Pure Blood - Part I

By Mike Safley

This story begins in a 19th century garden of sweet peas, tended by an Austrian monk named Gregor Mendel. Mendel the Monk was a scientist at heart and the work that he first published in 1866, after carefully observing the results of his pea breeding experiments, revolutionized the world of agriculture. The modern science of genetics emerged from his deductions, which became known as Mendel's Laws of Inheritance or just plain Mendelian Genetics.

For many years Mendel's paper lay unnoticed by the scientific world. He died in 1884 and it wasn't until about 1900 that the work was rediscovered by scientists, led by a man named Galton, who were attempting to arrive at the mathematical basis of genetic inheritance. The theorists from this school of thought were called biometricians. They believed that the mechanics of inheritance were a simple halving process. The biometricians and the Mendelians soon became opposing camps; each convinced that they were right and the other wrong. Time has favored the theories of the Austrian monk, who spent the last years of his life fighting oppressive taxes and running his monastery, dying without recognition for his monumental discoveries -- but, as we shall see, Galton's "Law" also made an important contribution to the science of genetics.

Now, I realize that neither Mendel nor Galton had probably ever heard of an alpaca and I am sure that the Quechua Indians have never heard of these two pioneering geneticists either. But, you might be interested to know that Don Julio Barreda was the first person to ever mention Mendel to me. I have been breeding alpacas for almost fifteen years and it is only in recent years that I have taken the time to research the scientific basis of inheritance. I have discovered that much of the conventional wisdom about breeding alpacas is ill founded and that, as an industry, we have a lot to learn. I have begun to change my ideas about breeding and selection and the initial results of my efforts have been encouraging. I will attempt, through this article and the four that will follow, to provoke the collective consciousness of the alpaca community and hopefully we can join together, breeding better alpacas. First you must know that I am not pretending to be a geneticist and I really don't have any particular aptitude for science. Furthermore, most of the texts that I have been reading lately have major sections in them so complex that I must confess I don't fully understand all of their nuances. But after many years observing hundreds of breeding and birthings, I can see the common sense of what they have to say and I believe there is much that alpaca breeders can learn from breeders and scientists in the dairy, cattle, horse, sheep, and seed stock industries.

Alpaca breeders will do themselves and our industry a great favor if they take the time to understand such things as, Mendelian genetics, Galton's Law of Inheritance, the five basic livestock breeding systems, stud rings, progeny testing, warning blood and estimated breeding values. The author of one paper I read was famous in his industry for producing a breed within a breed, creating a strain of animals that were recognized world wide for their excellence, and prepotency. He observed that breeders were constantly asking him his opinion of this mating or that mating. His standard reply was that the mating sounded okay, but whom were they planning to mate the progeny of the prospective mating to? He finished by noting that very few breeders ever seemed to have an answer to that question.

We, as an industry, need to answer the questions, what's next? How are we going to continue improving our herds? I was in Peru this July and, after visiting Accoyo and viewing the new additions to the Plantel herd, Don Julio turned to me and said in English, "twenty, twenty." I immediately asked my friend, Mario Pedroza, to inquire in Spanish about the meaning behind the phrase. Barreda, who is now 80 years old, said "My goal is to have every alpaca at Accoyo produce twenty pounds of twenty micron fleece every eighteen months." Now there's a man who has a clear idea of "what's next."

DEFINITIONS AND SIGN WRITING

It is my goal to convey a basic understanding of genetics and breeding systems so that the average breeder might gain a clear view of effective ways to improve the alpacas born on their ranch. The subject of genetics is very complex and often involves mathematical models that go on for paragraphs and pages. I promise you will find none of that here, but a few technical definitions are in order before we can move on to a discussion of specific improvement programs for breeders.

Genes: Bodies of all higher organisms are composed of cells, each of which contains heredity units called genes. Each gene is paired with a gene on the same site on the other chromosome of the pair.

