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How To Get Started With DNA Testing

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There are a number of different companies offering DNA tests, and testing is being done to answer a number of different questions. I have sometimes heard producers say they "DNAed" their cattle, but that is little bit like saying I vaccinated my cattle – the important question is "for what"? DNA is present in every cell and so DNA can be extracted from a number of different tissues including blood, semen, hair follicles, and an ear notch. Before going ahead to perform DNA testing there are a number of questions you need to ask as detailed in this fact sheet.

Step 1: What do you want to test?

There are several different types of DNA tests, including parentage tests that can determine a particular animal's sire, single trait tests that evaluate simple traits like coat color or inherited defects/diseases and SNP chip tests which can be used for genomic selection of complex traits such as weaning weight and calving ease. Some testing platforms can simultaneously provide parentage, single trait and information to enable the calculation of genomic-enhanced EPDs (GE-EPD) which can improve selection accuracy.

The value of DNA testing to an individual operation depends on a number of factors. These include the breed(s) and number of animals that will be tested, and sometimes the availability of health records, pedigrees and EPDs. The ultimate goals for testing results are also important to consider. DNA testing can be used for a variety of purposes such as aiding in selection and breeding choices, sorting into management groups, pedigree verification and even marketing. The successful use of DNA tests for these purposes requires a basic understanding of how they work and how the results should be applied.

Parentage and Paternity Tests

Parentage tests work with a variety of sample types, including blood, hair and tissue. They require that the breeder/producer identify at least one potential parent that has DNA on file or that can have a sample included with the offspring's sample. The quickest and best results are available if DNA is available from both the dam and all potential sires. Parentage tests generate DNA profiles for the offspring and the presumed parent(s) using multiple genetic markers. Parental status is determined based on exclusions (Figure 1). Parentage tests are required by many breed registries and are useful for ensuring accurate

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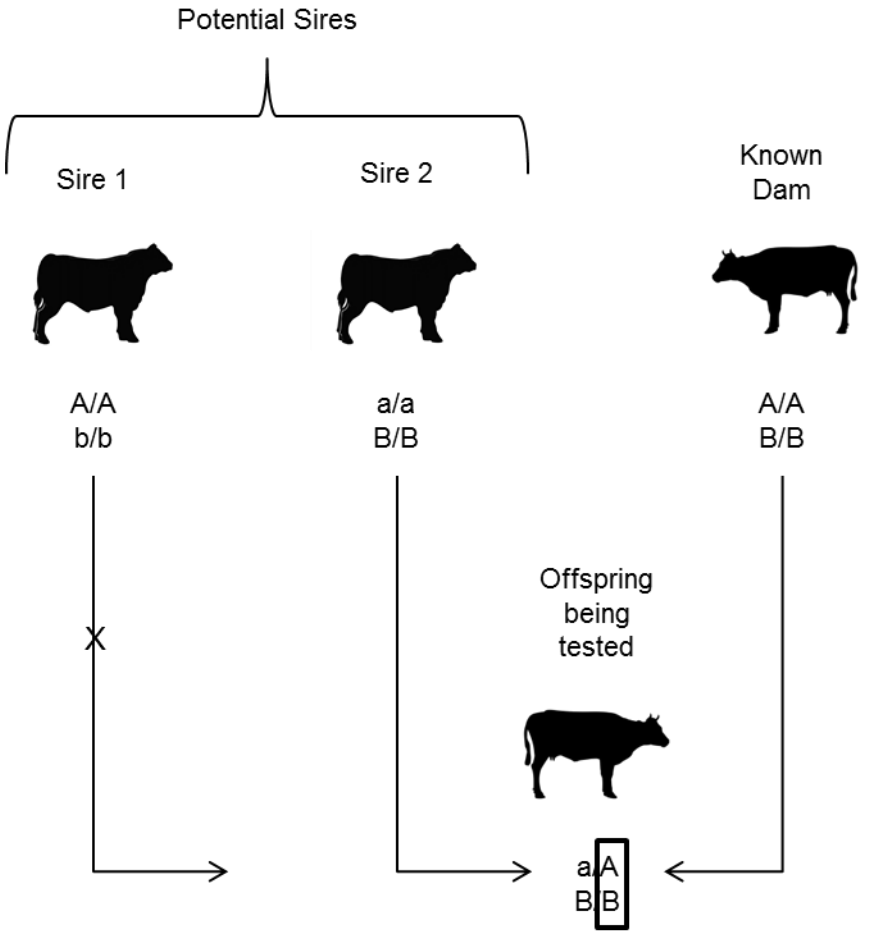

Figure 1. Example of sire exclusion using 2 genetic markers, A and B. The offspring being tested received one form of the gene (allele) at each marker locus from each parent. In this case, the offspring had to receive an "A" allele from one parent and an "a" allele from the other parent and a "B" allele from each parent. Since the known dam has two "A" alleles and no "a" alleles, the offspring's "A" had to come from the dam. This means that Sire 2 had to contribute the "a" since Sire 1 only has "A"s. The same is true for the "B" allele since Sire 1 only has "b" alleles and the offspring has no "b" allele. Sire 1 is excluded at 2 loci in this example, meaning that Sire 2 is the most likely sire for this offspring based on these two genetic markers.

pedigrees which increases the accuracy of genetic evaluations. Paternity results are also useful for evaluating the performance and prolificacy of new bulls in multiple-bull breeding pastures.

