A SURVEY OF ALPACA FLEECE CHARACTERISTICS

A Report to the Australian Alpaca Association

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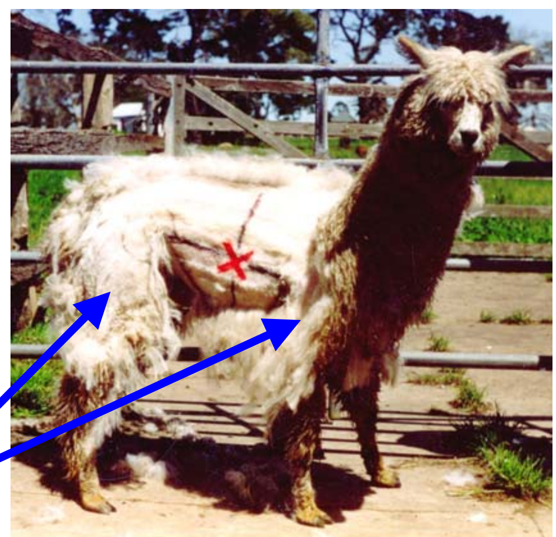
BACKGROUND to 1993 report –
Cameron Holt 2005

Before reading this report it is important to realise that the sample target was from the late 1980 imports. These ranged from good quality huacayas to those that were excessive in guard hair as well as an odd intermediate fleece type. The findings from this study formed the basis for fibre preparation and sampling guidelines for Huacaya alpacas.

Examples of range of styles of huacaya in the sample group



When comparing the individual site samples against a grid sample it is also important to remember that the grid sample came down into the middle leg area and in essence represented an **unskirted fleece.**

Although today the advances of the huacaya fleece are greatly improved on this original group, the basic knowledge gained from this research still applies today.

THE REPORT

INTRODUCTION

The single most important property of an animal fibre is the diameter which, in the case of wool, accounts for about 75% of the value of the top. For alpaca fibre to become a commercial raw material, it will be important to have an understanding of fibre diameter variations across a fleece and between individual animals so as to identify regions of fibre growth which produce superior textile-quality fibre. The prime purpose of this survey was to identify a site (or combination of sites) which would provide fibre samples of mean diameter close to that representative of the entire fleece. Tests performed on fibre from this site would provide a guide to the breeder of fibre diameter which could be used to rank alpacas for fineness or monitor yearly fibre diameter variation.

Other fleece parameters were also determined and collated in the course of this survey; these were clean fibre yield (after scouring), staple length and strength, extent of weathering damage, fibre style (character) and variation in medullation across a fleece.

SURVEY SAMPLE

Twenty animals were selected from a herd located on the one property. The selection of sample individuals was aimed to include a variety of ages, sexes, and period of fleece growth (Table 1). We have not considered the possibility that colour may be related to fibre physical properties.

TESTING

Fibre fineness was determined using the Fibre Distribution Analyser (FDA) from samples taken from each site and from a grid average sample by the Testing Service of the Melbourne College of Textiles who also determined washing yield, staple strength and length and medullation levels. Estimates of tip weathering damage were carried out by Mr. L. Holt of TFRI using a newly devised method. Mr. C.M. Holt of MCT planned the fleece collection design and assessed the fibre character. Dr. I. Stapleton of TFRI designed the scouring process and co-ordinated the management of the study.

TABLE 1:

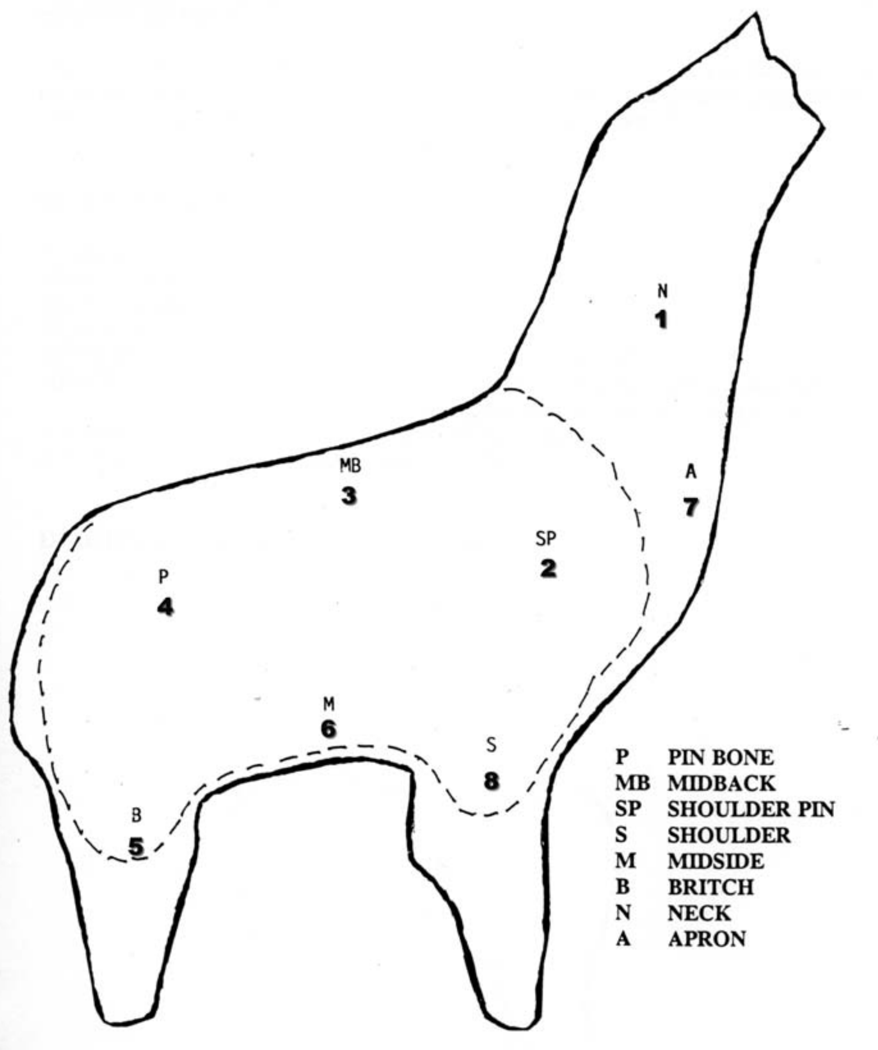
Characteristics of Animals in the Sample

Number	Group	Sex	Age(yr)	Fleece growth (yr)	Colour
1	|	F	1	1	White
2	|	F	1	1	White
3	|	F	1	1	White
4	A	M	1	1	Roan
5	|	F	1	1	White
6	|	M	1	1	Mid-brown
7	|	F	1	1	White
8	|	F	1	1	White
9	|	M	2	2	White
10	B	M	2	2	White
11	|	M	2	2	Mid-fawn
12	|	M	2	2	Light-brown
13	|	F	4	1	Black
14	|	F	4	1	White
15	C	F	4	1	Mid brown
16	|	F	4	1	White
17	|	F	4	1	Light fawn
18	|	F	4	1	Light fawn
19		M	6	2	Dark fawn
20		M	5	2	Light fawn

NB: Animals 19 and 20 were not considered as a group because of the small sample size.

