IS CRIMP IMPORTANT? by Cameron Holt
(WHAT DO YOU THINK?)

INTRODUCTION
Much has been written about crimp and their relationship with curvature, frequency and microns, as well as curvature and compression. Many of the comments you hear are fact and fiction. We have heard the crinkle theory, the popcorn theory and various statements like “crinkle provides bulk which is created by the air pockets” (processors have concerns re the lack of bulk in Huacaya fibre – products too heavy) and of course that “crimp frequency is a reliable indicator of fineness”.

I will demonstrate quite clearly that **well-defined crimp is more consistent in its relationships with crimp frequency, curvature and micron.** The facts are based on measurements of some 261 varying types of huacayas from Australia and the USA. The alpacas varied for age and fleece type. The total samples included elite and excellent fleece types (with a character score of “1”), and inferior types which had a character scoring of “6”. The results from these alpaca fleece samples formed the basis of this study. This is factual data, not unreliable speculation, but solid evidence and along with other published /unpublished data will I hope answer the question for you, “is crimp important?”. You will also need to decide on which crimp type/style you feel is the most desirable for your breeding program.

FACT: Results from any animal or fleece study are only as good as the “target group” being studied and the correctness of protocol and of measurements taken.

As a lot of comparisons are made between huacaya and merino wool, I have listed the following information to help you when making comparative judgments.

WHAT IS THE DIFFERENCE BETWEEN MERINO WOOL AND HUACAYA?
Believe it or not, merino wool and huacaya have much in common even though they have some critical differences. Some of these differences and similarities are demonstrated in this article.

Similarities: Both follow the same principles for forming follicles and growing fibre. Fibre growth in huacaya and merino is affected by nutritional change in a similar manner.

Merino and huacaya are both protein staple fibres. Both are referred to as a wool fibre.

Both display a bilateral structure in the internal cortical component of the fibre (hence the crimp). They display a crimp in the staple (and individual fibre) and have similar attributes relevant to that crimp. Merino and huacaya are both capable of deep crimping at all crimp frequencies (CPI).

Merino wool and huacaya are processed in a similar manner (both woollen and worsted). The huacaya fibre is in need of more anti static treatment and is sometimes run at a slightly slower speed than the merino.

Differences: Merino has a higher curvature when comparing microns between the two. This is most likely due to the higher number of crimps per inch with the merino. Huacaya fibre does not have the high number of crimps per inch, which is found in the fine and superfine merino but is more like the medium to stronger wool. Alpaca (huacaya) currently is probably more akin to the *SRS®* style of merino than the traditional merino. However both merino and huacaya follow similar principles for curvature. The compressibility (bulking properties) is similar in principle but the huacaya is below the merino on the scale of measurement (chart 3), due to the lower crimp frequency and curvature size.

Merino fibre is basically a solid fibre whereas alpaca huacaya fibre once it becomes broader than 20/22 microns takes on an internal medulla cell (medullation – fragmented / continuous), which increases in size with the increase of micron. This medullation is not guard hair (straight, brittle, broadest micron, harsh and usually dull). Merino wool is for all intensive purposes, free of guard hair. The huacaya fibre is not. Due to this medullation huacaya fibre may have marginally improved insulating properties and be slightly lighter in weight.

The cuticle cells, which are the external cells, overlap with a different scale height:

Merino .8 Micron Huacaya .4 - .3 Micron

This lower scale height on the huacaya creates a greater softness to the hand. Some people suggest this softness is the equivalent of 2 – 3 microns.

Merino wool does not vary greatly for mean micron from its 2nd to latter fleeces (the first years fleece tends to be around 1.5 – 2 microns finer than older fleeces), where as the huacaya fleece data indicates that the fineness for huacaya tends on average to gradually become broader for up to around 5/6yrs of age.

A SUMMARY OF THE IMPORTANT RESEARCH DATA FINDINGS WERE:

The most important observation for the breeder was the inconsistency of results (due to the high variability) for crimp frequency and micron across the entire population. These results would be indicative of a typical alpaca herd.

*This tells us that **across the entire National herd, crimp frequency on its own, is not a reliable indicator of micron.** 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 breed well defined crimped (good/excellent character) fibre their consistency of evaluation would be more correct.***

FACT: Crimp frequency (particularly average to poor character expressions) is not a reliable indicator of micron across a typical alpaca herd. Good/excellent charactered fibre would be more reliable albeit it only be around 50% accurate.

A second important observation was that only the good/excellent-charactered wools displayed any consistency between the samples for curvature and its relationships with other measured characteristics. Data indicated that micron was shown to have a greater effect on curvature than crimp frequency or character expression. Alpaca (huacaya) does not have the curvature value that is seen in merino fleece (see chart 3).

This consistency in the good characted fibre would enhance yarn performance (eg: less fibre loss during carding and spinning)and fabric construction (eg; softer yarn in the fabric).
Breeding for a higher number of crimps per inch and a finer micron would also have a positive affect on the fibre as to the performance in the yarn for bulking properties.

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

Another observation was that each of the groups in the research that were classified for definition of character averaged around 6 crimps per inch. However it was noticed that as the crimp became plainer the micron became broader (chart6). This relationship has also been seen in research of merino wool (Duerden1929).

This reinforces the importance to the breeder to breed for well-defined crimp to maximize potential fineness.

<u>NOTE:</u>
When testing for curvature, measurements were recorded on both OFDA and LASER machines (same samples), to identify repeatability between both machines. The significance of the <u>difference in curvature measurement results between both testing machines</u> was of concern (graph 14). There was an average difference of 17.4 deg mm.

Meaningful comparisons of fibre curvature between different fleeces can only be made if measured by the same techniques. <u>So stick to the same machine (OFDA or laser)</u>, and if quoting curvature results list the test machine.

<u>CRIMP</u>

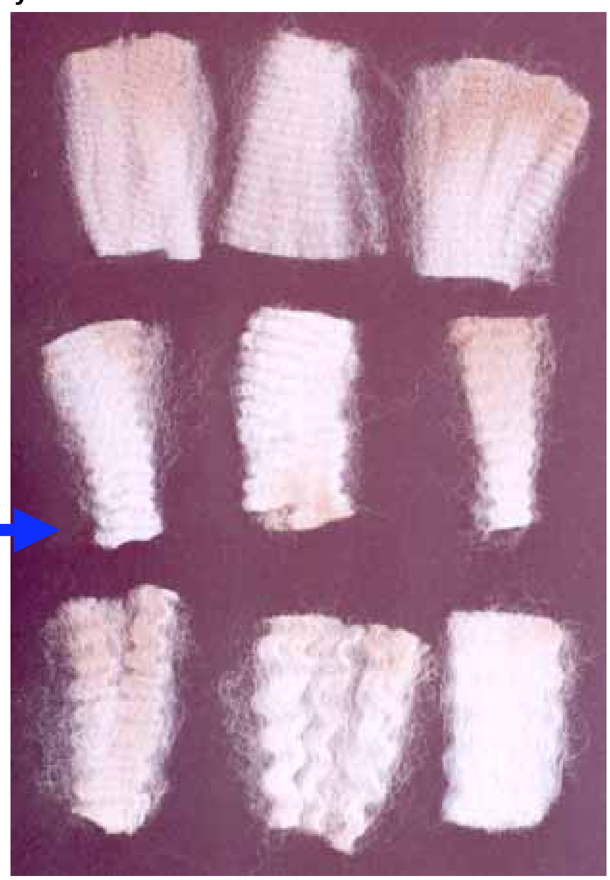
Crimp is the natural wave formation found in the Huacaya fleece.

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.

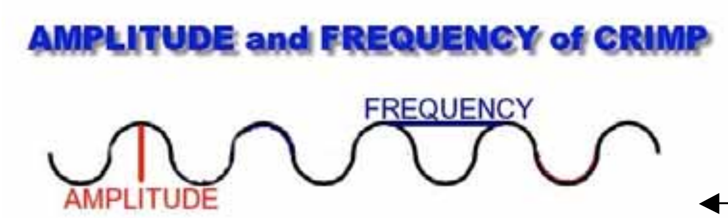
In the wool industry, a good well-crimped fleece is said to indicate that the sheep is well-bred and more likely to breed true to type.

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 (photo 1) 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.



(dia 1)

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.

A well-defined deep crimp could indicate fibres of a more similar micron growing uniformly together in a tightly packed staple. Dr. J. Watts suggests that with these uniform deep well-defined crimps are associated with lower C of V.

In traditional merino of low to medium frequency crimped wools (lower number of crimps per inch, eg: around 12/13 crimps per inch - 23 microns) enables the processor to produce yarns for both the worsted and woollen systems. Merino wools of high frequency crimped wools (greater number of crimps per inch, eg: fine merino around 16 crimps per inch for 19 microns) enables the processor to produce "more bulky" woollen yarns. The lower frequency deep crimped wools (less number of crimps per inch, SRS® types around 12/13 crimps per inch for 19 microns) of a **similar micron** tend to be smoother and leaner and have a kinder handle. These wools where their length is above 75 mm are desirable in the worsted system, although they can still be used in the woollen system.

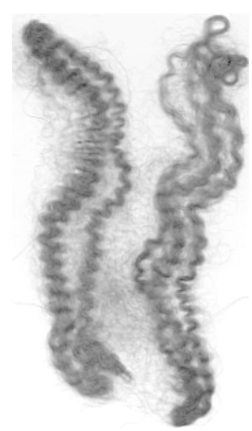
(chart 1) →

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. This indicates that alpaca breeders can breed for a higher crimp frequency (more CPI), that would be still suitable for both the woollen and worsted systems. The average CPI from the research was 6 CPI (chart 6). A long way from a possible fine microned 12 CPI fibre.

