UF-Gainesville Beef Cattle News Corner

Basic genomic principles for beef cattle

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A primer of genetics and inheritance.

Use of genomic technologies in the beef industry is rapidly increasing. To understand the value and use of DNA markers, it helps to begin with basics about the genome and about DNA. DNA (deoxyribonucleic acid) provides the code needed to perform processes within an organism's body both to keep it alive and to perform in an expected way. DNA is simply many bases (coded A, C, T, and G) bound together in long strings that are packaged into chromosomes within each cell. All of these chromosomes make up an organism's genome.

There are enough bases (letters) within the cattle genome to fill up approximately 2,000 New York City phone books. Given that, think of the genome as a giant stack of large phone books. Each book is like a chromosome and the entire stack of books is the genome. Inside each of the books, the names and numbers represent the DNA sequence.

Cattle have 29 pairs of autosomal (non-sex determining) chromosomes and one pair of sex chromosomes (either XX for females or XY for males). Cattle inherit one chromosome from each of their parents, so for every place in the genome, there are two different alleles (alternative forms of a gene). This is why genotypes (genetic make-up of an individual) are recorded in pairs (for example, AA, BB, or AB). Some regions of the genome are the same in all animals of a species such as in cattle. Regions of the genome that vary between animals are mutations, and these mutations can be used as DNA markers. If an animal has two copies of the same mutation (AA or BB), they are homozygous (think homozygous polled, or horned). If an animal has 2 different copies of the mutation, they are heterozygous (think heterozygous polled).

Even though an animal's genetics are determined at conception, many environmental factors can modify how genes are expressed. For example, an animal may have a very high genetic potential for weight gain, but if there is a drought or feed is limited, the animal will obviously be unable to fulfill that genetic potential.

Genomic Tests

Most current genomic tests for cattle use SNP (Single Nucleotide Polymorphism) technology. These tests take advantage of mutations in a DNA sequence to identify the unique genetic makeup of the animal. Although other methods are available to perform most genetic tests, SNP testing provides low genotype error rates, easy automation and the ability to easily standardize SNP tests across labs. A SNP represents a single base pair mutation found at a specific location. Although SNP testing looks for specific changes in specific base pairs, the SNPs may not be tied to specific genes. Instead, SNP testing looks at areas that may be associated with, or located close to, a segment of DNA that codes for a specific protein. SNP tests are easy to do from a producer standpoint as they can use a blood, tissue or tail hair sample. SNP technology can be used for a variety of objectives, including: parentage determination; trait assessment; genetic abnormality testing; increasing accuracy of EPDs; and to sort cattle into management groups.

When you hear that an animal has been genotyped for 50K, that means the genomic snapshot includes DNA markers at 50,000 locations on an animal's chromosome. In other words, at 50,000 locations, the technology tracks whether an animal inherited the most favorable or unfavorable genetics from his parents. Genomic tests can be used to increase the accuracy of EPDs. This does not guarantee that the EPD gets "better" - it just means it's a more reliable selection tool. Typically, as an animal has more offspring the accuracy of the EPD increases. A genomically-enhanced EPD allows that increase in accuracy to be seen before any progeny are produced. When buying young bulls, this helps commercial producers have a better idea of how a bull will perform and what his offspring will look like. Genomically-enhancing the EPDs does not change how the EPD can be used, it just increases its accuracy. Keep in mind, that a genomic test increases accuracy. The accuracy will always increase, but the EPD estimate can go up or down. But, the increase in accuracy can allow us to use younger bulls with more confidence. GE-EPDs allow commercial producers more confidence that they are picking the right bull.

In the genomics era, the phenotype if still king.

The application of genomics to improve the accuracy of EPDs is a rapidly developing field. There are ongoing improvements in genotyping and sequencing technologies, statistical methods to increase the correlation between genomic predictions and true genetic merit, and the computing systems to handle the large datasets associated with animal breeding. One thing still remains true in the genomic age and that is the need to collect accurate phenotypic records. It is essential to ensure performance data, pedigree, and DNA information are recorded and reported accurately. Genomic predictions will only be as reliable as the data upon which they are based. Although it might seem like the genomics era could signal the end of performance recording, the opposite is true. Now more than ever, it is important that producers accurately report data, and ensure that animals which are genotyped are correctly identified so that their information can contribute towards improving the accuracy of the genomic predictions of the future.