Chromosomes: A structure found in the nucleus of cells and composed of a thread of DNA, which consists of numerous genes. The chromosome transmits genetic information. An alpaca has 37 pairs of chromosomes.

Homozygous: An individual is said to be homozygous if the two genes it carries for a particular trait are the same. This means that the gene contributed to an offspring from that individual will always be the same. A pair of genes that are the same, either two dominants (AA) or two recessives (aa) are homozygous.

Heterozygous: An individual is said to be heterozygous if the two genes it carries for a particular trait are different. This means that either one of two genes for a particular trait may be contributed to an offspring. A breeder can never know which gene will be contributed to an offspring from a heterozygous individual as the contribution is entirely random each time. A mixed pair of genes (Aa) is heterozygous.

Genotype: An individual's genotype refers to its genetic make up.

Phenotype: The word phenotype refers to the appearance of measurable characteristics of an individual. An individual's phenotype is a result of the expressed portion of the genetic make up (genotype) of the individual and the environment to which it is exposed.

Quantitative Traits: Quantitative traits are those influenced by many genes that cannot be identified. They are easily influenced by the environment and exhibit what is called continuous variation. This means their measurement is undertaken over a continuous scale with no clear boundary between good and bad. Their description and analysis is undertaken on a population basis rather than an individual basis.

Qualitative Traits: These are traits influenced by only a few genes that are individually identifiable. They are not easily influenced by the environment and produce discreet, measurable classes of phenotype. They are described and analyzed in terms of individuals.

Geneticists use a system "sign-writing" when discussing genes. The dominants are written in capital letters, the recessives in small letters. So, for a character we might call A, the possible combinations are: AA, Aa, aa. There is a different letter used to express each pair of genes at each location on the DNA strip. Chromosomes may also be labeled with a combination of letters, such as XY, which can also be used to define a pair of genes. This code or sign writing allows gene combinations to be expressed as math formulas.

MENDELIAN GENETICS

Mendel, in his experiments with sweet peas, bred a tall and short variety and produced a hybrid. He bred these hybrids together and found that he obtained 75 percent tall plants and 25 percent dwarf plants. The small plants were then bred together and produced nothing but small plants, but the tall plants, when bred together, produced two varieties; (1) a mixed collection of talls and dwarfs, and (2) nothing but talls, the ratio of talls to dwarfs being as 2 to 1. Over time he learned that when breeding two hybrid pea plants (or intermediates) the net result was approximately 25 percent tall, 50 percent mixed, and 25 percent dwarfs. Till this day that ratio has served as a basis for many calculations of genetic inheritance.

THE PARTICULATE AND DUPLICATE NATURE OF INHERITANCE

The essence of Mendelism is that inheritance is by particles or units. These units are called genes and these genes are present in pairs. Every alpaca receives one member of each pair of genes from each parent. Each gene maintains its identity generation after generation. They don't blend with other genes to form a new gene or blend of hereditary substance, as was thought in pre-Mendelian days. When an individual alpaca reproduces, it transmits to each offspring only one gene or the other from each of its pairs, giving each offspring only a sample half of its own inheritance. The laws of chance govern this sampling, subject to the restriction that the sample must contain one gene of every pair of each parent. The sampling nature of the process of inheritance, scarcely suspected in pre-Mendelian days, allows the same parents to transmit different inheritance to different offspring. More precisely, if we let Aa represent a pair of genes in each parent which produce an offspring, there is one chance in four that the offspring will get an A from each parent. There is one chance in four that the offspring will get an a from each parent and there are two chances in four that the offspring will get the big A from one parent and the small a from the other parent. Similar probabilities apply to every pair of genes.

As a result, about half of the genes which two offspring receive from the same parents are exact duplicates; but the other genes the two get from these parents are opposite members of the pairs in these parents. This is why identical pedigrees do not mean identical inheritance, although they usually do mean a considerable degree of similarity.

