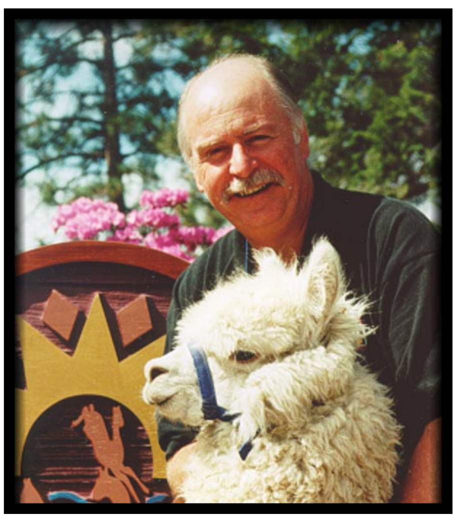
FIBRE TESTING FOR ALPACA BREEDERS

By Cameron Holt
(International School of Fibres)



AUTHOR -

Cameron, who has had some 40 years in the fibre industry as a wool broker, judge, educator and also in his semi retirement continues with alpaca research. He is currently judging for the Australian Alpaca Association and in his role as Senior Fleece Judge and trainer for AOBA, has been involved in the training of their judges as well as judging. Cameron, a leading alpaca fibre expert, continues his educational clinics and lectures throughout the world.

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SO WHAT IS MEASUREMENT?

It is the scientific evaluation of a given characteristic e.g. fibre fineness.
We can measure for many alpaca characteristics such as -

- micron
- c of v
- sd
- fleece weight
- yield
- length
- strength
- crimp
- fibre curvature
- follicle structure
- medullation
- bulk
- colour

Micron is considered to be the probably most important characteristic for measurement. Fibre diameter is the single most important characteristic/property for all fibre. It accounts for 75/80% of value in the processed "Top" (Bell-Ainsworth 1984).

Some measurements can be taken by the grower and I will go through various methods of measurement, both objective and subjective.

Some areas that can be objectively assessed are:

Total Fleece Weight	**Kg**
Yield	**%**
Diameter of Fibre	**Micron**
C of V (micron)	%
Fibre Curvature	**Deg mm**
Comfort factor (Prickle Factor)	**%Fibres less than 30 mic**
Medullation	**%**
Live Weight	**Kg**
Length of Fibre	**Cms**

The above measurements or samples can be taken easily by the breeder, and where necessary tests carried out by a testing house.

<u>Other tests which could be carried out within a herd, with assistance are:</u>

Primary Fibre micron
Secondary Fibre micron
S/P Ratio
Follicle Density

These tests could be of benefit for well-established studs.

NOTE: The correctness of any test result depends on the accuracy of the sample taken.

Most Australian sheeps' wool offered for sale today is tested before sale. Processors demand accuracy in the testing of fibre so that they can accurately batch (match) and blend the fibre to produce a yarn of a given specification.

Almost all alpaca fibre tests currently performed are called "Guidance Tests", because the results are not certified. Only those tests performed by a certifying authority (eg. Australian Wool Testing Authority) can be called Certified Tests, in which case the certifying authority itself samples, measures and weighs the fleece or bale. This type of test is used in the wool industry, as well as for the sale of other commercial fibres (including alpaca), when offering baled fibre for sale. The vast majority of alpaca fibre tests that are performed are done on samples taken by the breeder and then submitted for testing, and are hence uncertified "guidance tests." The testing procedure is, however, essentially the same as that used for certified tests, and the standards by which those machines operate are also the same.

Laser Scan Method

The Laser Scan is an instrument used for the rapid measurement of fibre diameter that also gives a full diameter distribution.

Prepared snippets of fibre (less than 2mm) in length are dropped into either a isoprepenol/water mixture or water based (AWTA), where they are dispersed. The dispersed snippets, still in the solution, are then carried past a light beam, and as the fibres intercept the beam, the amount of light scattered is measured. This light scatter is directly related to the diameter of the fibre, and so the machine can calculate the fibre diameter in microns. Mean fibre diameter, standard deviation, co-efficient of variation are all calculated and a histogram of the variation is printed.

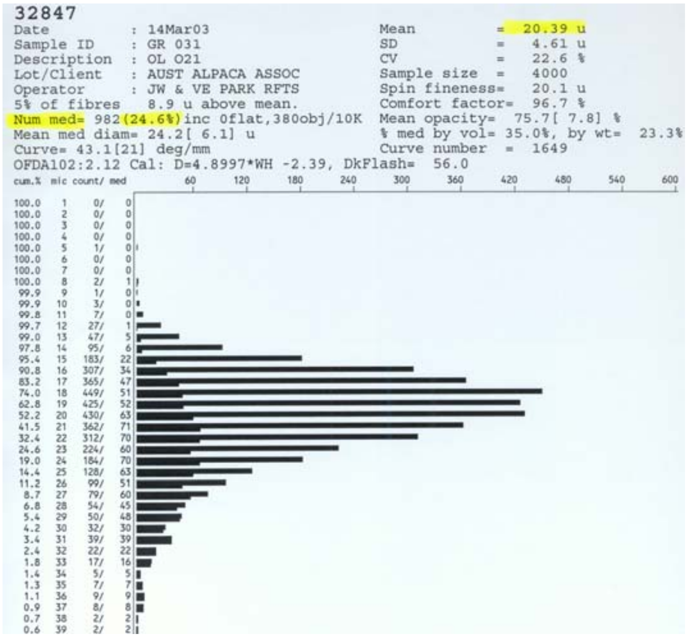
Optical Fibre Diameter Analyser (OFDA) Method

This optical measuring device was developed in Australia and is widely used in testing wool, Cashmere and Mohair.

The OFDA is an automatic microscope above a moving set of fibres. The analyser captures the magnified images of the individual fibres with a video camera. The diameter of each fibre identified is measured and recorded by means of computer aided image analysis. On completion of a pre-determined number of fibres, a histogram print out is produced similar to the Laser Scan/FDA.

The OFDA can identify medullated fibres.

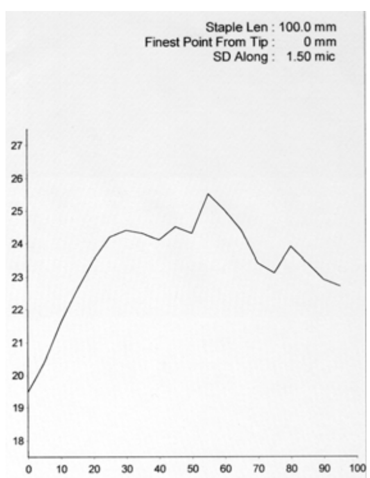
Fibre curvature can also be calculated on the OFDA.



OFDA100 histogram

OFDA 2000

OFDA2000 gives a report based on the entire staple, sampling it along its entire length, as well as the standard histogram.



OFDA2000 micron profile graph

All these instruments produce a graph of fibre diameter. The Laser machines and the OFDA produce a histogram, indicating the number of fibre measurements recorded in a sample for every possible fibre diameter value in a range. The highest peak or the micron with the greatest number of fibres recorded against it is called the mode (the most commonly occurring value). When the mean (average) and mode are similar then the shape of the histogram is said to have a bell shaped curve which indicates an even spread of the population around the mean. The OFDA 2000 produces a graph, which records the average fibre diameter of the staple, measured at different distances along the staple from the skin. Variations in the fibre diameter along the staple may be interpreted as representing variations in the health, nutrition or climate enjoyed by the animal at the time the fleece was grown.

SAMPLING

It should be obvious that whenever any testing is carried out, whether for fibre fineness, or yield, or perhaps vegetable matter content, the item requiring measuring (e.g.: bale or fleece) cannot be tested completely. In other words, EVERY fibre in a fleece or a bale cannot be measured, nor can EVERY piece of vegetable matter in the bale be collected. Complete testing cannot be carried out because either the test is destructive or the expense is prohibitive if every fibre is measured. For this reason a sample is taken from the population and this sample is tested.

