Sheep CRC Practical Wisdom Notes

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SHEEP CRC
Sheep CRC Practical Wisdom
Know it. Do it.

Genomics and DNA testing: new tools for ram breeders to accelerate genetic gain

By Julius van der Werf, University of New England; Stephen Lee, University of Adelaide; and Lu Hogan, Sheep CRC

Key points

- Genomics refers to the use of information from DNA samples.
- DNA samples can be generated by collecting blood from an animal on a specific bar-coded card and sending this to a service provider (currently Sheep Genetics and Sheep CRC).
- DNA tests are now available to determine parentage, poll status and to estimate breeding values for many economically important traits.
- The Parentage test is accurate and compatible with other SNP-based tests. It requires a DNA sample from an animal and its probable parents and provides an alternative, labour saving method for determining sire only or full pedigree.
- The Poll test identifies carriers of the horn gene and can assist in eradicating horns from a poll flock.
- The Sheep Genomic test provides information about breeding value and this information is combined with pedigree and performance data in the Sheep Genetics database to increase the accuracy of Australian Sheep Breeding Values.

Introduction

DNA technology has developed rapidly over the past decades and we can now relatively cheaply generate information from the DNA of individuals. Information from a DNA test can be used to predict traits or determine parentage. Taking a DNA test from an animal is sometimes referred to as ‘genotyping’ the animal. The Sheep CRC has developed a number of DNA tests useful for sheep enterprises. These are the Parentage test, the Poll test and the Sheep Genomic test.

How is a DNA test sample collected?

A DNA test requires the collection of a small blood sample on a blood card. This can be done, for example, by making a small cut on the ear. Blood cards are provided when ordering tests, they are

specially designed for collecting blood for the purpose of DNA testing. The cards are bar-coded and the identification number of the animal that the sample belongs to must be provided on the card.

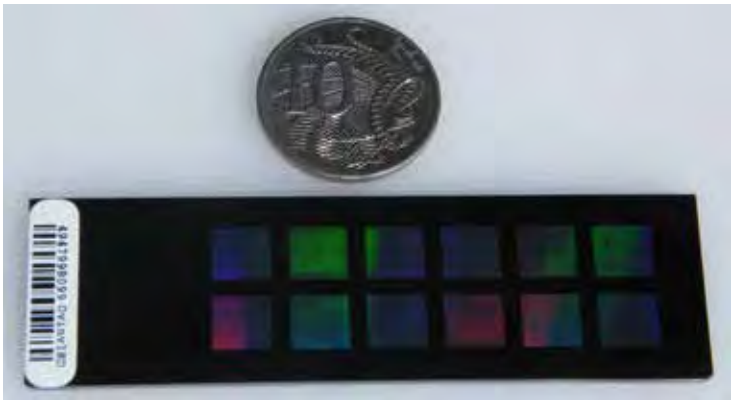

Figure 1. SNP chip.

What tests are available?

Parentage Test

The Parentage test uses about 180 genetic markers (SNPs) to test whether animals are the likely parents of a particular animal. The test requires a DNA sample from the animal and its likely parents. The Parentage test is suitable for all breeds of sheep.

Figure 2. Blood cards being used at lamb marking.

The Parentage test based on DNA has a number of advantages:

- The test is expected to be more accurate than existing parentage tests for sheep.
- The test is compatible with the other Sheep CRC SNP-based tests. This means that animals tested using the Sheep Genomic test will not need to be re-sampled by the breeder for parentage, as the genotyping has already been recorded.
- It is a labour saving alternative to manually allocating lambs to their dams at lambing time.
- It can be used to determine sire pedigree in syndicate matings.

The Parentage test can be used for ‘full pedigree’, that is, linking a lamb to its dam and sire, or ‘sire pedigree’, linking lambs only to their sire. Alternatively, breeders may choose to only link ram lambs with the sires. It is very important to collect blood samples from all of the animals that need to be matched up. For example, failing to sample a sire makes it difficult to assign lambs to their sires. The same applies to sampling all ewes if full pedigrees are required.

