

DNA Testing

With recent advancements in genetic technologies, selection of your next flock additions can involve much more than simple phenotypic appraisals. DNA testing can now allow determination of genotype directly from an easy-to-take sample. DNA testing may one day allow selection for carcass traits, such as muscling and tenderness, feed efficiency, out of season breeding and disease and parasite resistance. Already today, two disorders and diseases that in the past two decades have been detrimental to the sheep industry are now being controlled and even eliminated thanks to DNA testing. These disorders are Scrapie and Spider Syndrome.

Scrapie is a fatal degenerative disease that affects the central nervous system in sheep and can be passed from sheep to sheep. Positive diagnosis of scrapie can result in a flock being quarantined and animals destroyed. Fortunately, sheep can have genetic resistance to scrapie that can be detected with a simple and inexpensive DNA test. By using DNA testing it is possible and practical for a breeder to select for and breed resistant animals. Buyers can also be assured that they are buying resistant sheep.

Spider syndrome is a genetic disorder that causes bent legs, a twisted spine, nose and/or rib cage. Animals that have this disorder are economic liabilities to the producer. A DNA test is also available to determine if a sheep is a carrier of this genetic mutation.

How do I DNA test?

DNA testing is performed by a laboratory and only requires a sheep owner to submit a sample. Since DNA is found in every cell in a sheep's body (except red blood cells), DNA can be isolated and tested from a variety of sample types. For sheep DNA testing, the most commonly used sampling methods are blood tubes (there is plenty of DNA in white blood cells), blood cards and ear tag tissue samplers.

Blood tube collection requires the most expertise, since blood must be obtained from a vein or artery, and many producers utilize a veterinarian to collect samples in blood tubes. DNA tests require that blood be collected in purple top tubes, which contain an agent (EDTA) that prevents the blood from clotting. It is more difficult, but not impossible, to get a good DNA sample from clotted blood. Blood tube samples should be kept cold and shipped to the lab soon after collection.

Blood cards are easier for most users who want to collect samples themselves, although it is very important to take a good sample to avoid problems at the lab. A small cut or nick is made, most commonly in the ear, and a few drops of blood collected on the card. Some types of blood cards require that the sample be allowed to air dry thoroughly. Blood cards can be kept for a long period after collection and can be sent to the lab via regular mail.

Ear tag samplers may be the simplest of all to use and take a small punch of tissue from the ear using an applicator very similar to an ear tagger. Some of the ear tag samplers leave a tag in the ear, others do not. The container into which the sample is collected contains a drying agent that allows the sample to be stored at room temperature for long periods without damage.

Both blood cards and ear tag samplers allow the user to sample at one time and submit the samples later. For example, a sample may be taken when the lamb is first born and tagged, but the sample need not be submitted for testing until it is determined if the lamb will be kept in the flock.

Hair samples can also be tested, however, the hair must be pulled and not cut, since most of the DNA in hair is in the follicle. Any tissue sample can also be tested. It is best to freeze a tissue sample and submit it frozen.

How does DNA testing work?

First a little background. DNA is the genetic material of all higher organisms. It is the blueprint for making and maintaining the animal and consists of a long string of subunits linked together – imagine beads on a wire. In the case of sheep and humans, there are about 3 billion beads (actually nucleotides). The 3 billion nucleotides are in several different strings, which are organized in chromosomes. There are 54 chromosomes in sheep (humans have 46). These are actually 27 pairs of chromosomes. One chromosome of each pair comes from the mother and one from the father.

Along each chromosome are sequences of nucleotides that comprise genes. Genes are stretches of DNA that code for proteins, the building blocks and workhorses of all animals. It can be that changing a single nucleotide in a protein can change the function of that protein. In the cases of scrapie susceptibility and spider syndrome such changes have occurred in two sheep genes. (The prion protein gene in the case of scrapie and a fibroblast growth factor receptor gene in the case of spider.) DNA testing detects these single nucleotide changes.

DNA testing, especially testing for scrapie susceptibility, is sometimes referred to as “codon testing.” A codon is a subunit of a gene, actually 3 nucleotides that code for a single amino acid (amino acids are the subunits of proteins – proteins can also be thought of as beads on a wire, but this time the beads are amino acids). For example, the prion protein gene consists of 256 codons, which means that the protein contains 256 amino acids.

