Inbreeding : An Important Issue for Yak Breeders

Almost seven years ago, I purchased a yak heifer at the annual yak show held during the National Western Stock Show. I already had several yaks which came out of Colorado. They were just run-of-the mill-yaks, no pedigree, nothing special about them other than their quirky yak personalities. But at the NWSS there was this beautiful three-year-old heifer with flowing long hair. She was beautiful and was reluctantly for sale. She was from a great yak ranch, had great looks, a great personality and was pregnant from a very good bull. What more could you ask for?

So, I bought her and her baby grew up to be below average for my herd; grew on the slow side and never achieved any real size. I then bred her to a great bull I had purchased from Living Diamonds Ranch and got the same result. I tried again with a large Royal bull that had been siring great calves for me with the same result. I even bred her to a bull whose genetic history probably had no connection to hers based on where he came from, but again, the same result, a less than average calf.

She was beautiful and all the bulls were very good. Yet every time her calf was a dud. If I had looked at her pedigree, which I hadn't when I bought her, I would have discovered that one very excellent bull appeared three times in her pedigree (maternal and paternal) and another great bull appeared four times in her pedigree. The result was not only a most beautiful yak, but also a yak that would never have quality offspring due to her genetic makeup.

This heifer had been produced by using the same two bulls again and again in earlier generations of her pedigree to "bring out" certain attributes. This method of breeding when planned is called linebreeding. The approach allows one to get certain characteristics to dominate or "breed true". So, when she was born, she had all these wonderful visual attributes that made her so beautiful. However, while her genome was being "developed" by using these bulls again and again, at the same time these wonderful genes were locked into her genome other genes were being locked into her DNA which prevented her from having quality calves.

Suppose yaks had a recessive purple color gene and you discovered that your bull had this recessive gene and every so often one of your cows would give birth to a purple yak. It takes two copies, homozygous, of the purple gene to have a purple calf and animals with only one copy, heterozygous for purple, would be "normal" colored. If you got a purple heifer out of this purple bull she is homozygous meaning this baby now has two exact copies of this purple color gene. What if you bred the bull (dad) to the offspring (daughter), could you get a baby whose color genes were both purple? The probability is 50% now. And if this was a purple bull calf you now have a bull that will always contribute a purple color gene.

But suppose in trying to get more animals to be purple in color, other genes relating to smaller size and cleft palates were also getting locked into the genome. **This undesired outcome is what inbreeding can result in.**

The more one breeds yaks which have specific genes in common (good and bad), the greater the chance the offspring will have specific genes in common so that when the animal is used in a breeding program, these recessive undesirable traits have a greater likelihood of being expressed. Instead of the animal having no alleles for cleft palate, the animal may now have one allele for cleft palate and one allele for normal palate and you can't see the animal is carrying this undesirable recessive trait. When you mate this individual (heterozygote) with another animal having one copy of the cleft palate allele and one copy of the normal palate (heterozygote), you have a 25% chance of getting an animal expressing cleft palate (homozygote for cleft palate), a 25% chance of the animal having no copies for cleft palate (homozygote normal cleft), and a 50% chance of the progeny being a carrier having one copy of each allele. Without knowing, you are increasing the frequency of this undesirable trait as there is a 50% chance of having "carrier" animals that don't show the symptom which may be retained in the herd. This is a direct result of inbreeding, increasing the frequencies of undesirable traits.

Inbreeding does not create undesirable genes. These undesirable genes may occur from mutations of the DNA. However, inbreeding can lead to these undesirable genes being expressed and more often.

As animals become more homozygous or less variable in their genetic make-up, average performance for various production factors can be reduced; this is referred to as inbreeding depression.

The impact of inbreeding depression is opposite that of the ability of parents to pass their genetic superiority to their offspring which is referred to as heritability.

Reproductive traits are considered to be lowly heritable meaning that it is difficult to improve reproduction efficiency quickly in a herd based on selection of the bulls used and heifers retained. However, inbreeding has a large negative impact on reproduction efficiency which is exactly opposite of what is desired. **Why do we care?** Having our cows breed and give birth to healthy calves that mature well helps the pocketbook so we have something to market eventually.