McColl (2004) states, "Less crimp results in leaner, smoother, less bulky yarns and fabrics, an attribute for worsted constructions.

Dr. Jim Watts has identified in sheep, that the deep evenly formed crimped wools usually have more uniform fibre structure, density and lustre.

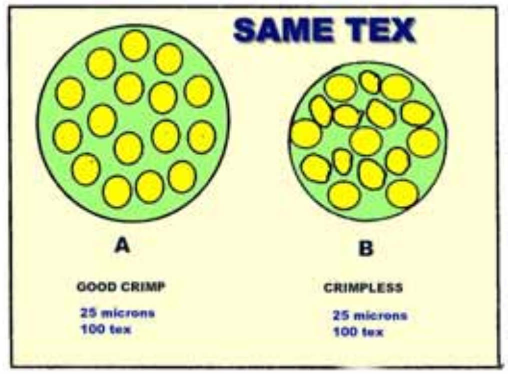
Trials carried out by the CSIRO identified sheep wools with a lower crimp frequency and a high crimp definition had a 3% improvement in card losses and up to a 16 mm advantage in the hauteur (top length). The well-aligned fibres (due to the high crimp definition) are usually more similar in micron and length and are generally softer to feel. *(photo 2)* →

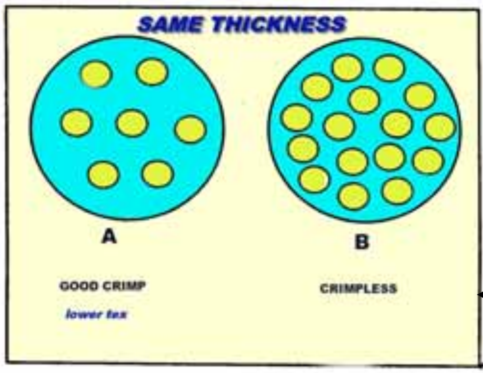


McColl (2004) states "(alpaca) mean fibre length after carding is also influenced, to varying degrees, by crimp……..and the degree of fibre entanglement after scouring."

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.

Examples of the above would be to compare 2 samples of the same micron e.g 25 microns, and the same weight e.g. 100 TEX. Sample (a) would create a more bulky yarn than (b) remembering they have similar numbers of fibres in the cross section of yarn. (dia 2) →





If you create two yarns of a given thickness (volume) with one yarn (a) being constructed with well crimped/crinkled fibres and another with little or no crimp or crinkle (b) there would be less fibres in the cross section of (a) which would equal low lineal density (lower TEX), but still retaining original thickness of yarn, it therefore would be lighter in weight than the yarn (b).
← (dia 3)

Note:

TEX, Universal Metric System for weighing yarns (most common) TEX = Weight in grams per 1000 metres

e.g. TEX = 500

therefore = 1000 metres of yarn weighing 500 grams
(A TEX of 300 is finer than 500)

Dr Paul Swan, Senior Australian fibre researcher made the following comments about crimp and curvature in a study done for IWTO, New Delhi, April 1994, by Brims and Peterson, "<u>Measuring Fibre Opacity and Medullation using OFDA - Theory and Experimental Results on Mohair"</u>:

"… The evidence linking wool fibre crimp to wool processing efficiency and product attributes is now unequivocal. Fibre crimp is a determinant of both topmaking and spinning efficiency and has an important role in influencing the mechanical properties of wool fabrics, especially tactile properties. In an age of increasing specification and product differentiation, a measurement of fibre curvature is ideally suited on the role of specifying fibre crimp throughout the wool-processing pipeline. I believe that in the near future the distribution of fibre curvature will join those of fibre diameter and length in being the primary fibre dimensions specified in wool trading …"

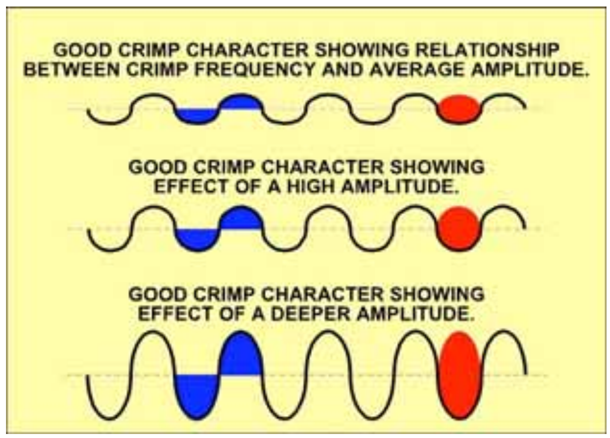
FACT: Averages can give you a good indication of trend but they also can hide some important information, particularly when the whole population is very scatted and therefore may not indicate the true picture.

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.

This illustration demonstrates what you would expect to see for a good crimp with average amplitude through to a good crimp expression with deep amplitude.

(dia 4)



Now apply the amplitude assessment to the three photos of degrees of excellence of character.

You can see the definition of crimp structure and deep amplitude in these superior fleece samples. This type of fleece structure was the most consistent of all the samples measured.

(photo 3)

This should be the aim of all huacaya breeders

NOTE, irregular crimp definition and amplitude in this average group when compared to the superior group. The research data showed this group to be unreliable in evaluation

(photo 4)

(photo 5)

NOTE, total lack of crimp structure (although has crinkle). Consistency was overall worse than the average group. Females with this fleece structure **can be improved** using males with a fleece structure similar to the superior group. I would not recommend using males from these fleece types.

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 (dia 5).*

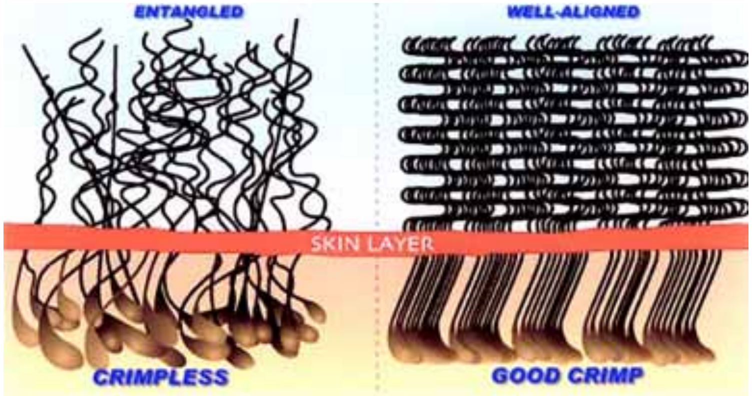
In alpaca, if it's crimpless with no fibre alignment, it will usually be an open fleece. Under the skin the follicles will be formed in an unorganized fashion (photo 7). These are sometimes referred to as fleece with crinkle, which usually have limited staple crimp structure.

Micro staples with well-aligned fibres are easily stripped without entanglement. (photo 6)

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

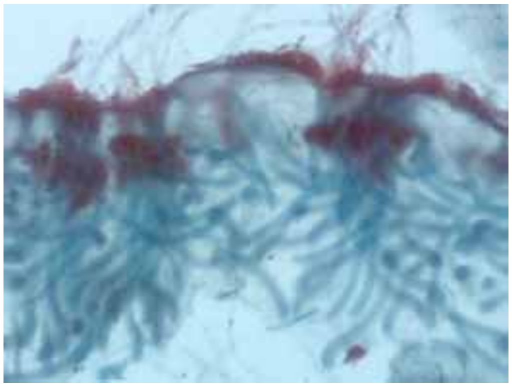
You will normally find that "well-organized" (aligned) follicles are growing denser fleece due to the close proximity to each other in the skin.

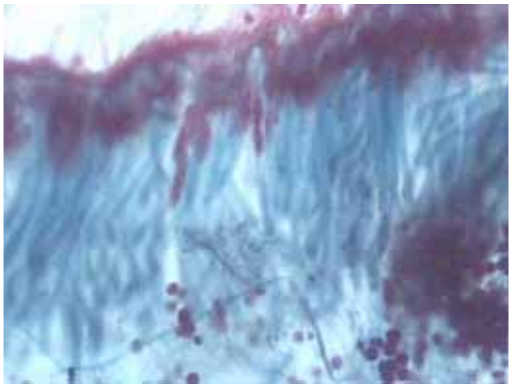
(dia 5) →



(Adapted from Dolling/Watts 1995)

Vertical skin sections





(Holt 1995) (photo 7)
ENTANGLED FOLLICLES

(photo 8)
REASONABLY ALIGNED FOLLICLES

Dr Jim Watts with his SRS® merino breeding has shown there is a close association between follicle density and "high crimp amplitude" (deep crimp). He has also found that high crimp amplitude and bold crimp contribute to greater fibre length. (ALPACA – photo 9))

Bold crimp example:
TRADITIONAL merino 19 microns (16 crimps per inch)
BOLD merino 19 microns (12/13 crimps per inch). A change of around 20/25%.

Watts is currently applying these sheep breeding principles to alpacas and has found that in the first stage of this breeding process the **huacaya fibre is following a similar pattern to that of merino wool.** Watts has noted from his research that SRS® merino sheep crimp around every 8 days whereas huacaya fibre crimps around every 16 days.

Crimp therefore becomes a good subjective selection trait to help obtain maximum fleece production.

