Beef Logic

by R.A. "Bob" Long

Basic genetics for cattlemen — Part II

Second in a series on basic genetics.

Last month's "Beef Logic" column mentioned the two types of cell division that take place in animal development — mitosis and meiosis. Recall that mitosis begins in the fertilized egg, and the nucleus of each cell formed during the growth and development of the animal contains the same genetic material. Further, this genetic material (chromosomes and the genes thereon) controls the design, construction and potential of an animal throughout its life.

Meiosis is entirely different and is involved in reproduction.

Meiosis takes place in the sex cells (the ovaries of the cow and the testicles of the bull). The ovary of the cow produces an ovum (egg cell), while the testicles of the bull produce sperm cells. Unlike the other cells in the body, the ovum and the sperm contain only one-half the genetic material of the nucleus, and it is a random one-half. This is known as the "sampling nature of inheritance" and is responsible for the tremendous variation that can occur among cattle — not only among breeds but within breeds and among close relatives.

When an egg or sperm is formed, the genetic material of the cell nucleus divides with only one-half of the chromosomes and genes going to the egg or sperm. The genes, which control the potential of an individual, occur in pairs. When this division takes place, only one gene of each pair goes to the egg or sperm. Which gene of each pair goes to the egg or sperm is random — determined strictly by chance. Therefore, since cattle have 30 pairs of chromosomes and each chromosome has thousands and thousands of genes, the number of different egg or sperm cells possible is tremendous. In fact, the chance that two egg or sperm cells from the same animal will be genetically identical is too remote to be considered.

A new calf results when a cow ovulates and the egg is fertilized by a sperm cell. At fertilization a random one-half of the cow's genetic material unites with a random one-half from the bull and develops into a new individual, which can be quite different from either parent. Likewise, full brothers and sisters produced by this same mating can be very different.

Thus, the sampling nature of inheritance explains why two full brothers can have very similar interim expected progeny differences (EPDs) as young bulls, yet after their progeny's performance enters the data bank, one brother's EPDs can go up and the other's down.

True, the sampling nature of inheritance explains the great variation that can occur within a breed or herd, but this variation should not be discouraging. On the contrary, it offers the only opportunity for genetic improvement. The breeder only has to identify those animals that are genetically superior and increase their rate of reproduction. Simply stated — select the best and cull the rest. Accurate identification of superior genetics, however, is the problem.

A few pairs of genes in cattle are relatively easy to identify and control. An example is coat color. Whether cattle are black or red is controlled by a single pair of genes. One gene of this pair is "dominant," and the other is "recessive." Using a capital B to represent the dominant gene and a lowercase b for recessive allows three possible gene pairs or genotypes — BB, Bb or bb. When both genes of a pair are the same, the animal is said to be "homozygous." If the genes are different, it is said to be "heterozygous." Since black is dominant, cattle carrying either BB or Bb are black, and those with bb are red.

Because both BB and Bb are black, there is no way to determine the genotype, or which one carries the recessive red gene, by looking at them. A simple progeny test, though, will answer the question. If a black bull is mated with 12-15 red cows and no red calves result, the bull does not carry a recessive red gene, and a genotype of BB is established. Of course, if even one red calf is born, the bull's genotype is Bb.

Because of the sampling nature of inheritance, only one gene of each pair is transferred to the egg or sperm. Therefore, if a homozygous black bull (BB) is mated with homozygous black cows (BB), 100% of the calves will be BB. Likewise, a homozygous red bull (bb) on a homozygous red herd produces all reds. A heterozygous black bull (Bb) on heterozygous black cows yields 25% BB, 50% Bb and 25% bb in genotype but 75% black and 25% red in color, or phenotype.

Unfortunately, only a few traits are inherited in such a simple fashion. Most performance traits — such as birth weight, growth rate or carcass composition — are much more complex, with each trait being controlled by literally hundreds of pairs of genes. The next "Beef Logic" column will address this topic.

Bob Long

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