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Alpaca Fleece Development and Methods of Assessing Fibre Quality

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Summary

The paper defines the major quality attributes of alpaca fibre (fibre diameter, fibre length, fibre colour, contamination and incidence of medullated fibres). The development of alpaca fleece and skin follicles is then discussed. The connection between the evolution in the textile market and alpaca fibre quality are discussed particularly in regard to fibre diameter variability. Suggestions on the methods of assessing fibre quality in the shearing shed, in the laboratory and in the office are made. Preliminary data from a survey of Australian alpaca fleece quality are presented along with some examples of fibre diameter and medullated fibre histograms produced by measurement on the optical fibre diameter analyser (OFDA). The paper concludes with a brief discussion on the main management and environmental effects on alpaca quality.

Introduction

What are the major quality attributes of alpaca fibre? What are the connections between alpaca fleece development and fibre quality? How will fibre quality affect marketing of alpaca textiles? What are the methods of altering production and management of alpacas to maintain the production of quality fibre? These and many more questions can be asked about producing quality alpaca fibre.

This paper also briefly refers to progress results from research I am undertaking on alpaca fibre quality in Australia (in collaboration with the South Australian Department of Primary Industries with support of the Rural Industries Research and Development Corporation). The paper also briefly mentions the main issues by which producers can influence the quality of their fibre. The paper does not discuss visual assessment, which can be of commercial importance when selecting animals and in assessing alpaca fibre. But first we need to define the major quality attributes of alpaca fibre and the relationship between alpaca quality and fleece development.

Quality Alpaca Fibre

The major quality attributes of raw alpaca fleece have been defined by processors and markets for many years. They include, in order of importance:

- fibre diameter,
- fibre length,
- fibre colour,
- freedom from contamination (vegetable fault, man made fibres)
- degree of medullation.

Each of these quality attributes affects directly the speed of processing, processing yield and yarn quality.

Alpaca fibre diameter.

Maximum prices are paid for fine "baby" alpaca up to mean fibre diameters of 22 µm. I have calculated the relative prices received for alpaca fibre based on values reported by Vinella (1993), see Figure 1. Prices decline rapidly above 22 µm, with an average decline in price of 7% per 1 µm increase in fibre diameter up to 27.5 µm. In some years prices stabilise above 27.5 µm but in other years the prices decline further so that 32 µm fibre was valued at only 38% of the value obtained for the finest fibre. At 27µm Suri fibre received a premium of 10 to 25% above the prices paid for standard adult white alpaca.

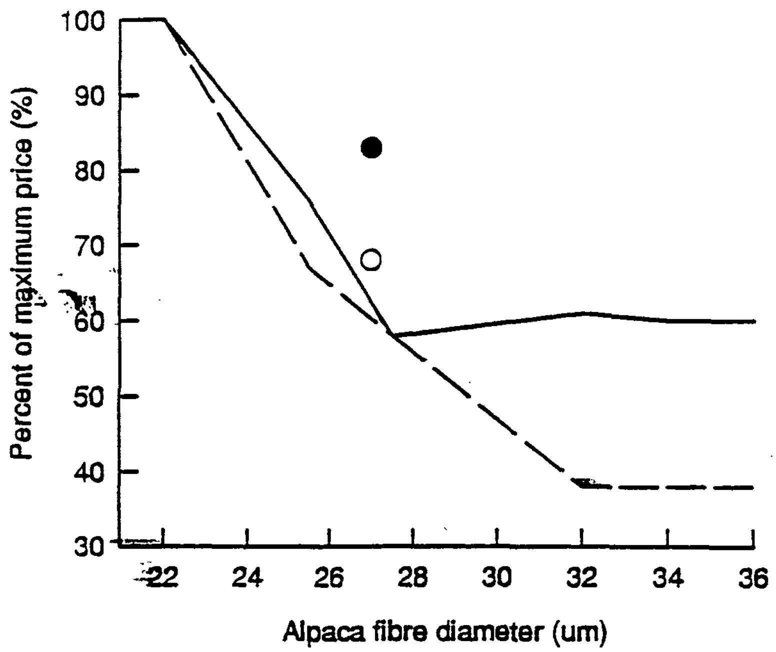

Figure 1: The effect of alpaca fibre diameter on the relative price of white alpaca tops in 1983 (——) and November 1993 (– – – –). The relative value of 27 µm Suri tops is also shown (1983 O; 1993 ●). Data calculated by author from values cited by Vinella (1993).