DIAGRAM 1A:

LOCATION OF INDIVIDUAL SAMPLING SITES AND BOUNDARY OF TOTAL HALF FLEECE COLLECTION



---- PERIMETER OF SHORN HALF FLEECE ----

FLEECE SAMPLE SELECTION AND COLLECTION

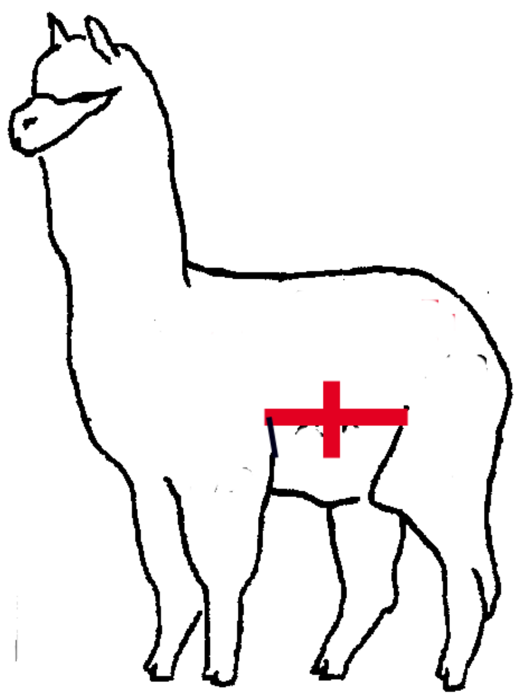
The protocol for this study was to select eight sites on one side of the animal and to shear the other half in full which was taken to be representative of the entire fleece after neck and apron fibre had been removed.

The location of the eight sites is shown in Diagram 1A. The half fleece was collected from the backline down to the middle-leg and upper-belly area (dotted line shown in Diagram 1A). The neck and apron fibre was not included in the half fleece sample.

SITE IDENTIFICATION (refer to Diagram 1A)

PINBONE (P)	Anatomical position
SHOULDER-PIN (SP)	Anatomical position
MIDBACK (MB)	Middle position on backline
BRITCH (B)	Middle back leg area in line with belly
SHOULDER (S)	Middle front leg area in line with belly
MIDSIDE	Middle position between front and back legs and skin-flap On front of hind-leg and back of front leg (Diagram 1B)
NECK (N)	Middle position on side of neck
APRON (A)	Middle position on Apron

DIAGRAM 1 (B) Location of midside site



SAMPLE PREPARATION

Preparation of fibre samples for yield and mean diameter measurements are as follows:

The half-fleece was sub-sampled using the "grid" method. The fleece was laid out on a table and overlaid by a trellis made up of 80 mm squares. Tufts of fleece were removed from each square which was more than half filled with fibre. This sample was then divided in half by splitting each staple in two; this provided two grid samples A and B. Sample A was used for yield determination and sample B was used for mean diameter measurement.

These composite samples are taken to represent a sample of fibre which closely approximates the properties and characteristics of the entire fleece (excluding neck and apron).

MEAN DIAMETER DETERMINATION

Grid sub samples B were further sub sampled using a minicore apparatus which provided a collection of 2 mm snippets. Site samples were randomly cut with a guillotine into 2 mm snippets.

The cored and site samples were solvent scoured and conditioned at 20 degrees and 65% RH for 24 hours prior to measurement.

Mean fibre diameters were determined using an IE 200 Fibre Distribution Analyser (FDA). The snippets are introduced into an aqueous isopropyl alcohol medium and passed through a laser beam, which determines the diameter of each fibre snippet.

The FDA instrument was checked and calibrated using standard laboratory wool tops T147 and T146 (used for wool, mohair and cashmere measurements).

4000 fibres were measured for the grid samples and 2000 for the site samples. From these measurements the following data were obtained:

Mean fibre diameter (microns)
Standard Deviation
Coefficient of Variation (%)
Printout of diameter distribution in histogram form.

YIELD MEASUREMENT

Grid samples (A) for yield measurement were conditioned at 20 degrees C, 65% RH before being weighed prior to scouring. Bagged samples were scoured in a mini-three-bowl train (each bowl of 60 litre capacity). The temperature, time and liquor composition of each bowl was as follows:

Bowl 1	52 degrees for 2.5 min with Lissapol detergent (1g/l)
Bowl 2	48 degrees for 2 minutes with Lissapol detergent (0.7 g/l)
Bowl 3	Warm water rinse for 2 minutes

The Lissapol detergent (ICI) is described as a 100% active water-soluble non-ionic surfactant.

After scouring, the samples were spun-dry and placed in a CSIRO Direct Reading Regain Tester (Rapid Dryer) and dried at 103 degrees to constant weight (ie. Free of all moisture). Washing yield was then calculated using the following formula:

$$\%\ \text{Washing Yield} = \frac{\text{Oven-dry Weight + 15\% Regain}}{\text{Greasy Weight}} \times 100$$

STAPLE LENGTH MEASUREMENT

The procedure using the Staple Length Measurement System (Agsearch/Agritest P/L) was as follows:

Ten staples of fibre were randomly selected from each site sample for measurement. The staples were measured for length by the S.L.M.S. procedure. Staples rejected for being too long or too short were manually measured. Mean staple length was then determined from the 10 individual measurements.

STAPLE STRENGTH MEASUREMENT

Using the Staple Strength Measurement System (Agritest) the samples in staple form used in the length test were measured for staple strength as follows:

The staple thickness (mm) was measured at three locations and average staple density (Ktex) calculated as follows:

The average of tip, middle and base x 3.2 = Mean staple density in Ktex. Staple Strengths were determined by placing the tip and base ends in clamps and exerting a force to break the staple. The applied force was measured in Newtons. The staple strength (Newtons/Ktex) was then calculated for each staple according to the following example:

	Thickness		**Strength (Newtons)**
Tip	**Mid**	**Base**	
0.45	0.65	0.80	90

Total 1.9 divided by 3 = 0.633

Mean staple density = 0.633 x 3.2 = 2.02 Ktex
Staple strength = 90/2.02 = 44.4 N/Ktex

The mean of ten staple strengths was then calculated for each site sample: position of break (tip, middle, base or random) was also recorded.

WEATHER DAMAGE ASSESSMENT

Randomly selected staples (total weight 1-2gm) were selected from the site samples and lightly scoured. The samples were treated with a mixture of Erionyl NW (Ciba-Geigy, 2mg/ml) and C.I. Food Red 17 (Williams 0.2mg/ml) at pH3 for 15 min at 80 degrees C.

The amount of dye absorbed by weather-damaged fibre tips was measured by extracting the top third (from tip) with aqueous isopropanol and estimating the concentration in a spectophotometer. The amount of dye so measured (in mgm) was divided by the total weight of sample; this value is taken to be a relative index of tip damage.

MEDULLA CONTENT

Staples are randomly selected from a sample and a 4 mm section cut from the centre.

The snippets are mounted in glycerine and examined in a projection microscope of magnification X500.

At least 200 fibre snippets are observed and the category of medullation in each recorded. (The various categories are depicted in a later section of this report).

The medulla may have the appearance of a dark central core in which case the medulla is hollow. In the other case a network of medulla cells can be seen. Both images are classed as medulla.

Three categories are counted – non medullated, interrupted and continuous. The extent of each is presented as a percentage of the total number of fibres in the sample.

TABLE 2: Mean Fibre Diameters From Individual Sites And Corresponding Fleece Grid Samples

Mean diameters in bold figures, Coefficient of Variation (%) in brackets, n.d: not determined.

