Réseau laitier canadien

Canadian Dairy Network

Quantifying Inbreeding Depression

Introduction

Genetic gain is achieved by selecting superior males and females as parents of the next generation. This is true at the herd level as well as for the national population in general. Genetic evaluations are required to accurately identify the elite animals in each breed. One negative consequence of such genetic selection strategies is that superior animals in future generations are more likely to be genetically related to elite animals of today. This means that a natural by-product of genetic selection is also an increase in the average level of inbreeding over time. Ideal genetic improvement strategies balance genetic gain with increases in inbreeding levels. The reason that increased inbreeding levels are usually considered undesirable is that (1) it decreases the amount of genetic variation in the population available for future selection, and (2) it results in reduced performance of inbred animals for certain traits. This reduction in performance due to inbreeding is termed *"inbreeding depression"*. Canadian Dairy Network (CDN) geneticists recently analyzed Holstein performance data to quantify the degree of inbreeding depression that exists for various traits.

Data Analysis

In order to quantify the impact of inbreeding depression it is important to concentrate on cows that have an accurate estimate of their inbreeding level. To achieve this goal the CDN study was based on Holstein cows that calved in the most recent ten year period and had at least six complete generations of known pedigree, which includes all 126 of its closest ancestors. The analysis evaluated the impact of inbreeding depression on measures of production, type, somatic cell count, fertility, calving performance, longevity and other functional traits.

Inbreeding Levels

It is well known that the average inbreeding level in dairy cattle populations has been increasing to a point where the most popular breeds in Canada have surpassed the 5% mark. A little known fact, however, is that less than five percent of Holstein heifers born in Canada each year actually have an inbreeding level greater than 10% (Figure 1). How is this possible? Basically, increases in the average inbreeding level during the past 15 years have not resulted from having more animals higher than 10% inbreeding but rather a shift in the proportion below 6.25% (now near 50%) versus from 6.25% to less than 10% (now near 45%). This fact leads to two clear conclusions as it relates to monitoring inbreeding. Firstly, it is obvious that producers desire and are able to avoid matings that yield inbreeding levels greater than 10%. Secondly, the effects of inbreeding depression therefore really only have a practical impact on genetic improvement within a breed when the inbreeding level of resulting progeny varies within the range below 10%.

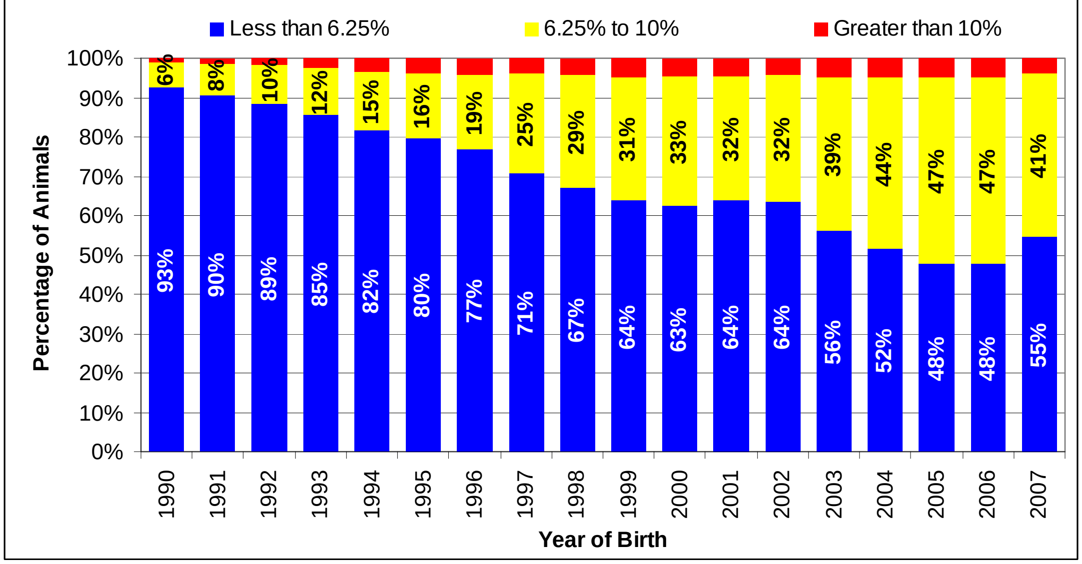

Figure 1: Distribution of Inbreeding Levels in Canadian Holsteins by Year of Birth

How Important is Inbreeding Depression?

