Demystifying Inbreeding

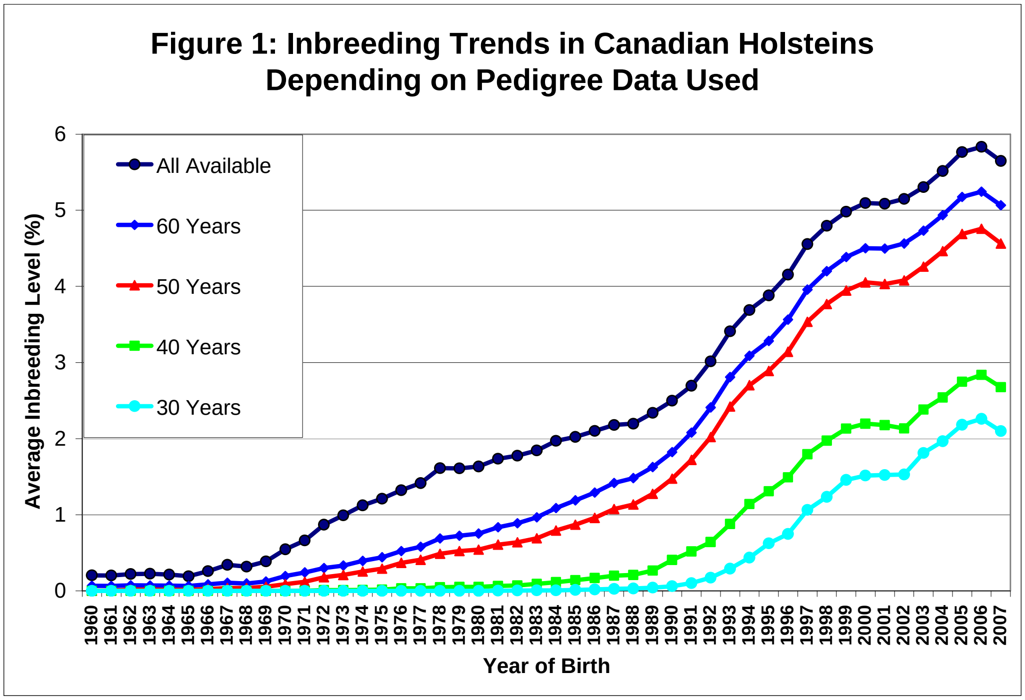
In recent years, “inbreeding” has become a common buzz word among dairy producers and within the national and international dairy cattle industry. Unfortunately, the circulation of information by word of mouth can lead to some misunderstandings and inaccuracies. What is inbreeding? How do we measure it? Is inbreeding good or bad? How much attention should be paid to inbreeding in genetic selection decisions? Here are the facts about inbreeding as it relates to dairy breeds in Canada, which should help to clarify some of the common myths that currently exist.

What is Inbreeding?

In technical terms, inbreeding is defined as *“the probability that the two parental alleles of an individual, located at the same locus, are identical by descent”.* To better understand what this means in practical terms, one must first have a basic knowledge of genes and alleles. Dairy cattle possess 30 pairs of chromosomes and each gene has a designated location on every chromosome, called a locus. For any gene, there may be multiple forms that exist, called alleles, which will be expressed as an alternative form of a trait. Each animal receives one allele from each parent. When an animal receives the same allele from both parents it is said to be homozygous for that gene while animals with different alleles of a gene are considered heterozygous. Animals with common ancestors are more likely to have inherited the same allele of a gene from each parent compared to progeny from unrelated parents. Therefore, in simpler terms, inbreeding values, expressed as percentages, reflect the “probability” that an animal has inherited the same gene that its parents have both received from a common ancestor and this probability increases depending on how close the parents are genetically related.

How is Inbreeding Measured?

Computer programs are used to calculate inbreeding values based on all known pedigree information available. This means that an animal’s inbreeding percentage is dependant upon the amount of pedigree data recorded. For example, the calculated inbreeding value of an animal with a known sire but no recorded dam will always be 0.0% since the parents are considered to be totally unrelated. Similarly, inbreeding values calculated using two or three generations of pedigree will always be lower than those based on complete pedigree data for ten or even twenty generations. This fact means that all estimated inbreeding values are a function of the completeness of pedigree used in their calculation. As an example, Figure 1 shows inbreeding trends in the Canadian Holstein population when different amounts of pedigree data are used for the calculations. Here it is easy to see the lower inbreeding levels that result when 30 or even 40 years of pedigree data are used compared to 50 years or more, with the difference being about 3 percent for recent birth years. This leads to an important message as it relates to inbreeding values used by genetic mating programs offered by various A.I. companies. Since each program uses varying amounts of pedigree data, the calculated inbreeding values will automatically be underestimated when less pedigree is considered. This means that the resulting mating recommendations would differ even though the programs may suggest the usage of a common minimum inbreeding tolerance level (i.e.: 6.25% for example). The only way for all mating programs to be equal in the inbreeding values considered is if they are computed based on the exact same pedigree data.