Potential parents may have been tested before, either in a Parentage test or via an Sheep Genomic test. In that case, these do not need to be tested again, but they need to be listed as potential parents using their Sheep Genetics ID (16 digit code).

The Parentage test can determine DNA mismatches between progeny and sires or dams, in which case we can be confident that those are not the parents. There could, in some cases, be a match with more than one sire (or dam), for example, when the potential sires (or dams) are closely related. In most cases, it is then still possible to determine that one is more likely the parent than the other. However, in a small number of cases the test may have difficulty to assign parentage with full confidence. This can occur if there is only one potential parent or potential parents are highly related.

In general, better results will be achieved if:

- larger numbers of progeny are tested in the batch
- at least two sires are nominated
- both sire and dam are DNA sampled

Poll Test

The Poll test has been developed by the Sheep CRC using measurements and DNA tests on animals in the Information Nucleus Flocks. The test is based on two genetic markers that are very close to the Poll gene. The test is normally used on Merinos.

Identification of polledness only requires individuals of interest to be sampled. In most situations this involves sampling only the rams and possibly some ewes being selected for a breeding program. The information on poll status of both parents provides a prediction of the progeny's poll status. The test provides an important opportunity for breeders to identify sires and dams that carry the Poll gene, and is therefore an effective tool to breed towards a purely poll flock. Another paper provides more detail and describes strategies on using the Poll test to eradicate the horned gene.

Sheep Genomic Test

The Sheep Genomic test provides information on 12,000 genetic markers. These markers are SNPs (Single Nucleotide Polymorphisms) and refer to a single letter variation in the DNA alphabet. SNPs are usually neutral markers that are close to a gene (rather than within the gene), but they can predict differences in performance or phenotype due to genetic differences.

The whole package of DNA, including the genes and the gene markers, is referred to as the genome, and selection based on the information obtained from many SNP markers is termed 'genomic selection'. Genomic selection allows ram breeders to select animals for breeding using a DNA test in conjunction with phenotypic data and pedigree to increase the accuracy of Australian Sheep Breeding Values (ASBVs). Genomic selection is now revolutionizing animal breeding around the world. For example, most of the dairy bulls used for artificial insemination are now selected based on a genomic test; this has replaced a lengthy and costly process of progeny testing. Also, in sheep, we can predict the breeding value based on the genomic testing with some accuracy. This is especially useful for traits that we cannot measure easily on an animal before we make selection decisions. Genomic selection is therefore particularly useful for traits that are measured later in life, for example adult wool weight or mature weight, or reproduction, and for traits that are difficult to measure on breeding animals such as meat traits.

Genomic selection works by DNA testing an animal and comparing its DNA profile with that of thousands of other animals that have been measured for traits used for selection. Based on this DNA comparison we can predict the breeding value of an animal. In Australia, we use information from the Sheep CRC Information Nucleus flock and the Sheep Genomics flock, which comprise close to 20,000 animals that have been DNA tested and measured for most important traits, including many meat quality traits. The MLA resource flocks continue to measure and genotype animals every year to maintain an ongoing data resource that can be used for predicting genomic breeding values.

When an animal is tested, the DNA information is merged with other information in the Sheep Genetics database, such as pedigree, the breeding value of its parents and its own performance information; this is used to predict the animal's breeding value. Ram breeders and ram buyers can use ASBVs to select animals based on genetic merit as they are the best prediction of breeding value, combining all the available information.

The Sheep Genomic test is available for four breeds: Merino, White Suffolk, Poll Dorset and Border Leicester. To use the Sheep Genomic test the breeder must be a member of Sheep Genetics with the individual animals to be tested entered into the database with at least sire pedigree recorded. The test will provide information for almost all of the major traits reported by Sheep Genetics and is also used to provide ASBVs for some new traits that are generally not measured by breeders, such as carcase and meat quality traits.