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. 3 or 4 years old, this would indicate that the alpaca has the ability to maintain its fleece excellence. This certainly is an important trait you should look for in your selection process.

To be of maximum benefit we need to have superior crimp. This crimp should display high amplitude and regular crimps per inch. Merino fibre with this superior crimp style has shown the following attributes, and considering the similarity between merino and huacaya it would be not unfair to hypothesise the following statements.

The superior fibre should express:

TO THE BREEDER

- High fibre density
- Highly aligned fibres
- More even sized primary and secondary fibres
- Greater softness
- More lustre
- Fibres should be more cylindrical
- Fibres should be finer in micron
- Provided length is maintained, higher fleece weights should be achievable

TO THE TOP MAKER

- A longer hauteur
- Less short fibre in the top
- Soft handling tops

TO THE SPINNER

- The ability to have higher spinning speeds
- Lighter weight yarns

TO THE FABRIC MAKER

- Softer and lighter weight garment
- Better drape and retention
- Better dyeing affinity
- Better cut and sew
- Softer and better handle in the knitwear

INTERVIEWS WITH PERUVIAN PROCESSORS

(Over a number of years)

CHARLES PATTHEYS (1998)
PROJECT DEVELOPMENT AND RESEARCH MANAGER - INCA TOPS GRUPO INCA

DEREK MICHELL (1998)
OPERATIONS MANAGER - MICHELL & CIA., AREQUIPA, PERU.

LUIS CHAVES (2005 through M. Safley)
SUPERVISOR - INCA TOPS GRUPO INCA

QUESTION: What importance is crimp to you in huacaya fibre.

ACP: We prefer to have a more even crimp than the non-crimped fibres. A well-defined crimp appears softer.

ADM: Crimp is important to the huacaya fleece and if I could, I would like the staples to have a good crimp formation.

LC: I prefer crimp – I prefer the high curvature. Breeders need to know that crimp fibre is important, they can earn more money from it. Alpaca is less uniform than wool and with more crimp, in my opinion; the alpaca will be more uniform.

QUESTION: How much importance when processing huacaya fibre is placed on the bulk (curvature of the fibre).

LC: Bulk from crimp is very important in the textile industry. With crimp my garment will be lighter and more valuable. It affects positively the entire chain of value.
The main problem with alpaca is the weight of the garment, and with crimp the garment is lighter (due to the bulking properties of crimp).

QUESTION: If you could change one or two things in the huacaya or suri what would they be?

ACP: No contamination of hair colour, improve the crimp and have no medullation (guard hair) in the fleece.

ADM: The alpaca fibre is heavy so would like it lighter if possible and less medullation (guard hair).

LC: I would like to improve the micron count, remove the kemp (guard hair) and remove colour contamination (black fibres from white fleece and conversely white fibres from coloured fleece).

QUESTION: What do you think is a good micron (huacaya) for alpaca breeders to aim for?

LC: A goal for the ideal micron count should be 18 microns. This would improve the entire value of the alpaca.

This would allow us to compete with cashmere.

There would still be a place for superfine alpaca with an overall average of 21 microns.

There would be a huge market for the 18 to 19 micron alpaca.

Juan Pepper of Michell Co at a lecture titled "The International Market Place" stated

"The lack of crimp in huacaya fibre is a significant problem for processors". He also went on to say "crimp could be added artificially during the manufacturing process, but that yarn made in this fashion did not retain a "memory" of the crimp which was a problem." (Safley 2005)

Note:

Huacaya fibre with good crimp definition retains its memory in the yarn.

It would be interesting for a fully controlled research project to be carried out using 1000 huacayas and 500 suris that are selected for their fibre types, micron, age, frequencies/lock type etc. This would give a more accurate indication. Having said that, nothing in the short term will change the genetic variance between animals and how they express their micron, crimp frequency and definition. Strains of alpacas will develop and have their own indicative characteristics. It will always be easy to have averages but from those averages there will be a number of animals that will lay either side of the mean, some close and some far away. You cannot say with confidence that a Huacaya with a given crimp frequency will always have a certain micron. You need to check to confirm its fineness.

REASERCH DATA INFORMATION

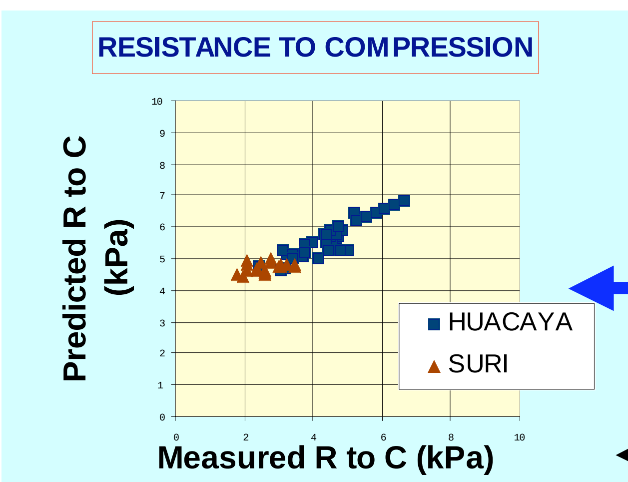
RESISTANCE TO COMPRESSION AND BULK

DEFINITION

Resistance to compression is the resistance offered by a known mass of wool when compressed to a known volume (it is like squeezing a handful of wool, some will offer no resistance, some will offer a lot.)

Back in the early 90's little information was around in Australia regarding the compressibility of alpaca fibre. C. Holt and S. Scott of the Melbourne Institute of Textiles whilst studying characteristics of suri fibre decided to investigate the resistance to compression (g.sq.cm) of both suri and huacaya fibre and compare those results to the curvature of those same samples. A small trial (Holt,Scott 1995) was started and the results were as follows.

The Suri fibre was shown to have the lowest reading of compression when compared to the crimpier fibred Huacaya. Suri (range 18 g.sq.cm - 35.5 g.sq.cm). Huacaya ranged for compression from 36 g.sq.cm - 55 g.sq.cm. It was also evident that those lustrous Huacaya (not Suri) fibre types (with the lower fibre amplitude) tended to have a lower resistance to compression to those of the more crimpy types. These results were then discussed and analyzed by Dr Paul Swan, an expert in this field of measurement.



Dr Swan compared the alpaca curvature/compression results with those he had tested on wool. He used the simple mathematic relationship between diameter, curvature and resistance to compression (compressibility equals mean diameter -power 2 x mean curvature -power 1.5). The data was expressed in kilopascals.

This can be seen in the graph showing predicted resistance to compression (using curvature data input) compared to known measures resistance to compression of both the suri and huacaya samples.

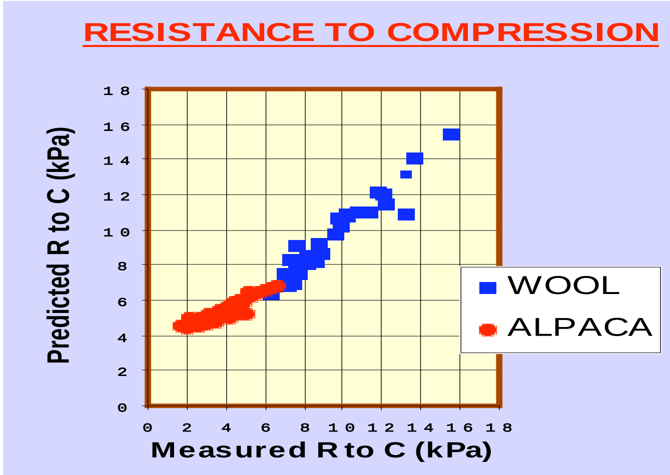
(graph 1)

Dr Swan, when he compared results of alpaca resistance to compression and curvature readings (Holt/Scott) to similar data that he had from merino sheeps wool said **"that the alpaca adheres to the same basic relationship between compressibility, diameter and curvature as does wool".**

Wool correlation .96
Alpaca correlation .92

(Holt/Swan1995)

(graph 2) →



Although when graphed, the slope of the relationship for alpaca differed slightly to that of merino wool. This may have been because of the different curvature measurement systems being used between the two sets of data, there may have been a difference between the keratin of the alpaca and wool fibre or the lower scale protrusion on alpaca fibre may have effected the measurement of the resistance to compression. **However the physical laws governing the compressibility of alpaca and wool fibres appear to be the same.**

It was however noticeable that the **alpaca fibre had a lower resistance to compression reading than was evident for merino wool.** It should be noted that in the merino results in the above graph the lower readings were from "SRS" type merino fleece. These are the fleeces that for a given micron display a slightly broader and deeper crimp frequency.

Some 10 years later from our small trial, Angus McColl et al (2004) found " The intrinsic resistance to compression of alpaca is low because of the relatively low levels of crimp". Things had not changed. A research paper from Deakin University (Liu, Wang, Wang, 2004) also found that the resistance to compression for alpaca was lower than for wool.

To better understand correlations a "layman's definition" is shown below (chart 2);

CORRELATION	DEFINITION
.8 / .9	QUITE GOOD
.7	REASONABLE
.5 / .6	AVERAGE
.3 / .4	POOR
.1 / .2	MEANINGLESS

CURVATURE

FACT Curvature is affected by

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

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

There is a good correlation between fibre curvature and staple crimp frequency (sheeps wool).

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.