Recent reports are that the total 1994/95 Peruvian clip, estimated at 5.5 million kg greasy, is made up from 93% Huacaya and 7% Suri, comprising 7% baby alpaca, 53% fleece, 30% coarse and 10% mixed pieces (Morales et al 1995). It is easy to see that the finest fibre (baby alpaca) is only a small proportion of the supply.

When a constant number of fibres is maintained in the cross section of the yarn, increasing fibre diameter reduces the potential speed during spinning, as yarn breakage increase. Increasing fibre diameter is likely to increase yarn hairiness and irregularity and in fabrics increase the severity of wrinkles and reduce the recovery from wrinkling. Increasing fibre diameter increases the flexural rigidity of fabric and increases the air permeability of fabric. Some of these characteristics can be modified depending on the finishing process (Leeder et al 1992).

Alpaca fibre length.

Alpaca from Peru has traditionally been classed into lengths of > 7.5 cm for worsted processing with shorter fibre being sold for the woollen processing system. Length commands a premium in the market. Markets usually discriminate against length to a lesser degree than against fibre diameter.

Worsted length alpaca increases the potential methods of processing the fibre and so increases the potential purchasers of the fibre. During worsted processing the spinners use combing to select the longer fibres to enable them to spin finer and stronger yarns for weaving. Increasing the length of alpaca fibre increases the spinning potential and reduces the number of potential yarn breaks. Fibre length affects yarn construction.

Alpaca fibre colour.

Generally white fibre brings the highest prices as it can be dyed to any shade especially pastel colours. Pastel dyeing can be undertaken at lower temperatures which results in less damage to the fibre thus maintaining better "handle" or softness. Japan mainly buys white fibre (Morales et al 1995). Dyeing is avoided if natural shades are used. The fawns are very popular when "camel" is fashionable and when vicuna is in demand with prices 15% greater than white Vinella (1993). Black is often preferred for worsted processing if the woven fabric is intended for dark suiting (Ross 1988) and can be sold at a 15% premium over white fibre. The effect of price on production can be seen in the Puno area of Peru where the number of coloured alpacas has fallen from 60% to 30% over the past 30 years (Renieri 1994).

Contamination and grease.

Vegetable matter (grass seed and burrs), urine and dung stains, in alpaca fibre incur serious price penalties of 50% or greater. These faults require carbonising which reduces the lustre, the handle and affects the colour of fibre. White fibre is most affected because heavy scouring and carbonising produces creamy coloured fibre which requires bleaching to restore the white colour. These treatments restrict the use of contaminated fibre to lower priced end uses and increase the processing costs. Soil contamination is common as alpacas are in the habit of dust bathing. Heavy soil and grease content requires longer scouring and increases costs per unit of clean fibre.

Medullated fibres.

Medullated fibres have a central canal or medulla which is largely hollow because the cells contain air. Fibres with a medulla reflect light differently to true fibres, are stiffer and are difficult to control in spinning and so become conspicuous in fine worsted materials. Stiff medullated fibres projecting from yarns may also cause prickle sensation on the skin and so reduce the comfort properties of garments containing medullated fibres. Medullated fibres usually grow from primary skin follicles but a proportion of secondary follicles grow medullated fibres. There are different types of medullated fibres found in alpaca fibre: kemps and hetero-type or gare fibres.

Kemp fibres are visible to the eye. The diameter of the medulla in a kemp fibre is more than 60% and up to 90% of the diameter of the fibre, although the tip may be solid. Kemp fibres are brittle, non elastic and usually oval or kidney shaped in cross section. They are found on the face and legs of alpacas and around the edges of the main fleece. Kemps are more common in llama fibre.

Hetero-type or gare fibres are an intermediate type of fibre consisting of medullated sections and non medullated sections. Some reports refer to fragmented, interrupted, partially or continuous medullated fibres, or non kemp medullated fibres. These descriptions are for fibres which contain continuous or sections of medulla which are less than 60% of the diameter of the fibre. Hetero-type fibres are longer and more difficult to remove during processing.

Medullated fibres increase processing costs and reduce the yield of processed tops as many coarse medullated fibres are removed during carding and combing. A high degree of medullation can restrict the use of the top as these fibres cause too much prickle in garments worn near the skin.