COLLECTION SITES (SEE DIAGRAM 1)

NUMBER	N	A	SP	MB	P	B	M	S	GRID
1	**21.3** (22.5)	**33.3** (32.1)	**24.3** (20.6)	**22.8** (19.3)	**24.4** (22.1)	**29.3** (22.3)	**23.7** (22.9)	**27.3** (24.2)	**24.1** (24.1)
2	**24.8** (28.1)	**31.5** (33.3)	**22.8** (25.5)	**22.1** (24.0)	**24.5** (26.4)	**26.9** (24.3)	**23.9** (25.7)	**25.7** (24.9)	**23.6** (30.5)
3	**24.3** (21.2)	**30.6** (29.7)	**24.8** (21.9)	**23.8** (21.6)	**26.0** (25.2)	**27.4** (19.8)	**24.8** (23.0)	**26.8** (22.4)	**24.5** (25.3)
4	**23.5** (29.7)	**33.3** (32.0)	**23.3** (25.6)	n.d	**24.0** (27.7)	**26.7** (25.9)	**24.7** (27.3)	**25.0** (27.3)	**23.2** (30.4)
5	**20.1** (21.3)	**28.6** (30.0)	**23.3** (23.1)	**20.5** (20.7)	**22.7** (19.2)	**23.8** (19.6)	**21.7** (19.3)	**23.6** (21.8)	**21.8** (25.6)
6	**21.9** (31.3)	**29.8** (36.6)	**22.5** (27.6)	n.d	**23.9** (27.3)	**26.3** (25.1)	**23.5** (26.2)	**26.3** (25.5)	**23.5** (26.9)
7	**25.0** (22.4)	**33.0** (29.9)	**25.5** (24.3)	n.d	**25.5** (26.6)	**28.4** (20.5)	**27.1** (24.8)	**28.0** (23.2)	**25.4** (27.0)
8	**23.8** (17.5)	**33.1** (27.1)	**27.1** (18.7)	**25.7** (15.7)	**26.3** (19.7)	**27.0** (20.0)	**25.6** (19.4)	**27.0** (21.2)	**25.2** (23.6)
9	**25.2** (20.4)	**43.7** (23.8)	**26.2** (19.4)	**24.7** (19.1)	**25.1** (20.5)	**30.1** (17.7)	**27.2** (18.7)	**28.4** (18.7)	**26.3** (24.2)
10	**24.2** (21.8)	**37.6** (27.4)	**23.7** (20.6)	**25.6** (19.4)	**23.6** (21.1)	**30.3** (20.8)	**25.6** (21.3)	**28.0** (20.9)	**24.4** (27.2)
11	**29.0** (23.5)	**41.6** (29.6)	**27.9** (22.7)	**28.7** (27.4)	**30.3** (18.4)	**32.8** (23.7)	**31.8** (26.1)	**34.2** (22.1)	**29.0** (31.2)
12	**31.6** (27.8)	**25.9** (18.8)	**25.6** (19.8)	**26.7** (21.1)	**25.3** (21.9)	**28.8** (20.1)	**25.1** (20.7)	**28.3** (21.1)	**25.4** (29.9)
13	**26.3** (17.0)	**35.3** (25.3)	**24.7** (22.9)	**23.2** (21.1)	**24.7** (18.3)	**26.9** (20.1)	**28.6** (22.7)	**27.8** (21.3)	**24.9** (29.6)
14	**29.3** (20.1)	**44.4** (27.1)	**29.6** (21.7)	**27.8** (20.4)	**33.6** (32.3)	**37.4** (21.5)	**30.5** (24.3)	**34.1** (25.6)	**29.5** (24.6)
15	**32.2** (21.4)	**48.0** (29.3)	**31.4** (20.3)	**27.9** (20.4)	**28.8** (20.7)	**33.6** (20.4)	**32.5** (23.8)	**36.1** (21.5)	**30.9** (27.8)
16	**31.5** (19.9)	**33.2** (23.8)	**30.4** (21.5)	**25.2** (21.7)	**27.4** (20.7)	**33.6** (18.9)	**27.3** (21.3)	**29.4** (21.4)	**28.0** (25.3)
17	**28.7** (21.0)	**42.5** (25.6)	**24.0** (23.9)	**24.0** (23.5)	**24.5** (25.1)	**36.4** (19.2)	**24.4** (24.3)	**28.5** (22.8)	**24.3** (26.9)
18	**21.9** (22.1)	**29.1** (37.8)	**22.4** (26.7)	**22.8** (27.2)	**23.4** (29.0)	**27.1** (25.2)	**23.2** (27.6)	**25.0** (26.0)	**22.6** (28.1)
19	**31.3** (14.8)	**50.5** (23.9)	**30.4** (19.0)	**29.8** (18.3)	**30.1** (18.7)	**33.8** (17.9)	**30.1** (19.3)	**33.8** (18.1)	**30.1** (33.8)
20	**30.1** (23.4)	**36.3** (30.2)	**25.3** (20.3)	**24.2** (19.6)	**24.1** (20.9)	**30.7** (18.9)	**26.5** (19.9)	**29.2** (17.7)	**25.7** (26.9)

SELECTION OF MOST SUITABLE SAMPLING SITE FOR FIBRE DIAMETER TESTING

Table 2 displays mean fibre diameters on all nominated sites as well as the total fleece average obtained from a grid sample. The results are also presented as bar graphs in Appendix 4. It is to be recalled that the primary aim of this study was to identify a site on the fleece which would provide fibre most closely resembling the total fleece average. We have arbitrarily decided that such a chosen site should differ in diameter from the grid sample by no more than one micron.

Table 3 presents the average deviations between site and grid (ie. Total fleece) diameters. The deviations are magnitudes of the differences (regardless of which is greater) between grid diameter and site diameter: these differences were then averaged for animals within a group and for the total sample. Neck and apron sites have been excluded as these areas do not form part of the main fleece.

TABLE 3:

Average Deviation Between Site and Fleece Grid Diameters (microns).

	SP	MB	P	B	M	S
Group A	0.7	1.1	0.8	3.1	0.6	2.3
Group B	0.5	1.1	0.9	4.2	1.3	3.7
Group C	0.6	1.6	1.3	4.8	2.3	3.5
Total Sample*	0.6	1.3	0.8	3.6	0.8	3.0
Standard Dev'n.	0.5	0.7	0.6	1.2	0.7	1.0

* Averages calculated on 90% of the sample.

It is apparent from the above data that three sites fulfil the previously set criterion; these are shoulder-pin (SP), pin (P) and midside (M) if the total sample is considered whereas the SP site alone showed deviation of less than one micron within each group. Mid-back was not considered because of weather-induced fibre degradation.

It should be stressed that mean fibre diameter measurements from any of the above recommended sites can only be considered as a close approximation at best to the most accurate value obtained by sub-sampling the entire fleece.

RANKING ANIMALS

If all the fleece sites tested in the sample had been collected from animals of similar age and breeding, the results could provide useful stat regarding ranking of the herd for fibre diameter.

Table 4 shows the sample of 20 animals ranked for increasing fibre diameter; the rankings were compiles from grid sample measurements (the most reliable) and shoulder-pin (SP), midside (M) and pin (P) site sample measurements.

TABLE 4:

Ranking of all animals in the sample according to fibre fineness:
A comparison of fineness based on mean fibre diameters (microns) from three fleece sites with mean diameter (grid) of the total fleece.

