Understanding and Managing Inbreeding

By Steven D. Lukefahr

KINGSVILLE, Texas: There is the adage that "if it works the calf is linebred and if it doesn't the calf is inbred."

First, linebreeding is the mating of parents that typically are less closely related with the aim of concentrating genes in the offspring from a superior ancestor/s shared by both parents. In contrast, inbreeding is the mating of close relatives. The most extreme cases of inbreeding are matings of a parent to an offspring and between full siblings.

Although the genetic effects of inbreeding and linebreeding are similar, the effects are more intense with inbreeding. Some breeders view linebreeding only as a mild form of inbreeding.

THE INBREEDING STIGMA

One reason why inbreeding has a negative perception is because in some cases the results were a disappointment. This perception is aggravated by the myth that inbreeding causes mutation. This is untrue because, instead, inbreeding only exposes so-called hidden recessive genes carried by the animal's parents. The effects of these genes could result in poor trait performance or the appearance of certain major anomalies to appear such as curly calf syndrome or dwarfism.

However, some lines or families, and even individuals, are relatively free of undesirable recessives. For example, decades ago one exceptional Red Angus bull by the name of Choctaw Chief 373 was

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frequently mated (mostly by AI) to his own female descendants. Also, numerous matings were made amongst his own descendants. This illustrates another advantage of inbreeding, which is to determine if the animal of interest is a carrier of any undesirable recessive genes. The traditional practice of inbreeding - used since the era of Sir Robert Bakewell - requires both time and patience. Fortunately, DNA tests are now available for several undesirable recessive genes.

INBREEDING AS A TOOL

Like any tool, inbreeding must be properly used. Despite the negative attitude often associated with inbreeding, if done correctly, the genetic results can sometimes even be astonishing. This tool is most appropriate in seedstock as opposed to commercial breeding herds. In seedstock operations, a prime example of the successful use of inbreeding with selection is in the poultry industry, modeled after the breeding system that developed hybrid corn in the early 20th century.

For decades, geneticists applied both inbreeding and selection to develop improved lines for specific traits involving large flocks. Within these lines, each generation represented another genetic opportunity involving a cycle of many matings of close relatives (oftentimes siblings) that were selected in the previous generation based on performance.

Inbreeding rapidly concentrate genes - both desirable and undesirable. This means that the chance or probability is high that two copies of the same gene found at a gene pair location is inherited. With inbreeding there was accompanying intense selection (a very small percentage of the best animals) of animals with outstanding performance records that presumably inherited the best desirable sets of genes. Concurrently, all the rest of the animals were culled.

When repeated cycles of close inbreeding and intense selection were practiced, breeders successfully purged any undesired genes from the line. Ultimately, after several such cycles or generations, inbred lines were later crossed to combine the best genes of lines for all traits selected, as well as to capture substantial heterosis. This breeding system resulted in remarkably high performing and more profitable hybrid birds as used today in the commercial industry.

Such results would have required more generations to achieve if linebreeding rather than inbreeding had been used. This is because the common ancestors of both parents are farther back in their pedigrees, which reduces the gene concentration process called homozygosity. Further, in seedstock operations there is additional value of animals that possess superior genes that are highly concentrated, especially when this contributes to the animal's EPDs (expected progeny difference). Such animals will more consistently transmit the same set of genes for traits, resulting in highly uniform offspring.

GENETICS 101

To better understand the essence of gene concentration, a brief lesson on the inheritance and behavior of genes is in order. First, genes are inherited in pairs, one from each parent. Each gene carries the chemical blueprint for a specific protein needed by the body. An animal has thousands of gene pairs. For some traits only one gene is involved (simply inherited); other traits involve many genes (polygenically inherited). In the former case, gene symbols are typically used.

The classic example is a bull or cow that needs only one dominant polled gene (P) in order to be polled - a condition called complete dominance. A letter symbol represents the dominant gene (P stands for polled). Instead, two recessive genes (pp) are needed for an animal to have horns.

Next is an example of two parents that have the same superior ancestor in their pedigrees. A superior ancestor, depending on species and breed, could be anything from a famous race horse to an exceptional ram for wool yield. Figure that for a single gene pair the superior ancestor had one gene that is highly desirable (A) and one gene that is less desirable (a). His genotype is Aa. If the ancestor is close up (such as a grandsire) as opposed to farther back in the pedigree, the chance or probability is greater that either AA or aa (representing gene concentration) could be inherited in the offspring.

