Prioritising traits for Associations' herd improvement programs

Establishing breeding priorities for alpaca association's herd improvement programs poses a responsibility on the respective associations, that such breeding priorities need to be well researched, considered and ultimately appropriate. Misguided breeding priorities poses a real risk of regressing the collective and individual genetic make-up of herds to the point that correcting the regression could well take many generations, only to regain the lost ground.

The following information is offered by Art of Fibre as a suggested set of priorities for breeding programs aimed at fleece quality, combined with rationale for making such suggestions.

1 The Framework. The reasons for owning alpacas are as varied as the range of fleece colours they produce. Some own alpacas to purely keep as pets, or for nothing more than the pleasure of enjoying animals on their lifestyle hobby farm. For others, owning and breeding alpacas takes on the form of a strident pursuit of commercial outcomes based entirely on a net return from alpaca and fleece sales and related activities such as 'alpaca walks'. Then there are breeders who have the overwhelming passion to succeed in the showring with their alpacas. None-the-less, almost all owners of alpacas fall within the range of these three key pursuits.

Drawn from the writer's 26 years' experience as a service provider to the global alpaca community, is the observation that irrespective of the reason for owning their alpacas, there exists the fundamental understanding that the alpaca is a fleece producing animal, and consequently, there is the concomitant urge to have their alpacas produce as high a quality a fleece as possible, even though there may be absolutely no expectation of a financial reward for doing so. The sense of pride and achievement from private contentment, a room full of show ribbons or a healthy bank account come back to the one purpose – to breed alpacas that produce quality fleeces.

So how then do associations develop breeding priorities upon which to base their herd improvement programs so as to reflect this combined pursuit of quality fleeces.

It should be stressed that the following is geared solely towards traits that reflect quality fleeces and intentionally ignores other important traits such as those that relate to the sound physiology of the alpaca – to do so would require a far more voluminous paper that would risk deviating from the paper's topic. In saying that, a sound physiology is a pre-condition for producing quality fleeces.

2 What are 'quality' alpaca fleeces At this stage, it will be prudent to reconcile the differences between what matters to end users of alpaca fleeces, what matters in the show ring and what matters with pursing genetic improvement towards quality fleeces.

For the end users of alpaca fleeces, it is the attributes of any fleece as it appears before them that counts. For instance, the respective fleece's average and range in fibre diameter, the degree of contamination, the length of the fibres etc dictate how the fleece

will process or spin or weave into a final product. The immediately observable attributes of the fleece/s in these cases are what counts.

In the showring, the judge will consider the whole package before them to evaluate criteria that fall into three main areas. They will look at the phenotype traits of the alpaca and its fleece. In other words, recognising what traits are immediately observable after the myriad of genetic and environmental influences have made their mark on the respective alpaca and its fleece. Then there is the consideration of aspects that reflect management of the alpaca, such as its body condition and grooming.

Finally, and perhaps to a lesser degree, they will look at indicators of genetic potential, or in other words, what traits they observe before them that indicate what traits will be apparent with subsequent progeny of the alpaca. In this regard, emphasis may arguably be towards identifying traits considered undesirable rather than preferred traits.

This point obviously raises the provocative matter of whether show ribbons should influence the selection of key breeding alpacas, however, this issue is not the subject of this paper.

For programs that aim to pursue genetic improvement such as with associations' herd improvement programs, there needs to be a focus on those traits that indicate genetic superiority towards established breeding objectives. In some cases, these programs will include progeny data to further strengthen the ability to predict breeding outcomes.

These programs rely on objective measurements. In other words, programs aimed at genetic improvement are geared towards indicators rather than focus on what is immediately observable for the simple reason that what is immediately observable has a significant chance of not being passed on to progeny – 'what you see, is not what you get' . In some cases, however, judge's subjective appraisals may be used to support objective indicators.

To summarise then, end users of fleeces focus on what's in front of them through subjective appraisal, judges have a shared focus on what's in front of them and to a lesser degree, the apparent genetic potential through subjective appraisal (although in some cases, may be aided by objective fleece tests), and breeding programs focus on an alpaca's genetic potential primarily through objective indicators.

Following from the statements made earlier in this paper, it will be taken that the traits to be pursued with the aim of breeding towards 'quality fleece' are those traits that dictate a genetic pathway towards improving the intrinsic value or worth of the fleece for end use. The obvious question at this point, is what determines the worth or value of an alpaca fleece.

The best way to determine what constitutes 'relative value or worth towards end-use' is to ask those who buy, process, spin, manufacture, sell etc alpaca fibre and/or end-products, as to what traits matter to them the most.

