Breeding Strategies:

Which is Which, and Which is Right for Your Alpaca?

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In alpaca breeding, as in any other worthwhile pursuit, establishing a guiding philosophy and then outlining your goals can eliminate a lot of wasted effort. Developing a philosophy is a rarely done but all-important first component of any breeding program.

Your guiding philosophy is really just your reasons for breeding alpacas, and once you identify what they are, you will know what your goals are. For you, these might be show ring wins, temperament, conformation, soundness, color, or fiber characteristics. Every breeding program places different emphases on different components. **Matings that are accomplished simply because males and females are conveniently available are frequently less rewarding than matings that are planned by carefully matching males and females for traits of interest.**

Two useful philosophies in common use concentrate on slightly different aspects of animal breeding. One, often followed by show participants, is the production of excellent individual animals. This approach generally tolerates a fair degree of variation in animals just as long as some excellent ones are produced. These excellent animals are skimmed off the top and used to good advantage as show animals and as breeding stock. **A second common approach is the "uniform population" philosophy, often followed by commercial livestock production breeders, whose goal is to produce genetically predictable, uniform offspring. Usually this means that the breeding program aspires to develop a uniformly good population, and therefore it accomplishes some of the goals of the "excellent individual" philosophy. The difference between the two philosophies is that the "uniform population" philosophy is more concerned with narrowing the overall range of variation.**

Neither of these philosophies is right for all situations. The importance of considering them is to realize that different strategies are necessary to accomplish them. Many other philosophies can govern animal breeding, but this essay deals primarily with these two because genetic phenomena and breeding strategies have especially dramatic impacts on them and less on some other possible philosophies. **For example, a less-useful philosophy is "anything will do." Little direction and progress are made possible by this approach, and we can only hope that few alpaca breeders are content with reproducing animals for the sole reason that they are alpacas.**

What Is Genetics Anyway?

Genetics is the science that studies the transmission of traits from one generation to the next. For those of us involved in its practical application, we use genetics to determine how the activities of animal breeding interact with the transmission of traits. Genes are ultimately responsible for most of the traits of animals, although they can be imperfectly represented in the individual final animal. **The other way to say this is that the *phenotype* (external appearance of the animal) does not always reveal the *genotype* (the full complement of genes in the animal).** The imperfect representation is due in part to the modifying effect of the environment. A genetically perfect animal in a hostile environment is going to look and perform shabbily. A genetically inferior animal in an ideal environment might actually end up looking pretty good.

The interactions among genes are complicated-another reason the phenotype can imperfectly represent the genotype. Genes may be expressed or hidden. Some genes or some gene combinations mask or cover up other genes. One of the challenges facing animal breeders is to unlock genetic combinations so that the animals reveal their true genetic potential. Once the genetic potential is revealed, knowledgeable breeders can pick

and choose breeding stock to make great progress in the production of alpacas that accomplish the goals of their breeding programs.

The importance of genetics to animal breeders is really twofold. First, the genes and the environment of the animal combine to produce the individual animal, and either one can limit its level of perfection. Most breeders are preoccupied with the genetic makeup of individuals. A second and very significant aspect of genetics is the makeup of the population. since the positioning of genes throughout a population affects the pattern of their expression in individuals within the population. The genetics of the population sets the pattern of occurrence for all traits, both bad and good. Maintaining a healthy viable population made up of sound, productive individuals should be a major goal of all alpaca breeders.

It is fairly obvious that any population is made up of individuals. What can be less obvious is the way those individuals relate to the overall population. Genes can be relatively evenly dispersed through a population. Alternatively, genes can be present in only certain subpopulations of an overall population, and absent from other subpopulations. If a population is subdivided into different isolated pockets of interbreeding animals, then each of these is going to produce different genetic combinations. Those combinations that are deleterious can then be eliminated without involving the whole population. Those that are advantageous can be fostered and introduced more widely across the whole population. One major advantage of at least some isolation of strains is that each strain will house its own array of genes. These can be more easily identified and manipulated in smaller groups. They can then work their way out of the small groups, to have advantages for the population as a whole. These different situations are going to govern the pattern of gene expression throughout the population.

Breeding Strategies: What They Are

Three common breeding strategies for domesticated livestock are outbreeding, linebreeding, and inbreeding. These have become charged with positive and negative connotations, especially in the breeding of alpacas and llamas, when in actuality each has a place in any domesticated population.

