GENETICS 101

GENETIC PROGRESS

Whether you milk 40 cows or 400 cows, for most dairy producers the ultimate goal is to produce quality milk in a sustainable and economical manner. This goal has been made easier over the years by introducing feed additives, new software, new technologies and selective mating, to name a few. Of course, each dairy producer likely has specific herd goals or targets that they are constantly working towards over a specific period of time.

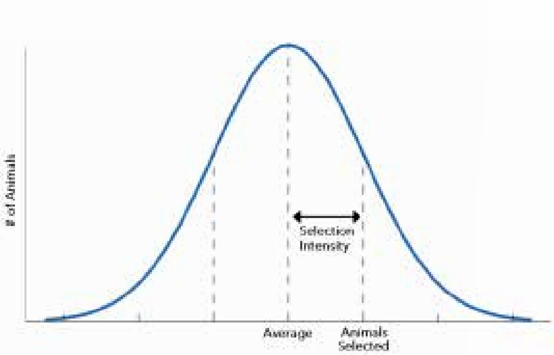
These goals include genetic improvement (genetic progress) in some form. Genetic progress is defined as the progress that is made when the average genetic value of the offspring is higher than the average genetic value of the previous generation. So simply put, increasing the rate of genetic progress is about making better cows, faster.

There are four key factors that influence the rate of genetic progress. These factors can be expressed by the following equation:

$$\text{Genetic Progress} = \frac{\text{Selection Intensity} \times \text{Accuracy} \times \text{Variation}}{\text{Generational Interval}}$$

Some producers may be using this equation every time they breed an animal without even realizing it. For others, these factors help make decisions about which animals stay in the herd or which leave.

FIGURE 1



Selection Intensity

Selection intensity is the intensity with which a subset of animals in a given group is selected to breed the next generation. Breeding every animal in the population is low selection intensity and, on its own, would not contribute to genetic progress in the next generation. Conversely, identifying the top performing 20% of the population and breeding them exclusively would represent high selection intensity and drive genetic progress in subsequent generations. Selection intensity is easily visualized using a bell curve distribution of animals (Image 1). For any given trait, the population has an average genetic metric: the highest point on the curve representing the majority of animals in the population. On either side of the average animal, there are desirable and undesirable extremes, with fewer animals in the population at those extremes. For selection intensity, choosing a group of animals with the above average desirable trait will drive positive genetic progress, whereas selecting an inferior group of animals for breeding would drive negative genetic progress. The more selective a producer is within the best of their herd, the greater the next generation can be. Selection intensity is prevalent with the use of AI sires, where out of the population of bull calves born, only a small number of them sire the next generation. In female populations, selection intensity varies significantly by producer – some breed all herd females for the next generation while others use grouping strategies within their female breeding program.

Accuracy

Accuracy is the strength of the relationship between a true breeding value and its predicted value being used for selection. For example, the reliability of the genetic evaluations used to make decisions about parents of the next generation can vary significantly trait by trait simply because some are more heritable than others. Reliability is further affected by the completeness of pedigree, genomic testing, and addition of on-farm data like classification and milk recording. The level of accuracy possible in a herd with no herd records is significantly less than the level of accuracy that could be achieved in a herd that keeps track of pedigree, animal performance and industry programs. The second herd's increased accuracy would give them a leg-up on the rate of genetic progress over the herd with no records.

Variation

Variation is the differences that exist among the best animals for a given trait and the worst animals for that same trait. Variation will differ from one herd to another, depending on the herd's goals and past genetic strategies. For example, a herd that has used a mix of herd bulls and AI across their whole herd in the past likely has more genetic variation in their current population than a herd that has intensively worked with their top end genomic females over the past several generations. Though the genomic tested herd likely has a higher average genetic potential currently, the first herd has extra variation that could increase their possible rate of genetic progress over that of the genomic herd, if all other variables were the same.

Generational Interval

Generational interval refers to the average age of parents when their first offspring is born. Comparatively speaking, cattle have a relatively long generational interval compared to species like swine or poultry. Traditionally, cattle need to reach sexual maturity before they can be bred, carry the calf full term and then calve. With new technologies, the generational interval has decreased. On the sire side, genomic testing has resulted in an industry shift with unproven sires (also known as young sires or genomic sires) having taken over more market shares. While flushing and IVF continue to increase in popularity in young heifers at an earlier stage of life with the intent of implanting these embryos in cows with inferior genetics.

At the end of the day, rates of genetic progress are a balance of these four variables. As any of Selection Intensity, Accuracy or Variability approach zero, so does genetic progress. Meanwhile, shorter generational intervals, while increasing rates of genetic progress, also decrease the levels of accuracy that could be achieved with more time.

It all comes down to current herd situation, goals and targets. Each producer will have to identify what works best for them and meets their needs and resources.