About 12 years ago, I lead a team who carried out a thorough market appraisal that looked at this question by surveying a range of professional people mentioned above, over a twelve-month period. The market appraisal was conducted by either lengthy telephone interviews or mill inspections and 'face to face' discussions. The responses were remarkably similar, which made things very convenient. A list of some of the key responses follows:

Shamarra Alpaca, New Zealand.
Uniformity of fibre diameter was crucial for processing performance and handle of end product.

East Anglia Alpaca Mill, UK.
For top-end product, batching must be correct and SD needs to be low

Adagio Alpaca Mills, Australia.
Uniformity of fibre diameter is critical for processing the fibre for superior outcomes

Great Ocean Road Woollen Mill, Australia
Variation in micron, SD, colour and length leads to inferior product so fleeces need to be skirted/classed correctly

Loro Piana, Ermenigildo Zegna, Vitale Barberis and Reda mills, Italy.
At that time, they were all reluctant to mill alpaca fibre due to incidence of coarse fibres – dehairing was not an option due to cost and time delays. Would require consistent and uniform, commercial consignments. It is noteworthy that alpaca fibre was eventually sold to some of these mills once the problem of coarse fibres was addressed.

Fibre Naturally, Australia
Evenness of length and micron with no heavily medullated fibres produce best 'next to skin' wear

Two Rivers Mill, UK
Consignments need to be well skirted and graded with uniformity of key fibre traits.

In addition to the above is the well-established fact that average fibre diameter primarily determines the price paid per kilo for the fibre while weight determines the eventual total price paid for the respective fleece/s.

The reason why fibre diameter has such a huge influence on the price paid for fibre, and in fact has much influence over the relative worth of any final product from fibre, is the fact that buying behaviour studies have continually found that comfort or relative softness of the product is a major influence as to the likelihood a person will buy, wear or use a product made from fibre. A typical study revealing this fact can be found with the study by Chaure (2024). To follow-on from this, is the subsequential fact that fibre diameter is the main trait that influences comfort or softness of the final product as finer diameter fibres are more likely to be more flexible, and hence more unlikely to irritate the skin to the point that very fine fibres feel comfortable on the skin.

A summary of the crucial fibre traits that end-users of alpaca fleece prefer, might be presented as follows:

1. Low average fibre diameter of fibres
2. Uniformity of fibre diameter in terms of variation between fibres within fibre bundles or staples and variation in fibre diameter over the fleece
3. Reduction of coarse, medullated fibres within fleeces
4. Skirted fleece weight and/or fibre density should be maximised without detriment to the welfare of alpacas

At this point, it is worth noting that crimp definition or curvature did not get a mention during this market appraisal, nor is it found notable in papers that look at the processing of alpaca fleeces (Wang et al; and Frank, 2005). This might be contrary to the desire by some breeders and judges that crimp definition is a desirable trait.

It so happens, however, that crimp style, character or fibre alignment are all heavily influenced by uniformity in fibre diameter. The reason for this is that uniformity in fibre diameter leads to uniformity in fibre development and growth, thereby resulting in closer alignment of crimp definition and hence, more favourable character or style of the fleece. Therefore, a well aligned crimp structure or character of a fleece is an indicator of the important trait of fibre uniformity.

With regards to staple length, this trait has not been included as the market analysis found no issues with required fibre length other than the need for greater uniformity which is a management (skirting and grading issue). Further, as Ponzoni (1999) found, staple length generally has a moderate to low level of heritability. It is suggested that to ensure staple length levels are adequate, monitoring skirted fleece weight might effectively deal with this trait.

These fibre traits that are critical to the relative value or worth of the fleeces are referred to as ‘Key Production Traits’. I should stress that while we use the word ‘Production’, we are looking at traits of fleeces irrespective of the fleece’s intended end-use, whether it be commercial production or home spinning for personal use.

It is the consideration of what constitutes ‘key production traits’ that forms half of the equation as to what traits should be prioritised with a set of breeding objectives. The other half is what we refer to as ‘Trait Heritability’. Trait heritability is a measurement of the likelihood a trait will be passed to progeny (through the passage of relevant genes).

While a particular trait may be considered a key production trait, if that trait has low heritability, that is, low likelihood that trait will be passed on to progeny, then using this trait as a breeding objective is merely based on good luck rather than strategy.

Breeding priorities therefore need to reflect key production traits that have moderate to high heritability.