Inbreeding is usually defined as the mating of animals that have common ancestors. Parent to child, brother to sister, aunt to nephew, and a host of other combinations are classed as inbreeding. What inbreeding accomplishes is the pairing up of genes so that they are *homozygous*(both members of a gene pair are identical). Being homozygous can be either good or bad depending on the genes. Inbreeding in and of itself is neutral-the outcome of inbreeding depends on which specific genes are present to be paired up. "Good" genes pair up to make good sound animals; "bad" genes can pair up to produce defective animals. The key point is that inbreeding generally exposes the entire range of genes to view. Nothing is hidden; everything can be seen in at least some of the animals produced by inbreeding.

Linebreeding, a less extreme form of inbreeding, is generally considered to be the mating of individuals that have a single ancestor in common. One example is the mating of half brothers to half sisters. Usually this takes the form of mating sons and daughters of a single outstanding sire or dam. This mating is frequently used in order to regenerate an animal as close to the original outstanding animal as is possible.

Outbreeding, linecrossing, outcrossing, and crossbreeding are all variants of a strategy opposite to inbreeding. They involve the mating of animals that have totally different ancestors. Crossbreeding is usually considered to be mating between different breeds. Examples from lamoids could include llama-to-alpaca matings. Usually the mating together of sun and huacaya types of alpacas is considered crossbreeding, although it might also be considered outcrossing since these two fall short of being breeds in the narrow sense.

Linecrossing is usually considered to be mating that is accomplished within a general type or breed, but to animals that represent different lineages of that type or breed. Examples here could include the crossing of English, Bolivian, Peruvian, or Chilean huacaya alpacas. They are the same general type but are representatives of different portions of the population and therefore are unlikely to have common ancestors. Mating of animals from within these various countries but from different regions or herds also qualifies as outbreeding. The problem at this stage of alpaca breeding in North America is determining just exactly the relationship between potential mates, since the South American background of these is frequently a black box. As a consequence, just exactly which type of mating is being accomplished is difficult to know in any given situation involving recently arrived animals.

Breeding Strategies: What They Do

Inbreeding and **linebreeding serve to pair up genes in such a way that both members of a pair are the same *(homozygous).*This pairing does not occur in each inbred or linebred mating but does occur much more frequently than it does with the other breeding strategies. Like pairs of genes result in animals of consistent genetic makeup, so that they produce predictably. On the positive side, these strategies can produce prepotent breeding animals that stamp their offspring with uniformity since they themselves have only a single sort of gene to pass along. The uniformity is a reflection of low levels of genetic variation within individuals.**

The flip side of the inbreeding coin is the need to cull substandard variants. This can be difficult, but if culling isn't done, problems in a population can be expected to increase. For example, many defects in domesticated animals are due to recessive genes. Few of these are proven in lamoids, but if the general rule holds, then many (but not all) alpaca defects are due to recessive genes. Inbreeding and linebreeding are going to bring them to the surface. Defects that are revealed then need to be removed from the breeding population. The trick, though, is to realize that many (though not all) of the normal siblings and half siblings of a defective animal are also likely to have the genes for the defect although in an unexpressed *heterozygous* state (in this situation, each member of a pair of genes is different rather than the same). All that inbreeding does in this situation is alert the breeder to the presence of these weaknesses within the population. Actually identifying and removing the genes from the populations is complicated, time consuming, often emotionally painful, and expensive. Strategies for this will be outlined below.

Inbreeding, if taken to extremes, can lead to general diminishment of vigor Decreases can occur in disease resistance as well as in general reproductive vigor It is, however, a useful strategy for detecting any weaknesses that might be present in a population if it is used wisely and with intense selection for animals that have vigor and are free of genetic defects. Without such selection, inbreeding can be a disaster.

Outcrossing accomplishes a result opposite to that of inbreeding. Genes in outbred animals are likely to be in unlike pairs *(heterozygous),* and few recessives are likely to be expressed. **The upside of this is that few genetic diseases are expressed. The downside is that few really prepotent breeding animals are likely to be produced by this strategy because most outbred animals lack the genetic consistency to produce evenly. With outbreeding, an important factor to consider is that recessive genetic diseases are unlikely to be expressed, but they are still being passed along to carriers in the population.** Outbreeding is unlikely to reveal carriers until the gene responsible for the defect gets to high frequencies in the population, at which point it will be expressed periodically because carriers will be mated on occasion, providing the opportunity for the expression of the recessive genetic disease in the offspring. Very rare recessives are unlikely to be detected in populations that are bred by outcrossing; more common recessive are much more likely to be detected. Widespread use of outcrossing ensures that carriers will be undetected, especially when recessive diseases are relatively rare.

So Which Is Best?

No simple answer will determine which breeding strategy is best-it all boils down to philosophy. Each strategy has favorable and adverse consequences. Using a combination of strategies and knowing how they drive selection and breeding in various portions of the population can help you choose among them, depending on the goals of your breeding program.