SAMPLING METHODS & TECHNIQUES

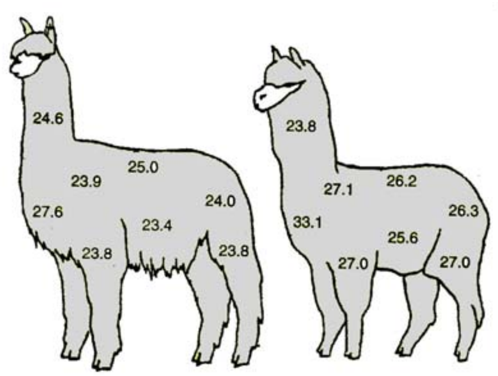
Sampling taken must fulfil 2 basic requirements.

1. Every fibre has a chance of being selected.
2. The method should not be intentionally or unintentionally manipulated.

NOTE. Nearly all methods depending on personal selection of fibres lead to biased samples.

SAMPLING INDIVIDUAL ANIMALS

The Alpaca does vary for fibre diameter from neck to the britch:



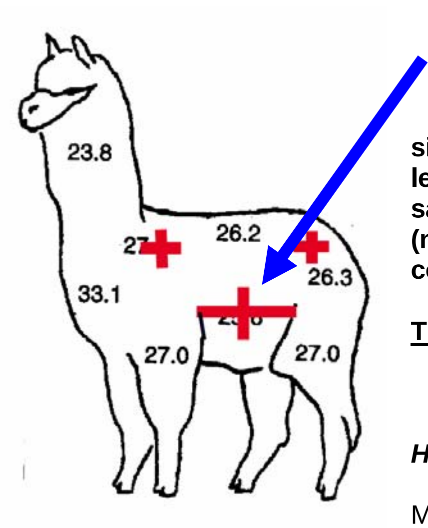
HUACAYA **SURI**
Holt/Stapleton (1993) **Holt/Scott (1998)**

This would suggest that the most accurate form of fibre measurement would be by griding the fleece area. Research (Holt/Stapleton 1993) done on variation of Alpaca Huacaya fleece has shown that animals vary in evenness, that is, some display a more even fleece (fineness) to that of others. Studies on Suri fleece (Holt/Scott 1998) have shown similar results. This variation may cause problems when comparing one animal with another.

When testing with site measurements for micron and/or yield they should carefully **be used only as a guide,** and/or ranking for that animal within your herd. It also can be used to monitor the fibre change in micron from year to year. The full fleece test takes into account micron variation over the fleece (C or V) and should be read in conjunction with the Histogram print out.

A sample is drawn from the mid side as shown (A). Such a sample (although scientifically biased) as mentioned early may be a reasonable representative of the total fleece. Care must be taken on site selection as sampling too high or too low may give a finer or stronger result.

Site sampling can also be carried out using the shoulder pin and hind pin in conjunction with the midside. These will give an indication of variance over the animal. A more accurate measurement would be to send the whole fleece for assessment or grid the fleece. This may only be practical for the top animals.
Within each breed of Alpacas (Suri/Huacaya) there was a variation between sites on the individual breed, but there was no significant variability between the Suri and Huacaya in variability between sites. (Holt/Scott 1998)



(A) midside

<u>NOTE</u> A word of caution. When taking a midside or site sample from an animal, you <u>must</u> cut the sample at skin level. If you vary the level of the plain of the cut between your samples then the cut would represent different growth patterns (nutritional and health as well as possibly age). this would make comparisons amongst animals unreliable.

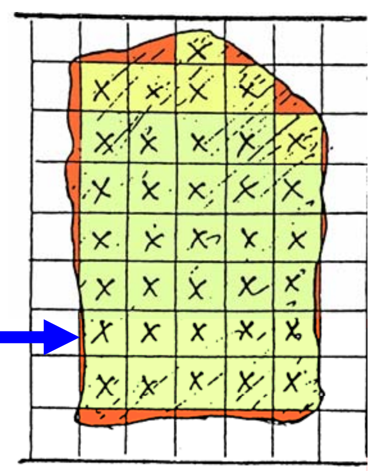
<u>The sample must be:</u>

(a) Carefully and Accurately Identified
(b) Securely packaged for dispatch to a Testing House.

Mid side sampling can also take place during shearing. Sampling taken at this stage can complement fleece weighing, which is done at this point of time.
The same procedures for testing would apply.

Studies into site variation (Holt/Stapleton 1993) gave impressions that the shoulder pinbone and mid were more reliable than those of the Hind pinbone for fibre diameter measurements.

A reliable method for obtaining a representative sample from an Alpaca fleece is the **grid sampling technique**.



All testing must be put into context. Research by Holt and Stapleton 1993 showed that fleece on a huacaya alpaca indicated an average difference of .77 microns between the grid sample <u>(unskirted fleece)</u> and the midside sample (on animal). The mean magnitude of difference was .92 microns. These indicated a correlation between the two sites of .93.

Later research in 2004 by Davison and Holt on a huacaya fleece, where comparisons were made between a grid sample (skirted fleece) and a midside sample (on animal), showed an average difference of .4 microns with a mean magnitude of difference of .87. This was the equivalent of a correlation of .94. Breeders must remember that on some alpacas, the fleece does vary considerably.

Test results (based on research from Holt / Stapleton 1993) indicated an average variance (over the research huacaya fleece) of 4.8 microns (excluding apron) and 11 microns including apron. Research in 1997 by Holt / Scott on suris fleece indicated an average range of 3.2 microns (excluding apron) and 10.1 microns (including apron) over the tested Suri herd.

USING TEST RESULTS

A note of caution to all. When using results to compare one animal with another, a number of factors need to be considered.

1. Some research and anecdotal evidence suggests alpacas increase 2 microns (10%) in their first year and then an annual increase of around 5% up to 5/6 years of age. Then they tend to remain static.

2. Genetics and body weight are likely to be influential factors in the rate and extent of fibre blow-out with age.

3. Nutritional intake/stress/illness/pregnancy will also affect fibre growth and fibre diameter.

4 When measuring fibre there can be small differences between results, brought about by

   - Variation between samples
   - Variation between machine type
   - Variation between machines of the same type

The Laser and OFDA 100 used in the laboratory have IWTO accreditation and are approved for certified measurements.

NOTE: Different properties will exhibit pastures of different nutritional value. If identical animals were to be reared on those properties, it can be reasonably assumed that their fleeces will show different characteristics on fibre measurement, reflecting those nutritional variations. The same applies to animals reared on the same property, where some are fed supplementary feed, and others are left to graze and forage. So, when comparing animal tests results on your property, you need to consider the four vital parameters, which affect fleece growth:

Age
Genotype
Health
Nutrition

So in considering any single fibre test, note firstly the *date of sampling* (which is not the same as the date of testing), and therefore the age of the animal at testing; the nature of the sample (grid of whole or skirted fleece, or single site from midside or elsewhere), and the condition of the animal's health and nutrition at the time of sampling. Only where these factors are comparable can a fleece test be presumed to reflect a truly genetic difference between animals.

BREEDERS
It is recommended to alpaca breeders that

1. Any sample being sent for testing, at any test house and by any method, should clearly identify whether it is a **mid or grid sample**.
2. Large grid samples (at this stage) are not tested using the OFDA 2000 method until a satisfactory sub-sampling method is invoked. However, the "**6 position show fleece grid"** can be done on the OFDA2000, by testing each staple separately and combining the results.
3. If measuring and recording **curvatures**, breeders should select and stick with one or other of the OFDA or laser format due to the variances in recording by these machines.

Regardless of what method is used, an understanding of some statistical terms is necessary.

MODE: The most commonly occurring value.

MEAN: The average of those values (MEAN MICRON)

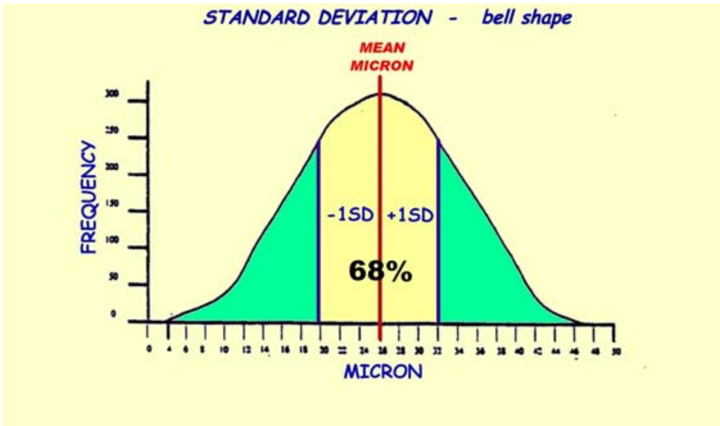
When the values (mode – mean) are the same, the histogram will be evenly balanced, however the height and base can vary.

