Selection of Alpacas for Breeding

Chris Tuckwell

At present, the U.S. and Australian alpaca industries are based on small populations that are widely dispersed throughout each country. Most alpacas are maintained in herds of fewer than fifty head, and there is a large within-herd variability in quantity, quality, and color of fiber produced. There is obviously scope for genetic improvement in the production characteristics of the U.S. and Australian alpaca through application of breeding methods based on sound genetic principles.

When commercial profitability is considered, selecting for high fleece weight, fiber diameter, yield, and perhaps body weight seems desirable. This can be achieved only through the use of objective measurement, recording and analysis of animal performance (commercially important traits), and application of this information to select genetically superior animals for use in well-designed genetic improvement programs.

This discussion will consider breeding programs where selection is based on characteristics that are economically important in commercial production and where the breeding program is designed to lead to genetic improvement of commercial production.

METHODS OF SELECTION

Selection refers to the method of choosing the parents of future generations. The two main techniques for selecting individuals are family selection and mass selection. In family selection, the breeder considers the relatives of the individuals under selection. Examples of family selection are pedigree selection and progeny test. Mass selection is the simplest form of selection of individuals and involves selecting the animal on the basis of its own performance relative to the performance of other animals that are the same sex and age and affected by a similar environment.

DESIGN OF BREEDING PROGRAMS

The first stop in designing a breeding program is to define breeding objectives--that is, the economically important production characteristics involved in alpaca breeding for fiber production. Breeding objectives need to be continually reviewed.

In addition to breeding objectives, the development of a breeding program requires information on genetic parameters (heritabilities, genetic correlations), phenotypic parameters (means, variances, repeatabilities, phenotypic correlations), and environmental effects (age of dam, type of birth and rearing).

PRODUCTION CHARACTERISTICS OF IMPORTANCE

Alpacas primarily produce fiber (wool); meat and skins are likely to be important only in the long-term future. Breeders should be concerned with the alpacas' ability to produce fiber in sufficient quantity and of an acceptable quality in a given environment at minimum cost. Therefore, many production characteristics will be of interest, but it must be remembered that the fewer the characteristics in a selection program, the more rapid the progress that may be made in each.

For alpaca fiber production, the economically important production characteristics are the following:

Reproduction rate (aim to maximize annual weaning rate, ideally one cria per hembra per year)

Body size (only as large as is necessary to maximize fleece production economically)

Greasy fleece weight (as high as possible)

Fiber diameter (fiber of a lower diameter is likely to command a higher price per pound in the long term)

Fleeces of single uniform color (reduces skirting and clip preparation needs; in addition, large volumes of single-color fiber are more attractive to processors)

Before deciding which characteristics should or should not be subjected to selection, the breeder must determine whether the characteristic can be objectively measured, whether it is heritable, and what phenotypic and genetic correlations exist between the characteristics.

MEASUREMENT OF CHARACTERISTICS

The objective measurement of those production characteristics mentioned above provides information that can be used in direct selection for productivity. All of these characteristics can be measured; some are relatively simple and cheap to measure (examples: body weight and greasy fleece weight); others are time consuming and expensive (such as fiber diameter) to measure.

Greasy fleece weight can be easily measured with a spring balance and weighing pan, but to measure fiber diameter and clean scoured yield requires some special equipment, such as a projection microscope or air-flow testers.

It is important to remember that a test giving a mean fiber diameter of, say, 30 microns does not mean that the animal will always produce 30-
micron fiber. Older animals produce coarser fiber than younger animals, and nutrition influences fiber diameter.

The phenotype (appearance or performance) of each animal is the result of the genetic makeup of the animal's genotype and the environment in which it is run (phenotype = genotype + environment). Therefore, valid comparisons can be made only between animals of the same type (sex, age), run under the same conditions (same property), and at the same time (that is, same shearing dates).

