Inbreeding - or Line Breeding?

By Peter Woodyer

When first we started to import alpacas from South America, we did not know, with any real accuracy, the pedigrees of the animals that we had bought. In a few cases the immediate forebears of our chosen animals were known, but accurate relationships extending beyond more than one, or at the most two generations were only conjecture. What we imported were described somewhat flamboyantly, as genetic black boxes.

It is from these unknown genetic quantities that we have developed the animals that we have today. We are beginning to discover, and in some cases partially understand, the genetic make up of the occasional animal.

Breeding is all about improvement of the species so that in breeding alpacas, we are attempting to make our animals more productive than their forebears. Because our animals are used for the production of high quality fibre, we consider certain characteristics of the fleece to constitute 'better' or more desirable. But in the same way as a human dress designer has his/her creations modelled by human individuals of a certain body type, we also try to have our fleeces carried by a certain alpaca body type. Our goal is to show off not only the fleece to its best advantage, but also ensure the animal will live and enjoy a normal, sound and healthy life. In consequence, at our shows, we have our animals judged for those criteria that we consider to be important for fleece quality, as well as for sound conformation.

The rudimentary concept of breeding the animals that we imported was to breed 'like to like' to maintain and improve the qualities of fleece and soundness. Female animals that exhibited a lesser quality of fleece or soundness were, in general, not exempted from breeding programmes. The cost of importation had been so high that every such animal was considered valuable enough that it should be 'bred up' or 'improved'. This was done by mating to a male that exhibited particularly strongly the features in which the poorer female was considered to be lacking.

On the negative side, hereditary abnormalities such as patellar luxation and subluxation, coarse fibre, poor bite, crptorchidism and others were also seen and noted. Alpacas that either had these perceived faults or produced cria with these faults were generally omitted from our breeding programmes. Thus we have approached the elimination of most easily recognisable faults by the elimination of the dominant genes with which they are associated.

In very general terms, 'Phenotype' is a word that describes what we can see in an animal, its physical attributes and appearance. 'Genotype' refers to the genetic makeup of an animal, specifically, the presence of dominant genes which control the features represented in the phenotype in quantity as well as type. Quite obviously we cannot easily see the genetic make-up. We have to resort to other means to identify the genes involved, and to understand exactly what the animal in question is capable of producing when bred.

If all characteristics in which we are interested were controlled by only one or two genes that could be either dominant or recessive, breeding would be greatly simplified. But there would be a very limited number of variations possible for any one characteristic (ignoring the modifying environmental factors such as management that also play a part). But, in fact, each characteristic may be subject to control by many genes. Each gene may be 'turned on', said to be dominant or may be 'turned off' or recessive so that the greater the number of dominant genes present for any given characteristic, the greater the effect exhibited in the phenotype.

Progeny inherit genes from both parents. Therefore, if both the parents have a greater number of dominant genes than recessive ones for any one characteristic, a cria stands a greater chance of inheriting a larger number of dominant genes for that characteristic than is present in either of individual parents. Conversely, if both parents have a predominance of recessive genes for any one characteristic, then the progeny stands a greater chance of having fewer dominant (ie. more recessive) genes for that characteristic than either parent.

This is the rationale behind the breeding of 'like to like' to produce characteristics in the cria more desirable than in either parent. In short, dominant genes are concentrated for required characteristics and recessive genes are concentrated for the unwanted ones.

To return to the breeding history of alpacas in North America, it can be seen from the foregoing that by the (unselfish and potentially costly) refusal to breed alpacas displaying phenotypically recognised defects, dominant genes controlling those defects have been severely reduced in number in the overall alpaca population. Equally, however, it can be envisioned that the complete elimination of these genes is probably unlikely, given the large number of genes that control any one characteristic.

Now the breeding of genetic 'black boxes' one to another is obviously risky. Today, however, we have, through the medium of our registries, pedigree records which can give us a clue as to which animals are best bred to one another to achieve a better alpaca. And, with a little bit of research and the use of some statistical formulae, we can begin to predict the effect that one individual animal may have in improving a desirable characteristic by passing on dominant genes to his or her immediate and subsequent progeny. Thus is introduced the subjects of inbreeding and line breeding.