- **MEAN FIBRE DIAMETER**
  This is a measure of central tendency and gives mean (average) of the fibre diameter in the sample expressed in microns. One micron is one millionth of a metre.

- **STANDARD DEVIATION (SD)**
  This indicates how the fibre diameter in the sample vary around the mean. The smaller the standard deviation the less the variation around the mean.

  One standard deviation (+1, -1 either side of the mean), will represent 68% of the fibres measured
  e.g. given
  Mean 26 microns
  SD 6.0 microns
  then 68% of the fibres will occur between 20 and 32

2 SD will represent 95% of the fibres measured
(95% of the fibres will occur between 14 and 38



"The concept of SD assumes that the fibre diameter is normal (bell shaped)"
(Summerville AWTA 2000)

CO EFFICIENT OF VARIATION (COV)

Is the percentage of variation in the measurements and is related to the mean and standard deviation. The C.O.V. enables various populations to be compared to each other.

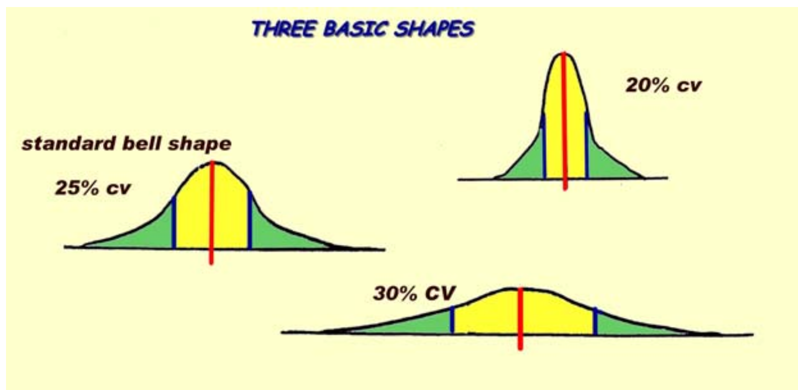
Both SD and CV measure the degree of variation of micron in the tested sample.

THE FORMULA FOR CV% IS

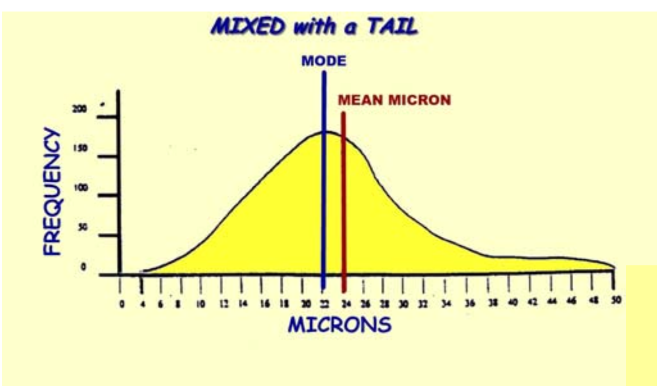
$$\frac{\textbf{SD}}{\textbf{MICRON}} \quad \textbf{X100 = CV\%}$$

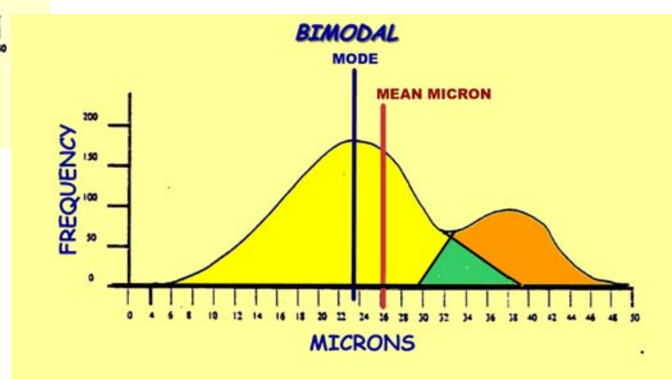
There are three basic shapes

All these have an even spread around the mean but No. 1 is very even and would have a low COV e.g. 20%
No. 2 is a normal distribution and would have a COV around 25% and No. 3 would be considered to be a mixed histogram with a COV around 30%



There are other histogram shapes we may see when testing Alpaca fibre





The fineness of fibre you are breeding in your herd must be considered if you reflect on what the end product that the fibre is to be used for. Breeders should be aware of the average micron of each animal in their herd not only to identify those finer or superior types, but those that are undesirable for the owners breeding goals. The fineness of the micron will determine the final use of the fibre and in some cases how the fibre is to be processed, that is whether the Alpaca is to be blended with another fibre e.g. wool or processed by itself.

I would advise that testing for micron is done at yearly intervals up to 5 years of age (animal's micron goes out for 3 to 4 years on average).

The following table **represents 25% CV for each micron.** The equivalent SD is next to the listed microns.

MICRON	SD	MICRON	SD
17	4.25	24	6.00
18	4.50	25	6.25
19	4.75	26	6.50
20	5.00	27	6.75
21	5.25	28	7.00
22	5.50	29	7.25
23	5.75	30	7.5

Whichever you are aiming for I suggest that once you have all the conformational and fleece characteristics of the Alpaca selected you should then look at microns and select the animal whose micron fits your goal.

TYPES OF MICRON MEASUREMENT

Before deciding on what type of measurement or sampling procedure ask yourself - **What do I want to know and why?**

The normal measurement for micron is usually measured on 12 months fleece or thereabouts. The testing is carried out representing the total sample sent to the laboratory. (If the sample is less in growth the procedure is usually the same.) In some cases where breeders wish to get an idea of their animals follicle structure they will have carried out what is called "single plain cut (butt cut)" usually 1-2 cm from the butt. This method gives a good indication of a staple make-up but only measures at 1 point in time of growth and gives lower CV and SD. (does not have any environmental influence). **CANNOT BE COMPARED WITH MEASUREMENTS MENTIONED ABOVE.** Those animals that test well may then have skin histology tests taken depending on the histograms from the "single plain cut."

ALPACA FIBRE CHARACTERISTICS

The main characteristic is **MEAN FIBRE DIAMETER**. This is expressed in microns (1 micron = 1 millionth of a metre) and is probably the most important characteristic of any fibre. The micron determines the fineness of the yarn and when using fine micron fibre soft lightweight fabrics can be produced.

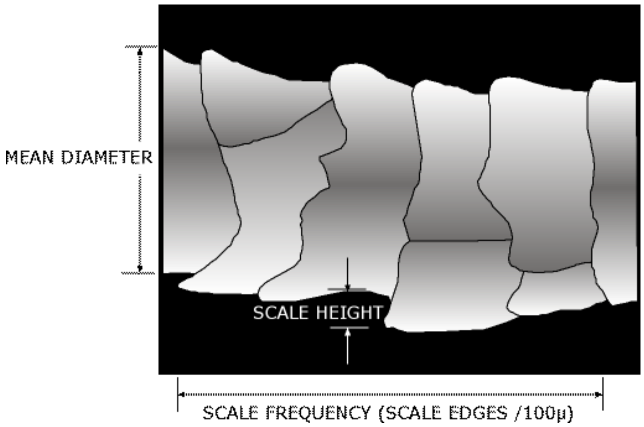
Micron accounts for approx. 70/80% of the value of alpaca fleece.

The fineness of fibre you are breeding in your herd must be considered if you reflect on what the end product that the fibre is to be used for. Breeders should be aware of the average micron of each animal in their herd not only to identify those finer or superior types, but those that are undesirable for the owners breeding goals. The fineness of the micron will determine the final use of the fibre and in some cases how the fibre is to be processed, that is whether the Alpaca is to be blended with another fibre e.g. wool or processed by itself.

