdown rams and Norfolk Horned ewes. It was first recognised as a breed in early 1859. Introduced to New Zealand in 1913, it is now used throughout the country as a terminal sire. (The South Suffolk was developed in New Zealand from the Suffolk and Southdown.)

Suffolks are polled with a white fleece, black face (clear of wool) and black nostrils. They have black legs, clear of wool and black hooves. They are a large, hardy and robust breed.

Features

Body weight	Ewes 60-80 kg and rams 80-106+ kg
Breeding/lambing	Lambing percentage typically 110%-150%
Wool	A short, fine, down-type wool of 30-35 microns, staple length 75-100mm and fleece weight 2.5-3.0 kg
Use	Rams are used to cross with Romney, Perendale and other main breeds to produce lambs for slaughter. Ewes are typically confined to stud farms, specialist meat farms and lifestyle farms.

Suffolk ram

Texel

The Texel originated on the island of Texel in the North Sea off the coast of Holland. It developed in harsh and bleak conditions and has an ability to thrive despite short growing seasons and poor pasture quality. It has become a very efficient converter of feed to meat. The Texel was introduced into New Zealand in 1990 and is now found throughout the country. They are used in many composite sheep breeding programmes, as terminal sires and to introduce Texel traits into ewe flocks.

Texels are not considered the prettiest of sheep but have excellent production characteristics. They have high muscling which results in good meat yields. They have few metabolic disease problems, are good foragers, have a high conversion rate of dry matter to body weight, a strong maternal instinct and a high lambing percentage. The lambs are hardy but later maturing than some other meat breeds. Texels are polled with a white fleece, white head and black nostrils. They have a low, wide body with white legs clear of wool and dark hooves.

Features

Body weight	Ewes 65 - 80 kg and rams 80-90+ kg
Breeding/lambing	Lambing percentage typically 120%-170%
Wool	Fibre diameter is around 33-37 microns, staple length 75-125mm and fleece weight 4.0-5.0 kg
Use	Main use is meat production but their high bulk, medium coarse and moderate length wool is also used for bedding (pillows, duvets and mattress overlays) and high quality carpets

Texel ram

Poll Dorset

The Poll Dorset was developed in Australia from the Dorset Horn. Horns can cause carcass damage, create handling difficulties and are generally not desirable in most breeds. The Poll Dorset was established in New Zealand in 1959 and is now found throughout the country. One of the Poll Dorset's main advantages is that they are not seasonal breeders as most breeds are. This means they can be mated at any time of the year, although in practice mating is typically timed to allow for spring or autumn lambing. It is also possible for ewes to lamb three times in two years.

Poll Dorsets are a hardy, vigorous breed with rapid lamb growth rates and ewes with good mothering and milking ability. They are polled, with white fleece, white face clear of wool, and noticeable pink skin and pink nostrils. Legs are white and free of wool with white hooves.

Features

Body weight	Ewes 70-80+ kg and rams 80-95+ kg
Breeding/lambing	Lambing percentage is typically 110-160%

Wool	Fibre diameter 27-32 microns, staple length 75-100mm and fleece weight of 2.0-3.0 kilograms. A short, down-type wool that is very white
Use	Poll Dorsets are used as a terminal sire to produce lambs for meat, particularly early and out-of-season lambs. The very white, bulky wool is used for making hosiery, dress fabrics, flannels and fine tweeds. Skins are used for lining boots and shoes.

Poll Dorset ram

Composite sheep

Composite sheep are developed from a number of different breeds specifically to improve productive performance with no concern about appearance. Examples are the Kelso and Greeline. These are not fixed breeds in the traditional sense but are bred for particular traits and performance levels. The actual mix of breeds used to produce the composite varies with the targeted market and can be altered to suit changing markets or production requirements. There are no 'breed standards' to meet.

Many composites result from crosses between Romney, Finn, Texel and East Friesian breeds. Finn and East Friesian are used to improve fecundity, mothering ability and milk production. Finns also pass on genes for resistance to facial eczema. Texels are used for their meat characteristics and Romneys for their good all-round performance in most areas of New Zealand. Other breeds are also used to produce composite sheep depending on the aims of the breeder.

If a composite becomes stabilised over time (i.e. no further genetic changes occur by introducing new breeds to the mix) the composite may eventually become considered a pure breed.