HERITABILITY OF CHARACTERISTICS

Heritability refers to the degree to which an animal of a superior phenotype (performance) will transmit to its offspring that advantage. For example, if the heritability of body weight at tuis age is 50 percent and each parent has a selection differential of 22 pounds (10 kg), then on average they would transmit 50 percent (11 pounds, or 5 kg) of their advantage to their offspring. The remainder of their advantage may not have resulted from their genotype but rather from having been reared in a favorable environment. This part of their advantage cannot be handed on to the next generation. It must be remembered that the machos and hembra contribute equally to the genotype of their offspring, so therefore, when estimating the improvement in the offspring, gains expected from each parent must be averaged (selection differential of the sire **x** heritability **x** 1/2 + selection differential of the dam **x** heritability **x** 1/2). In the example above, the total gain expected in the next generation would be 22 **x** 50/100 **x** 1/2 + 22 **x** 50/100 **x** 1/2, or 11 pounds in body weight at tuis age.

There are no Australian estimates of heritability for production characteristics of alpacas, and therefore we have to rely on overseas information, which itself is limited and of a preliminary nature. However, the heritability values shown in Table 1 have been estimated by research workers in Peru. Characteristics can be classified as having high (greater than 0.30), medium (0.15 to 0.30), and low (less than 0.15) heritability).

Table 1. Alpaca Heritability Estimates

(Peruvian research data)

Characteristics	Age	Heritability Estimates
Body weight	Birth	0.34; 0.53
	Weaning	0.39
	First shearing	0.55; 0.69
Fleece weight	First shearing	0.21; 0.22; 0.35
Survival to weaning	0.10	

The heritability of a characteristic indicates whether selection for that characteristic will be effective. The fleece characteristics outlined above have moderate-to-high heritability estimates, suggesting that gains in these characteristics can be made relatively quickly.

ASSOCIATION BETWEEN CHARACTERISTICS

A phenotypic correlation estimates the degree of association between two characteristics in the same animal. For example, if data suggest that significant and positive phenotypic correlations exist between greasy fleece weight, clean fleece weight, fiber diameter, and staple length, and if a selected animal has a fleece weight higher than the average of the herd, then the selected animal is one with higher than average fiber diameter and staple length. A high negative correlation has the obvious reverse implications. The phenotypic correlations shown in Table 2 have been estimated by researchers in Peru.

Table 2. Phenotypic Correlation Estimates (Peruvian research data)

Characteristics	Age	Machos	Hembras
Body Weight			
with fleece weight	Juveniles (< 4 yrs)	0.40	0.58
with fleece weight	Adults (> 4 yrs)	0.45	0.32
with survival		0.26	0.26
Fleece Weight			
with staple length	Juveniles (< 4 yrs)	0.30	

with staple length	Adults (> 4 years)	0.32	0.20
Fiber Diameter			
with fiber length	Adults (3 years)		0.27
with yield	Adults (3 years)		0.42
with % grease	Adults (3 years)		0.28
Fiber Length			
with yield	Adults (3 years)		0.40
with % grease	Adults (3 years)		0.18

A genetic correlation estimates the extent to which selection for one characteristic in the parent will cause a change in another characteristic in the offspring. As an example, if a significant positive genetic correlation exists between greasy fleece weight and fiber diameter, there is an implication that as parents are selected for greasy fleece weight, fiber diameter may increase in their offspring. No genetic correlations have yet been measured on Australian alpacas. It is worthwhile to note that the genetic correlation between greasy fleece weight and fiber diameter in Australian merinos is not strong (+0.13 to 0.19), and that it is possible to hold fiber diameter relatively constant while selecting for fleece weight.

THE IMPORTANCE OF SIRE (MACHOS) SELECTION

Increases in commercial profitability from genetic improvement programs can be substantial over time, and selecting the best sire replacements for the sire breeding flock provides the greatest opportunity for genetic improvement. Determining from which stud to buy sires is the machos buyer's most important decision. Genetic differences between studs can be substantial, while only minor genetic differences can be made to a commercial flock by buying different grades of sire from a particular stud. For long-term genetic gain, the machos buyer's flock is entirely dependent on improvements made in the sire breeding flock.

INDUSTRY BREEDING STRUCTURES

In the common, traditional flock/herd breeding structures used in Australia's animal industries, parent studs are closed to outside introductions, whereas daughter and general studs buy sires mostly from parent studs. Sires and some females move down from parent studs to daughter and general studs, but never upwards. Culling of females in commercial flocks has no impact on the breeding program in studs. Only selection of sires and females in the stud's sire breeding flock can influence the stud's genetic improvement program. The commercial sire buyer's flock is entirely dependent on improvements made in the sire breeding flock source for long-term genetic gain.