What is the benefit of using an Sheep Genomic test?

Genomic information is most useful if the information about an animal is otherwise limited. Genomic information increases the accuracy of ASBVs, particularly early in the life of an animal when only few performance records are available. Increased accuracy has a positive impact on the rate of genetic gain.

Table 1, below, shows how the value of genomic information changes as the animal gets older and information is gathered on its parents, the animal itself and siblings and progeny.

Table 1. Accuracies of ASBVs change depending on the sources of information used.

	Trait with heritability of 10%		Trait with heritability of 30%	
Information used	**Without genomics**	**With genomics**	**Without genomics**	**With genomics**
DNA test only	0	0.22	0	0.39
Parents records (PR)	0.22	0.31	0.39	0.51
PR + 20 half sibs (20H)	0.35	0.40	0.49	0.58
PR + 20H + own info (OI)	0.45	0.48	0.66	0.69
PR + 20H + OI + 20 progeny	0.66	0.67	0.84	0.85
PR + 20H + OI + 100 progeny	0.86	0.86	0.95	0.95

The Sheep Genomic test is expected to significantly increase the ASBV accuracy for young rams. The accuracy increase can vary from 0.02 to 0.24 accuracy points. This means that breeders can select and use rams, especially at young ages when little phenotypic information is available, with more confidence than without this DNA information.

Selecting rams more accurately and earlier is beneficial for breeding programs as higher rates of genetic gain can be achieved in a ram breeders flock with a high accuracy of selection of breeding animals combined with a short generation interval.

For older rams with many progeny recorded, the ASBV accuracy will already be high (as shown in Table 1) and the additional gain in accuracy from the Sheep Genomic test is relatively small. The largest increases in accuracy will be for rams prior to first use when ASBV accuracy is low. Sheep Genomic testing will bring the accuracies of young rams closer to those of older rams, therefore making it more likely that they can be competitive for use in the breeding program.

Using genomic selection will improve the rates of genetic improvement especially for traits that:

can only be measured late in an animal's life, such as mature weight and mature wool production

have a low heritability and that can only be measured on females, such as reproductive rate

are not measured at all, such as carcase traits and eating quality traits

The net outcome of DNA testing based on the Sheep Genomic test is faster genetic gain within the stud, which is then passed onto commercial flocks using rams from that stud.

Refer to the other Practical Wisdom notes that quantify the likely benefits of genomic testing specifically for Merino, maternal and terminal ram breeding flocks and describe which and how many animals should ideally be tested in order to be cost-effective.

How do I get a DNA test?

The blood cards needed for DNA testing will be provided when the genetic test is ordered via a designated website (via Sheep Genetics or another provider, currently the Sheep CRC). The card must clearly identify the animal being tested using its 16 digit Sheep Genetics identification code. Once the blood cards are returned to Sheep Genetics, they are forwarded on to a laboratory for analysis. The test results are returned to Sheep CRC and Sheep Genetics. Parentage and Poll results are returned directly to the breeder, whilst Sheep Genomic tests results are incorporated into the ASBVs provided by Sheep Genetics.

Take home messages

- The Sheep Genomic test increases breeder confidence to use animals at a young age.
- The Sheep Genomic test increases the rate of genetic gain in ram breeding flocks by increasing the accuracy of selection and reducing the generation interval.
- Testing older animals is still beneficial due to the increased accuracy of ASBVs, but the quantum of benefit is reduced.
- Commercial flocks benefit from the increased rate of genetic gain that ram breeders can achieve with genomic testing.

Further information and to order tests

Sheep CRC website: www.sheepcrc.org.au, then choose Genotyping tests.

Sheep CRC Practical Wisdom notes:

- Sheep CRC genomic test for Merinos—what are the benefits?
- Sheep CRC genomic test for maternal breeds—what are the benefits?
- Sheep CRC genomic test for terminal breeds—what are the benefits?
- Breeding towards a poll flock with the Sheep CRC Poll test.

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