Scrapie susceptibility is affected by a few amino acids, the most important of which is coded for by codon 171, although codon 136, 154 and 141 also have some effect. Codon 171 codes either for the amino acid glutamine, which in the single letter amino acid dictionary is abbreviated as “Q”, or for arginine, abbreviated as “R”. Thus, sheep may be referred to by their codon 171 genotype as QQ, QR or RR. Remember, sheep carry two copies of the prion protein gene (one from mother, one from father) and, therefore, the genotype must have two letters.

To determine the sheep's genotype, a laboratory will isolate DNA from the sample submitted and, by any of a variety of methods, determine the codon 171 genotype. This sounds simple, but the difference between Q and R is a single nucleotide – one out of 3 billion. The fact that this genotyping can be so easily and economically accomplished is really quite remarkable.

How do I use DNA test results?

The results of DNA tests can be used to guide selection of replacements and help make breeding and purchase decisions.

Results for scrapie susceptibility (codon 171) will say that the sheep is QQ, QR or RR. The very good news is that both QR and RR sheep are resistant to scrapie. In other words, resistance is dominant and “R” can also be thought of as standing for “Resistant.” Therefore, a RR ram or ewe will only produce resistant (QR or RR) offspring. When mated to an RR sheep, all the offspring will be RR, when mated to

a QQ sheep, all the offspring will be QR and when mated to a QR sheep, half the offspring will be RR and half will be QR.

It should probably be noted that the codon 136 genotype is sometimes important. Sheep prion protein genes will be either “A” (alanine) or “V” (valine) and, therefore, sheep will be either AA, AV or VV. Both VV and AV sheep are susceptible to scrapie. Again, there is good news. “R” and “A” are linked, such that if the gene is “R” at codon 171, it will be “A” at codon 136. Therefore, all RR sheep are AA and completely resistant. QR sheep can be AV, which could make them susceptible. It may, therefore, be a good idea to test QR sheep at codon 136. However, once you find that a sheep is AA, you never need to test its offspring at codon 136 if you only breed it to other AA sheep. The offspring of RR by RR crosses never need to be tested.

Spider Syndrome

Spider syndrome is a recessive genetic condition that is widely considered to have originated in Suffolk sheep. Although sheep with two copies of the “spider” gene are severely deformed and rarely live to maturity, however, sheep with a single copy of the gene have increased bone growth that generally makes them larger and taller than an otherwise genetically identical sheep without the “spider” gene.

The results of a DNA test for Spider Syndrome will be NN (non-carrier), NS (carrier) or SS (possess Spider Syndrome, most commonly known as a spider lamb). “N” and “S” do not, in the case of Spider Syndrome, stand for the names of amino acids, but rather mean “Normal” or “Spider” An NN individual does not carry the “spider” gene and will never pass it to its offspring. An NS individual can pass the gene onto its offspring, but when mated to a NN individual will never produce a spider lamb. An SS individual is a spider and probably will never carry a lamb to term. But in the unlikely case that this occurs, when bred to a NN individual the offspring will all be carriers. When bred to an NS individual 50 percent of the offspring will be carriers and 50 percent will be spider lambs. Crossing two NS sheep will, on average, produce 25% normal (NN) lambs, 50% carrier (NS) lambs, and 25% spider (SS) lambs.

Suffolks and DNA testing

Suffolks have definitely been the “Breed in the Lead” when it comes to DNA testing and have widely adopted DNA testing to manage both scrapie susceptibility and Spider Syndrome. Several breeds at many sales now require that sellers guarantee the codon 171 and spider genotypes of their sheep, a practice originated by the USSA.

A cautionary note

The laboratories that do DNA testing are very good and mistakes are very rare. Breeders are generally very good sample takers and mistakes are very rare. However, humans are involved and mistakes are made. There are sad stories of people paying lots of money for their RR stud ram, using him on a large group of their top ewes and then finding QQ lambs among the offspring. (Remember, it is not possible to get QQ lambs when even one parent is RR.) The take home lesson is that sometimes the expense of an extra DNA test is very inexpensive insurance.