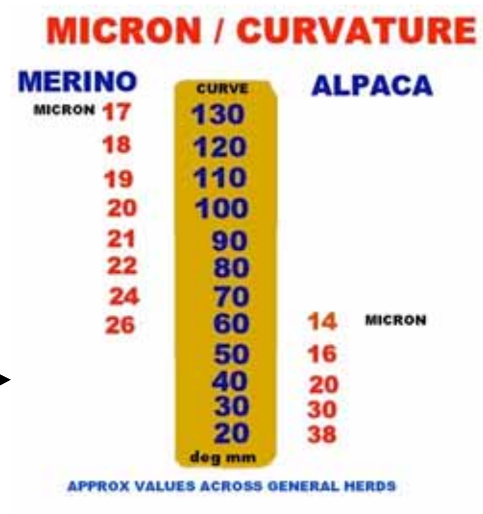
It is found in wool that a very high curvature value for a given micron is associated with increased noil (due to breakage during processing) in the top which creates lower spinning performance. The fibres, which have a lower curvature for a given micron, tend to be softer to hand and do not have the same noil wastage. It was also found that wool of poor character (crimp definition) tended to show fibre breakage in processing compared to fibres of good character.

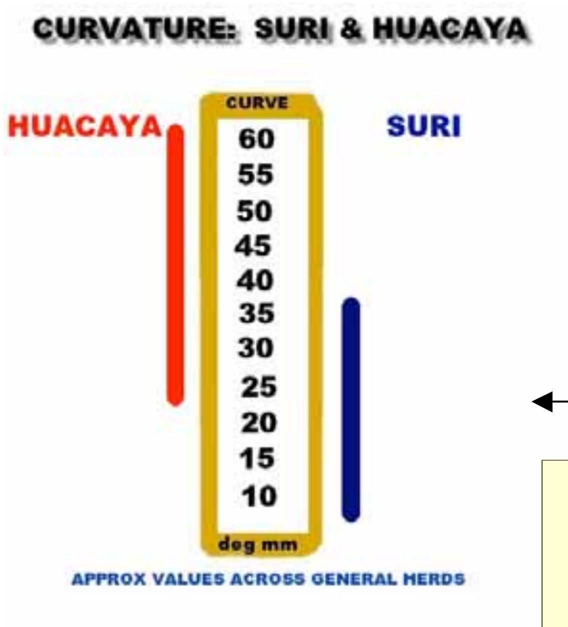
Mark Dolling during processing trials found that the curvature in the top was less than in the greasy wool. He suggested that some of this was due to the straightening of the fibres during processing and also the removal of the short high curvature noils during the combing process. He also found wool of lower curvature to be more efficient to process giving a higher yield of top than wool that has a higher curvature.

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.”

Dr Paul Swan has identified that for traditional merino sheeps wool of low crimp frequency (around 8 CPI), curvature readings were around 60 degrees per mm and up around 130 degrees per mm for superfine wool (around 20 CPI). As you can see the alpaca (Huacaya) slips in at the 60 degree area and below.

(chart 3)



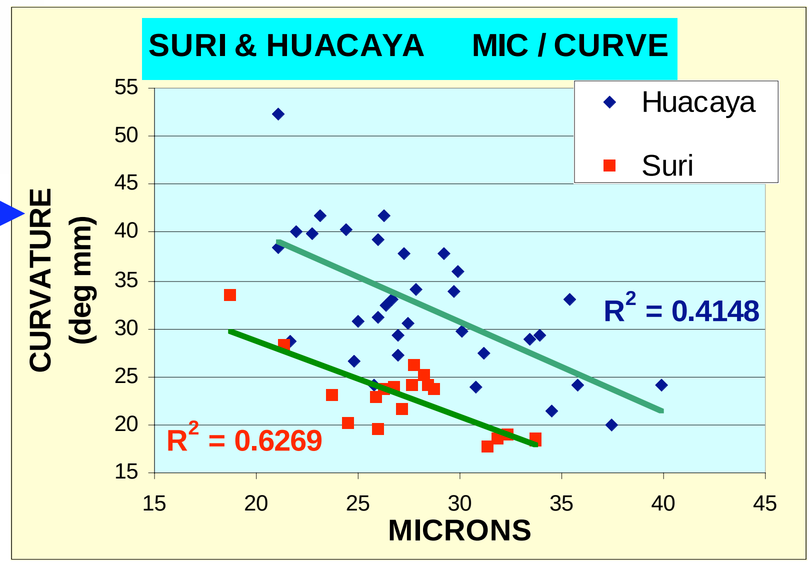


Curvature (ofda) values in Suris have tended to give a range from 15 to 35 (some as low as 10) with the Huacaya showing a range from around 25 to 60. It was noted that the coarser the micron, generally the lower the curvature value. Also when the C of V was more variable (higher) the curvature value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

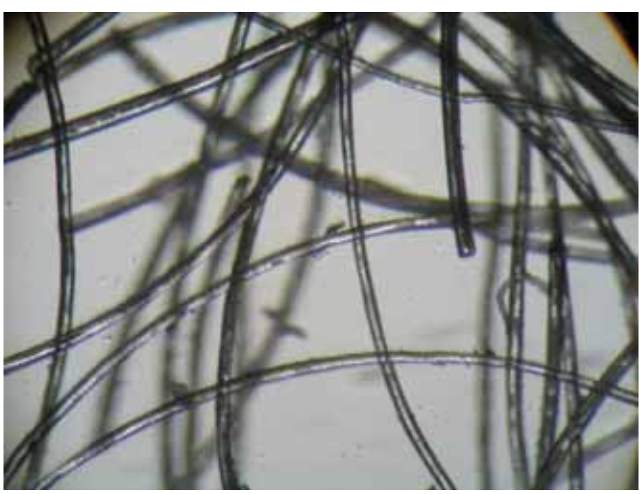
(chart 4)

The graph, (no 3)

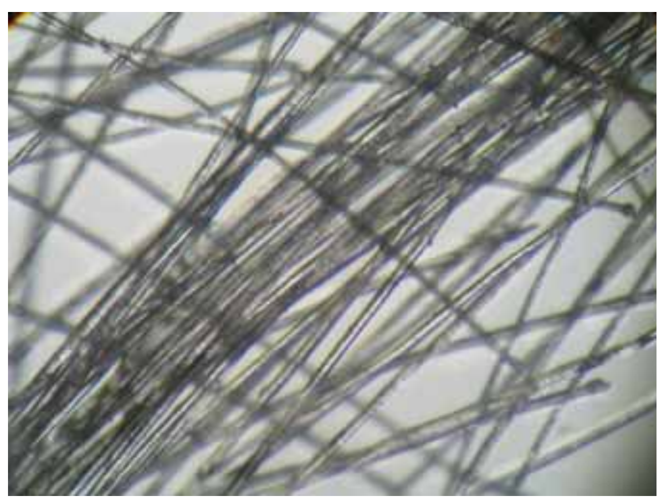
formulated from measurements in the study (Holt/Scott 1994), show the spread for micron and curvature in both suri and huacaya. The huacayas had a .64 correlation, whilst the suri had .79 correlation.



Note below the curvature in the huacaya fibres compared to the straighter Suri fibres.



HUACAYA (X120) photo10
(photos-Abiola/Holt)



SURI (X120) photo 11

DEFINITION

CHARACTER is the expression of depth and evenness of the crimp or wave throughout the staple and entire fleece. The character indicates how well the fibres are aligned in the staple (definition of character).

CHARACTER RATING USED IN THE CRIMP / CURVATURE STUDY

The ratings for character definition were

1. **Excellent-superior** – 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. **Poor** – little crimp definition or regulation visible
6. **Inferior** – no crimp definition visible. Straightish fibres (not Suri)

(photo 12)

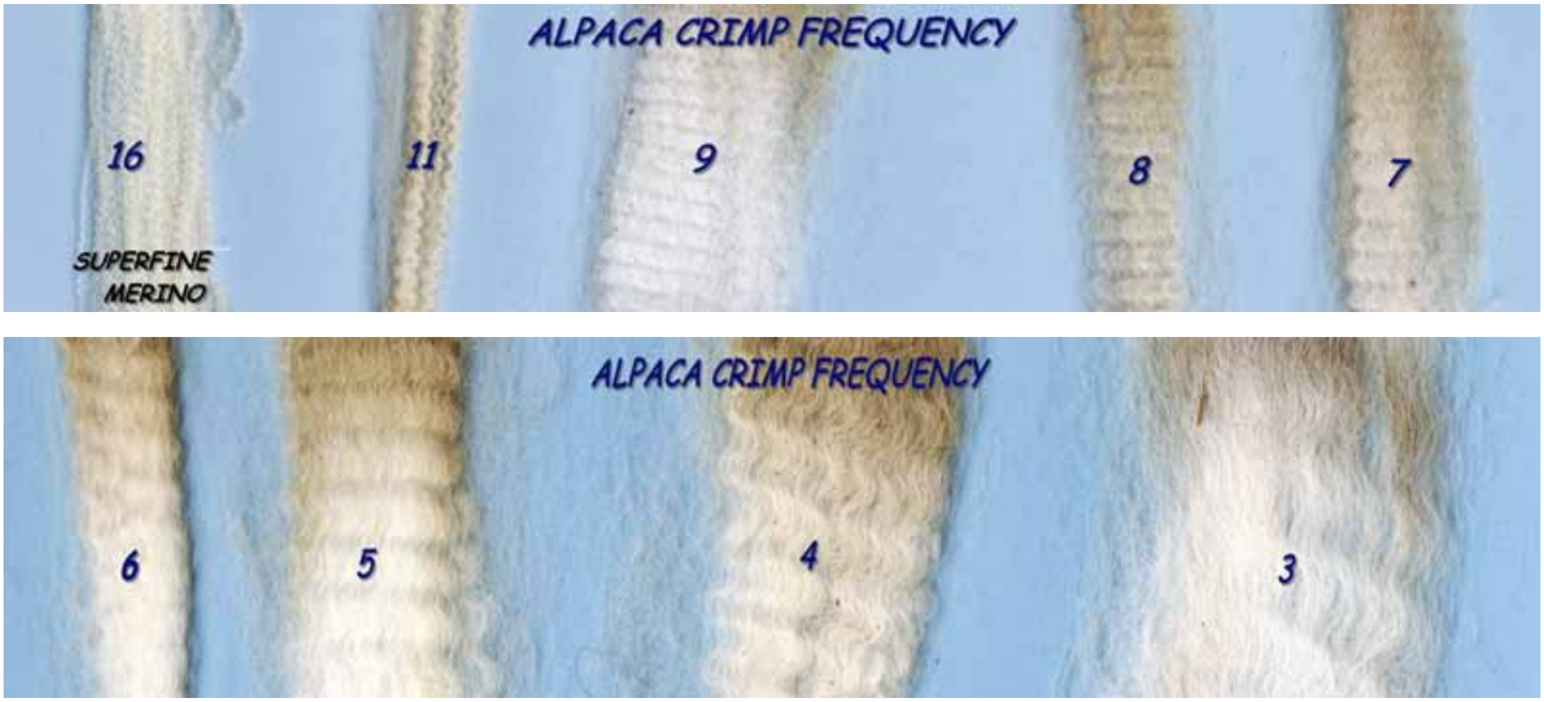
10/9	**8**	**7**	**6/4**	**3/2**	**1/0**
excel-sup	good	g/ave	average	poor	inferior

