Improving Accuracy of Selection

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As alpaca breeders, we have a shared goal of improving our herds with each successive generation. In other words, we all want to see genetic gain – improved conformation and superior fleece characteristics, for example – of each cria over that of its dam and sire.

In part one of this article "Alpaca Builders: Breeding for Genetic Gain" I mentioned that heritability plays a vital role in the accuracy of selection. So what is this heritability business and why is it important? The idea behind selection is simply to allow the individuals with the best genes to reproduce so that the next generation has, on average, more desirable genes than the current generation. But is it really that simple? And how do you know which alpacas truly are the individuals with the best genes? The key to improving your selection accuracy lies in developing a solid understanding of the principles of heritability and breeding value.

The Basic Principles of Heritability

Let's start with a quick review. You can speed up genetic improvement within your herd by increasing the accuracy of selecting replacement alpacas, by increasing your selection intensity, by having extreme phenotypes (genetic variation), and by shortening the generation interval.

Have you ever been disappointed after the birth of the long anticipated arrival of the next Mr. Studley when Mr. Dudley showed up instead? After all, you bred your beautiful female alpaca to a male with a very impressive show record – a champion, no less. You eagerly awaited the results for more than 11 months. You had a lot of time, money, and emotion invested in the outcome, so what went wrong?

In the case of Mr. Dudley, let's assume your selection accuracy was faulty. The only selection criterion you used was the individual show record or "phenotype" of the herdsire. This is the simplest, yet least accurate form of selection, known as phenotypic selection. In this case, we'll assume you didn't pay attention to the pedigree of the herdsire other than the meaningless fact (from a genetic point of view) that all his distant ancestors originated in a certain country. You did not evaluate the champion herdsire's dam or sire, or his siblings. In addition, the stud was just beginning his breeding career and had no progeny to evaluate.

Why is it important to consider these other items when making selection decisions? It is important because they provide us with a window into the breeding value of the individual alpaca, in this case an estimate of the breeding value of the champion herdsire. The relationship between the phenotype and breeding value is a very important one, called *heritability*.

The Highs and Lows of Heritability

Think of heritability as a measure of the strength of the correlation between phenotypic values and breeding values for a trait in a given population. If you are selecting for a trait with low heritability– one that will not be passed on to the offspring in a consistent manner -- progress will be slow. Conversely, if you are selecting for a trait that is highly heritable, transmission to the offspring will be more consistent and progress will be quicker.

Some traits are more heritable than others are. When we say that a trait is heritable what we really mean is that the differences seen between various offspring for the trait are heritable. For some traits, there are no phenotypic differences within the species; therefore, they are not considered heritable, even though they may be genetically controlled.

This might appear confusing, but it's actually pretty straightforward. Take for instance the trait for the number of ears in alpacas. All alpacas are born with two ears (we hope), and the number of ears is coded by the DNA, thus it is genetically controlled. However since there is no difference in the number of ears from one offspring to the next we say that the trait is not heritable -- its heritability is zero. Now consider ear length. Alpaca ears come in a variety of lengths. There is both a genetic as well as phenotypic difference from one offspring to the next, regarding ear length, and I suspect this trait is highly heritable.

The heritability of different traits is expressed numerically and ranges between 0 to 1.0. The larger the number for a trait the higher the heritability is for that trait. Traits with heritabilities above 0.4 are considered highly heritable, traits with heritabilities between 0.2 and 0.4 are considered moderately heritable and traits with heritabilities below 0.2 are considered lowly heritable. A general rule is; traits that relate to fertility generally are lowly heritable, traits that have to do with fleece production are generally moderately heritable and traits that have to with adult body size are generally highly heritable.

Table 1: Heritability estimates for selected sheep traits

Trait	Range of probable values
Greasy fleece weight	.30 to .40
Staple length	.40 to .50
Fineness	.30 to .35
Number born	.10 to .20
Birth weight	.20 to .30
Wean weight	.20 to .30
Yearling weight	.30 to .40

Table 1 shows typical heritability estimates for various sheep traits. Heritability estimates are based on how closely relatives resemble each other. It takes large numbers of records and observations in order to establish heritability estimates. I am not aware of any established heritability estimates specific to alpacas. Sheep along with other species of fleece-producing livestock have similar heritability values for similar traits, so it is reasonable to use sheep values when talking about heritability estimates for alpacas.