In reality, the greatest strides in reproductive traits are made in mating animals that have less in common genetically such as outcrossing or crossbreeding. When animals that are far apart genetically are mated, there is more hybrid vigor or heterosis which is the advantage the offspring exhibits over the average of the two parents. For example, if a Yak bull weighed 275 pounds at weaning and the cow weighed 225 pounds, the average weaning weight expected of their progeny would be 250 pounds. However, if the offspring weighed 260 pounds, this 10-pound increase over the expected average is the advantage from heterosis. In contrast, inbreeding reduces genomic variability meaning heterosis is reduced or lost.

Consider the following diagram which shows two effects of an increase in the coefficient of inbreeding for a herd of cattle. The diagram shows that as the coefficient of inbreeding increases there is an increase in the percent of cows that do not conceive (are open) and in the number of calves that are stillborn.

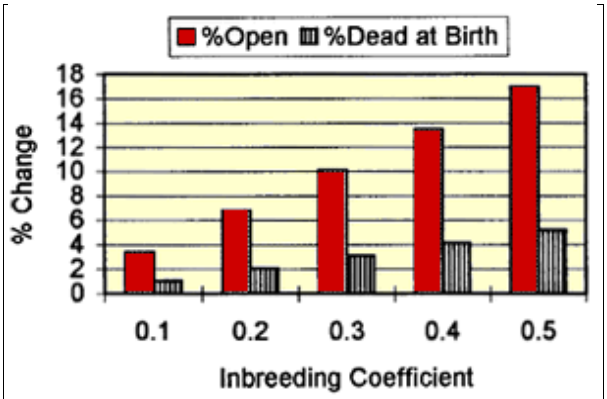

Figure 1. Inbreeding depression for % open and % dead at birth.

Decreased fertility and increased stillborn calves mean increased economic loss. **This change in fertility and number of calves dead at birth is in addition** to the number of cows who would normally fail to conceive and the still born calves in a herd that were not inbred.

But it is not only these two traits which are negatively impacted by an increase in a herd's coefficient of inbreeding. Studies have shown that other traits affected by inbreeding (inbreeding depression) include

- Smaller birth weight
- Coat color and fiber characteristics
- Reduced rate of weight gain
- Smaller mature size
- Higher mortality at birth and pre weaning ages
- Reduced immune function
- Increased risk of cardiovascular disease
- Increased facial asymmetry
- Increased risk of genetic disorders

Some of the depression may be sought after such as coat color and fiber characteristics. Others may not be good and largely go unnoticed due to the small change from generation to generation such as growth rates and size at maturity or seen as isolated events as in the case of a cleft pallet or a stillborn calf.

Note: In the beef industry one of the popular bulls used for artificial insemination in the early 1990's turned out to have a deadly recessive gene. It took more than twenty years for this to be discovered. Why so long? This bull had to produce enough generations of offspring which carried this recessive gene to the point that these later generations were

breeding one another with both the bull and cow carrying the recessive gene and the alleles for the gene combining (25% probability) which resulted in a deadly syndrome in the calves produced from these carrier bulls and cows. Then there had to be enough cases of this syndrome showing up so that it wasn't seen to be an isolated anomaly but that there was a genetic problem at play. The source of the gene was identified only through detailed breeding and birth records of the producers over multiple generations so scientists could track backward to the original source. Once the bull was identified, the beef association then informed breeders to not breed bulls and cows which had this bull in their lineage.

What is important to see in this is:

The bull (or cow) had to have enough generations of "genetic" offspring who carried this recessive gene to start breeding one another to the point that the defect was showing up.

Breeders had to take notice of the defect and start reporting it to a central data collection site.

The breeders needed to have lineage, breeding and calving records of their herd which could be used by scientists to work backwards to identify the "source" of the defective gene.

Inbreeding in the United States Yak Herd

The US yak herd has developed from a small number of yaks that came from zoos and several hundred yaks purchased from a ranch in Alberta, Canada. As such, the starting point for the U.S. herd was a small gene pool.