ANIMAL	GRID		SP		M		P	
Number	Micron	Ranking	Micron	Ranking	Micron	Ranking	Micron	Ranking
1	24.1	6	24.3	8	23.7	4	24.4	7
2	23.6	5	22.8	3	23.9	5	24.5	=8
3	24.5	9	24.8	10	24.8	8	26.0	14*
4	23.2	3	23.3	=4	24.7	7*	24.0	5
5	21.8	1	23.3	=4	21.7	1	22.7	1
6	23.5	4	22.5	2	23.5	3	23.9	4
7	25.4	=12	25.5	12	27.1	13	25.5	13
8	25.2	11	27.1	15*	25.6	=10	26.3	15*
9	26.3	15	26.2	14	27.2	14	25.1	11*
10	24.4	8	23.7	6	25.6	=10	23.6	3*
11	29.0	17	27.9	16	31.8	19	30.3	19
12	25.4	=12	25.6	13	25.1	9	25.3	12
13	24.9	10	24.7	9	28.6	16*	24.7	10
14	29.5	18	29.6	17	30.5	18	33.6	20
15	30.9	20	31.4	20	32.5	20	28.8	17
16	28.0	16	30.4	=18	27.3	15	27.4	16
17	24.3	7	24.0	7	24.4	6	24.5	=8
18	22.6	2	22.4	1	23.2	2	23.4	2
19	30.1	19	30.4	=18	30.1	17	30.1	18
20	25.7	14	25.3	11	26.5	12	24.1	6*

The reliability of these three sites regarding the proximity of the results to the grid values was gauged by comparing the differences in rank number between site and grid. The results are shown below for frequency of differences which are one, one or two, one two or three numbers apart and for frequency of differences which are 3 or more apart.

	SITE		
	SP	M	P
Frequency of identical rankings	3	5	6
Frequency of identical or differing by one rankings	12	12	10
Frequency of identical or differing by 1 or 2 rankings	17	17	13
Frequency of rankings differing by 3 or more	3	3	7
Frequency of rankings differing by 4 or more (* in Table 4)	1	2	5

The impression given from this analysis is that SP and M sites are more reliable than P for a ranking of animals based on fibre diameter. This is most apparent when considering the differences of 3 or more in the ranking numbers. A possible reason for variances between grid and site samples may be explained as follows:

1. Testing for fibre diameter is recorded within a 95% confidence limit. This can be shown in the Australian Standards 1133-1985 for "Wool – Determination of the Mean Fibre Diameter of Raw Wool".

The range limits are shown for one instrument as –

Diameter (Microns)	Number of test specimens	
	2	3
Less than 26	0.3	0.4
26 or greater	0.4	0.6

2. On examination of the fleeces in total there were extremes in fleece type, fibre length, fibre diameter and in some cases great variation within individual fleeces for that fibre diameter. This may explain the variation in the order for the ranking shown between the sites.

It has been demonstrated with other animals that where large variation over the fleece occurs repeatability of a given site may not be as reliable as that of the grid sample which is representative of the total fleece. This factor must be noted by people using the site measurements for any ranking within a given herd. Site testing would appear to be quite reliable to monitor changes of fibre diameter either during the year or over a number of years.

SUBJECTIVE APPRAISAL OF FIBRE STYLE (CHARACTER) IN RELATION TO FLEECE SITE

It has become apparent during the course of this study that the fibre style or character varies according to the area of fibre growth on the animal and that this property at a specific location changes with the age of an animal. An arbitrary rating from 1 to 5 was assigned to fibre style based on the following descriptions:

RATING	DESCRIPTION
1	Well defined crimp with crinkle
2	Average crimp definition with crinkle
3	Little or no crimp with crinkle
4	Straight with crinkle
5	Straight with no crinkle

Diagram 2 (a) displays photo images of staple exemplifying the five categories of crimp definition

Diagram 2 (b) displays images of the five styles in relation to crinkle. The staples were dyed a darker colour to enhance contrast.

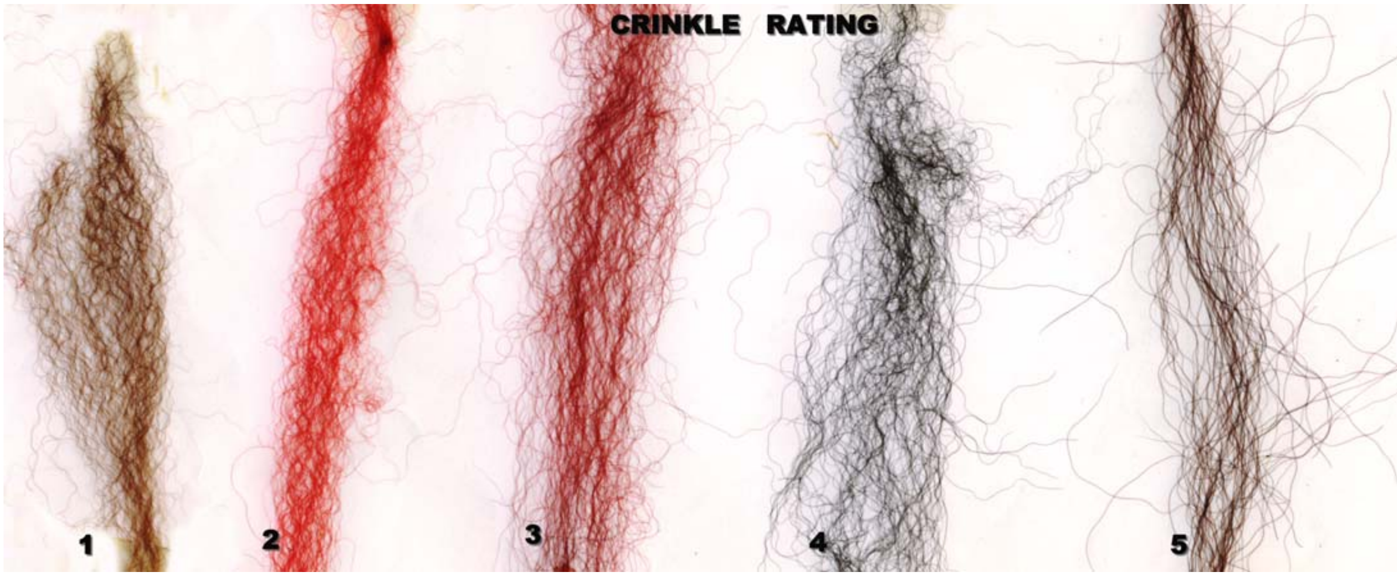
DIAGRAM 2A

Representations of fibre style (character) In staple form.

DIAGRAM 2B

Fibre separated from staples shown in diagram 2A

To demonstrate variation (graduations) of crinkle.
(Fibre has been dyed to enhance appearance)



Staples from all fleece sites were assessed according to the above criteria and the results are shown in Table 5.

TABLE 5:

Assessment of Fibre Character According to Site

Number	A	P	S	N	B	M	SP	MB
1	5	2	3	2	2	2	2	2
2	3	1	2	1	2	1	1	1
3	3	2	2	1	2	1	2	2
4	3	1	2	2	2	1	1	-
5	3	1	2	1	1	1	1	1
6	3	1	1	1	1	1	1	-
7	3	2	2	1	2	1	1	-
8	5	2	2	2	5	2	2	2
9	3	1	2	3	2	1	1	2
10	5	1	2	2	3	2	1	2
11	3	3	3	3	3	3	3	3
12	3	2	3	3	3	2	2	2
13	4	3	3	4	4	4	4	4
14	5	3	3	3	5	3	3	3
15	5	2	3	3	3	3	3	3
16	3	3	3	5	3	3	3	3
17	3	3	3	3	5	3	3	3
18	5	3	3	3	5	3	3	3
19	5	2	2	5	5	3	2	3
20	3	2	3	3	3	2	2	2

Fibres in the rating range 1 – 4 were observed to vary for crinkle ie. Rating 1, a tight crinkle to rating 4 which displayed a poorly defined crinkle. The possibility that this gradation in crimp and crinkle definition was associated with an increase in mean fibre diameter was tested by correlating the average of mean fibre diameters of a sample consisting of fibre accorded to same style rating. This data shown in Table 6 established the validity of such a correlation. Thus it can be seen that style 1 rating was accorded to fibre with an average diameter of 24.1 micron, whereas samples of rating 5 were found to have an average diameter of 36.3 micron. Incremental increases in fibre diameter are seen to progress from style 1 to style 5.