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, but not absolute.

CRIMP FREQUENCY RATING USED IN ASSESSMENT



(Photo 13)

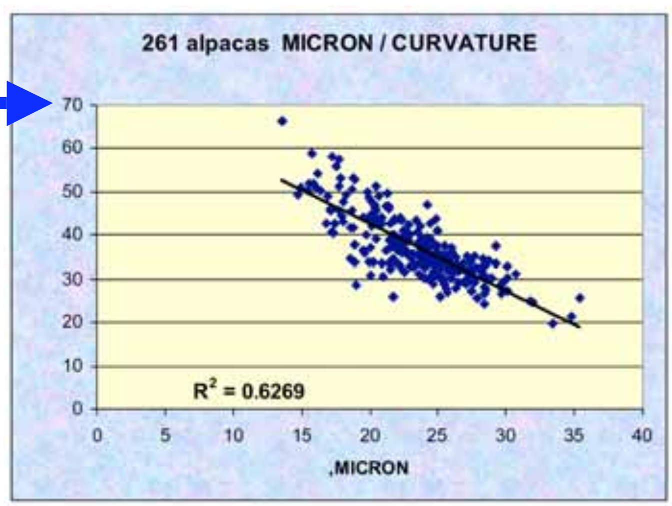
CHARACTER DATA FROM THE 261 ALPACA RESULTS
(Divided into character groups, 1&2, 3&4, 5&6. (chart 5))

	CORRELATIONS			
Crimp rating	1/6	1/2	3/4	5/6
Number x/261	261	97	88	76
MICRON / CURVATURE	.79	.81	.41	.72
MICRON / CRIMP FREQUENCY	.44	.71	.30	.19
CURVATURE / CRIMP FREQUENCY	.46	.77	.08	.03
CHARACTER/ CV of CURVATURE	.33	.31	.11	.15

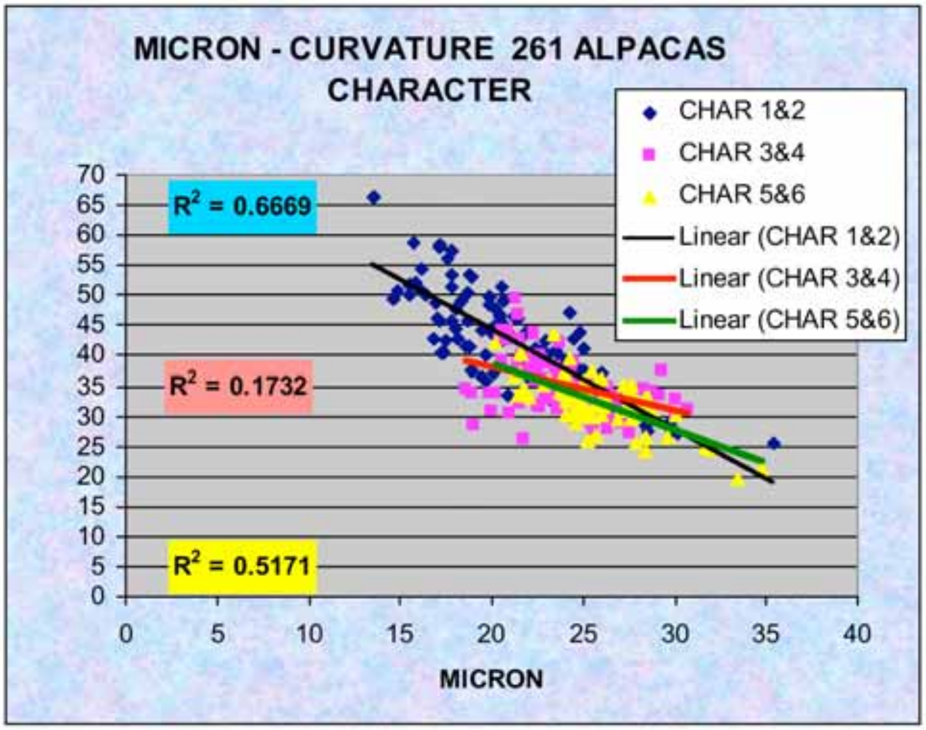
MICRON, CURVATURE COMPARISON (261 alpacas)

This graph (no 4) shows the spread and relationship of micron and curvature in the 261 samples. A trend line indicates the approximate average between the micron and curvature. This spread indicated a .79 correlation

This suggests that overall relationship for micron and curvature is reasonably good for the entire sampled population and that micron is a strong influence on curvature.



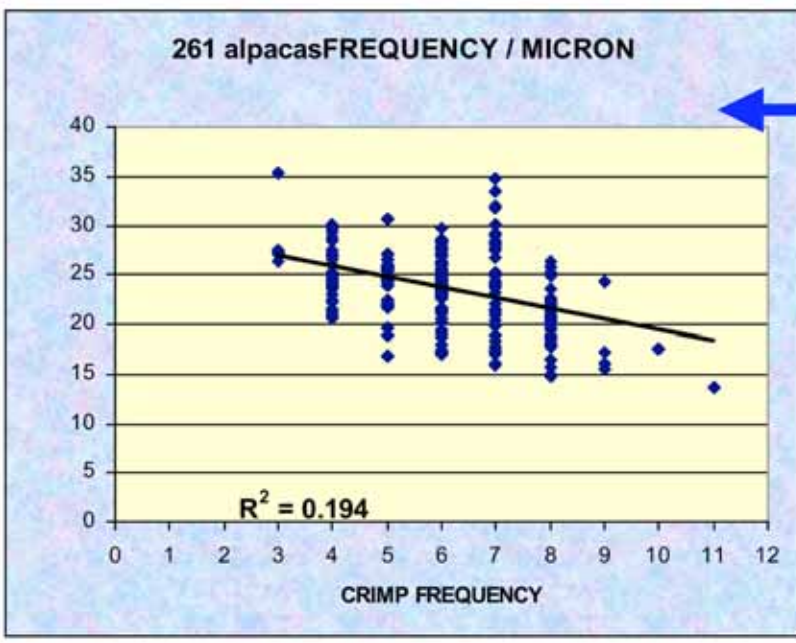
Showing the spread of the above graph in character groups.



Note in particular the 3 / 4 charactered group, showing a greater spread.

(graph 5)

CRIMP FREQUENCY, MICRON COMPARISON (261 alpacas)



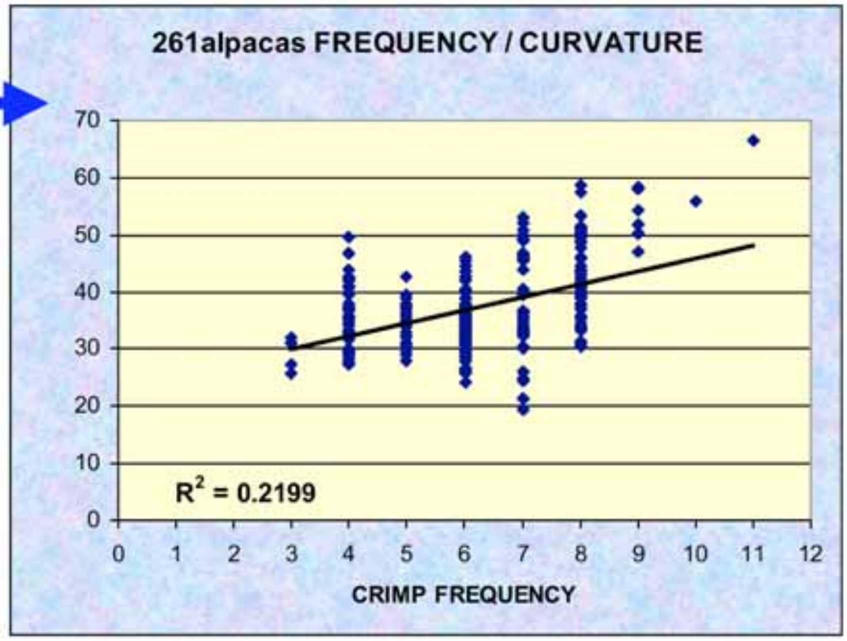
This graph (no 6)

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.