You should open the staple into a spider web like appearance. Then look at the individual fibres for thickness. What you are doing is estimating micron. This is quite hard to do at the beginning but after practice you will find it quite achievable. If you are an alpaca breeder and send samples for testing, keep a reference sample and you can create a micron library that you can use as a reference

HANDLE AND SOFTNESS

are in my opinion one of the main assets of Alpaca fibre. The softness is usually due to the micron of the fibre but when comparing Alpaca with wool we have a major difference. The cuticle cells (outer) on wool protrude approximately 0.8 of a micron (scale height) compared to Alpaca that protrudes approx. 0.4 – 0.3 of a micron (suri less). This gives a feel of around 2/3 microns finer (softer) than the equivalent micron in wool. With some lustrous Huacaya fibre and Suri fibre you can get also a more slippery feel due to the scale frequency per 100 microns being lower. These characteristics are advantageous to Alpaca not only from the softness angle but also from the ability to wear Alpaca fibre on the skin. You would assume that the prickle factor which applies to wool with 5% of fibres over 30 microns, may not be as severe on the equivalent Alpaca fibre, although if the yarn has a lot of coarse fibres through it this may not be the case. Coarse fibre ends touching the skin triggering pain receptors just below the epidermis layer cause the prickle factor.



A low CV fibre usually has fibres more similar in fibre thickness, therefore being softer to handle.

CO EFFICIENT OF VARIATION

As well as micron you should also be aware of the COV. The average COV in Australia (using Australian testing methods) for single site samples for Alpaca is around 24/25 % (Holt unpublished data). The average C of V over the individual sites tested for the Suris was 24.4% with the Huacaya being 23.2%.

Grid samples can have a higher COV if the animal varies over the body. A single site should be more even (mid side) therefore having a lower COV than the grid. The laboratory test method of single cut per staple, butt-cut (as frequently used in USA) gives a average 2% lower CofV than the single site (using Australian test methods) used in Australia.

The Co Efficient of Variation was seen to be independent of fibre diameter. That is fibre diameter was not seen to have any effect / influence on the C of V.
Variation of C of V over the life of an alpaca tends to indicate that the first year of fleece production shows a higher C of V, especially if tested under 6 months of age (anecdotal from breeders tests). The second years fleece onwards tended to show a C of V staying in a range of around 2 – 3 per cent.

SPINNING FINENESS

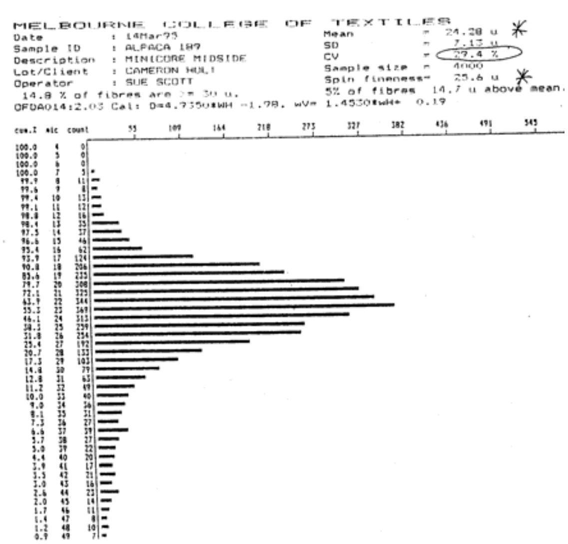
This is a measurement (using micron and cv%) to estimate the performance of fibre when it is spun into yarn. It has been shown in the sheep industry that if you can reduce your COV by around 5% then you achieve a yarn that performs like a yarn one micron finer (spinning fineness) The reverse also applies.

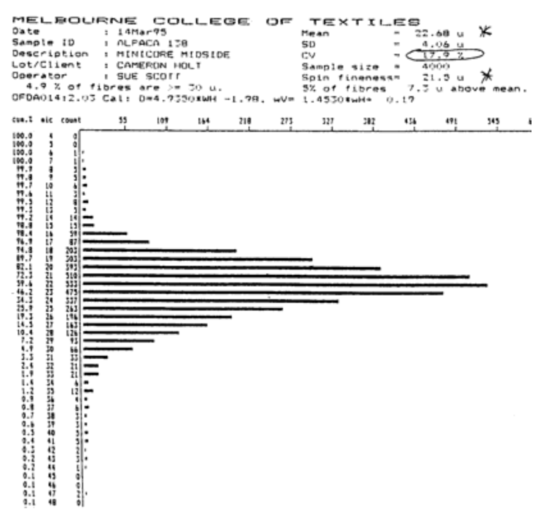
e.g. 22 micron - COV 24% = spinning fineness approx. 22u
22 micron - COV 19% = spinning fineness approx. 21u
22 micron - COV 29% = spinning fineness approx. 23u

Those with a high COV may not only indicate fibre that varies greatly from the mean but may also indicate a larger number of coarse fibres (which may or may not be guard hair) throughout the staple or fleece. This is usually identified by the histogram shape.

Some buyers of wool take into consideration “spinning fineness” when purchasing fibre, but the majority still buy on micron.

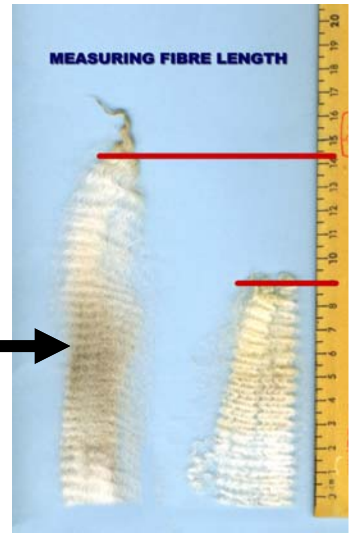
The following histograms can give you an indication of the above.





STAPLE LENGTH is also an important characteristic. Length basically controls the method of processing Alpaca (woollen or worsted), that is, the shorter length fibres will be processed via the woollen system (e.g. 2"-3", 50-75mm) and the longer (3"-6", 75-150mm) by the worsted process. The mean (average) length in the top contributes to yarn strength by increasing adhesion of fibres during spinning. It is most important in processing that length is relatively even. It is hard to set processing equipment when the length is uneven. Like micron, lower CVs produce a better product.

Suri fibre is all processed on the worsted system.
Length should be recorded by the breeder as such.
This will enable you to identify any animal not producing commercial length fibre.



LUSTRE

Good lustre is an important characteristic for Suri fibre. It is one of the main attributes, as this is what is required in a finished garment of Suri or Suri blend yarn. In Huacaya a "brightness" or sheen is desirable by the processor again for the finished garment. It is therefore important for the breeder to be able to identify chalky type fleeces and either breed this fault out or sell the animals concerned.

Breeders should record fleece as,
High
Good
Average
Dull/Poor (Chalky)

NATURAL COLOURS are one of the unique attributes of Alpaca fibre. The colours range from white through cinnamon, various shades of fawn, brown, grey/roan to black. Although in the commercial field processors generally value white fibre more highly due to its ability to be dyed with colours which are currently in fashion, the various shades of colour in Alpaca fibre are also highly valued.

Much debate has taken place about whether to breed for colour or white. There are those processors who like natural colours. It is the breeder's responsibility to determine their direction. The main requirement of the processors is that the colour is pure, that is not contaminated by odd fibres of another colour (excluding roan/grey). **Some dark colours are bleached prior to processing.**

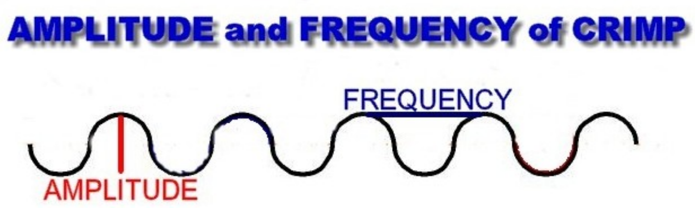
CRIMP

Crimp is the natural wave formation found in the Huacaya fleece.
Crimp is a multi dimensional structure and how the crimp is expressed is determined by genetics (cortical cells- bilateral structure), amplitude, crimp frequency and micron.

Variation in the crimp can also indicate how the animal has thrived during the period of fleece growth. A well-defined crimp with its even structure is more likely to dry faster than fleeces that are lacking crimp definition and are cross-fibred.

Crimp comes in various sizes (frequency) and can also be shallow or deep in the curve (amplitude). The photograph gives an indication of the various frequencies that can be seen in alpaca fibre ranging from 12 crimps per inch down to 2 crimps per inch.

Frequency is the number of times the fibre crimps (waves) per inch (CPI).
Amplitude is the height (deepness) of the wave. Deep crimp is said to have high amplitude.