TABLE 6:

Correlation of Style Ratings With Average Fibre Diameter

Style Rating	Mean Diameter (micron)		
	Range	Average	Std Deviation
1	21 - 27	24.1	1.7
2	23 - 30	26.3	2.2
3	22 - 44	29.8	4.6
4	28 - 44	33.2	6.2
5	27 - 51	36.3	7.6

Also arising from this aspect of fleece properties was a correlation of the style of individual sites to overall fleece character. Such correlation is shown in Table 7 where the value “1” indicates the character best representative of the whole fleece. Numbers greater than 1 indicate a progressive deterioration in style relative to the individual fleece being appraised.

TABLE 7:

Correlation of Site Character With Overall Fleece Characteristic.

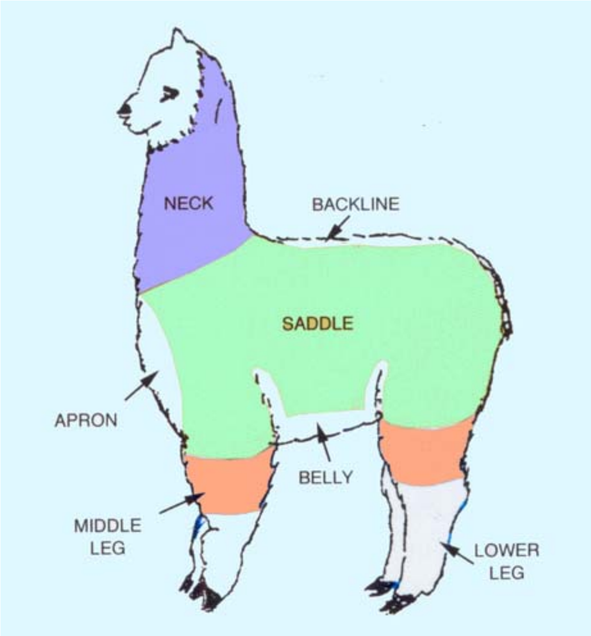
NUMBER	A	P	S	N	B	M	SP	MB
1	4	1	2	1	1	1	1	1
2	3	1	2	1	2	1	1	1
3	3	2	2	1	2	1	2	2
4	3	1	2	2	2	1	1	-
5	3	1	2	1	1	1	1	1
6	3	1	1	1	1	1	1	-
7	3	2	2	1	2	1	1	-
8	4	1	1	1	4	1	1	1
9	3	1	2	3	2	1	1	2
10	5	1	2	2	3	2	1	2
11	1	1	1	1	1	1	1	1
12	2	1	2	2	2	1	1	1
13	2	1	1	2	2	2	2	2
14	3	1	1	1	3	1	1	1
15	4	1	2	2	2	2	2	2
16	1	1	1	3	1	1	1	1
17	1	1	1	1	3	1	1	1
18	3	1	1	1	3	1	1	1
19	4	1	1	4	4	2	1	2
20	2	1	2	2	2	1	1	1
Average	2.85	1.10	1.55	1.65	2.15	1.20	1.15	1.30

Using this data and referring to Diagram 3 it can be deduced that the best-styled fleece can be found in the saddle area (P-SP-M). The mid-back (mentioned later in the report as regards weather-damage) was weaker in staple strength and shorter in staple length compared to other sites within the saddle area.

The shoulder and neck were next best for style but it is to be noted that the neck staple length was relatively shorter. The britch area was lower for style (and also stronger for fibre diameter).

The apron was very plain, highly medullated (see later) and considerably stronger for fibre diameter.

DIAGRAM 3 Definition of various fleece areas.



STAPLE LENGTH.

This parameter along with staple strength, is frequently used in the wool industry to predict processing and product performance.

TABLE 8:

Collation of Staple Lengths of Fleece Taken From Various Sites (mm, see Appendix 1 for all measurements)

		Site							
Group		**A**	**P**	**S**	**N**	**B**	**M**	**SP**	**MB**
A	Range	78-117	81-145	75-131	69-91	63-102	93-142	77-154	95-140
	Median	90	124	116	79	80	125	117	105
B	Range	173-208	190-196	148-158	103-128	117-161	147-195	161-195	85-135
	Median	185	193	154	119	143	175	179	113
C	Range	98-165	89-145	91-146	58-85	72-106	100-143	89-138	70-110
	Median	134	102	105	80	78	111	110	85

Observations arising from data in Table 8:

(a) In the first year of fibre growth (Group A) uniform staple length is apparent in the saddle area, whereas neck (N), britch (B), apron (A) and mid=back (MB) areas are somewhat shorter.

(b) The same conclusions can be drawn from the results gained from 4-year-old animals with 1-year growth (Group C), except that the apron (A) area now shows a considerable extension in staple length.

(c) In 2-year fleece growths (Group B), the staple lengths are relatively uniform except for the N and MB areas which are somewhat shorter.

The increase in staple length found in this group compared to one years growth (Group A) Varies from 33% (S) to 105% (A); the MB area on the other hand shows only a 7% increase.

(d) MB staple lengths were invariably shorter relative to other saddle areas in all Groups. This can be explained by fibre breakage caused by weather damage: the distribution and extent of this damage is discussed in a later section.

STAPLE STRENGTHS

Information on staple strengths is useful in processing because it is related to the extent of fibre breakage during carding and combing.

Staple strengths from individual sites are recorded in Appendix 2; a summary of these data are presented in Table 9.

TABLE 9:

Collation of Staple Strengths of Fleece Taken From Various Sites (Newton/Kilotex).

	Site	Range	Median	Position of Break
Group A	A	30.7-62.2	51.5	Tip
	P	40.7-59.0	55.3	"
	S	46.9-68.8	53.6	"
	N	44.4-79.8	60.6	"
	B	33.5-65.2	52.4	"
	M	45.2-64.0	51.4	"
	SP	45.0-66.9	51.8	"
	MB	22.8-63.8	37.0	"
Group B	A	38.1-43.9	41.3	Tip
	P	35.9-50.2	36.8	"
	S	12.9-40.3	39.1	"
	N	26.3-46.1	42.7	"
	B	23.2-47.4	48.6	"
	M	40.1-59.2	51.8	Random
	SP	36.2-61.4	47.2	Tip
	MB	28.6-44.1	38.0	"
Group C	A	55.3-76.3	59.2	Tip
	P	54.1-77.6	69.2	Middle
	S	62.2-86.5	67.1	"
	N	67.9-97.0	89.8	Random
	B	62.1-104.4	78.6	"
	M	53.2-85.6	72.7	Middle
	SP	60.3.74.9	67.8	"
	MB	27.9-55.0	40.2	Tip

Several observations and comments can be made regarding the above data.

Group A, With the exception of MB, staple strengths on all sites are relatively constant within this group of 1-year-old animals.

Group B. It is clear that fibre from this group of 2 year old animals with 2 years of growth are more tender (weaker) compared to samples from Group A. Fibre weakness may be due to a number of factors such as seasonal conditions, nutrition and pregnancy, all of which can affect fibre diameter. The MB site is again noted to be weaker than other sites.

Group C. Staples of fibre taken from this group of 1-year growth fleeces are significantly stronger than samples from the other two Groups.

