GENETICS 101

A review of dominant and recessive traits.

by ***Jon Beever,*** *University of Illinois*

The recent acknowledgement of a new recessive genetic defect within the Hereford breed called idiopathic epilepsy (IE) provides an opportunity to review patterns of genetic inheritance. It's also a good time to discuss perspectives on ways to manage breeding animals with pedigrees that are similar to those that have produced affected calves. Importantly, these issues are not limited to only this most recent condition and are applicable to other genetic traits such as horned/polled and hypotrichosis (hairlessness).

The term "recessive" implies specific rules about the inheritance of these traits. Specifically, recessive traits require an individual to inherit the same recessive gene variant — variants of the same gene are called alleles — from both parents in order for the individual to show the trait.

In turn, this also implies that individuals not showing the trait have at least one dominant allele for the gene. Panel 1 of Figure 1 below shows a Punnett square that is used to depict the mating between a bull and a cow that carry different alleles — "A" or "a" — for a gene. These individuals are termed heterozygous and would be "carriers" of the trait.

In this example, the "A" allele is dominant to the "a" allele, meaning only the "aa" individual will express the trait while no other individuals will show the trait. Furthermore, only 25% — one of four boxes within the Punnett square result in "aa" — of the offspring from a mating of carrier animals will have the trait.

Panel 2 of the figure demonstrates the outcome of matings between a homozygous dominant parent — both alleles are "A" — and a heterozygous parent. Note that no offspring will express the trait because none are "aa." However 50% of the offspring will be carriers of the trait. The mating of two homozygous dominant parents is not shown, as all the offspring would also be "AA." We can use these simple genetic concepts to help us with breeding decisions.

Recessive traits

In regard to recessive traits, it is obvious that most breeders would try to avoid the mating of carrier animals and thus, eliminate all risk of producing affected calves. However, some breeders may find the risk acceptable.

Of course, the trait under consideration also heavily influences this decision. Granted, conditions such as epilepsy and hypotrichosis are much more serious than being horned or polled. I would like to use the following example to demonstrate the use of the above genetic principles to make selection decisions for my own herd by first using the more benign horned example.

Living in Illinois, I find it easier to market polled animals. As my cow herd is predominantly horned, I would need to use a homozygous polled bull to maximize the number of polled calves I produce. However, because of other attributes that a bull might have, I would not hesitate to use a heterozygous polled bull on my cows, understanding that approximately 50% of the calves may have horns (i.e., an acceptable risk). This is rather simplistic, of course, but nonetheless, demonstrates how I might use these genetic principles to predict the outcomes of particular matings and represents a consideration that many Hereford breeders already make.

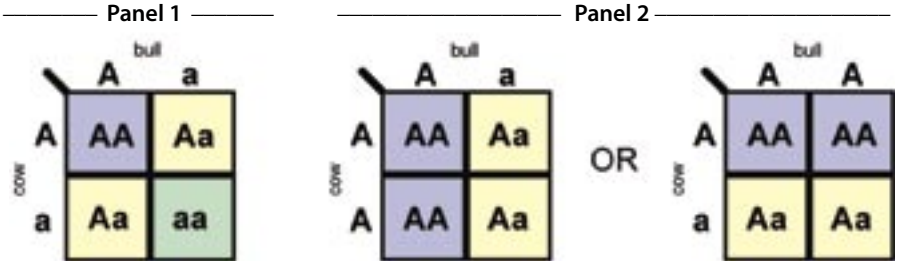
So, what about traits like epilepsy? Using my cow herd as an example again, I would like to provide some perspectives on how breeders can manage this trait. Of the 40 females in my current inventory, 26 have suspected epilepsy carrier animals in their pedigrees within the first three generations. In fact, many are direct daughters of a bull I consider to be a known carrier.

If I apply the genetic concepts above, this means that approximately 50% of them are probably carriers themselves. Thus, it seems obvious that I need to use a bull that is not a carrier of epilepsy in order to eliminate any risk of having an affected calf.

Of course, an alternative would be to eliminate all of the potential carrier cows in my herd. However, it should be just as obvious that this is probably not economically possible, especially given that each animal represents an accumulation of certain genetic resources important to my breeding program. This is a more subtle point. Most of us, as animal breeders, do not consider just a single trait when making our selection decisions. The objective of our breeding program is to accumulate value in our cattle by using matings that bring together attributes that each of us consider important.

Does this change the way that we look at these genetic traits? It

Figure 1: Punnett Square



should. Is there a place for animals that are carriers of these traits in breeding programs?

Returning to the first example above, would I mate a horn carrier bull to my horned cows even if my objective were to maximize the number of polled calves I produced? Yes, I would because of other attributes that he might possess. Would I use a potential epilepsy carrier bull? Yes, I would if I knew he would contribute to achieving my genetic goals. Would I use him on my potential carrier cows? Of course, I would not. I would mate him to those cows with the highest probability of being homozygous normal and, thereby, reduce the risk of producing an affected calf to an acceptable level while bringing necessary genetics to my breeding program.

Again using the genetic concepts above, I could do this knowing that each calf would have a 50% chance of not carrying the trait and, thus, allow me to make genetic progress without propagating the epilepsy trait.

DNA research

How can I tell which are carriers and which are not? During the past decade, there has been a tremendous amount of scientific effort directed at the understanding of cattle genetics at the "molecular" or DNA level. What this means is that we now have access to methods of looking at our animals' DNA to determine things that we cannot necessarily observe or measure.

Currently, we are conducting research to identify DNA markers for both the epilepsy and hypotrichosis traits. In the coming months, I hope that we will be successful in identifying DNA markers that can classify animals with 100% accuracy concerning their genetic status for these traits.

With the availability of such DNA markers, we will be able to monitor these genes in our breeding programs and be able to apply the same genetic principles for making breeding decisions with certainty. This data will allow breeders to make informed mating decisions with no risk of producing affected calves.

Furthermore, the markers will be essential for the selection of superior offspring that are not carriers of these traits when we are using carrier parents that are of value for other traits.

Essential to our research efforts is the continued cooperation from breeders who provide pedigree information and DNA samples from affected calves and their parents. Please contact the American Hereford Association (AHA) or me directly at (217) 333-4194 or jbeever@uiuc.edu for instructions on how to collect samples for analysis.

In summary, recessive genetic traits are always going to be present in breeding populations. It is up to us, as breeders, to educate ourselves about ways to manage these traits in our programs. By understanding and implementing simple genetic principles, we can limit or avoid the production of animals that are affected with these traits.

We should approach our breeding decisions with the overall objective of enhancing genetic progress of the Hereford breed. This approach requires us to recognize that some animals genetically superior for other qualities can have value even if they are carriers of these genetic traits.

We should evaluate and embrace appropriate new technologies, such as DNA markers, to help us make informed selection decisions and to move beyond genetic problems while simultaneously retaining valuable genetics. Finally, as advocates of the Hereford breed, we can facilitate the ongoing research by sharing information. **HW**

IE carriers

A recent recessive genetic defect, idiopathic epilepsy (IE), has been discovered in Hereford cattle. According to the rules and regulations of the American Hereford Association (AHA), any animal that has produced two known affected calves must be listed in the *Hereford World* and pedigrees will be identified.

Known carriers of IE

K&B Advance 1638
registration no. 42175189

K&B Advance 1563
registration no. 42175194