Two of the statistical formulae that have proven to be of the most use in the prediction of heritable traits are Galton's Law and the calculations for an inbreeding coefficient, known as Wright's Law. Both are based on the assumption that the two parents together contribute half of the genetic material in their progeny. Galton thus indicates that each parent contributes one-quarter of the genetic makeup of the progeny, each grandparent one sixteenth, each great-grandparent one sixty-fourth and so on. By adding up the various fractions, one may estimate by how much a common ancestor may affect the genotype of a proposed cria.

The second calculation, also based on the assumption that each parent passes on only half of their genes, arrives at an

estimation of the effect that a single animal might have if it occurs at more than one place in the pedigree by calculating:
$0.5^{(n + n' + 1)} \times (1 + Fa) =$ The inbreeding coefficient for a given breeding where

n = the number of generations between the common forebear and the sire

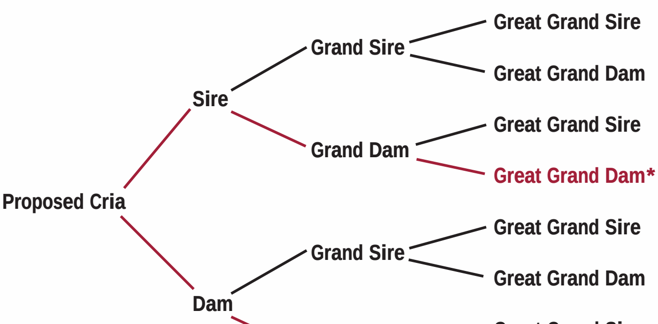
n' = the number of generations between the common forebear and the dam

+ 1 = added to n + n' representing the single generation from parents to cria

Fa = the inbreeding coefficient of the common forebear

0.5 = the fraction of its genetic material passed on by one parent

The resulting figure is referred to as the inbreeding coefficient of the (proposed) cria. Multiplying that figure by 100 converts it to the percentage likelihood of that cria having in its genetic makeup (dominant) genes for a specific characteristic from the common forebear. Consider if you will the following example.



*Where Great Grand Dam and Grand Dam are the same forebear.

So applying the formula, Wrights Law:
$0.5^{(2 + 1 + 1)} \times (1 + Fa) = 0.5^{4} \times (1 + 0) = 0.0625 =$ inbreeding coefficient... or, x 100 = 6.025% Meaning that the proposed cria has a 6.025% chance of carrying genes for a certain characteristic from that forebear.

If a second forebear appears more than once in the pedigree then the formula is also calculated for him/her. The two resulting coefficients are added together to reach the total percentage likelihood of the cria carrying genes for the particular characteristic under consideration.

Line breeding or inbreeding can be as radical as you want to make them. The closer you breed, the more you stand to gain. Conversely though, should there be a previously unrecognised dominant gene controlling a fault somewhere in the genetic makeup, you run the risk of exposing it and losing not only the cria but also a year of the dam's limited breeding life. Is it worth the risk? Apply the formulae and then you decide whether the chances are worth taking, comparing how much you are prepared to lose against however much you may gain.

Oh yes - The difference between linebreeding and inbreeding is a differentiation that we are often called upon to explain. Really it is just a matter of where you draw the line, how much risk do you find acceptable? Cynics that I have met have defined it thus: If it works its called linebreeding. If it does not, then it's inbreeding.

CQ

About the Author

Peter grew up in South West England and graduated from the University of London, Royal Veterinary College in 1964. In 1965 he immigrated to Canada and a large animal practice, devolving to small animal practice, with a special interest in orthopedic surgery. He retired from veterinary practice in 1995 but in 1998 he and his wife Anne developed an interest in alpacas. After researching them and the industry for two and a half years, they purchased their first animals in 2000. They run their modest herd of over 40 animals, including boarders, at their farm in the famous Annapolis Valley of Nova Scotia - an hour or so from Halifax and the international airport.