CRIMP FREQUENCY, CURVATURE COMPARISON (261 alpacas)

This graph, (no 7)

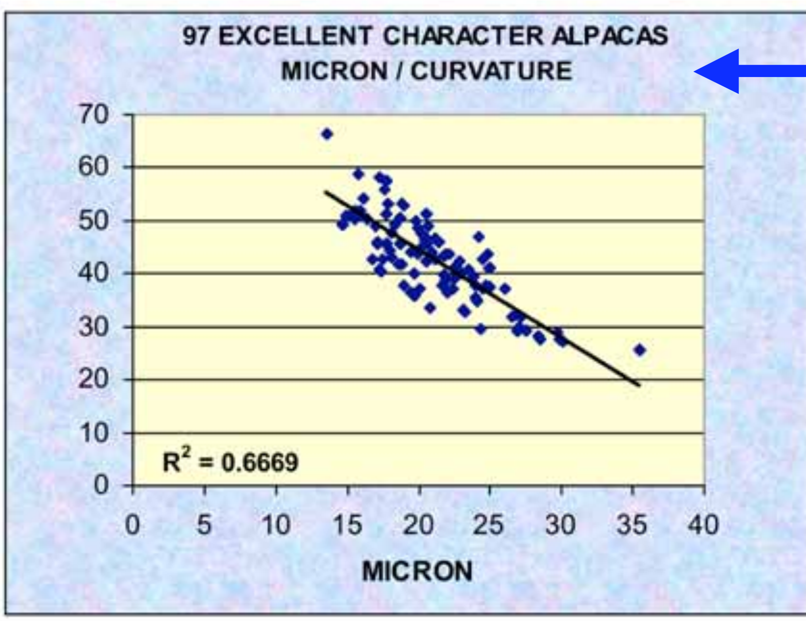


shows the relationship and spread of the curvature and crimp frequency. The data indicated a .46 correlation.

A similar result to graph 6 is indicated with some 78% of the measurements not being able to be explained. This is surprising as one would think the frequency would have a stronger relationship with curvature.

COMPARE THE 261 GROUP TO THE SELECTED 97 SAMPLES OF GOOD CRIMP FORMATION

MICRON, CURVATURE COMPARISON (97 alpacas)

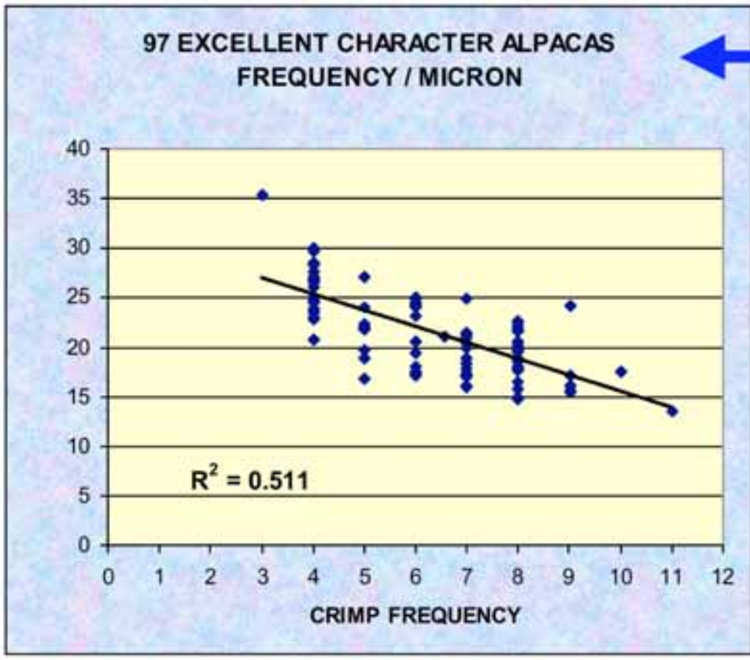


This graph (no 8)

shows the spread and relationship of micron and curvature in the **97 excellent characted** alpaca samples. A trend line indicates the approximate average between the micron and curvature. This spread indicated a .81 correlation

A stronger relationship is shown for micron and curvature in the selected "good/excellent" group. This tends to reinforce the influence of micron over curvature. It also demonstrates that the better crimped fibres are more consistent, when compared to the overall herd with their varying crimp definitions.

CRIMP FREQUENCY, MICRON COMPARISON (97 alpacas)

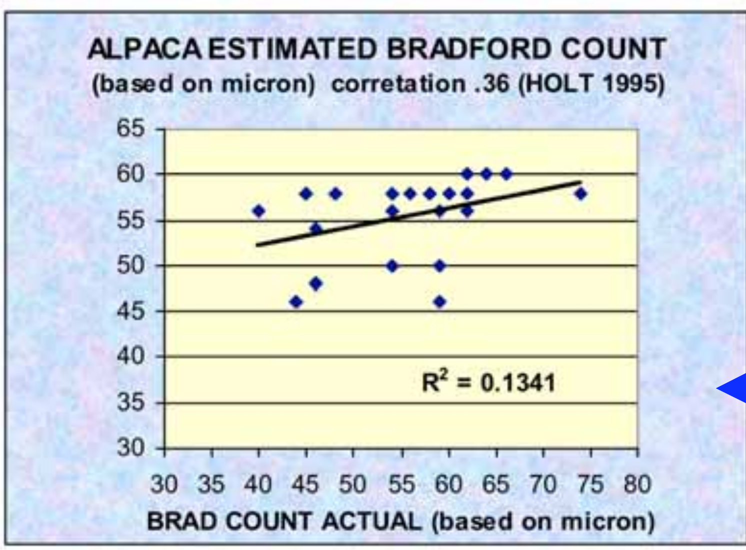


This graph (no 9)

shows the relationship and spread of the micron and crimp frequency in the **97 excellent characted** alpaca 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.

If you were going to use crimp frequency as an indicator of fineness it is only going to be the good, well defined charactered wools that have a chance of being consistently assessed. The data suggests that in this group there is only a 50/50 chance of a correct assessment without the use of other characteristics or knowledge to help in that assessment.

Professor J. Duerden, a researcher from South Africa, developed a wool appraising system. He matched the Bradford quality count (which was used as an indicator of the processing abilities of the wool), to the Merino wools crimp frequency. He allocated quality numbers to this relationship.

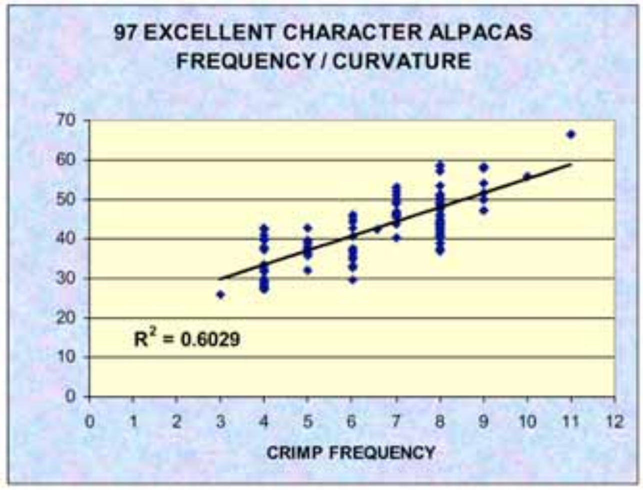


Using his system, Holt (1995) applied the Bradford counts (CRIMP FREQUENCY& MICRON) to a small number of Huacaya alpaca samples and compared them to the Duerden scale of Bradford counts.
The graph (no 10) represents this comparison

The correlation was a poor .36, similar to the result (corr .44) above for the 261-study group, micron to crimp frequency.

CRIMP FREQUENCY, CURVATURE COMPARISON (97 alpacas)

This graph, (no 11)



shows the relationship and spread of the curvature and crimp frequency in the **97excellent characted** alpaca samples. The data indicated a .77correlation, which is a reasonably good relationship when looking at the overall picture and confirms that the better styled crimp is more consistent when comparing the frequency of crimp and curvature.

The well characted group was far superior to the total sample of 261.
This would reinforce the view that well characted fleece is more consistent and therefore a more reliable selection tool than fleece lacking good crimp structure.

AVERAGE RESULTS FOR, MICRON, FREQUENCY, CURVATURE & CV micron (261 ALPACAS). (chart 6)

NUMBERS (261) CHARACTER GROUP	AVE MICRON	AVE FREQ	AVE CURVE dg sq mm	AVE CV & SD Of CURVE		AVE CHARACTER RATING	AVE CV of MICRON
				CV	SD		
261– 1 / 6	23.49	6.16	37.15	65.4	23.9	3.29	21.36
97 – 1 / 2	21.15	6.58	42.62	61.3	25.7	1.51	21.45
88 – 3 / 4	24.12	5.68	35.30	67.3	23.6	3.27	21.96
76 – 5 / 6	25.82	6.21	32.37	68.4	22.0	5.58	20.57

It was noticeable within the individual crimp frequency groups of the 261population (4 – 8 crimps per inch), that there was considerable variation for **micron** as well as for **curvature**. It is well known within the sheep industry that within different genetic strains of sheep each of the crimp frequencies have a range of microns within that group.