Breeders knew in pre-Mendelian days that identical pedigree did not equal identical inheritance, but they considered this one of the unexplained mysteries of heredity. It was believed that a large amount of entirely new inheritance, or mutations as we would call them today, was being created in each individual.

DOMINANTS AND RECESSIVES

As noted above, genes come in pairs and each of these pairs are comprised of genes of two possible types, dominant and recessive. A dominant gene is so named because when there is a mixed pair of genes, it is the one that expresses its character over the recessive; and the recessive is the one whose character is partly or completely concealed. This is simple and straightforward enough in principle, but dominance is often a matter of degree only. It is not always complete and a mixed pair of genes may give rise to an intermediate character.

Genetic birth defects are caused by recessive genes. Since recessive genes do not often express themselves when paired with dominants, most birth defects do not occur unless the gene pair is a double recessive or “aa” for that particular trait. Many birth defects are the result of multiple genes, but the principal is the same. We will discuss this in more detail in later articles.

HOMOZYGOUS VS. HETEROZYGOUS

It is very important to grasp the concept of homozygosity and heterozygosity. To understand how this principal works in actual practice we must keep in mind that a cria receives one gene from each parent for each pair of chromosomes. In the simplified examples found below let us assume for a moment that a particular characteristic, such as crimp, is a qualitative trait and is controlled by one pair of genes at one location on the DNA thread.

For our examples, the range of hypothetical crimp genes are as follows:

A = Good Crimp

Aa = Mediocre Crimp

a = Bad Crimp

Please note that the example of Aa for mediocre crimp assumes the incomplete dominance of the A crimp gene. As a practical matter, it is likely, as in many examples of heterozygous gene pairs, that the large character gene would be dominant for a particular trait.

Example I: When both the male and the female parents are homozygous for the good crimp gene “A”, then it follows that the cria will have good crimp. In other words, if both parents have AA genes for crimp, the cria will have AA genes for crimp.

Example II: Now consider the possibilities for achieving good crimp from two parents who were heterozygous for good and bad crimp genes or Aa. The results would represent the following statistical probability for good crimp, expressed as a percentage of matings.

Aa x Aa =

One AA 25% good crimp

Two Aa 50% mediocre crimp

One aa 25% bad crimp

In the first example, the parents were both homozygous for good crimp. In the second example, the parents were heterozygous for good crimp. In the real world of breeding alpacas, it is highly unlikely that production characteristics are controlled by a single pair of dominant genes. Most characteristics are controlled by multiple genes at multiple locations. There are exceptions such as the polled gene, for the absence of horns, in cattle which is dominant and found at a single location.

The goal for an alpaca breeder should be to develop animals which are homozygous for as many positive qualitative traits as possible. If, for instance, one of the alpacas in the example above was homozygous (AA) for good crimp and the other heterozygous (Aa), all of the cria would either have mediocre crimp or good crimp, since it would be impossible to produce a cria which was “aa” for bad crimp.

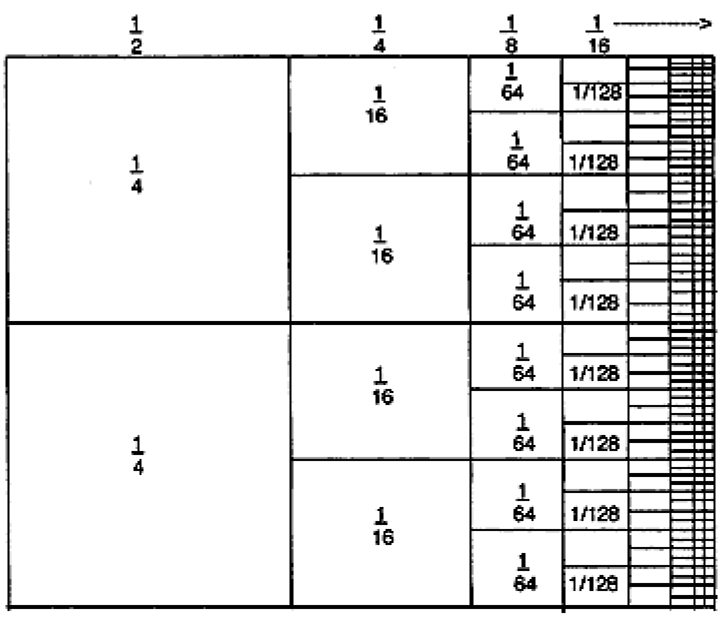
Taken a step further, if the homozygous "AA" animal was the sire and he was bred to all the females in the herd, there would be, over time, fewer and fewer progeny with bad crimp since each cria would receive a minimum of one good crimp "A" gene, thereby increasing the mathematical chance that their progeny would be "AA" for crimp. On the other hand, if the sire was homozygous for bad crimp "aa", it wouldn't be many generations before the entire herd had bad crimp.