***CRINKLE: a slang term** introduced into the alpaca industry in 1991 by Cameron Holt (myself). This term has taken on a life of its own. Crinkle was used to describe the crimp in the individual fibre, particularly where the staple itself showed little or no regular crimp formation. The term originated in an educational class on cashmere fibre in approximately 1981 when a student, looking at the cashmere fibre, commented that it had a crinkle like formation. To be correct, when we talk of the individual fibre, we should probably use the term "Crimp". But who am I to remove such a descriptive word from the alpaca vocabulary.*

IMPORTANCE OF CRIMP TO PROCESSING

In the wool industry, crimp is considered an important factor in the manufacturing process (although not as important as uniformity of micron and length). Although the crimp loses its staple definition in scouring it maintains its individual fibre structure. The crimp is combed out during combing but the memory within the individual fibres enables the fibres to return close to their natural shape, tightening and strengthening the fabric. This adds to the elasticity and draping qualities of the fibre.

MICRON-CRIMP per INCH

MERINO (MICRON)	CPI	ALPACA (MICRON)
16	20	
18	18	
19	16	
21	14	
23	12	13
24	10	15-16
	8	19-20
	6	22-23
	4	25-26
	2	30

APPROX VALUES FOR GOOD CHARACTERED WOOL & ALPACA

A well-defined deep crimp could indicate fibres of a more similar micron growing uniformly together in a tightly packed staple.

Huacaya fibre, unlike Suri, exhibits varying degrees of crimp in the fleece (from around 12 CPI – 2 CPI). For **good crimped alpaca fibre** of 19 microns, the average crimps per inch were around 8 CPI. The average CPI from research (Holt 2006) was 6 CPI. A long way from a possible ULTRA-fine microned 12 CPI fibre.

It has been shown in sheep that wools with crimp allow the processor to spin a yarn, that is lighter due to its bulking properties. Crimp also helps in promoting improved cohesion of fibres whilst processing.
The same principals apply to huacaya.

Breeder's assessment for crimp should be as follows

1. **Excellent** – very evenly defined crimp with deep amplitude
2. **Good** – well defined and regular crimp formation
3. **Good/Average** – showing good to average crimp definition and regulation
4. **Average** – showing some crimp definition but not as regular as No 3
5. **Average/Poor** – little crimp definition or regulation visible
6. **Poor/Straight** – no crimp definition clearly visible

10/9	**8**	**7/6**	**5/4**	**3/2**	**1/0**
excel-sup	good	g/ave	average	poor	inferior

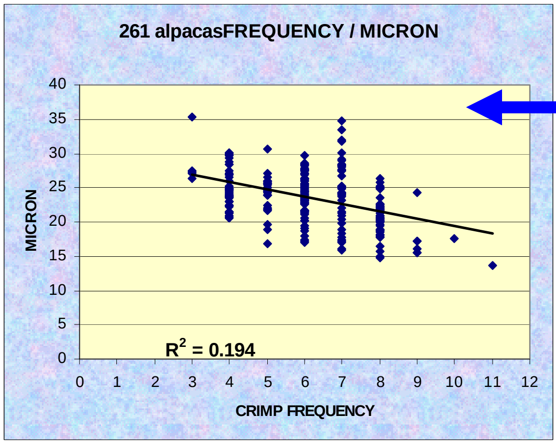
FLEECE JUDGES RATING FOR CRIMP

DEFINITION

CRIMP FREQUENCY is the expression of the number of times the fibre crimps (waves) per inch. In good crimped huacaya fibre there is a general relation between crimp frequency and micron, <u>but not absolute.</u>

In Peru some breeders use the number of waves per inch (crimp) to indicate fineness (more per inch = finer), but data collected by the writer showed where the genetic background (LLama/Suri/Huacaya) was unknown, <u>no relationship between fineness and number of crimps per inch could be established.</u>

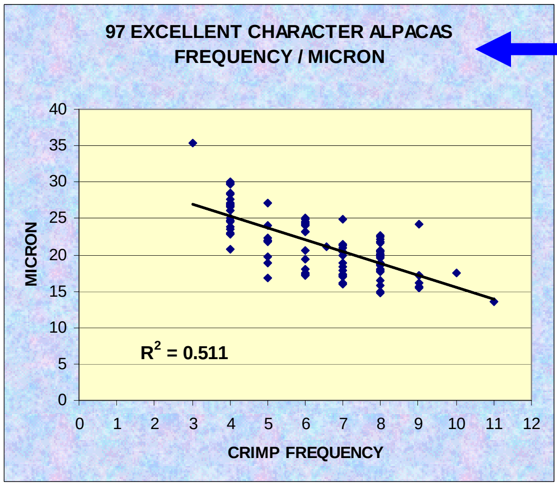
<u>CRIMP FREQUENCY, MICRON COMPARISON (261 alpacas) (Holt 2006)</u>



This graph shows the relationship and spread of the micron and crimp frequency. The data indicated a .44 correlation.

For the entire range of character groups the relationship is poor. Some 80% of the measurements are unexplainable. This would suggest that over the entire herd crimp size of varying character definition is not a good indication of micron.
How ever in the graph below it

<u>CRIMP FREQUENCY, MICRON COMPARISON (97 alpacas)</u>



shows the relationship and spread of the micron and crimp frequency in **97 excellent characted** alpaca samples. These were the best of the previous 261 samples.

The data indicated a .70 correlation. A much better relationship in this select group is shown, even though this result indicated a reasonable correlation, there was still 49% of the measurements that could not be explained.

This tells us that <u>across the entire National herd, crimp frequency on its own, is not a reliable indicator of micron.</u> However in very well crimped fibre some consistency is evident, which would suggest selection for this expression of crimp would be more reliable albeit it only be around 50% accurate. If growers <u>breed well defined crimped (good/excellent character) fibre their consistency of evaluation would be more correct.</u>

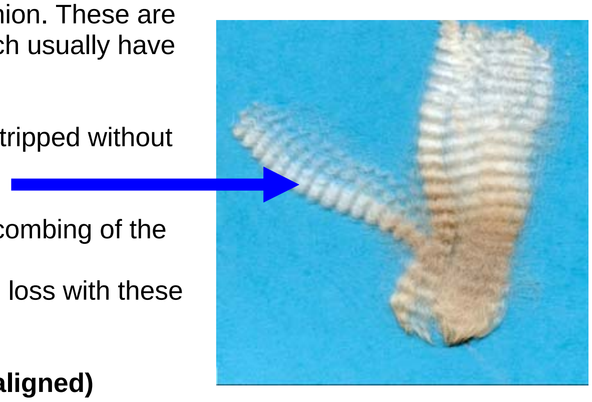
IMPORTANCE OF CRIMP TO BREEDERS

How can we apply the research findings to our improvement of the alpaca herd? Firstly the data has clearly shown that selecting for well-defined expressions of character of the crimp (whatever frequency) is more likely to be successful due to its consistency. Crimp is a highly heritable trait (around .5) and therefore selecting for a well structured staple and crimp expression provides a strong chance of this trait being passed on to the offspring.

Crimp is a good indicator for the Alpaca breeder to estimate what is under the skin
Research with sheep has shown that a well-aligned, good character fleece has a good follicle arrangement under the skin.

Dr Watts states that "well-aligned fibres are associated high density and fineness".

In alpaca, if it's crimpless with no fibre alignment, it will usually be an open fleece. Under the skin the follicles will be formed in an unorganised fashion. These are sometimes referred to as fleece with crinkle, which usually have limited staple crimp structure.

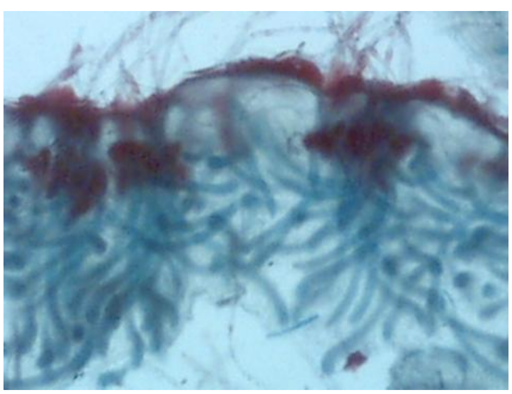


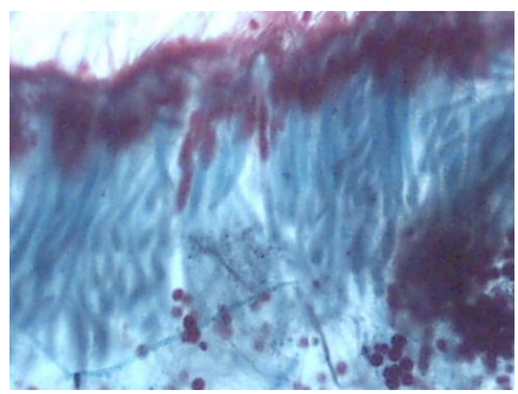
Micro staples with well-aligned fibres are easily stripped without entanglement.