In chart 7 to 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 (chart 7) 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

AVERAGES FROM THE AUSTRALIAN ALPACA ASS DATABASE

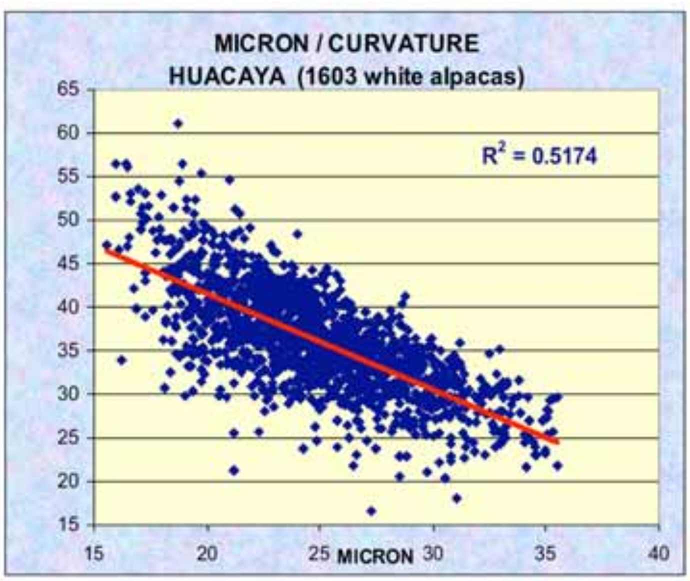
Data from 5430 huacayas along with 223 white suris were analyzed for a number of characteristics. These are shown in charts 8, 9, 10, &11 as well as graphs 12 & 13. Of particular interest was the comparison (chart 10) of average micron to average curvature. Looking at the averages a trend does appear but when looking at the actual variance (graph 12) there was still 48% of the measurements unexplained with a reasonable correlation of .72.

(5430 huacayas) (chart 8)

COLOUR	NUMBER HUACAYA	AVERAGE MICRON	AVERAGE CURVATURE
BLACK	795	28.77	26.50
BROWN	938	27.28	31.46
GREY	324	26.76	32.60
FAWN	1755	25.69	35.20
WHITE	1618	25.02	35.97

WHITE BY AGE (chart 9)

AGE	NUMBER HUACAYA	AVERAGE MICRON	AVERAGE CURVATURE
1	473	22.28	37.46
2	406	24.26	36.83
3	263	25.78	35.90
4	182	27.02	34.80
5	106	28.07	34.50
6	62	28.70	32.3
7	36	29.43	31.78
8	33	27.96	33.80
9	35	28.27	33.38
10/12	21	27.83	33.38
TOTAL	1618		



Huacaya 1603 white alpacas

(graph 12)

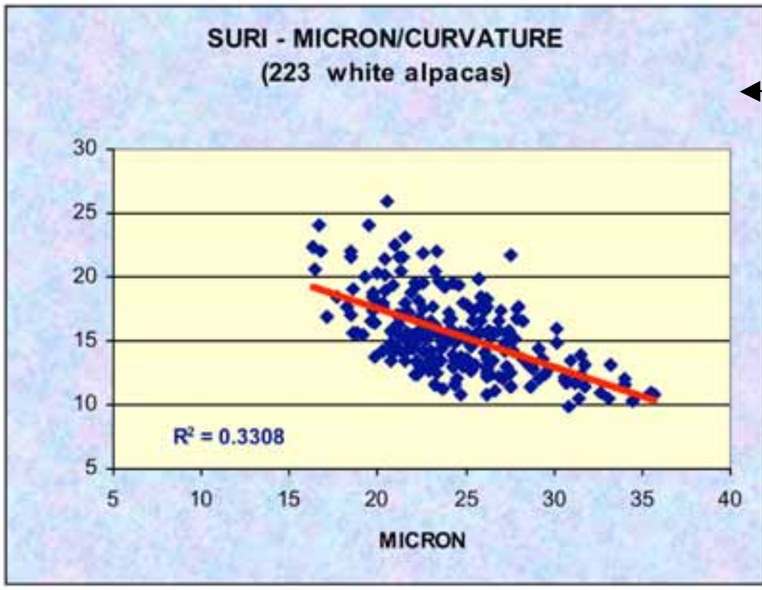
With a good spread of fibre type in the1603 white huacayas, the data indicated that there was a 48% unexplained variance (.72 correlation). The results were not dissimilar to the research data in graph 4.

McColl (2004) "average fibre curvature is negatively correlated with…fibre diameter"

This is also seen in the chart 10 (white by micron – AAA data), where as the micron gets larger the curvature value gets smaller.

WHITE BY MICRON (chart 10)

MICRON GROUP	AVERAGE MICRON	AVERAGE CURVATURE	RANGE CURVATURE	SD CURVATURE
16	16.2	49,4	56.5/33.9	28.5
17	17.1	47.7	53.6/39.0	28.9
18	18.3	43.8	52.9/30.8	26.1
19	19.1	42.9	61.0/29.8	25.3
20	20.1	40.8	55.3/29.9	24.4
21	21.1	39.7	54.6/21.3	24.5
22	22.1	38.8	49.1/25.8	23.9
23	23.1	38.2	47.2/28.6	23.7
24	24.1	37.3	48.4/23.7	22.8
25	25.1	35.8	44.4/24.7	23.0
26	26.1	34.5	43.8/21.7	22.2
27	27.0	32.9	39.4/16.6	21.9
28	28.1	32.6	39.6/20.6	22.1
29	29.0	31.8	41.2/22.9	21.5
30	30.0	30.3	36.4/14.8	20.1
31	31.0	29.5	35.9/18.0	20.0
32	32.0	28.9	34.6/23.1	21.2
33	33.0	28.2	35.2/24.0	20.5
34	34.1	26.1	31.6/21.6	19.9
35	35.1	26.6	29.6/21.8	19.8
TOTAL	24.9	36.1	61.0/14.8	23.0



Suri 223 white alpacas

(graph 13)

With a widespread grouping of animals for fibre style in the 223 white suris, the data indicated a 67% unexplained variance (.57 correlation).

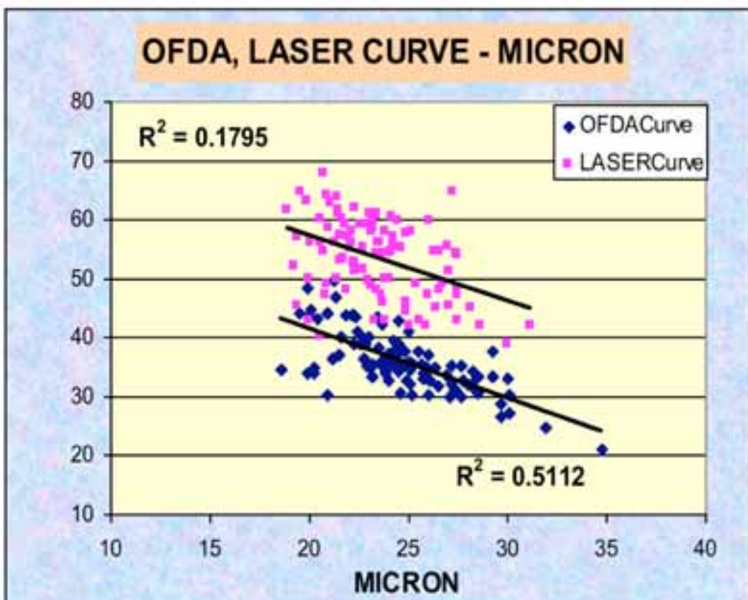
As the suri breeding becomes more advanced this correlation should improve as the range of fleece types becomes more uniform.

SURI CURVATURE White by micron (223 alpacas) (chart 11)

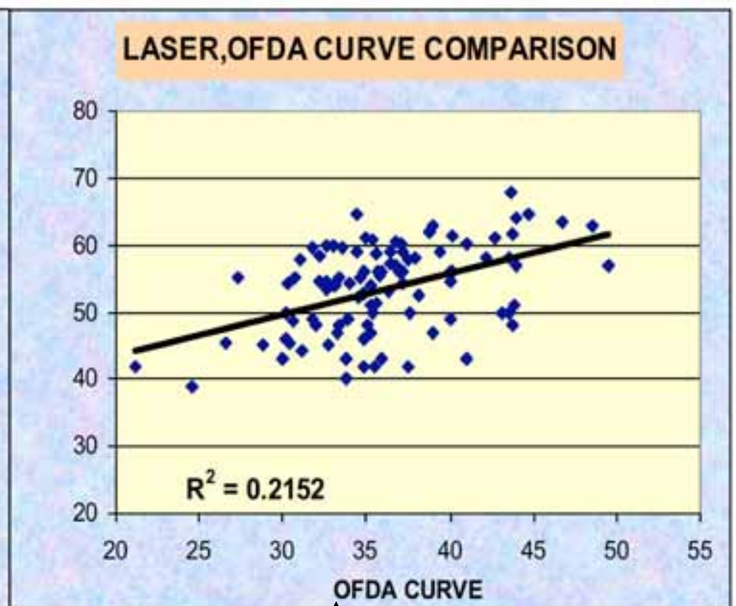
MICRON	CURVATURE	SD CURVE
16/18	20.28	19.2
19/20	18.34	19.3
21/23	16.01	16.28
24/25	15.05	16.2
27/30	14.41	16.5
31/35	11.66	14.2

<u>COMPARING OFDA CURVES WITH LASER CURVES</u> (Same 100 HUACAYA FLEECES/SAMPLES tested on each machine) (chart 12)

MICRON	AVERAGE MICRON		AVERAGE OFDA CURVE	AVERAGE LASER CURVE	DIFF LASER/ OFDA CURVE	DATA NUMBER	
	OFDA	LASER				OFDA	LASER
19 –20	19.80	19.63	40.12	54.76	14.64	9	9
21 – 22	21.68	21.49	41.27	56.09	14.82	15	29
23 – 24	23.67	23.50	37.29	54.44	17.15	29	33
25 – 26	25.30	25.50	34.48	49.51	15.03	22	13
27 – 28	27.59	27.23	32.50	50.69	18.19	15	13
29 - 30	29.57	28.45	30.95	43.50	12.55	8	2
31 – 34	33.3	31.15	22.90	41.95	19.05	2	1
AVE	24.66	23.51	36.01	53.41	17.4	TOTAL 100	



(graph 14)



(graph 15)

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).