An alternative breeding structure used in some industries is a nucleus breeding scheme. In contrast to a more traditional structure, females can be taken to higher levels from lower down. Although selection of females in the top and lower tiers influences the program at the top tier, the selection of sires remains the main way of making genetic improvement.

IMPORTANT CONSEQUENCES OF INDUSTRY BREEDING STRUCTURES

Commercial flocks "lag" behind stud flocks in genetic merit, on average, by two alpaca generations (five to seven years). Table 3 shows the length of time it takes, from the decision on which sire replacement is selected in general studs to sire progeny that are ready for sale to commercial flock owners, about two years. For an assessment of offspring, replacement sires likely need to be at least three years of age. Pregnancies will result in tuis available for shearing two years after conception.

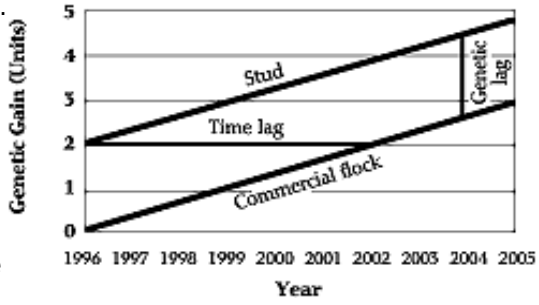
Table 3. Breeding Timetable

Sires selected "today" will produce progeny for sale in two years.

Event	Time
Final sire selection	January 1996
Joining	March 1996
Cria drop	February 1996
Tuis measurement	January 1998
Sale of tuis	January 1998

Figure 1. Genetic lag between stud and commercial flock.

Long-term genetic gain is the same in stud and commercial flock.



With regular purchase of flock sires from the same stud, the commercial flock makes genetic gains at the same rate as the stud, although it lags behind in terms of absolute genetic merit. Furthermore, the genetic progression (direction and speed) of the commercial flock/herd is the same as that of the stud, regardless of the individual sires used from the stud (see Figure 1).

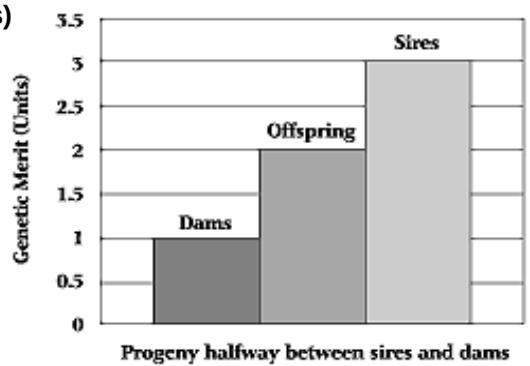
GENETIC MERIT

In commercial flocks or herds, new sires that are genetically superior to those purchased previously are introduced each year. This means that the next offspring obtained are genetically halfway between the new sires purchased and the females on the property and so are a little better than the previous year's offspring.

Figure 2. Genetic merit of progeny

(by using a new group of herd sires)

Imagine that commercial-flock females are all mated to one group of new flock sires. The genetic merit of the offspring will be halfway between that of the sires and the females, as shown in Figure 2. Unless the



offspring are backcrossed to the same sires repeatedly, the commercial flock will never get to a situation where it gets all the genes of those sires, and it will always "lag behind" in genetic merit.

SIRE SELECTION

Selection of sires is paramount, especially the sires that are to be used as replacement sires in the herd or flock. This is the engine room where genetic gains are made. Determining from which stud to buy sires is the sire buyer's most important decision. Evidence from many trials and experiments has shown that genetic differences between studs can be quite large. Only relatively minor differences can be made by buying different grades of sires from a particular stud.

Currently the alpaca industry needs to retain all sound females in the breeding herd. In a stable industry situation, most female tuis will be needed to replace the flock (usually in the range of one-half to two-thirds). Far fewer sire tuis are required as sire replacements. This means that much more intense selection of sires can (must) be practiced (as low as 2 to 5 percent of the sire drop selected), and because of the small numbers required for replacements, they can be used for fewer years than females.