This alignment is transposed to the carding and combing of the fibre.
There is less entanglement and subsequent fibre loss with these fibres.

You will normally find that "well-organized" (aligned) follicles are growing denser fleece due to the close proximity to each other in the skin.

Vertical skin sections





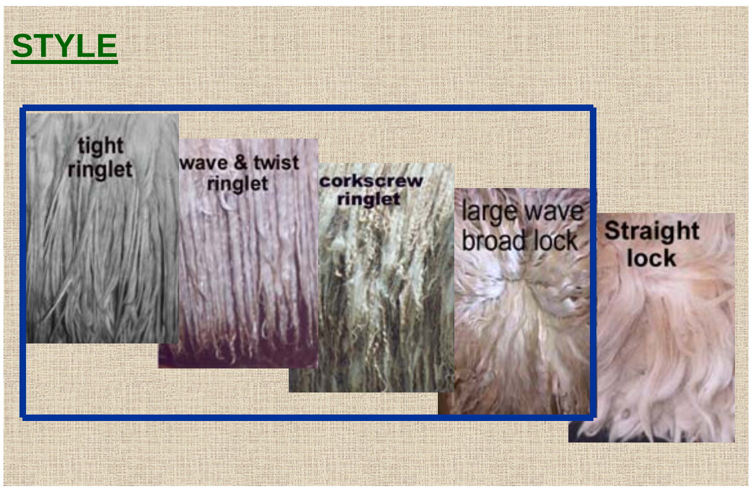
(Holt 1995)
ENTANGLED FOLLICLES **REASONABLY ALIGNED FOLLICLES**

Crimp is the expression of the excellence of breeding. It will, by its degrees of excellence, help you estimate, in particular density and fineness with the help of handle. We have learned from experience that if the crimp is well-defined and superior in nature in an older huacaya, e.g. > 4 years old, this would indicate that the alpaca may have the ability to maintain its fleece excellence. This certainly is an important trait you should look for in your selection process.

SURI FLEECE TYPES

Suri fibre is basically a straight fibre and is used like mohair for specialised fibre production. One of the main difficulties when processing Suri, (like Mohair), requires some twist in the sliver so it will not pull apart during the drawing process. This is due to the lack of cohesion when spinning caused by the low, smooth cuticle scale structure. Processors have suggested that they prefer a fibre with a slight wave in preference to a straight fibre. From a breeding perspective, Dr Julio Sumar would prefer the ringlet type followed by the lock with twist and wave.

Many variations of suri lock type exist. However, in Australia five types are commonly identified. These range from a tight ringlet, wave and twist ringlet (sometimes known as curled ringlet), corkscrew ringlet and large wave with broad lock. These three would be the most common of the five types with the other one being and a straight fibred lock.



1. The lock twists into tight ringlets almost to the skin.

2. The lock grows showing a small wave with twist. It also grows in a ringlet formation. The best locks will almost twist and wave to the skin.

3. The lock grows in a corkscrew like curl. It also grows in a ringlet formation. The lock can be small or large.

4. The large wave with the flatish broad lock is a much thicker looking lock than the above three. The thickness does not necessarily mean density.

5. The fibre grows straight showing no signs of ringlet, wave or curl.

Within the above four main types (not straight) many variations can be seen. These variations can be affected by the trueness to type of the fibre and can be changed, eg. fanned ringlet, when the fibre becomes excessively over long.

Another type of lock sometimes found when breeding Suris is that with a crimp like wave along the length of the staple (Husui). This is a much bolder and wider crimp/wave than found in the Huacaya fibre. This not desirable.

It is most important that the Suri fleece displays high luster than those that are chalky. These animals producing the chalky fleece should be bred to a male displaying high lustre in its fleece.

Processors requirements for Suri fibre are
- **luster**
- **fineness**
- **length**
- **straightish fibre (no crimp)**

All these characteristics can be obtained in the above fibre types. So for a breeder it is important to identify those styles that produce not only fine fibre but also density and high fleece weights.

CURVATURE

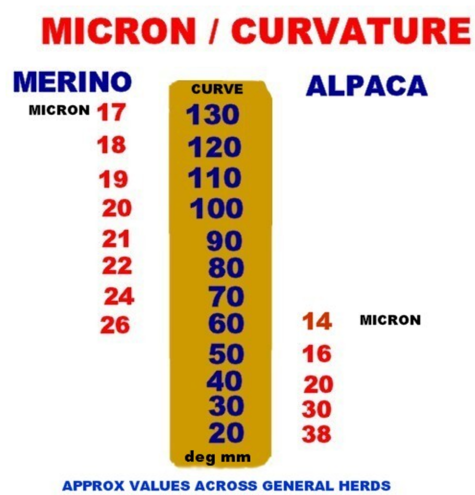
Fibre curvature is the measure of the fibre crimp frequency and amplitude

FACT **Curvature is affected by**

-Crimp frequency
-Micron
-Character of the crimp (definition /amplitude/ alignment)

The curvature value is expressed in degrees per mm fibre length.

As the frequency of the crimp increases the curvature value is increased, and conversely the lower the curvature value the lower the staple crimp frequency. Fibre curvature can be measured at all stages of processing e.g. greasy to fabric. The curvature of the fibre influences how the fibre will process, particularly during top making and spinning.



Curvature (ofda) values in Suris have tended to give a range from 15 to 35 (some as low as 10) with the Huacaya showing a range from around 25 to 60. It was noted that the coarser the micron, generally the lower the curvature value. Also when the C of V was more variable (higher) the curvature value also tended to be lower.

Alpaca fibre does not seem to have a problem with too much curvature in fact it does not have enough. Angus McColl et al (2004) also found “The average level of fibre curvature in alpaca is quite low, compared to fine wool or cashmere.”

FACT: Given a similar micron, huacaya does not have the same higher curvature value to that seen in merino fleece.

In the chart below, groups of crimp frequencies (given as an example) clearly show that the micron influenced the curvature and not the crimp frequency. Some have thought that a given crimp frequency would have some form of consistency in the curvature, but as we know there are different amplitudes (shallow and deep) which contributes to the variation of this result. There is also another belief amongst some wool scientists, that is, when the fibres are cut into two mm snippets when preparing for testing, some of the stronger microned fibres do not maintain their curve, but tend to straighten out (changing from their original shape), hence the lower curvature reading. This may, along with the various amplitudes, help explain the variation found in curvature for a given crimp frequency. **Genetics and age are also involved.**

Some interesting selected observations were,

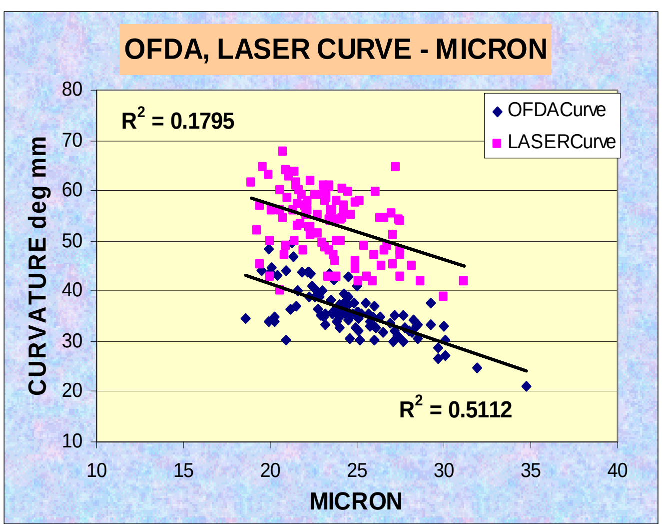
CRIMP FRQ	MICRON	CURVE	CHARACTER
8	21.4	43.5	2
8	22.7	40.7	2
8	26.4	33.2	3
8	25.3	35.4	3
4	20.5	44	3
4	21.5	42.8	3
4	28.5	27.7	2
4	29.7	28.8	2

ALPACA (HUACAYA)

These (below) are estimated relationships for micron, crimp frequency and curvature (based on good crimp definition and better). These are based on the study in 1995,2004 2005 as well as data from Groupa Inca. I would expect these averages to improve in time as the alpaca herd in Australasia, Northern America and Britain improve. A bias towards the better crimped fibre.