Mid-back site Fibre from the backlines of the total population shows a marked loss of strength compared to other sites. The reason is without doubt the degradative effect of solar (UV) radiation on the tip region causing fibre breakage. A comparison with Peruvian fibre grown at high altitudes would be of interest.

COMPARISON OF ALPACA AND WOOL STAPLE STRENGTHS

The strength of alpaca fibre compares favourably to that of sheep wool which lies in the range of 10 and 70 N/Ktex. Wool with staple strengths lower than 35 are progressively discounted in value whereas small premiums apply to wools stronger than 40 N/Ktex.

Recent studies have shown the 30-50 N/Ktex range is an advantage in processing as the average fibre length in top increases as the strength increases. The chart below sets out the range of staple strength in wool.

Range in mean staple strength of Australian wool.

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

The results of this survey shows that alpaca staple strengths from all sites of the fleece are above the "bench-mark" value for wool (30). It can be predicted therefore that fibre breakage during processing will not be a concern. There may furthermore be a basis for the unsubstantiated claim that alpaca fibre is stronger than wool (some claims mention a factor of 3!). A carefully controlled scientific study on single fibres would be required to confirm this statement.

WASHING YIELD

The aim of this test is to determine the clean fleece content (expressed as a percentage) after the removal of grease, suint (sweat salts) and mineral matter (dirt) from the raw fleece. Vegetable matter is not removed and must be determined in a separate test.

Preliminary trials carried out at TFRI indicated a low (around 4%) grease content in alpaca and so the normal four bowl scour train was shortened to three bowls. The residual grease content after this scouring procedure was found to be 0.2 – 0.4 %.

TABLE 10:

Washing Yields on Grid Subsamples from all Animals.

Number	Yield (%)	Number	Yield (%)
1	93.6	11	92.0
2	87.6	12	88.3
3	93.4	13	81.5
4	92.2	14	89.6
5	90.2	15	88.5
6	93.7	16	92.0
7	93.6	17	87.0
8	93.5	18	84.9
9	89.0	19	89.0
10	87.9	20	92.0

Average Washing Yield of Groups and the Total Sample.

Group	Range	Average
A	87.6-93.7	92.2
B	88.3-92.0	89.3
C	81.5-92.0	88.1
Total Sample	81.5-93.7	90.0 (SD 3.3)

As the yields shown in Table 10 are considerably higher than for most wools, a greatly simplified process could be applied in the scouring of alpaca. Thus a three bowl rather than the normal four to six bowl train would result in several benefits eg, easier disposal of scour effluents and lower carding losses as a consequence of less fibre entanglement. One possibility being explored at TFRI is the omission of scouring entirely and cleaning the fibre in a later back-washing step (the only impediment to this novel approach would be the retention of excessive amounts of vegetable matter in heavily contaminated fleeces).

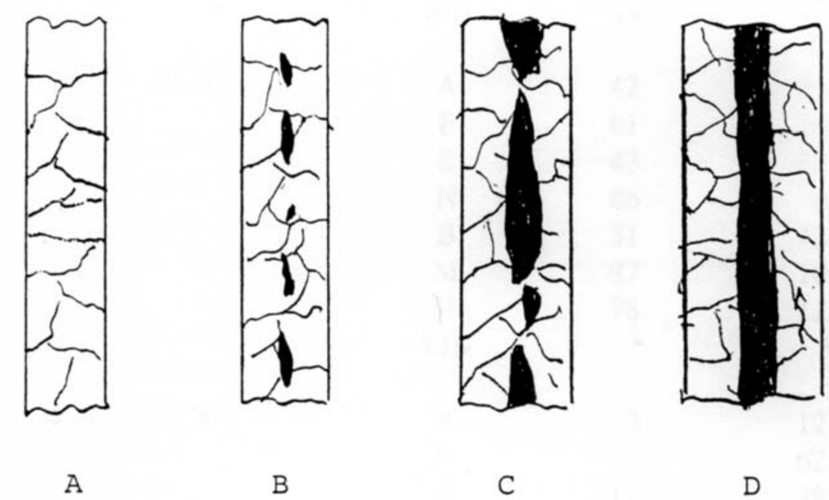
In the case of wool it is known that fibre diameter, length, density, environment and nutrition are all factors controlling the clean fleece weight.

MEDULLATION

Many animal fibres contain, as a structural element, a continuous or fragmented core of cells (either filled or empty) known as the medulla. In coarser carpet wools this is considered an advantage, but in finer apparel fibres the presence of a medulla is associated with weaker and shorter fibres (especially if the medulla is continuous) and lack of colour uniformity in dyeing.

The various categories of medulla (which can easily be seen through a low-powered microscope) are shown in Diagram 4.

DIAGRAM 4: Categories of Medulla



Non Medullated (A)

No dark regions seen in the fibre under the microscope. Most of the finer fibres belong in this category.

Fragmented (B)

Here the medulla occurs irregularly as fragments or pockets in the fibre core.

Discontinuous of Interrupted (C)

The central canal is seen to be partially blocked or bridged by cortical material at irregular intervals.

Unbroken or Continuous (D)

Table 11 shows, in the case of four animals, how the proportion of the various categories of medulla vary across the fleece. The column "interrupted medulla" is a combination of types B and C (Diagram 4).

TABLE 11:

Distribution of Medullation Across a Fleece.

Animal No.	Age (year)	Average Fleece Diameter	Site	Medulla (Percentages of Fibres) None (A)	Interrupted (B+C)	Continuous (D)
5	1	21.8 (micron)	A	39	30	31
			P	29	56	15
			S	24	46	29
			N	74	18	7
			B	27	57	16
			M	58	33	9
			SP	52	32	14
			MB	84	11	5
6	1	26.9	A	42	31	27
			P	61	16	23
			S	43	27	30
			N	86	8	6
			B	31	42	27
			M	87	10	3
			SP	78	11	11
			MB	*	*	*
15	4	27.8	A	3	12	85
			P	23	62	15
			S	11	38	51
			N	12	50	38
			B	5	48	47
			M	3	48	48
			SP	18	38	44
			MB	25	53	23
18	4	22.6	A	57	21	23
			P	55	24	21
			S	47	38	15
			N	57	24	19
			B	72	20	8
			M	65	24	11
			SP	66	26	7
			MB	73	20	7

*Fibre too badly weathered for examination.

OBSERVATIONS AND COMMENTS:

In the two 1 year old animals (Numbers 5 and 6), the fleece sites showing the highest proportions of non-medullated fibre are MB, SP, M and N. The sites showing the highest proportion of undesirable continuous medullation are A, S and B, the latter two being located on the lower extremities of the fleece.

Animal 18, a 4 year old of similar average fleece fineness to the above two, shows a high degree of uniformity of non-medullated fibre across all sites ranging from 43 to 77%. The only sites showing significant extents of medullation are A, P and N.

Animal 15, a 4 year old which presents a broader average fleece diameter, is found to have a very high proportion of continuous medullation in all sites except P and MB.

From these results it seems that broad fibre diameter is associated with medullation, however the experience with Angora goats points to a strong genetic influence which can be manipulated by judicious programs.

WEATHER DAMAGE

Weather damage on wool tips causes losses in carding and combing due to fibre breakage and problems for the dyer caused by uneven uptakes of dye along the fibre length.

The major factor responsible for weather damage is solar UV radiation. The end result of prolonged exposure to sunlight and other environmental factors is the loss of cuticle followed by rapid degradation of the cortex: these events then result in a significant loss of fibre strength in the tip region. A simple staining test which allows the extend and severity of tip damage to be readily assessed has been developed at the TFRI. Greater amounts of dye are taken up by the more weather damaged fibres.