Single Gene Tests

Single gene and genetic defect tests also work with a variety of sample types and usually test for single, known, genetic variants (Table 1). The results are used to make appropriate breeding decisions to reduce or eliminate genetic disorders/diseases in herds and to optimize beneficial traits. (Please see fact sheets 2014-9 and 2014-10 for more information.)

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Table 1. Commercially available mutation tests

Phenotype	Common Abbreviation	Mode of Inheritance	Breed(s)*
Arachnomelia		AR	Braunvieh, Simmental
Arthrogryposis Multiplex (Curly Calf Syndrome)	AM	AR	Angus
Bulldog Dwarfism (chondrodysplasia)	BD	AR	Dexter
Chondrodysplasia	CHO	AR	Angus
Contractural Arachnodactyly (Fawn Calf)	CA	AR	Angus
Coat Color	CC		
Red/Black		Black AD Red AR	Angus, Simmental, Limousin, Gelbvieh, Dexter
Dilution	DL	Incomplete Dominance	Hereford, Charolais
Dun	DN	AR	Dexter
Developmental Duplication	DD	AR	Angus
Deficiency of Urine Monophosphate Synthase	DUMPS	AR	
Digital Subluxation	DS		
Hypotrichosis	HY	AR	Hereford
Idiopathic Epilepsy	IE	AR	Hereford
Alpha-Mannosidosis	MA or MAN		Red Angus
Myostatin			Belgian Blue, Piedmontese, Limousin
Neuropathic Hydrocephalus	NH	AR	Angus
Osteopetrosis	OS	AR	Angus, Hereford, Simmental
Pulmonary Hypoplasia with Anasarca	PHA	AR	Shorthorn, Dexter
Horned/Polled	Polled		
Holstein-Friesian/Jersey	Pf	AD	Holstein, Jersey
Celtic	Pc	AD	Angus, Brahman, Brangus, Blonde d'Aquitaine, Charolais, Dexter, Hereford, Limousin, Santa Gertrudis, Shorthorn, Simmental, Tropical Composite
Tibial Hemimelia	TH	AR	Galloway, Shorthorn

*Animals from breeds with open herd books may consider testing for mutations found in other breeds.

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SNP Chip Tests

SNP assays work on multiple sample types and are used to analyze thousands, or tens or hundreds of thousands, of single nucleotide polymorphisms (SNPs) (FAQ #8, #9, #10). SNPs are single base pair changes in the DNA (FAQ #5). Large numbers of SNPs can be rapidly evaluated using SNP chips (FAQ #6).

Genomic testing is available through breed associations who have partnered with two companies that provide genotyping services; Zoetis and Neogen/GeneSeek. There are several types of tests which differ mainly by the number of genetic markers that are included in the test. There are the so called high-density chips which have somewhere between 50,000-150,000 single nucleotide polymorphism, or SNP, markers on a single assay. There are also some lower-density chips that are less expensive and can be used for "imputation" up to the high density chip (e.g. Zoetis® i50K and GeneSeekLD).

Many SNP panels often include established parentage markers as well as some single trait or genetic defect tests mutation tests for common genetic abnormalities. This can decrease the cost of these tests quite dramatically when they are ordered as an add-on test, rather than a stand-alone test. Please see fact sheet 2016-1 for more information.

There are several tests that are being marketed for use on commercial cattle that are not directly part of a breed association genetic evaluation program. There are two products exclusively distributed by Angus Genetics Inc. (AGI) and marketed by Zoetis® which are designed for animals that are at least 75% Black Angus. These include GeneMax Advantage ($39) and GeneMax Focus ($17). The first test involves tens of thousands of markers and is marketed as a heifer selection and mating test that ranks heifers for net return using three economic indices (Cow Advantage: Predicts differences in profitability from heifer development, pregnancy and calving, to the sales of weaned progeny; Feeder Advantage: Predicts differences in net return of feeder calf progeny due to growth, feed efficiency and CAB carcass merit; Total Advantage: Predicts differences in profitability from genetic merit across all economically-relevant traits captured in Cow and Feeder Advantage index scores). It also identifies genetic outliers for cow cost, docility, marbling and tenderness, and allows for paternity assignment if the sires have been 50K or i50K tested by Zoetis®.

GeneMax Focus utilizes fewer genetic markers and is marketed to provide genomic predictions for feedlot gain and marbling, in addition to sire assignment. These two tests are only intended for use on unregistered, commercial high-percentage Angus cattle. As such, GeneMax predictions do not contribute to Angus breed association genomic-enhanced EPDs (GE-EPDs).

There are also some tests being marketed for crossbred cattle.