Inbreeding (and to a lesser extent linebreeding) makes for more consistent and more predictable animals, which can be good in some situations. It is useful if selection for vigor is going to be possible (save the vigorous, chuck the wimps). In South America, selection is accomplished fairly readily, since a meat market is functioning to absorb the less-desirable animals, although identifying carriers of defective genes is nearly impossible because of the absence of verifiable pedigrees. In North America, we do not have the same mechanism for removing defective animals from the breeding population, nor for the removal of their relatives. Inbred populations have little variation, so that performance (fiber, conformation, color) can be accurately predicted. Inbreeding can also bring recessive defects to light. This too can be either good or bad. It is bad if selection is not going to remove (or at least identify) carriers from the population. It is good if the identification of carriers is going to act to reduce their frequency in the population.

With outbreeding, vigor goes up, especially reproductive vigor. Uniformity generally goes down, although one notable exception is the first cross between inbred or linebred animals that are from different tines. Crossing inbred lines usually generates very uniform animals, but these uniform animals do not in their own turn produce uniform offspring. An extreme example is the crossing of Hereford and Angus cattle. All the resulting calves are black baldies. If the black baldies are used for reproduction (and they do reproduce very well), they can throw black, red, black baldy, and red baldy offspring. So the initial cross is uniform but cannot itself produce uniformly Still, for the production of stunning individual specimens, outbreeding certainly has merit. Think show winners here!

Outbreeding also tends to decrease (at least initially) the chance that rare recessive genes are brought to light. The good news is that many diseases are probably due to rare recessive genes, and therefore outbreeding is one way to avoid their expression. The bad news is that they will eventually show up in a population, for carriers eventually become common enough that outbreeding pairs them up and the diseases or deformities are expressed. In a deliberately outbred population the expression of defects can indicate that the genes responsible (for those defects that are genetic in origin) are widely dispersed throughout the entire population.

So what is *my* choice? Generally, I prefer to have both linebreeding and outbreeding going on in a population. My overall choice is for outbred females and linebred males. A single strategy to accomplish this is somewhat tricky but possible. In this system it is essential that the linebred males come from carefully documented lines, and that they are not carriers of any deleterious genes. Not just any male will do!

Selection Is the Key

Selection is the force that allows reproduction of some individuals and not others. It operates independently of any type of breeding system in animal populations. Selection is therefore a force for change in the overall genetic makeup of a population. Selection is a powerful tool, one that can irreversibly change a population. In a single decade, for example, fleeces presented to markets in Arequipa changed from 70 percent colored to 70 percent white-a change brought about because only white males were allowed to reproduce.

Selection can involve any trait whatever: size, staple length, fiber color, fiber fineness, conformational type. Selection can be intense and cause fairly rapid change over a few generations, or it can be more relaxed and change the population more slowly in the desired direction. Because selection can irreversibly change a population, the breeder needs to carefully consider his or her goals.

Selection can be responsible for changing the incidence of recessive alleles. If a malformation is due to a recessive allele and the defect can be treated, then it is possible for the defective animals to reproduce. All offspring of these animals will carry the gene for the defect, whether or not they actually express it. This transmission, repeated in many individuals, can act to increase the frequency of genes for defects. Other alternative plans have different consequences.

Limiting reproduction of known carriers is important for the long-term genetic health of the population, although its practice will always be unpopular with owners of otherwise-outstanding individual breeding animals that happen to be carriers of genetic defects. Such a phenomenon occurred in Arabian horses with the lethal recessive defect of combined immunodeficiency. Currently about 20 to 25 percent of Arabian horses carry this gene so that 4 percent of Arabian foals are born with the defect. The widespread use of carriers ensures that this will be the case, and the difficulty is that, if left unchecked, the genes can become so common in a population that selection becomes a difficult pill to swallow, because then a high number of individuals must be removed from reproduction. Some of the carriers are bound to be otherwise exceptional, and these are the animals for which the choices become very difficult.

Identification of carriers can come about in different ways. One way is to simply let individual breeding practices eventually bring carriers to light. This works reasonably well for defects of low incidence, since they are unlikely to overwhelm the population. The danger of this approach is that a single undetected carrier sire that is used widely can spread the defective gene far and wide before it is detected. Examples occurring in various other livestock species are relatively common. Once these genes become common, reducing their incidence is a real headache.