NUMBER OF CRIMPS PER INCH	FIBRE CURVATURE (DEG mm)	MICRON (approx)
11/12	60/55	13/14
10	54/51	15/16
9	50/47	17/18
8	46/44	19/20
7	43/41	20/21
6	40//38	22/23
5	37/36	24
4	35/33	25/26
3	32/29	27/28
2	28/25	29/31

COMPARING OFDA CURVES WITH LASER CURVES
(Same 100 HUACAYA FLEECES/SAMPLES tested on each machine)



NOTE: Since the tests for this comparison were taken, the AWTA has altered their solution to a "water base". This has altered how their current laser views the curvature. The data in this study was from a LASER SCAN using a 92%Isopropanol – 8% water formula as its liquid medium.
Other laboratories using a Laserscan are most likely to still be using the isopropanol/water formula, as it is believed the AWTA is the only laboratory at this stage to have gone to this water based solution.

The comparisons between the OFDA and laser for curvature indicated an average difference of 17.4 deg mm (100 huacayas measured in this trial by both machines). The correlation between curvature measured by OFDA or laser for any one sample is poor, with **OFDA measuring significantly lower curvature than Laser**. The spread of the OFDA was much more consistent than what was found in the laser. However, the comparison of the relationship of micron and curvature for the OFDA still indicated a 49% unexplained variance (.71 correlation). The laser had an 82% unexplained variance (.42 correlation). When directly comparing the OFDA and laser curvature comparisons for each animal there was 78% unexplained variance (.46 correlation)

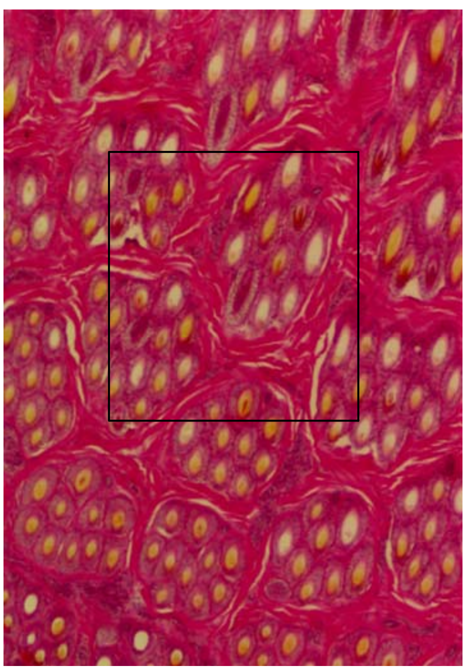
The significance of difference in curvature measurements between machines **suggests that meaningful comparisons of fibre curvature between different fleeces can only be made if measured by the same techniques.**

NOTE

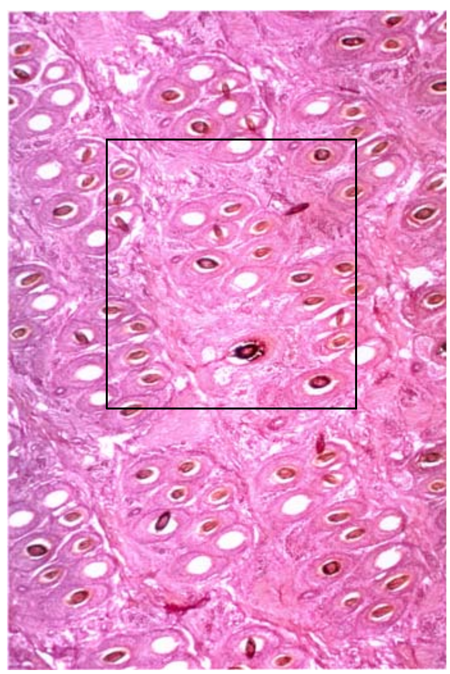
Currently there is no International standards for the measurement of curvature. The OFDA and Laser do however have their own calibrations and standards for their machines but as you can see above they do not interpret the results in the same manner. Consistency of measurement is also affected by variances between machines as well as laser and OFDA measure different length snippets. Research by CSIRO quoted in AWTA Fact Sheet 004 by Peter Sommerville shows a comparative graph of OFDA and Laser scan curvature on merinos, which indicate a closer consistency than that found above in the alpacas. It should be remembered that the alpaca fibre at this stage of its development is nowhere near as consistent as merino fibre.

DENSITY

This is basically not of interest to processors, but very important to breeders for total fleece production of a given animal. Density not only helps keep out vegetable matter and dust but contributes to fleece weight. Improved density is obtained by an increase of follicles in the skin over a given area.

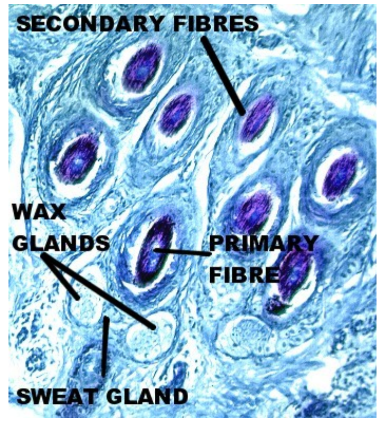


(Uphill)
average/good density



(Feakes)
poor density

FOLLICLE STRUCTURE



Leading sheep breeders in Australia have now for some years been using skin biopsy to help in their selection of superior stock. They use this information as an aid as well as other selection traits. T. Nay in his publication "Technique for examining in the skin of sheep" describes the techniques for sampling follicles for examination.

There are two basic methods for appraising follicles in the skin

1. **Horizontal** – These are usually cut at the Sebaceous (wax) gland level. This shows the follicle structure in the skin, density per square mm and S/P ratios can be calculated.

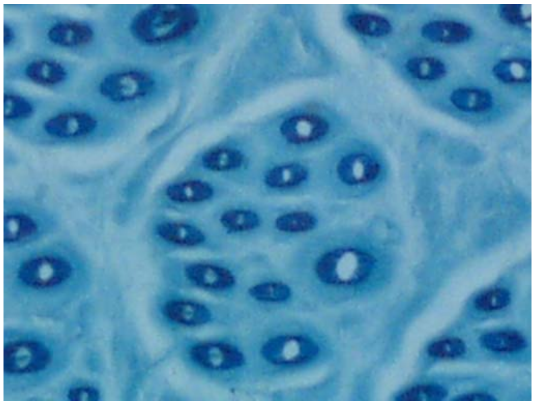
Superfine sheeps wool used to have an S/P ratio of 25/1. Modern breeding techniques and measurements show some animals have progressed up to around 60/1. Primary follicles are identified by their associated structures (wax, sweat glands and arrector pili muscle).

Dr Jim Watts (1996) found in a group of Alpacas, S/P ratios (secondary/primary) of 16.5/1 to 3/1 averaging around 7/1. In mature alpacas, average follicle densities of around 24 follicles per square mm with measurements up to 60/70 follicles per square mm were found.

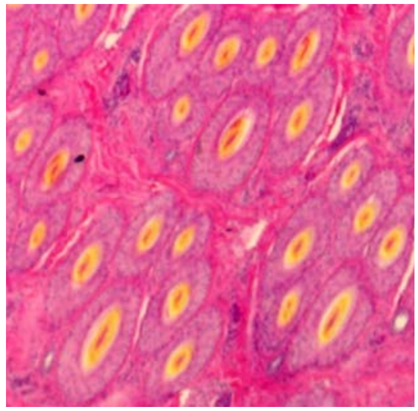
In a private communication,Dr A. A. Charry, University of Sydney, supplied the writer some 57 follicle measurements. These measurements ranged for secondary to primary ratio (S/P) from 17.4 to 5.8 with an average of 9.9. The follicle density ranged from a total of 82.3 per square mm to a low of 15.9 per square mm (average was 41.1 per square mm).

An important observation of these measurements was that a high S/P ratio did not necessarily mean a high-density count (or vice versa), when comparing these results in isolation.