If the aa genotype contributes to lowered performance, then the breeder should cull the animal. Of note, this is a simplified example of a dominant gene being desirable and the recessive gene being undesirable. In several reported cases, the opposite is true where a dominant gene is undesirable such as "double-muscling" in certain breeds.

This same ancestor also possesses the desirable A gene. An offspring that has the AA genotype may have improved performance and so this animal is more likely to be selected. This highlights again the advantage of combining inbreeding with selection. However, unlike the common ancestor who was heterozygous (Aa), this offspring is homozygous (AA) for the best gene.

Another adage when it comes to breeding is that "Homozygotes breed true." This reflects the concept of gene concentration also referred to as prepotency. Each cycle or generation of inbreeding with selection is yet another opportunity to further advance the gene concentration process to produce offspring that possess the best set of concentrated genes. But this is only effective if intense selection and culling are practiced. This gene concentration process occurs over all gene pairs for all traits involving the entire genome of the animal.

MANAGING INBREEDING

In general, inbreeding may result in poorer performance, especially for production traits such as fertility and health and to some extent growth. When this occurs, it is likely due to the accumulation of undesirable recessive genes that exist in the line that are expressed due to the homozygosity process. This phenomenon is called inbreeding depression. Mostly for this reason, inbreeding is generally avoided by breeders. Further, the majority of breeders do not have sufficiently large populations with the opportunity to practice inbreeding with the same intensity of selection and culling as afforded to genetics companies in the poultry industry.

One way to understand inbreeding depression is that the genetic effects are the exact opposite of those of heterosis. Those traits that are the most favorably influenced by heterosis from crossbreeding (e.g., fertility, health and growth) are the most unfavorably influenced by inbreeding depression.

Overall, inbreeding depression is largely associated with homozygosity while heterosis is largely associated with heterozygosity. Under crossbreeding, undesirable recessive genes are not expressed because desirable dominant genes prevent their expression.

In commercial operations, the focus is on total genetic performance through the positive effects of both EPDs and heterosis in order to maximize profits. This entails the breeding aim to minimize inbreeding depression. This occurs by either the crossing of lines within the same breed or by the crossing of breeds, which are popular breeding practices of commercial producers. Instead, heterosis is exploited to manifest its well-known economic advantages.

At Lukefahr Ranch located in south Texas, a composite herd is maintained of Red Angus, Senepol, and Tuli breeds, including the recent addition of Mashona. The breeding objective is: To breed tropically adapted cattle to promote high fertility and survival in a low input system while working closely with nature. As a composite population, inbreeding depression is minimized because heterosis is emphasized. In addition, breed complementation (defined as combing breed strengths which contributes towards EPDs) is utilized that involve the best genes and combinations thereof from all breeds for traits of importance.

From a practical standpoint, to minimize inbreeding depression, simply avoid the mating of animals that have a common ancestor less than three generations back in their pedigrees. The common ancestor/s is no more closely related to either parent than that of a great grand-parent. In my operation, I use a software program that computes the level of inbreeding of a set of planned matings. If the level of inbreeding exceeds my parameter limit of 15% (slightly higher than 12.5%, which is the figure from a grand-parent to grand-offspring or half-sib mating) then another, less-closely related mating is chosen.

My herd is "tightly-bred" as one

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rancher once put it because my cattle have pedigrees that show multiple common ancestors across breeds. However, the herd is also open and relatively small, so introducing new animals with sought after genes is important and is yet another check to minimizing inbreeding depression. While the herd is highly heterozygous (the basis for heterosis), composite-bred populations can be remarkably uniform for production traits due to the positive effects of heterosis.

For closed herds, the population size must be sufficiently large to avoid inbreeding depression. Such is the case for the famous Line 1 Herefords, which was developed at the Ft. Koegh Livestock and Range Research Laboratory in Miles City, Montana. This line has been closed for over 75 years. Although the line originated from only two sons of one bull (Advance Domino 13), through many generations of careful linebreeding (choosing less closely related parents to limit inbreeding depression), culling purged the line of undesirable genes. Ultimately, a highly uniform line of prepotent cattle was developed, which is especially well known for its maternal performance. Line 1 Herefords have had a profound influence on the breed.

In conclusion, to either utilize or manage inbreeding it is first important to understand well the effects of inbreeding. It can be a powerful tool, but it must be used correctly. Happy breeding! ■

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