In the case of more common or severe defects, it is possible to test for carriers more deliberately One of the most powerful tests for genetic defects is the mating of parent to offspring. In alpacas, this generally takes the form of sire mated to daughters because only a single offspring is produced per pregnancy. The reason this is such a powerful test is that it simultaneously tests the male for all defective genes. That is, if anything weak is present it will be exposed. Unfortunately, the number of matings needed for this type of test is relatively high. To be 95 percent sure that the animal is not carrying deleterious recessives, it takes twenty-three normal offspring from daughters. To be 99 percent sure, it takes thirtyfive normal offspring. Obviously, any abnormal offspring produced at any point along the way implicates the sire as having the genes for that defect. Nevertheless, this conclusion would be something of an intuitive leap because few defects are proven to be genetic in alpacas. The logic works only if the defects are genetic.

If a carrier is detected, by whatever means, then the next step needs to be pondered carefully. If selection is aimed at decreasing the number of carriers, many different routes can be taken. One method is to neuter the affected individuals as they become known, the parents of the defective individual, and all of their previous offspring. This is the most radical selection against a defect, and it effectively removes carriers from the population as they are detected as well as some noncarriers simply because, based on the law of averages, they are more likely to be carriers by virtue of their relationship to known carriers. At very low gene frequencies carriers are unlikely to be detected because they are unlikely to be mated to another (equally rare) carrier. So while the "neuter all carriers" approach will work to dramatically reduce the number of carriers in a population, it rarely completely eliminates all carriers since some slip through the cracks of the system.

Other selection plans that work against carriers are better than nothing, but less drastic than neutering all carriers. One such plan is to neuter the sire because he can spread the gene more widely than can the dam, which produces fewer offspring. Still, half of the offspring of the carrier dam will be carriers. One approach to this problem is to geld all of her sons but allow her daughters to reproduce. About half of these will be carriers. If these are in turn used for reproduction, the carrier rate goes down to about one-fourth, although which specific fourth is uncertain without a breeding test. If excellent males are generated, an alternative to this scheme would be to test-mate them to known carrier females to determine which of the males do not carry the defective gene. Those documented as free of the gene can then be used widely and safely for breeding of animals free of the specific defect. In this way, the positive traits of the line can be continued while leaving behind the defect. The process is long and involved but well worth the effort in some circumstances.

Alpacas in North America: Just What Do We Have?

Alpacas come to us in North America as an interesting population, and various aspects of their origin have consequences for any breeding program. Breeding strategies throughout most of the alpaca range in South America involve fairly rigid isolation into small subpopulations, with little transfer of genetic material among them. As a result, the subpopulation-to-subpopulation variability can be great. Putting this factor to good use is one of the challenges facing the alpaca breeders of North America.

A second important factor is that pedigree mating is not accomplished throughout most of the South American range. That is, the specific sire of a cria is usually unknown. Couple that with somewhat casual culling of various deformities, and the result is that very little documentation of background or family characteristics exists for most alpacas coming to North America. In most cases, all that is known is the animal's visual appearance and perhaps its geographic origin. This lack of information makes breeding and selection decisions difficult, but rich opportunity for progress is likewise possible.

The alpacas imported into the United States can usually be assumed to be inbred or linebred to some extent, and in some situations greatly so. The problem with this is that the overall extent of linebreeding is undocumented, as is the relationship of the different lines to one another As a result, the North American breeder who has imported animals is never really certain of which sort of breeding strategy is actually being accomplished. One strategy, then, is to cross the various lines to one another, to the extent it is known that different lines are represented. This is linecrossing, a form of outbreeding. Very little expression of recessive genes is expected for a generation or so under this breeding scheme. Great individuals will be produced, although few of them may be prepotent enough to reproduce uniform offspring themselves. A disadvantage is that the strategy can spread defective genes far and wide before their existence is discovered.

Alpacas in North America: Selection and Breeding Practices Determine What They Will Become

Alpaca breeders in North America have a few advantages over South American breeders. One is the requirement for pedigree breeding. With the accurate identification of sires, dams, and crias comes the information needed to make intelligent and wise breeding and selection decisions. Accurate pedigrees and monitored performance of animals will demonstrate which animals are truly excellent and can improve the population. Wise and talented breeders can use accurate pedigree information to good advantage.

Knowing the exact pedigree and production characteristics of their alpacas also allows North American breeders to put more selection pressure on traits of interest than is possible in South American systems, which are characterized by multisire matings in subsistence situations. **North Americans have the luxury of using alpacas not for subsistence but for enjoyment. It is entirely possible that North Americans will be able to unlock the genetic combinations of some of the preconquest Alpaca types, which can then be used to good advantage internationally. The challenge confronting them is huge, but the opportunity is likewise immense, and the ultimate accomplishment will be very satisfying.**

About the Author

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