S/P RATIO	TOTAL DENSITY per sq mm
17.4	67.0
14.9	82.3
13.4	67.2
12.6	40.1
8.6	57.4
6.6	43.0
6.5	15.9
5.9	21.1



S/P RATIO 13/1
(holt)



S/P RATIO 5/1
(Uphill)

ALPACA (Huacaya) S/P ratios and density averages compared to microns (2005/2007)

(holt/watts 2005) (holt/watts/SRS AI 2007)

MICRON	FOLLICLE DENSITY		S/P RATIO	
	2005	2007	2005	2007
<18	51.12	56.7	10.42	10.5
19 – 21	44.47	49.1	10.37	10.6
22 – 26	44.6	43.5	10.27	10.1
27 – 30	36.44	40.0	9.24	9.9
31 – 37	30.52	36.0	8.10	9.2

Huacaya numbers measured in 2007 data = 625
Huacaya numbers measured in 2005 data = 345

ALPACA (SURI) S/P ratios and density averages compared to microns (2007)

(holt/watts/SRS AI 2007)

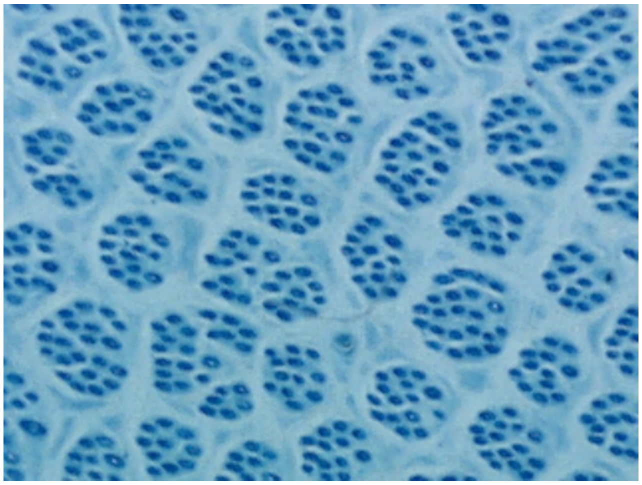
MICRON SURI	FOLLICLE DENSITY	S/P RATIO
	2007	2007
19 – 21	42.62	9.76
22 – 26	33.47	8.87
27 – 30	27.72	7.58
31 – 37	24.72	6.60

Suri numbers measured in 2007 data = 82

With the aid of testing, identification of fleece markers and correct mating decisions, progress can be made towards higher S/P ratios.

FIBRE AND FOLLICLE COMPARISONS

Example HUACAYA



SP RATIO 11.1/1 DENSITY 68.2 per sq mm
Dp = 24.8 Ds = 18.6
MICRON AVE 19.1

A note of caution

Alpacas should not have their follicle density measured until they have reached maturity, e.g. 2 years of age.

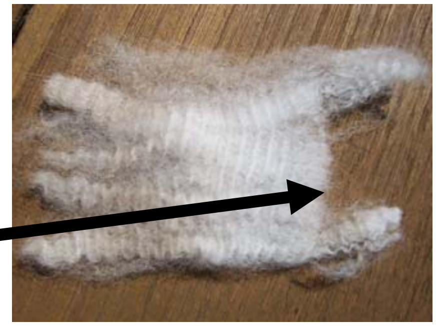
The fibres in the square millimetre measurement area become coarser in micron during their maturity. This is due to increase in body size/weight. During this time the skin stretches and the number of follicles in the given test area increase in size and therefore reduce in number. This is known as the "balloon effect". The alpaca technically has not lost or gained any fibre producing follicles over its body.

STAPLE STRENGTH

Alpaca is generally strong in tensile strength although this can change and become weak if the animal is stressed e.g sickness, lack of nutrition etc. Research (Holt Stapleton 1993) has shown Australian Alpacas have a tensile strength range of 22-104 N/KTex. 35N/Ktex is considered sound when used on conventional machinery. With the introduction of new modern machines and improved processing techniques 40N/Ktex is now considered the minimum strength for sound wool. Note a break in the centre of the staple is more heavily penalised for price by the fibre buyers.

N/KTex				
Very Tender	Tender	Weak	Sound	Very Sound
10 15	20	25 30	35 40	45 50 55 60
Increasingly weak			Increasingly sound	

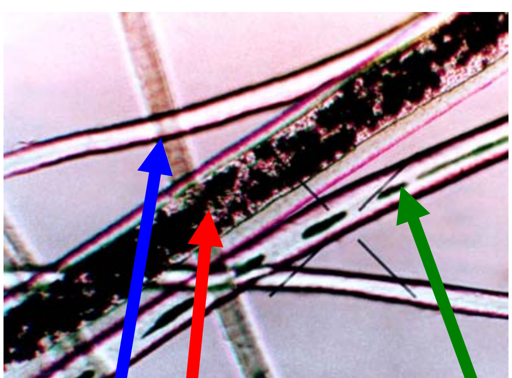
TENDER (note break at bottom of staple)



For breeders to assess soundness of the fibre place a pencil like staple between the thumb and first finger of the right hand, and the thumb and first finger of the left hand. Exert a pressure of approximately 7lbs (3kg) and flick with the middle or ring finger. The staple will either stay in tact (sound), have a slight tearing but stay in tact (stretchy) or will partly break (part tender)or break with great ease (rotten).

GUARD HAIR (MEDULLATION)

The medullated fibres called **"guard hair"** are not desirable in the finished product. They are stiff and hollow with pointed tips. They reflect light differently to solid fibres and are hard to control when spinning. Medullation (guard hair and continuous medulla) is also considered a disadvantage because of fibre breakage. Partial fragmented medulla has little affect on fibre tenacity. Medullation (guard hair) also creates non-uniformity of colour levels in the dyed fibre. A large number of these fibres are removed during the carding/combing process but a number still remain and these are a contributor to the coarse edge, which gives the "prickle factor" (now known as the "comfort factor") in garments. Being stiff they will protrude from the yarn. A Harris Tweed would welcome this effect.



SOLID

GUARD HAIR. partial medullation **GUARD HAIR**

Breeders can measure the numbers of medullated fibres including those partially medullated, using an O.F.D.A. 100 (white only). A Histogram of medullated fibres is superimposed over the solid fibres and records the various diameters and spread. Dark coloured fibre is more difficult to calculate and results for these colours are not as reliable.

A visual assessment can be made on the coarse guard hair fibres and the fleeces are rated as

Free or nearly free
Light
Medium
Heavy

The shape of the staple will be a help in identifying content of the coarse medullated fibres. These fibres will usually protrude from the tip of the staple and will have the appearance of a spikey tip.

It should be noted that medullation in Suri appears lower than that of similar microns for Huacayas. (Holt/Scott 1998) . It was noted that as the fibre became stronger in micron there was an increase in medullation.

Micron	Huacaya	Suri
20	12.9%	4.7%
26	36%	16%
36	60%	42.4%

CLEAN FLEECE WEIGHT

This is of great commercial value to the breeder. The more weight of a given micron the more return in dollars. The processor pays by the LB/kilo and is not worried how many animals it takes to produce the weight.

Fleece weight is a most important factor in your breeding program as you need to identify those animals which are below the herd average as well as identify those superior animals with top fleece weights.

Fleece weights and micron are, in the goat and sheep industry, two of the important selection characteristics along with conformation of course. Clean fleece weight is affected by –

Micron
Staple length
Follicle depth (related to staple length)
Follicle density

Fleece weight can be recorded by the breeder. All it requires is a set of scales which record in 50 gram (1.75 ozs) increments and should be able to record up to 10 kilos (20 lb's) in weight. Electronic scales are easier to use and tare weights can be calculated into the scales. You should weigh the saddle, neck, middle leg area and the balance as well as a total fleece weight. Yield needs to be calculated by a registered fleece testing laboratory. At this stage a knowledge of your yields will suffice. This will with greasy fleece weight enable you to estimate your clean fleece weight (CFW) on each animal.

Any knowledge you can gain by measuring your Alpacas can only help you in achieving your breeding objectives.

CAUTION When analysing microns or any other characteristic care must be taken as the characteristic you are measuring may vary according to their environment, age/bodyweight. Therefore when comparing data from different animals, allowances should be made in your interpretation. Remember statistical data is only one part of the picture when you are making breeding decisions.

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