IMPORTANCE OF STUD SELECTION

It is very difficult to use a visual appraisal to compare the genetic merit of animals from different environments (soil, water, feeding, management, genetics, climate, and so forth), unless special precautions regarding the mating and management of animals in different herds are taken genetic links between animals exist and are known (within the current alpaca industry structure this information is often not available) the information on genetic links is assessed by people who have understanding and competence in genetic assessment of relatives

The most accurate assessment of the genetic merit of individual animals for any one or group of characteristics or traits is done by objectively measuring those characteristics presented by individuals and comparing data for each with the mean value of the same characteristics in its contemporaries. If genetic relationships do not exist or are not known, it is extremely important that the animals compared are the same age, the same sex, and at the same production status, and that they have been managed in the same environment for a reasonable period (twelve months).

It is also true that as the size of the group of animals measured increases and the number of times the measurements are repeated is increased, the confidence in the prediction of relative genetic merit increases. The reverse is also true.

It is a false estimation of genetic merit to look at individual animals that have been extremely well fed, managed, and prepared for sale and assume that they are "genetically superior" or "stud-quality" animals. This false estimation of genetic merit includes both visual assessment data and objectively measured data of an animal considered in isolation.

The major influence on an individual animal's visual appearance and objective measurement data (fiber diameter, fleece weight, body weight, and so forth) is the environment. On average, genetics account for 20 to 40 percent of what can be seen and measured. This means:

The same animal managed in two different environments (soil, water, feeding, manage-ment, genetics, climate, and so on) may look and measure differently.

Animals in different environments cannot be reasonably compared for genetic merit. An animal from a "poor" environment that looks and measures worse than an animal in a "good" environment may have superior genetic merit that can be displayed only when the two animals are managed in the same environment.

Animals of different age, sex, health status, and production status cannot be meaningfully compared on the same property or, especially, on different properties.

Detailed knowledge of an animal's pedigree, the heritability of characteristics used in selection, and the performance data of related animals can be used to accurately predict the genetic merit of bloodlines and, to some extent, individuals.

Without this information, the most practical way to assess relative genetic merit of bloodlines is to choose several animals of the same age, health, sex, and production status from each of the bloodlines to be compared and manage them together in the same environment for a reasonable period (at least twelve months). These groups of animals can then be compared by careful interpretation of objectively measured characteristics. Confidence in comparison between the groups will increase as more animals from each bloodline are used in each group and the more often the process is repeated (new groups from each bloodline in successive years).

DETERMINATION OF A SOURCE OF GENETICS (STUD)

My advice to purchasers of alpacas as replacement sires, or dams, is to consider carefully the source of genetic material well in advance of purchase. After a source has been decided, it is important to remain with that source until a "better" source can be determined.

First breath

If a breeder uses sires from a different genetic source each year, the likely outcome is that little or no genetic gain will be made over time, and, in fact, there is a chance that genetic merit could be lost. The reason, as described above, is nonvalid comparison of animals between environments.

GUIDELINES FOR CHOOSING STUDS

1. Before attempting to identify a source of replacement sires or dams for improvement of a herd, first determine your own breeding objectives--in other words, the goals of the breeding program, the type of animal considered ideal, and how the current stock compares with the ideal.

Breeding objectives may relate to color, body weight, fleece weight, fiber diameter, degree of kemp within the fleece, and cria birth weight. Any number of characteristics can be bred for, but remember that some are not highly heritable. Furthermore, as the number of characteristics used as a basis for selecting individual animals increases, the slower will be the rate of change for each.

My recommendation is to look at and select animals on the basis of traits of commercial economic importance that can be objectively measured.

2. Visit potential sources of new genetic material and discuss breeding objectives of the property with owners or managers. Ask how, at what age, and how frequently they objectively measure and record data used for animal selection.

3. When you have identified genetic source properties with breeding objectives similar to your own, ask to see data of available animals before making your selection.

For example, if I were interested in male tuis, I would ask for data like fiber diameter, fleece weight, body weight, and fleece yield on all the male tuis and their averages. Remember that comparing data for animals of different ages is difficult.

Animals can then be culled from selection on the basis of physical faults first and then on the basis of your breeding objectives. To derive the best estimate of relative genetic merit, compare animals with one another and, more importantly, with the group average for a particular trait.

Remember: The smaller the population you are selecting from, the less confidence you will have in estimating genetic merit. If a source of genetic material cannot or will not supply the data required to aid in your selection, it may be worthwhile to look at an alternate genetic source.

4. As explained above, once a source of genetic material has been identified, stay with that source for a reasonable period (five years) before considering a change based on rates of genetic improvement.