Please keep in mind these were oversimplified examples, but as we move forward the concepts are extremely important. If an alpaca has "pure blood" for positive qualitative traits, he will produce offspring with a preponderance of positive traits.

GALTON'S LAW RESTATED

An alpaca is half her sire and half her dam, and the parents are, in turn, half of each of their parents, and so on back for as many generations as you care to go. Yet each parent contributes only half of its own genetic potential, so that the chance of getting a certain character from a parent is not a half, but half of a half, or for a grandparent, one quarter of a quarter.

By converting the concept into a diagram we create the following chart, which represents the fraction of genetic contribution made by the various parents and grandparents of an alpaca.



The implication of Galton's law, which considers the mathematical probability of a given ancestors influence on the specific animal in question, is well worth thinking about. Galton's Law forms the basis for a good deal of genetic theory in which assumptions are made that the individual will closely conform to the average of its ancestors. The implication is that selection in succeeding generations does not easily offset the average mathematical expectancies of inheritance.

Galton's Law suggests, mathematically, that having the occasional outstanding stud in a particular alpaca' pedigree might not have as much influence as one might think. An exception would occur when the same stud appears frequently in a pedigree and the breeder has been careful to preserve the animals with desirable characters in their strongest expression. When that happens the cumulative math of an animal's genes can be more readily directed by the breeder's selection. But where the stud appears only once, and far back, the chances are that his merits will have been diluted by the mathematics of Galton's Law. For this reason herds of alpacas bred on a random or constant outcross basis can only be expected to equal the average quality of the entire breed.

AN ALPACA'S PHENOTYPE VS. GENOTYPE

An alpaca's phenotype includes its external features such as head, body conformation and quality of fleece; it includes measures of productivity such as body weight and fleece weight; it includes physiological characteristics of the blood, intestinal tract, reproductive organs, and other parts of the body. It embraces everything to do with the physical appearance of an alpaca.

We can obviously ascribe a degree of merit to a phenotype. An alpaca gelding with a high fleece weight may be described as having a good phenotype; a huarizo or llama cross as having a poor phenotype. Remember that when classifying phenotypes on merit, we are not saying why one phenotype is better than another. We are simply saying that one is better than another. To understand the why, we must understand the genetics of inheritance.

On the other hand, the genotype of an alpaca is the total complement of genetic factors, or genes, which the alpaca inherits from its parents. These genetic factors contrast with environmental factors which affect the animal, such as pastures, parasites, and predators. The genotype is stable, or fixed. Once an alpaca receives its genes, which are the direct genetic link between parent and offspring, it retains them for life and it passes a portion of them on to its progeny.

The importance of the differences between the two terms can not be overstated. Alpacas which manifest positive phenotypic traits will not necessarily breed true for these traits. The environment plays a large role in the expression of many traits. An alpaca may be genotypically heterozygous for a certain trait, but because of the effect of dominance, express itself as if it were homozygous for that trait. If we, as alpaca breeders, are going to breed consistently uniform alpacas for the traits we deem desirable, we must organize our breeding programs to identify animals which are genetically consistent for the traits we desire. We must learn to create "pure blood." To understand how this might be accomplished we can learn much from plant breeders.