PredicGEN

PredicGEN ($19.50) is a test marketed by Zoetis® as "a heifer selection tool for straight-bred or crossbred British/ Continental animals that are less than 75% Black Angus". Data is reported back on a normally distributed 0 to 100 scale, with a mean of 50 based on Zoetis'® database of 20,000 animals. It provides predictions of genetic merit for key carcass traits – marbling score, USDA yield grade and tenderness, as well as an index that predicts carcass grid value The economic importance of these traits for heifer selection will depend upon the individual marketing strategy and value of carcass traits to overall ranch returns.

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Igenity Gold and Silver

The Igenity Gold and Silver tests, which include approximately 1000 markers associated with 13 traits of interest and some randomly spaced markers, are being marketed by Neogen® as "DNA profiles for crossbred and purebred cattle." A single prediction equation is used for each trait to give the score or molecular breeding value, irrespective of the breed makeup of the animal being tested. The silver test evaluates six traits (calving ease maternal, stayability, residual feed intake, average daily gain, tenderness, marbling), and the gold test includes an additional 7 traits (birth weight, calving ease direct, heifer pregnancy, docility, milk, ribeye area and back fat thickness). A selection index score is provided for each animal based on the six traits that are in both tests. According to the Neogen brochure, the development of these tests involved large populations with phenotypic data and/or expected progeny differences (EPDs) comprising tens of thousands of animals that represent various biological types. The six main datasets used to form the training data set for this test were from six breed associations: Angus, Hereford, Gelbvieh, Limousin, Red Angus, and Simmental. Data is reported back on a 1 to 10 scale.

Step 2: Which company do you want to use for testing?

Several companies offer various combinations of mutation tests, and many offer both mutation tests and parentage testing in cattle along with a variety of other species. For a list of companies and currently-available tests, please visit the following webpage at UC Davis:

http://animalscience.ucdavis.edu/AnimalBiotech/Biotechnology/Companies.

In order to have genomic information included in breed association genetic evaluations the DNA sample typically has to be submitted through the breed association. The cost for genetic testing the tests that are used in genetic evaluation is ~ $75-90 for the high-density chips, and $45-50 for the low-density imputation chips. Breed associations obtain either molecular breeding values or genotypes from the service provider and work to include that genomic information to provide genomic-enhanced EPDs (GE-EPD) that have improved accuracy due to the inclusion of the genomic information in the EPD calculations.

Zoetis (http://www.zoetis.com/products-services/animal-genetics.aspx) and Neogen's GeneSeek (http://www.neogen.com/Genomics/Beef.html) are currently the companies that are partnering with US beef breed associations to provide the genotypes needed to develop genomic-enhanced EPDs.

Step 3: How much do genetic tests cost?

The costs for various DNA tests in cattle vary based on the type of test(s) being performed, the company and the number of animals being tested. Costs can range from ~ $13-20 for parentage testing, ~$20-$30 per animal for a single mutation test for a disease or trait, up to $75-90 for the high-density SNP chips for genomic-enhanced EPDs. If multiple tests can be performed on a single DNA sample or a large volume of samples is tested then the cost per test is reduced. Additional costs can include the cost of DNA cards, sample collection, sample storage and shipping and sample processing, again depending on sample type, test and application.

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Step 4: What kind of sample do you need to submit?

Most of the DNA testing that has been described here can be performed on a variety of samples. These include tail hairs, blood (in tubes or on blood spot cards), semen, or tissue. Hair samples and blood spot cards are the easiest to submit as they generally do not require refrigeration or any special packaging. The hairs themselves do not contain DNA; it is located in the hair root bulb. Submitted hair samples must contain root bulbs in order to be processed for DNA. Always be sure to follow collection procedures closely and properly label all samples. Please see factsheet 2015-2 for more information on DNA sample collection. It is important to note that preferred sample types may be requested for specific tests, so be sure to carefully review the instructions provided by the testing company prior to sample submission.

Step 5: How do you ship the sample?

Many sample types can be shipped at room temperature. Tissue samples may need to be frozen upon collection and shipped in a cooler with an ice pack. Never store samples in direct sunlight or expose them to heat. Heat denatures DNA and will result in a poor sample and potentially inconclusive test results.

Step 6: What do you do with the results?

Parentage and mutation test results often need to be reported to specific breed associations for registration purposes. This is also true for SNP results for breeds that use them for genetic evaluation. Results of disease, trait and coat color mutation tests can be used to manage breeding decisions to avoid undesirable phenotypes in offspring. See fact sheet 2014-10 for more information.

Conclusion

DNA technologies are evolving rapidly and it is likely that in the future DNA information will play an increasingly important role in beef cattle breeding and management. Even if you are not currently testing it may be prudent to collect DNA samples (e.g. tail hair) on important animals in your herd (e.g. herd bulls) and store them for potential future uses. Many times when performing parentage determinations using DNA information, producers realize they are missing DNA samples from potential sires which typically sired the calves 12-18 months prior to the paternity test. It is also likely there will be future uses for DNA the technology that have not been thought of yet – like smart phone technology this is a rapidly moving field and it may be wise to have some archived DNA samples on hand to make use of new innovations in the future.

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