Using the above information, you can see that staple length is highly heritable (.40 to .50). Breeding your dams to a herdsire that has a long staple length will result in improving the average staple length in your offspring. When selecting for traits with high estimates of heritability the phenotype of the parents is a reasonably accurate estimate of the parents' breeding value for that trait. In other words, when heritability is high, phenotypic values and breeding values are highly correlated, and relatives tend to resemble each other.

Conversely, when a trait is lowly heritable, there is little similarity between relatives. For example if you were breeding sheep and wanted to increase the number born (low heritability of 0.1 to 0.2) by selecting offspring from parents that had produced twins in the past, progress would be slow. When heritability is low, phenotype generally reveals little about the underlying breeding values, and it is difficult to select which animals have the best breeding values and therefore the best potential parents.

When the heritability for a trait that you are selecting for is low, the alpaca's phenotype is a poor indicator of breeding value. Your accuracy of selection is poor, resulting in a slow rate of genetic gain. When the trait is highly heritable, just the opposite is true. The alpaca's phenotype is a good indicator of its underlining breeding value. Accuracy of selection is good and genetic change is faster.
This does not mean that you should completely forget about selecting for lowly heritable traits, as some traits are economically important enough that they still warrant selecting for even though they have low heritability. Identifying alpacas with superior breeding values even for traits with low heritability will improve your rate of gain.

The Value of Values

Heritability values are estimates used in context with populations, whereas breeding values refer to individual animals. Heritability is a population measure and is not something that is associated with an individual animal. It would be incorrect to speak of a certain alpaca's heritability for a specific trait. For instance, we would not say that a certain herdsire has a high heritability for fiber diameter. What we can correctly state is that a herdsire's own breeding value for fiber diameter is high, and because fiber diameter is moderately heritable in alpacas his progeny's performance for fiber diameter should somewhat resemble his.

It is also incorrect to assume that if a trait has a high heritability that it also has a high breeding value. High heritability only indicates that there is a strong correlation between phenotypic values and breeding values. Regardless of the level or heritability, there are low breeding values, moderate breeding values, and high breeding values within a population.

The key to improving accuracy of selection is to consider both the heritability of the trait, along with the individual alpaca's breeding value for the trait. Selecting for a trait that has a high heritability, coupled with an alpaca that has a high breeding value for the same trait will result in the best selection accuracy. In order to do a good job of identifying those alpacas with the best breeding values we need good information. Good information will lead to good decisions. We cannot simply take a tissue sample and magically run a test to determine the genotype (genetic makeup) of the alpaca under consideration. Therefore, the only information available to us is the phenotypic information of the alpaca and hopefully of its close relatives.

It's All Relative

So how does looking at the performance of close relatives help estimate the breeding value? Close relatives share many of the same genes because they inherited them from common ancestors. Full siblings share 50 percent of their genes with each other, half siblings share 25 percent of their genes with each other and progeny share 50 percent of their genes with their parents. When alpacas share genes, they also share the independent effect of those genes. As a result, close relatives have similar breeding values. This correlation has nothing to with heritability. It is strictly a result of pedigree relationship. The more distant the relative the less similar the alpacas will be with regard to individual breeding values.

Let us look at an example of how you would use this information. You have established a goal to improve fineness with in your herd, by two microns. You know that fiber diameter is a moderately heritable trait, so progress can be made regarding fineness, with proper selection. The first thing you will likely do is identify a herdsire that meets your selection criteria for fineness. Next, you should not only consider how fine the herdsire is but also whether or not the herdsires other close relatives are also fine. You may find that his dam is not fine and her other offspring (half-siblings of herdsire under consideration) also lack fineness. Since close relatives have similar breeding values, you could conclude with reasonable confidence that even though the herdsire under consideration has a fine fleece his breeding value for fine fleece is moderate at best. You would likely be much better off not choosing this herdsire and instead continuing your search for a herdsire that meets your fineness criteria (selection intensity) coupled with a high breeding value (selection accuracy) for fineness.

Successful breeding programs are built on simple concepts. They have well defined goals related to important economic traits. This helps us to avoid the latest fad, or falling for grand schemes designed to beat the genetic odds. The wisest alpaca breeders play the odds by following the rules of heritability and genetic gain. They slowly pursue perfection, with a comfortable assurance that the next generation of cria resulting from their breeding program will be better than the last. And they foresee the next generation as being even better. Occasionally, the random nature of genetics rewards us with a gift from nature, that truly superior alpaca. As alpaca breeders, we learn to be patient opportunists.

References:

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