PLANT VS. ANIMAL BREEDING

The laws of heredity that govern reproduction are identical in all living organisms -- in plants, in animals and in man. For this reason the principles of animal and plant breeding should be similar. Yet, at a practical level, plant breeding and animal breeding differ in a surprisingly large number of ways. Studying the differences is enlightening and might lead the alpaca industry to rethink its current breeding practices.

The discovery of Mendel's principles furnished the key that made it possible to discover the real nature of heredity. Plant breeders were very quick to see the possibility of applying these discoveries to their methods of plant improvement. During the first ten years of the century there was a revolution in plant-breeding technique. Today there are very few plant-breeding methods left which could be improved upon by a geneticist. Current plant-breeding methods are said to be genetically sound.

Animal breeders are a long way from this ideal condition. In general, animal breeding methods, especially when contrasted with plant breeding methods, are speculative and more influenced by tradition than science.

Why is it that animal breeding lags so far behind plant breeding? Several things contribute to the differences. First, from an economic standpoint, the production of agricultural crops is more important than the breeding of most categories of animals; second, in plants there is an enormous difference in the relative value of one individual as compared with the crop. For instance, in wheat, sugar-beet, and flax, the quality of the breed as a whole or the value of a large field of plants is important, but the individual plant is relatively valueless. In animals an individual holds considerable value relative to the herd.

Another difference lies in the rapid reproduction rate of plants versus animals. With alpacas it takes approximately three or four years to produce another generation. In plants there is a new generation every year, and every year the number of individuals can multiply a thousand times.

The production of seed is in the hands of a few specialists who do nothing but multiply and select plants. The breeding of horses and cows, however, is in the hands of hundreds of thousands of people. Most breeders are farmers or ranchers and the use of their animals comes first and breeding comes second. As a consequence, trained geneticists have devoted their lives to the genetic aspect of plant breeding. The decentralization in animal breeding, however, has kept most breeders from being very strongly influenced by geneticists. The tradition of centuries past, rather than science, dictates most animal breeding practices.

Another animal breeding problem arises because, in most instances, breeders have not clearly thought out their goals. Many breeders of economically-important animals, such as dairy cattle, set up a standard of excellence that includes a number of wholly irrelevant fancy points -- such as length of the vertebrae, a special backline, color, shape of the horns, etc. Even when their aim is milk production, they lose sight of real economic value in favor of characteristics which don't contribute to value. Alpaca breeders should try to avoid this pitfall; it may be time to begin considering a breed standard which would hopefully be based on economically important characteristics.

In plant breeding the greatest successes have been attained by substituting a system of selection, in which breeding value or genotype is the real test of superiority, as opposed to a system where individual merit or phenotype is foremost. This approach allows the environment and other factors unrelated to genetic merit to be disregarded when making selection decisions.

When breeding animals, the only certain way to judge the merit of an individual as a breeder is to judge the quality of its descendants. Geneticists have worked hard, and often unsuccessfully, to make animal breeders accept this simple truth. How many breeders want to defer the judging of an alpaca stud until they can actually assess the quality of his get? Breeders want simpler, quicker, more market friendly methods of selection. Stud males are generally chosen at an early age. The breeder often chooses to keep those that best conform to his ideal of beauty without understanding which males are superior genetically.

Alpaca breeders could profit by the lessons learned from plant-breeding practice, which is genetically tried and true. With proper selection and the use of effective breeding systems the genetic merit and overall quality of alpaca can become highly predictable.

The next article in this series will deal with the myths of selection. We will cover topics such as variability, phenotypic selection, line breeding, inbreeding, warning blood, lethal genes, and yes, "pure blood." With any luck, you will not find it boring!