For dairy cattle populations, various researchers worldwide have analyzed the impact of inbreeding depression on specific traits of interest. Generally, within the range of inbreeding levels found within such populations (i.e.: up to 15-25%) any effect of inbreeding depression has been linear, meaning that it is consistent with each increase of 1% inbreeding. For this reason, the results of the CDN analysis in Table 1 for Canadian Holsteins provide the effect of inbreeding depression for each 1% increase in the animal's inbreeding level. Most traits listed represent first lactation performance whereas the fertility and calving traits also include measurements in heifers.

As with previous research in this area, some level of inbreeding depression occurs for yield traits, female fertility, calving performance and longevity. No significant effect of inbreeding depression was found for fat and protein percentages as well as all type traits and only a minor impact was found for the other functional traits. To facilitate the understanding of the impact of inbreeding depression for each trait, Table 1 includes a description of the expected difference in performance for an animal that is 10% inbred versus one that is closer to the breed average at 5% inbred. As noted earlier, these differences would be expected for any increase of 5 percentage points in inbreeding within the range from zero to 25%.

Table 1: Inbreeding Depression on Phenoptypic Performance in Holsteins

Trait	Per 1% Inbreeding	Expected Impact for a Cow 10% Inbred versus 5%
First Lactation Production:		
Milk Yield (kg)	-18.4	92 kg less milk per lactation
Fat Yield (kg)	-1.06	5.3 kg less fat per lactation
Protein Yield (kg)	-0.53	2.6 kg less protein per lactation
Fat Percent	-0.005	No significant impact
Protein Percent	0.001	No significant impact
First Lactation Classification:		
Conformation (60-89 points)	0.00	No significant impact
Mammary System (40-89 points)	0.03	No significant impact
Feet & Legs (40-89 points)	-0.01	No significant impact
Dairy Strength (40-89 points)	-0.02	No significant impact
Rump (40-89 points)	0.00	No significant impact
Fertility in Heifers:		
Age at First Service (days)*	0.35	1.7 days older at 1st insemination
56-d Non-Return Rate (%)	-0.14	NRR reduced by 0.7%
1st Service to Conception (days)*	0.11	Conception delayed by 0.6 days
Fertility in 1st Lactation Cows:		
Calving to 1st Service*	0.22	1.1 days longer to 1st insemination
56-d Non-Return Rate (%)	-0.04	NRR reduced by 0.2%
1st Service to Conception (days)*	0.09	Conception delayed by 0.5 days
Days Open (days)*	0.29	DO longer by 1.4 days
Calving Interval (days)*	0.31	CI longer by 1.6 days
Performance at 1st Calving:		
Calving Ease (% Unassisted/Easy)	-0.08	0.4% fewer Unassisted/Easy births
Calf Survival (% Alive)	0.10	0.5% more calves born alive
Performance at 2nd Calving:		
Calving Ease (% Unassisted/Easy)	-0.06	0.3% fewer Unassisted/Easy births
Calf Survival (% Alive)	-0.01	No significant impact
First Lactation Functional Traits:		
Average Somatic Cell Count ('000)*	2.4	Increase in average SCC of 11,800
Milking Speed (% Avg, F & VF)	-0.04	0.2% more Slow or Very Slow milkers
Temperament (% Avg, C & VC)	0.08	0.4% more Average or Calmer milkers
Body Condition Score (1-5 scale)	-0.03	Lower score by 0.1 points
Longevity:		
Age at Culling (days)	-13.1	Age at culling reduced by 65 days
Productive Life (days)	-12.9	Culled 65 days earlier after 1st calving

** Indicates traits where positive inbreeding depression is undesirable.*

Summary

Based on a recent CDN analysis to quantify the impact of inbreeding depression in Canadian Holsteins, some effect was found for the yield traits, female fertility, calving performance and longevity. There was no significant impact for fat and protein percentages as well as all type traits and only a minor effect was found for the other functional traits. Less than 5% of the Holstein population is more than 10% inbred so the impact of inbreeding depression should focus on the range of inbreeding below this level. Cows that are 10% inbred versus 5% are expected to have reduced yields by 92 kg milk, 5.3 kg fat and 2.6 kg protein per lactation, add 1.4 days to their days open, have up to 0.4% more calving difficulties and have a reduced longevity of 65 days. While these negative effects of inbreeding do represent some economic loss, they need to be weighed against the additional genetic gain that would be expected from each mating. Ideally, genetic mating programs should deduct the combined effects of inbreeding depression from the total genetic merit (i.e.: LPI) expected from each mating, instead of using a minimum inbreeding tolerance level to avoid specific matings.

Author: Brian Van Doormaal
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