Réseau laitier canadien
Canadian Dairy Network

How Are Cow Indexes and Bull Proofs Calculated?

By: Brian Van Doormaal

Dairy cattle breeding has become quite a science, with too many numbers for anyone to clearly understand. In Canada, we have genetic evaluations for five production traits, close to 30 conformation traits, five auxiliary traits, the LPI and TEV values plus inbreeding percentages, all which are expected to be considered before each mating decision. Sometimes, with all this information available, the entire value of genetic evaluations can be overlooked due to confusion and often, misunderstanding. Perhaps, it is time to take a closer look at how cow indexes and bull proofs are calculated so that the chore of making selection decisions might somehow become less laboursome.

Garbage In, Garbage Out!

All genetic evaluations are calculated starting with actual performance data collected on each cow at the farm level along with pedigree information provided by breed associations based on herdbook registrations. This is true for production records, type classifications, somatic cell scores, calving ease, milking speed and all other traits. It is therefore very important that all producers and industry personnel understand the principle of AGarbage In, Garbage Out@ and strive to provide the most accurate information possible on every cow in the herd.

Phenotype Versus Genotype

Whenever performance information is recorded on a particular cow, this is a reflection of her phenotype. It is well understood that a cow=s performance, or phenotype, is a function of her genetic potential, also known as her genotype, and the environment which surrounds her so that:

Phenotype (Performance) = Genotype (Genetics) + Environment

The challenge with calculating genetic evaluations is to use the phenotypic information for an animal and its relatives and adjust it for environmental factors in order to isolate the animal=s genotype. In mathematical form, this means the above equation can also be written as:

Genotype (Genetics) = Phenotype (Performance) - Environment

When CDN changes how genetic evaluations are calculated, most of the time these changes are aimed at enhancing the methods of adjusting the phenotypic records for environmental factors, therefore increasing the accuracy of the resulting cow indexes and bull proofs.

Environmental Factors

There are several environmental factors which affect a cow=s performance. Some of the most obvious ones, such as herd management, age of the cow and lactation number seem to be important when estimating genetic evaluations for any trait. Other factors such as the stage of lactation when a cow is classified, the sex of the calf for calving ease or even the test day milk yield when evaluating milking speed are very specific to the trait in question. Researchers are constantly identifying which environmental factors are the most important to consider in genetic evaluation systems and what the appropriate adjustments should be.

One of the most important environmental factors to consider is the Aherd effect@ which includes all herd management and environmental elements which are common to the whole herd, such as the herd health, milking and feeding programs, barn structure and temperature, climate, etc. These factors are accounted for through the use of herdmate deviations. In this way, the herd average performance which is due to non-genetic factors is considered and there is also an adjustment for the amount of variability in the performance of animals within the same herd.

In the type system, for example, each cow=s first classification in first lactation is compared to the average of all first lactation, first classifications done in that same herd by the same classifier on that same classification date. This group of cows is considered a Acontemporary group@ and are assumed to have been exposed to the same herd effects. In this way, the differences in classification scores between cows in the same contemporary group are due to differences in their genetic potential as well as differences in other environmental effects such as the cow=s age at classification and the month of lactation when classified. For production traits, analyzed with the Canadian Test Day Model, contemporary groups consist of all cows which are tested in the same lactation on each herd test date. This means that each time the herd is tested, the comparison group for each cow=s 24-hour yields will change as other herdmates in the same lactation start or complete their 305-day record.

As mentioned earlier, in essentially all genetic evaluation systems, the age of the cow must be considered. The exact adjustments for age effects are updated each genetic evaluation run based on an analysis of the performance data after all other known environmental factors have been accounted for. A similar

approach is used to adjust the phenotypic performance for each environmental effect, therefore producing an estimate of each cow=s genetic potential for that specific trait.

Estimating Genetic Merit

A final step in determining each animal=s genetic merit is to incorporate all information from the relatives. This is done through the use of known genetic relationships derived from breed association pedigree data. Each genetic evaluation system in Canada automatically accounts for the genetic merit of each mate when considering progeny information. In this way, if a bull, for example, happens to have been used more often to breed below-average females then he is properly credited for any improved progeny performance. The reverse is also true for bulls and cows which are selectively mated to only above-average mates. The use of accurate adjustment factors for environmental effects, complete pedigree information to incorporate the performance of all ancestors, brothers, sisters and progeny as well as the fact that the genetic merit of each mate is considered, are all important components of the complex genetic evaluation systems in Canada.

Trait Expression

Prior to publishing the genetic evaluation for each trait, each bull=s proof and cow=s index must be expressed on a scale that is meaningful and leads to a relatively easy interpretation of the published values. This is done by defining a group of animals which are used as the reference group, or the Agenetic base@. Genetic evaluations for most traits, such as production and conformation details, provide an estimate of each animal=s superiority or inferiority compared to animals with a rating of zero. A bull with a Milk EBV of +1000 kg, for example, is expected to produce daughters which produce 500 kg more milk per lactation than daughters of a zero-rated bull, assuming they are mated to cows of average genetic merit in average herds. For auxiliary traits, a descriptive scale is used which indicates the expected future phenotypic performance when that particular bull is used. An example is that a bull rated 70% for Milking Speed is expected to have 70% of his daughters appraised as AAverage@ or AFast@ milkers in their first lactation.

Genetic evaluations are an **estimate** of each animal=s true genetic potential. The accuracy of that estimate is partly reflected by the associated AReliability@ value which is published, but also by the complexity of the methodology used. Researchers, industry personnel and breeders/producers must continue to strive for the best system possible, through communication, consultation and collaboration.