Appendix 3 shows the relative extent of tip damage in all fleece sites for the total sample. Table 12 is a summary of the data relating to tip damage detailed in Appendix 3. The data is collated according to groups (Table 1) and the numbers in the Table indicate the amount of dye taken up by weather-damaged tips.

TABLE 12:

Summary of Weathering Damage Measurements.

		Site							
Group		**P**	**SP**	**S**	**M**	**B**	**N**	**A**	**MB**
A	Range	38-104	49-109	34-85	20-73	51-114	34-59	16-32	228-538
	Median	80	77	60	53	82	47	27	253
B	Range	65-296	81-147	37-208	54-101	67-145	81-94	22-44	258-438
	Median	99	106	78	70	68	68	33	340
C	Range	62-179	95-131	52-114	57-138	71-229	35-90	13-23	138-604
	Median	90	109	69	70	123	67	17	276

The overwhelming conclusion from the above results is that the mid-back site is severely weather-damaged compared to the rest of the fleece. We have not been able to determine how far down the flank of the animal this degradation extends. It would be reasonable to speculate that Peruvian fleece, grown in the altiplano region of Peru would suffer significantly higher levels of tip degradation because of the greater levels of UV at high altitude.

Also observed (not recorded in this report) was minor fibre damage along the entire length of the staple in the lower areas of the fleece. The cause of this damage was not identified, but may possibly be due to microbiological damage in fleece areas of continually high moisture content.

SUMMARY OF RESULTS

Average Fibre Diameter Sampling Sites.

Pin, mid-side and shoulder-pin areas are fleece sites which can be used to most closely approximate the total fleece average diameter when a grid sample is not used.

Apron fleece is considerably broader than the fleece average by up to 20 microns.

Fibre from the britch area is also broader than the fleece average.

Staple Length

Staple lengths (given 12 months growth) from all sites are all longer than minimum lengths required for processing on either the woollen or worsted systems.

Staple Strength

Staple strengths are high compared to wool.

Fleece from 4 year old animals is much stronger than that from 1 year animals.

Washing Yields

The yields of clean fibre do not appear to be related to animal age or duration of fleece growth. An average yield of 90% is much higher than that given by sheep wool.

Medullation

Although fibre from only four animals was examined, the indications are that the extents of medullation across the fleece increases with increasing fibre diameter.

Weather Damage

Fibre degradation resulting from solar radiation is most severe on the mid-back region. This conclusion is supported by observations relating to staple lengths (shorter because of tips removed by abrasion) and staple strengths (weaker due to cortical damage).

RECOMMENDATIONS REGARDING FLEECE PREPARATION

Apron, belly and leg fleece must not be included in lots of fleece intended for sale to commercial processors or home spinners.

Neck fleece should be separated because of its shorter staple length.

RECOMMENDATIONS FOR FUTURE RESEARCH

Further sample collections from the M, P and SP sites be undertaken on a large herd to establish more reliably the most favoured test site.

Where possible collection of fleece from the 1 year animals used in this sample to be continued to follow changes in fibre diameter with age.

Early-stage processing to be examined with a view to shortcutting wool procedures where appropriate. The ultimate aim will be to produce quality yarn by the most economical route, for the most appropriate end uses.

Explore possible marketing advantages in blending alpaca with wool and other natural fibres.

Undertake a program of basic research aimed at establishing possible superiority of alpaca fibre in terms of strength and other properties over other animal fibres.

APPENDIX 1: Site Staple Lengths (mm, average of 10 measurements)
(% Coefficient of Variation)

	SITE							
NUMBER	A	P	S	N	B	M	SP	MB
1	87 (27.0)	124 (15.8)	131 (15.1)	77 (8.6)	102 (11.5)	134 (10.4)	146 (5.0)	125
2	93 (17.2)	102 (7.6)	85 (7.9)	66 (7.6)	63 (13.2)	108 (7.1)	91 (16.5)	110
3	98 (34.7)	132 (15.3)	123 (19.9)	84 (16.8)	85 (15.9)	132 (20.8)	126 (19.4)	100
4	80 (16.9)	81 (15.7)	75 (24.9)	61 (10.1)	78 (6.4)	93 (13.7)	77 (17.4)	-
5	105 (21.3)	128 (6.3)	114 (13.1)	81 (10.4)	99 (12.6)	133 (9.2)	127 (11.8)	95
6	78 (34.6)	97 (7.8)	100 (10.7)	82 (13.0)	82 (22.8)	119 (13.6)	97 (12.4)	-
7	87 (25.6)	124 (12.7)	87 (21.3)	75 (8.4)	65 (8.1)	112 (27.6)	107 (16.3)	-
8	117 (19.2)	145 (12.1)	117 (10.9)	91 (8.3)	77 (18.3)	142 (13.9)	154 (5.4)	140
9	173 (19.2)	193 (10.3)	155 (22.2)	103 (18.9)	147 (17.7)	184 (12.5)	189 (8.8)	130
10	186 (10.2)	196 (9.7)	153 (23.3)	123 (13.7)	117 (18.2)	147 (22.7)	161 (16.3)	95
11	208 (10.0)	190 (8.6)	154 (18.7)	115 (19.9)	161 (10.3)	166 (18.5)	167 (10.8)	85
12	184 (15.6)	194 (10.4)	148 (23.0)	128 (12.0)	139 (20.0)	195 (12.0)	195 (10.0)	135
13	107 (17.1)	105 (11.3)	126 (8.9)	81 (10.3)	106 (6.5)	135 (8.6)	125 (7.5)	95
14	156 (13.9)	145 (17.4)	146 (6.1)	85 (9.3)	101 (10.4)	143 (13.7)	138 (10.8)	95
15	98 (15.8)	105 (12.1)	99 (26.2)	84 (8.4)	73 (14.5)	104 (15.4)	104 (9.7)	110
16	124 (10.8)	99 (14.6)	104 (12.1)	79 (14.0)	76 (20.3)	111 (7.9)	117 (10.3)	75
17	165 (6.8)	89 (12.3)	106 (5.8)	58 (13.6)	81 (12.6)	108 (8.0)	87 (8.6)	70
18	144 (6.3)	90 (13.0)	91 (17.7)	77 (3.6)	72 (6.0)	100 (10.5)	98 (10.0)	-
19	128 (12.3)	130 (6.6)	106 (7.6)	79 (10.8)	74 (33.2)	116 (8.0)	101 (11.1)	100
20	153 (6.2)	145 (10.3)	117 (20.2)	108 (6.5)	106 (8.9)	159 (4.3)	147 (4.9)	90

APPENDIX 2: Site Staple Strengths (Newton/ KTex; average of 10 measurements).
Position of break indicated by T(tip), B(base), M(middle), R(random).
(% Coefficient of Variation)