There are many research papers against which to consider relative heritability, however, we will use the work by Ponzoni et al (1999). Traits with heritability scores of more than 60% are considered to have high heritability, and therefore highly suitable for a breeding objective.

The Ponzoni paper reports the trait of fleece weight as 83%, mean fibre diameter as 67% and fibre diameter variation as being 90%. It is noted these heritability scores are higher than reported in other papers such as Cruz et al, (2025) however, the relatively high heritability of these traits is generally accepted.

With regard to the objective of reducing coarse fibres, this would be achieved by reducing fibre diameter variability.

In other words, mother nature has delivered the matter of balancing ‘key production traits’ with ‘trait heritability’ on a silver platter, as the most important production traits also happen to be highly heritable.

3 What measurements to use

There is an old saying, that to monitor anything, it needs to be measured. To monitor the above traits in a breeding program therefore, we can use the following measurement statistics.

Mean or average fibre diameter (measured in microns) is regularly reported in all fibre test reports. It needs to be kept in mind, however, that fibre diameter is very much influenced by availability and quality of nutrition in that fibre diameter increases as follicle nutritional intake increases.

Variability of fibre diameter is arguably the most important breeding trait for fleece quality as the predictability of fibre diameter in a breeding program is heavily influenced by fibre diameter variability. That is, low variability increases the predictability of average diameter with progeny, in addition to also being a key production trait in itself. The measurement of variability we use is Standard Deviation of Fibre Diameter, or **SD** for short. There is one slight problem with using SD in that fibre testing technology measures fibre diameter variability both between fibres and along fibres, and therefore incorporates environmental influences as well as genetic influences.

More recent fibre testing technology now allows us to measure '**SD Across'** which isolates the genetic influences with fibre diameter variability from the variation caused by environmental factors.

To monitor the incidence of coarse fibres, the statistic referred to as 'Coarse Edge Micron' or **CEM** identifies how many microns from the average do we start to find the coarsest 5% of fibres in a sample. In other words, the higher the CEM, the higher the number of microns from the average are the coarsest fibres. Put another way, how coarse are the coarsest fibres.

To monitor progress in pursuing this basket of highly heritable key production traits, 'Comfort factor' or **CF** is the preferred statistic. This is the percent of fibres in a sample that measure 30 microns or less. In other words, as fibre diameter is lowered, variability is reduced as well as CEM being reduced (with regard to the coarsest fibres), then the percentage of fibres equal or under 30 microns increases. Therefore, a continued increase in CF indicates an overall improvement towards fleece quality. The aim of course, is 100%.

The reason we call this measurement 'Comfort factor' goes back to my previous comments in that the lower the diameter of all fibres, the softer the feel of the fleece and eventually, the better the comfort of the end-product.

To monitor variation in diameter across the fleece, it is suggested that a **3 Point Grid test** is used whereby samples are taken from the shoulder, midside and hip.

Monitoring fleece weight is more problematic. In the sheep wool industry, fleeces are weighed at their annual shearing, with **skirted fleece weights** collected in order to concentrate on the volume of useable wool produced rather than include the coarser edges of the fleece which are removed during skirting.

A similar method has been used with alpacas, with emphasis on collating the weights based on age as well as annualising the weight so that a standardised 12 month seasonal growth is being monitored.

In some cases, fibre density is monitored. The problem with fibre density is that unless biopsies (not permitted in some countries) or skin imprints are taken, calculating fibre density involves a subjective appraisal, and therefore, at risk of a lack of standardised and comparable reporting. Further, the tactile assessment of fibre density may be impacted by falsely interpreting a higher mass of fibre due to high diameter rather than a

density of fibres. It is noteworthy that lower fibre diameter is correlated with high fibre density, but that the low fibre diameter often conceals the true density of fibres.

Some work has been conducted on the objective measurement of fibre density such as Cruz et al, (2025), however, the writer feels more work is required before an objective measurement for fibre density might be included in a group breeding program, say, for alpaca associations.

4 In conclusion Summarising the above points therefore, the key production traits of high heritability that are suggested to form the basis of a herd improvement program aimed at improving fleece quality are, in order of priority:

1/ SD or preferably, SD Across
2/ Mean fibre diameter
3/ CEM
4/ 3 Point Grid Testing
5/ Annualised skirted fleece weight based on age.
6/ CF to monitor overall progress.

If possible, intergenerational recording of the above data linked by parentage, would enhance predictability of how these traits might be realised in subsequent progeny. When progeny data are collected, it is often surprising how some sires are clearly genetically superior with regard to preferred traits compared to other sires, however, their genetic superiority is often not evident by immediate observation.

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