Using data from approximately one thousand yaks whose coefficient of inbreeding was analyzed as part of their registration, the average coefficient of inbreeding of the U.S. yak herd is approximately 43%. This means that 43% of the alleles in each yak are homozygous (providing no diversity for a particular trait). Unfortunately, there has been no widespread long term record keeping that has been analyzed to determine what extent of inbreeding depression has occurred over the years and in what ways. Are yaks getting smaller? Have there been negative structural changes? Are there more still born calves now than ten years ago or more cleft pallets? We don't know. All there is are anecdotal observations.

What we do know is that it is important that breeding programs which will reduce the degree of inbreeding should be implemented.

Consider the following:

Think about a small yak operation that has one breeding bull and enough yak cows to average ten calves a year. All female calves are sold each year and one out of ten of the bull calves produced are sold for breeding purposes. The bull is used for ten years before retiring, which is typical among breeders.

Assumptions:

1. Offspring each year are 50% female and 50% male
2. The bull calves sold for breeding will breed for 10 years
3. The average number of females the offspring bulls will breed per year is 10
4. The calves produced are either breeding or have their first calve by age 4.
5. The other breeders sell 1 out of 10 bull calves for breeding.

Let us calculate what has happens after two generations and three generations of production

1. The original bull over ten years will produce 50 cows and 5 bulls that are sold for breeding. These will have ½ his genetics.

2. Each of the second generation cows will produce 5 cows each and 1 breeding bull over ten years giving a total of:

   250 cows and 25 bulls with ¼ the original bull's genetics.

   And each of those 5 second generation breeding bulls will breed ten cows a year for ten years producing 50 more cows and 5 more breeding bulls each. This totals 250 cows plus 25 more bulls with ¼ the original bull's genetics.

   Total with ¼ the original bull's genetics = 500 cows and 50 bulls

3. Going to the third generation: each of the 500 cows will produce 5 cows and 1 bull sold for breeding and each of the third generation bulls will produce 50 cows and 5 breeding bulls totaling:

   500 x (5 cows and 1 bull) plus 50 x (50 cows plus 5 bulls) = 5000 cows + 750 breeding bulls with 1/8 the original bulls genetics.

   Now it took 36 years to get all the third generation births. And certainly there were deaths of yaks, infertility issues and so on. So cut it by 50% and you have about 2500 cows and 325 breeding bulls with 1/8 the genetics of the original bull.

   The thing is: The current US yak herd numbers approximately 7000 yaks. So for this bull, if the breeding program started in the late 1980's, 1/8 of his genetics would be in more than one-third of the US yak herd.
   The exactness of the numbers is not important, What is important to see is that given the smallness in numbers of the US yak herd, a breeding program of one bull being used repetitively for ten years on ten cows can get to point where the bulls genetics are in a significant portion of the US herd to the point a significant number of breeding pairs will

have 1/8 of his genetics: **The result being the expected presence inbreeding depression.**

What we can do:

1. Keep herd production records that track calf outcomes for dam x sire pairs for economically viable AND negative traits.
2. Check any pedigree information you have on your breeding bulls and cows so you can see how your herd is related and form breeding pairs that are least related.
3. If you have yaks registered with USYAKS you can use the Match-a-Yak program on the website to calculate the expected coefficient of inbreeding from a specific bull x cow pair. If you have access to multiple bulls this tool will allow you to pick which bull will result in the least inbreeding.
4. You might want to use the match-a-yak program on last year's breeding program to determine the impact of it on the coefficient of inbreeding of your herd. If it is causing it to increase you may want to think about how the size of successive generations of your yaks is changing, birth and weaning weights, birth mortality, health etc. Are there negative changes occurring which may be due to inbreeding?
5. As artificial insemination for yaks develops you will have the option for selecting semen from a bull that will bring the attributes you are seeking while potentially reducing inbreeding.
6. If you are thinking about purchasing a bull for your herd be sure to look at the bull's pedigree and how close it is to those of your breeding females. You might also want to run the Match-a-Yak program for the bull and your herd cows if your herd is registered with USYAKS.