	SITE							
NUMBER	**A**	**P**	**S**	**N**	**B**	**M**	**SP**	**MB**
1	**51.7** T (47.0)	**55.2** T (22.2)	**55.1** T (14.3)	**52.9** T,M (44.8)	**65.1** T (23.7)	**56.6** T (10.5)	**49.9** T (24.0)	**34.9** T (45.7)
2	**37.9** T (35.6)	**56.6** T (26.9)	**60.7** T (23.5)	**76.3** T (11.2)	**59.3** T (23.7)	**64.0** T (12.1)	**66.9** T (15.6)	**32.0** T (37.1)
3	**57.8** T (20.7)	**55.8** T (12.2)	**68.8** T,M (13.3)	**68.4** T (13.0)	**51.3** T,M (22.3)	**59.9** T (23.5)	**53.1** T (22.1)	**22.8** T (102.3)
4	**62.2** T (12.3)	**54.0** T (30.4)	**51.6** T (24.0)	**79.8** M,T (19.5)	**53.5** T (15.9)	**54.0** T(19.6)	**58.0** T (24.9)	-
5	**30.7** T (25.9)	**54.3** T (26.7)	**46.9** T (34.8)	**53.2** T (19.6)	**42.9** T (32.9)	**48.8** T (30.4)	**45.0** T (29.0)	**46.5** T (28.2)
6	**51.2** T (35.5)	**59.0** T (17.2)	**52.2** T (22.3)	**44.4** T (26.6)	**33.5** T (20.4)	**45.2** T (32.2)	**50.6** T (20.7)	-
7	**42.2** T (23.5)	**40.7** T (27.1)	**47.5** T (18.1)	**67.2** T (14.8)	**57.4** T (26.8)	**48.1** T (17.1)	**53.4** T (6.5)	-
8	**53.6** T (19.1)	**55.4** T (30.7)	**58.4** T (19.2)	**54.0** T (15.0)	**50.9** T (18.5)	**47.8** T (18.7)	**47.7** T (11.1)	**63.8** T (24.9)
9	**39.7** T (23.4)	**50.2** T,M (25.5)	**39.9** T,M (30.1)	**41.9** T,M (9.5)	**42.2** T,M (38.7)	**59.2** M (16.4)	**61.4** T (21.0)	**38.0** T (43.4)
10	**43.0** T (15.3)	**36.6** T (37.4)	**38.4** T (31.3)	**46.1** T (13.0)	**29.9** T (23.4)	**52.3** T (13.0)	**46.1** T (22.6)	**44.1** T (25.0)
11	**43.9** T (19.6)	**36.9** T (30.3)	**40.3** T (26.8)	**43.6** T (11.0)	**47.4** T (11.8)	**51.4** T (18.3)	**48.3** T (21.1)	**42.8** T (29.3)
12	**38.1** T,M (25.2)	**35.9** M (18.4)	**12.9** T,M (30.2)	**26.3** T,M (17.9)	**23.2** M (40.5)	**40.1** M (20.2)	**36.2** T (28.2)	**28.6** T (30.0)
13	**56.1** T (27.3)	**54.1** M (15.2)	**62.2** B (8.5)	**67.9** T (11.3)	**62.1** B (12.2)	**53.2** B (16.2)	**60.3** B (16.1)	**32.9** T,M (38.8)
14	**59.9** T (9.3)	**71.7** T,M (11.0)	**69.3** M (15.7)	**92.7** B (13.3)	**79.9** T,M (18.1)	**73.1** M (9.0)	**73.3** M (11.1)	**27.9** T (63.4)
15	**58.5** T (27.7)	**77.6** B (8.9)	**86.5** M (7.4)	**93.6** T (5.1)	**104.4** T (6.6)	**74.9** T (10.6)	**74.9** M,T,B (11.6)	**55.0** T,M (40.6)
16	**67.8** M,T (24.8)	**62.9** M (18.9)	**65.0** M (16.6)	**97.0** B (5.6)	**71.6** T,M,B (11.6)	**79.5** M (5.8)	**62.6** M (20.2)	**40.2** T,M (28.8)
17	**76.3** M (15.9)	**75.6** M (13.0)	**64.9** M,B (12.5)	**87.2** T (8.7)	**88.5** T (7.7)	**72.2** M (9.1)	**67.4** T (14.4)	**47.5** M (31.3)
18	**55.3** T,M (25.0)	**66.8** M (15.3)	**82.9** M,B (14.6)	**80.9** M (6.9)	**77.4** M (8.5)	**71.0** M (11.4)	**68.2** M (9.4)	-
19	**63.9** T (14.1)	**82.1** B (18.2)	**73.4** M (10.8)	**90.6** T (8.6)	**57.0** T (39.0)	**79.2** M (10.4)	**78.4** B (23.2)	**69.5** M,B (12.2)
20	**77.7** T (13.5)	**71.0** M (14.8)	**56.1** M (15.3)	**90.1** T (4.7)	**59.6** M (10.2)	**80.2** M (9.5)	**86.0** M (9.2)	**45.0** M (45.7)

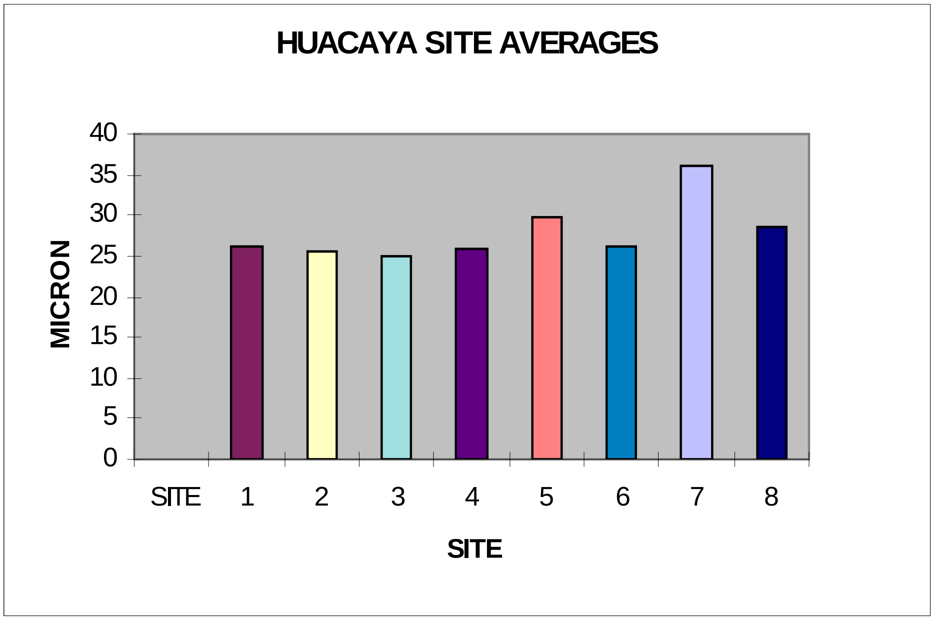
APPENDIX 3: Relative Tip Weather Damage

	SITE							
NUMBER	**A**	**P**	**S**	**N**	**B**	**M**	**SP**	**MB**
1	23	104	34	34	51	73	79	538
2	30	74	85	38	66	52	76	228
3	30	97	62	42	88	55	109	265
4	29	66	36	41	75	20	62	-
5	32	86	82	59	95	61	49	476
6	25	38	57	60	52	41	71	-
7	16	64	79	53	114	42	102	-
8	19	87	59	58	101	64	88	243
9	34	93	71	74	67	67	105	438
10	44	296	86	65	67	101	147	357
11	22	65	37	51	70	54	107	321
12	32	105	208	72	145	74	81	258
13	18	136	67	82	71	92	125	183
14	17	62	70	70	131	60	109	604
15	13	96	70	35	101	57	108	138
16	23	179	114	64	229	138	131	408
17	14	84	52	90	116	64	101	249
18	17	80	59	50	164	77	95	303
19	62	95	166	91	177	84	111	176
20	18	77	59	50	164	77	83	150

APPENDIX 4:

HUACAYA SITE AVERAGES

SITE	MICRON
1	26.30
2	25.70
3	25.00
4	25.90
5	29.80
6	26.30
7	36.00
8	28.60
ave	27.95
sd	3.63
cv	12.97



MID = 26.30 microns

SITE 2,3,4,5,6,8 = 26.88 microns (unskirted fleece)