At the time of writing this article it is important to say that each of the testing machines have their own testing standards (even though their scales of measurement are different). No international standard has been agreed to, where you would expect to get the same result from both machines (as is found when testing for micron).

(chart 13)

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.

So if you are a breeder pick a machine that gives the group of results you want, and stick to it.

ALPACA (huacaya)

The Alpaca chart below are **<u>estimated relationships only</u>** **for crimp frequency, curvature and micron** (<u>based on **good / average crimp definition and better: I – 3 appraisal**</u>). These are based on general data in studies conducted by the writer in 1994,2004 2005 as well as data from AAA & Groupa Inca 2004. I would expect these estimates to become more accurate in time, as the alpaca herd in Australasia, Northern America and Britain become more consistent
<u>A bias was made in this chart towards the better-crimped fibre.</u>

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

(chart 14)

Regression relationships with crimp frequency for the character group 1 / 2

The table below shows **predicted values for micron and curvature based on the regression relationships with crimp frequency for the character group 1 / 2 (good to excellent character).** These values are consistent with those in the table above, as mentioned, estimated qualitatively from a broader range of data. (chart 15)

Frequency	Curvature	Micron
12	62.24	12.25
11	58.62	13.89
10	55	15.53
9	51.38	17.17
8	47.76	18.81
7	44.14	20.45
6	40.52	22.09
5	36.9	23.73
4	33.28	25.37
3	29.66	27.01
2	26.04	28.65

WOOL (APPROX AVERAGE CURVATURE VALUES) (chart 16)

NUMBER OF CRIMPS PER INCH	FIBRE CURVATURE (DEG mm)	MICRON (approx)
19/22	130/140	16/17
18/19	120/130	17/18
17/18	115/120	18/19
15/17	100/110	19/20
13/15	85/100	20/22
10/13	75/85	22/24
8/10	65/75	24/26
7/8	55/65	26/28
5/6	45/55	29/31

FOR THE MATHEMATICALLY INCLINED,

SOME FINDINGS FROM STUDY

OBSERVATION

When analyzing the 261 alpaca samples it was very evident that the good styled character (1/2 rating) displayed more consistency between the relationships of micron – frequency – curvature. However as a total group, only the micron to curvature showed any reasonable relationship.

This trend makes it very hard to confidently assess or estimate characteristics, particularly crimp frequency to micron on a herd of mixed types.

DETAIL

The good styled character (1/2 rating) displayed more consistency between the relationships of micron – frequency – curvature.

The correlation between **micron and curvature** in the 1/2 group was good (.81) compared to the average group, which displayed a poor correlation (.41). In the 1/6 group (all 261 samples) a reasonably good correlation (.79) for micron to curvature was evident. The relationship for micron and curvature was strongest throughout for this comparison when compared to the other relationships.
In the AAA Data, the curvature to micron showed a .72 correlation. This was similar to the 261 alpacas in main study (.79 correlation). This could indicate that the sample population in the main study is indicative of the population in the AAA Data, which was drawn from all over Australia.
The AAA Data group averaged 24.9 micron with a 36.1 dg.mm average and a CV of curve 63.6%. This is not that different to the main study with the 261 total group having a 23.5 micron and 37.15 dg. mm average and a CV of curve 65.4%.
The #5430 alpacas of all colours (AAA Data) had a correlation of .76 for the micron to curvature. This group had averages of 26.3 microns, with a 33.4 dg.mm average and a CV of curve 64.7%.

In the **micron to crimp frequency** (#261) comparison the relationship was poor **-** (corr .44) except in the **1/2 group, which displayed a reasonable correlation (.71).** This is still about a 50/50 estimate.

Brown (2005) for stud sheep research (from some 3500 sheep of various genetic backgrounds, good crimp definition), where he found a correlation of .52 for the mean fibre diameter to crimp frequency relationship. Indicating the variances between CF and MFD, not to dissimilar to alpaca, but slightly less consistent.

The curvature to crimp frequency, except for the group 1 / 2, was poor to meaningless. The overall result of .46 correlation was indicative of the influence of the 3 / 4 and 5 / 6 groups, (.08 / .03 correlation respectively). However the **1 / 2 group (.77 correlation) was far more consistent.**
These results were similar to Brown (2005) stud sheep research where he found a correlation also of .77 for the curvature to crimp frequency relationship.

The **average micron** also increased from the 1 / 2 group (21.15) through 3 / 4 (24.12) to the 5 / 6 group (25.82). Unfortunately ages were not known, as older animals in the lower groups may be an influence. However this may be due to the character becoming more irregular and lacking of definition.

This has been shown in past research (merino sheep) to be an influence (Duerden 1929). He whilst allocating quality numbers on adult wools, found, that the plainer wools (lacking regular character, expression and definition) tended to become coarser in fineness as the character expression diminished.

The first factor, mentioned above, that may affect the consistency of the Alpaca results, is that the samples ranged from an age of 1 year to 5 years (ages were not available). Alpacas are at their finest as a 1 year old, the same as sheep and tend to become stronger with age/body size increase. This is shown in the AAA data. Averages (white by age). 1 yr – 22.3u 2 yr – 24.3u 3 yr – 25.8u 4 yr – 27.0u 5 yr – 28.1u.

It was interesting to note that the increase in micron seen as the animal became older, shown in the AAA data, was similar in trend to that found by Holt (2001) from data collected in 1999.

As mentioned earlier, if growers breed well defined crimped (good/excellent character) fibre their consistency of evaluation would be more correct. I therefore suggest that selection for good expression of crimp would be more reliable.

Curvature appeared to be influenced more by micron than the frequency and amplitude although the frequency and amplitude did have a varying influence.

When comparing the large group of alpacas (1603) curvature AAA data with data of the selected 97 alpacas in study 1 (which had a crimp character rating of 1 – 2), the latter showed a higher curvature reading in general for the above 22 micron groups.

From the AAA data coloured fibre was coarser in micron and lower in curvature relatively in shade compared to the white fibre.

Of interest were the **low curvatures on the black coloured samples** (# 795) with an average micron 28.77 and a curvature of 26.5 dg. mm compared to the fawn and white (# 1755/# 1618) with a 25.69/25.0 average micron and 35.2/35.97 dg. mm curvature respectively. (Data from the # 5430 population)

Data from 223 white suris. The lower correlation, .57 for curvature is probably due to the mixed fleece styles and ages of the fibre that was tested in this population. Fleece types are not as advanced as the huacayas. The high CV of curve (106.48) would tend to support this assumption when compared to the huacaya with a CV of curve (63.7). Suri curvature over the 223 alpacas ranged from 9.8 dg mm to 25.9 dg mm. The average micron for the suri (24.3) was similar to that of the huacaya (24.9).

Coarse micron fleece with high frequency when compared to fine micron fleece with the same frequency tended to have lower curvature readings. This may be due to sample preparation in the laboratories where the 2 mm snippets of coarse microned fibre do not maintain their curvature. (Opinion of leading wool scientist).

Curvature results varied between OFDA and Laser results (laser reading around 17.4 deg mm higher than the OFDA).

Resistance to compression adheres to the same basic relationship between compressibility, diameter and curvature, as does wool. The physical laws governing the compressibility of alpaca and wool appear the same, however alpaca fibre has a lower resistance to compression than merino wool.

Over the total sample selection (1/6 character rating) the comparison between **curvature and character** rating showed an average result of .57correlation, indicating some influence by the crimp structure on the curvature result.

OTHER CORRELATIONS THAT SHOWED NO REAL RELATIONSHIP WERE

CV of micron – character groups. It was surprising to see that there appeared to be no real relationship between the various groups of character and the expression of CV of micron (.17 correlation) unlike that of merino sheeps wool. The average of each of the groups was all within a maximum variance of 1.39%. The average CV for the 261 samples was 21.36%.

Curvature and CV of micron showed no real relationship as evident by the .35 correlation.

SO WHAT DO YOU THINK, IS CRIMP IMPORTANT?

THE FINAL COMMENT AND CHOICE IS YOURS

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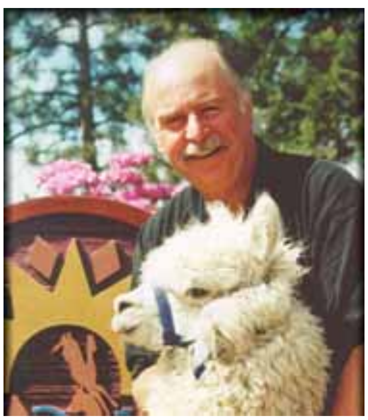

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