Is Inbreeding Good or Bad?

A common myth about inbreeding is that it always has a negative, undesirable effect. Looking back in history, it is easy to find elite breeders that used “linebreeding” to concentrate positive genes in the progeny, which was achieved by mating family members together. The resulting animals were therefore more inbred than usual but the increased homozygosity of their genes made them a more uniform group. With this in mind, inbreeding is not always bad and, in fact, may be desirable for specific matings. On the other hand, for the longer term viability of a breed, genetic selection requires genetic variation, which is decreased as average inbreeding levels in the population rise.

Inbreeding and heterosis have opposite effects. Inbred animals will experience some degree of inbreeding depression for certain traits, which basically means that their performance for those traits will be reduced because they are inbred. When unrelated animals are mated, the opposite effect occurs, called heterosis. Heterosis refers to an increased performance of the progeny compared to what is expected based on the average of its parents. Unrelated animals may come from the same breed but the phenomenon of heterosis is easier to understand with crossbreeding, which produces progeny that are zero percent inbred since the parents would clearly not have any genes in common inherited from their ancestors.

A second myth about inbreeding is that the effect of inbreeding depression is the same for all animals with the same calculated inbreeding value. This statement is false for various reasons. Firstly, as explained previously, two animals may have the same estimated inbreeding value but they are not truly equal if one was based on much more pedigree depth compared to the other. The animal with the least amount of available pedigree data would have an estimated inbreeding value that is more of an underestimate of its true inbreeding level. Secondly, as previously outlined in the definition, inbreeding values are “probabilities”. Without analyzing the exact DNA make-up of both animals it is impossible to really know which genes each animal randomly inherited from their parents. For example, two animals with an estimated inbreeding value of 8% will have different degrees of homozygosity in the genes they inherited so their true inbreeding level will vary around this estimated value, which is true even if the two animals are full-sibs.

How Important is Inbreeding?

A common perception among dairy producers is that any observed decrease in reproductive performance that they may be experiencing in their herd is due to the increase in average inbreeding levels within dairy cattle populations. Given the relatively small effect of inbreeding depression on measures of fertility, this is not a strong reason for wanting to control inbreeding. Some producers are strictly against any matings that would yield an offspring with an inbreeding value above a given tolerance level, say 6.25% for example. While inbreeding trends in each breed and within each herd need to be monitored, the strict use of minimum tolerance levels is not the ideal way to control inbreeding. This practice could have major consequences on the genetic gains achieved. Optimal approaches for controlling inbreeding levels balance the benefits of genetic progress with the undesirable effects of inbreeding depression, both in the short and longer term. Also, the effects of inbreeding depression have been found to be quite linear in that the impact of a one percent increase from 2 to 3% inbreeding leads to the same degree of reduced performance as the same increase from 10 to 11% inbreeding. Therefore, what makes a given tolerance level, say 6.25% for example, so magical that a mating yielding 6.5% inbreeding is prohibited but one yielding 6% is acceptable? This point is amplified by the fact that all estimated inbreeding values are dependent upon the amount of available pedigree information.

Summary

It seems that inbreeding is a growing concern for producers in all dairy breeds due to the higher rates of increase over recent generations. The rising levels of inbreeding are an expected by-product of genetic progress in a population and surely need to be monitored. As with most things, a balance is required between high rates of genetic gain and increased inbreeding levels. While computerized mating programs are an excellent means for identifying matings that would produce highly inbred offspring, approaches that account for expected levels of inbreeding depression are preferred over the use of minimum inbreeding tolerance levels for disregarding potential matings. Research aimed at estimating the impact of inbreeding depression for various traits is ongoing at Canadian Dairy Network (CDN), which will be a topic for a future CDN article. In the meantime, remember that estimated inbreeding values on an animal by animal basis are dependent upon the completeness of pedigree data available and simply reflect the “probability”, not necessarily the reality, that the animal has inherited the same gene from both parents, which they received from a common ancestor.

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