For most production traits, 20 to 40 percent of the observed superiority of an individual with respect to the mean of its contemporaries is of genetic origin; the remainder is of environmental origin.

USE OF THE ALPACA REGISTRY IN THE UNITED STATES

As discussed earlier, an animal's appearance (phenotype) can change as aspects of its environment (management, nutrition, climate) change. However, the animal's genetic merit remains constant from birth.

Careful use of the U.S. alpaca registry offers breeders the ability to identify family and individual animal pedigrees. Correctly interpreted and applied, this information will allow an assessment of an animal's genetic merit from the performance of its offspring and of its sire and dam line. It is still important to determine the merit of an animal from objectively measured criteria meaningfully compared with consideration of environmental differences. Nevertheless, **a detailed knowledge of an animal's pedigree, the heritability of characteristics used for selection, and the performance data of related animals can be used to accurately predict the genetic merit of bloodlines and, to some extent, individuals.**

RECOMMENDATIONS FOR SELECTION

1. Initially all animals should be visually assessed for structural soundness (feet, jaws, teeth, udder, and so forth), and those found to be inferior should be culled.

2. With hembras, ideal selection can be on the basis of a visual assessment for a single, uniform coat color in combination with the objective measurement of body weight and greasy fleece weight. The greasy fleece weight at the animal's prejoining shearing is the most appropriate to use for selection purposes. Selection of hembras before their first joining ensures that their production has not been influenced by the stresses of pregnancy and lactation. Fleece weight tends to be highly repeatable, so the one measurement is sufficient to rank hembras on fleece weight.

In reality, at present all females in the U.S. and Australian alpaca herds that are structurally sound should be retained to maximize growth of the total population.

3. The selection of machos should be on the basis of a visual assessment for single-colored fibers in combination with the objective measurement of the desired production characteristics. Because machos have a greater influence than hembras on the genetics of future generations, the following objective measurements might be considered as an ideal basis for selection:

single, uniform coat color

body weight

greasy fleece weight, clean scoured yield, staple length

fiber diameter

Both body weight and greasy fleece weight of machos should be recorded at their first shearings before joining, whereas the other characteristics need only be recorded at the shearing immediately before their selection for mating.

4. Obviously, high levels of hembra fertility and cria survival are desirable. Therefore, the most useful reproduction-related measure to consider is the percentage of cria weaned to hembras mated. The main factors affecting reproduction rate are age of hembra and body weight at first mating. The body weight of hembras at their first mating has a marked effect on reproduction levels. Producers should aim to have hembras weighing at least 88 pounds (40 kg) at their first mating and at least twelve months of age.

5. The maintenance of accurate records of all breeding animals is important if genetic pro-gress is to be made in the breeding program.

CONCLUSION

The production characteristics of importance in alpaca selection are likely to include reproduction rate, body size, fleece weight, and fleece quality. Selection for these characteristics, based on a sound knowledge of genetic and phenotypic parameters, will result in increased productivity and assist in the long-term future of the alpaca industry. Selection procedures should be based on the visual assessment of animals in combination with the objective measurement of the important production characteristics.

A prediction of the genetic merit of an individual is an attempt to predict the ability of the animal to pass desired characteristics on to its progeny. Environmental effects significantly influence an animal's phenotype and can detrimentally or advantageously mask genetic potential.

The breeder must carefully and objectively make assessments of the relative genetic merit of different animals to make genetic improvements toward his or her breeding goals.

About the Author

Chris Tuckwell is currently the managing director of Rural Industry Developments Pty, Ltd. (RID), which provides assistance with industry and enterprise development. From 1978 to 1996 he worked for the South Australian Department of Primary Industries (PISA), where, as Senior Officer for Developing Animal Industries, he served as an advisor on industry policy, production, processing, research, and marketing to government and industry partners.

Tuckwell has worked with the Australian alpaca industry since 1990. In 1993 he traveled to Peru to research and report on the Peruvian alpaca industry on behalf of the Australian government and the Australian Alpaca Association. He is the principal investigator of a national three-year project titled "Productivity and Marketing Improvement of the Alpaca Fibre Industry in Australia," funded by the Rural Industries Research and Development Corporation and due for completion in 1997. Tuckwell also works with other new animal industries. His second book on ostrich farming is in press.

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