Research with mohair suggests that the limiting thickness of solid keratin surrounding the medulla was 5 µm and at 20 µm there are no medullated fibres (measurements of alpaca fibre in our laboratory suggest a similar situation exists for alpaca fibre). In mohair, as fibre diameter of medullated fibres increases, the medulla diameter increases, and between 20 and 30 µm all medullated fibres are hetero-type fibres, and above 100 µm all medullated fibres are kemp.

Dyeing properties of medullated fibres. The vast majority of studies have shown that the medulla substance in the medullated fibres dyed equally or to a similar shade to the solid portion of the fibre. The different appearance of dyed kemp fibres being solely due to the enclosed air causing different reflection and transmission of light. Dye exhaustion curves for kemp and mohair have been reported as being little different for most dyes. Kemp fibres can be seen to various degrees depending on the colour and depth of shade to which the material is dyed (Hunter 1993).

Alpaca Fleece Development

During the growth of the foetus the skin develops follicles from which the fibres grow. The first follicles to develop are called the primary follicles. The primary follicles in sheep and goats are usually arranged in small groups but in alpaca samples studied in our laboratory the primary follicles were mostly in "groups" of one.

Later in pregnancy secondary follicles develop around the primary follicles. The birth coat contains a high proportion of fibres growing from the primary follicles and during the first months of life most of the secondary follicles begin growing fibres so that by the fourth month of life the fleece is mainly composed of fibres growing from the secondary follicles.

Alpaca fibres are elliptical in cross section with the major axis being 15 to 30% greater than the minor axis. For example, a fleece may have a mean fibre diameter of 28 µm with the mean diameter of the major axis 32µm and the mean diameter of the minor axis 26.2 µm. The ellipticity of the fibre affects processing performance and fabric behaviour.

The fibres growing from the primary follicles usually have a greater mean fibre diameter than the fibres growing from the secondary follicles. These primary fibres are often referred to as guard hair. Among the 4 llama species the vicuna and the guanaco have the fleeces where the guard hairs are predominant. The guard hairs in vicuna are impurity fibres in textiles and must be removed by special processing called dehairing.

Dehairing, which costs about $US 25/kg (McGregor 1994), leaves the finer downy vicuna, grown from the secondary follicles, with a residual guard hair content of usually less than 1%. For dehairing to be successful the distribution of fibre diameters of the guard hairs and the downy undercoat must be separate and not overlapping. In real life this has meant that the fibre diameter of the guard hair must be approximately 4 times the diameter of the finer downy undercoat to enable the machinery to physically separate the coarse and fine fibres. For vicuna the downy undercoat has a mean fibre diameter of about 13 µm and the guard hair must have a fibre diameter greater than 50 µm for dehairing to be successful. Animals with this type of fleece are known as "two coated" and include cashmere goats and yaks.

During the past 5000 years of domestication selection of the alpacas has seen the guard hairs become finer and the downy undercoat become coarser so that alpacas are now "single coated". The fibre diameter distribution of the medullated fibres (the residual guard hair from the primary follicles) now overlaps with the fibre distribution of the finer secondary follicle fibres. In all of the Australian alpaca samples I have studied the distribution of medullated fibres is at the coarsest end of the fibre diameter distribution (see Figures 3 and 4).

S:P ratio and follicle density.

With animals growing wool fibres it is common to refer to the ratio of secondary to primary follicles as the S:P ratio. In alpacas the S:P ratio has been reported as 7.2 (Martin and Gaitan 1969). Studies at my Institute of skin sections from South Australian and Victorian properties have indicated S:P ratios ranging from 4:1 to 9:1 (Cotton unpublished).

With most alpacas almost all of the fibres growing from the primary follicles are medullated and many of the fibres from the secondary follicles are medullated. Thus even if only primary follicles were medullated an animal with an S:P ratio of 9:1 would have 10% of the fibres medullated. We have seen animals with almost no medullated follicles.

The density of follicles can also be measured. Escobar (1984) cited two reports where the follicle density of alpacas ranged from 15 to 20/mm^2. As the alpacas grow the density of follicles will decline as the area of skin increases. This decline in density of follicles as the animals grow is associated with an increase in mean fibre diameter.

Alpaca Fibre Quality and The Textile Market Evolution

While alpaca fibre has been used in the western textile industry for about 140 years considerable changes in consumer lifestyle have occurred during the past 30 years. It is important to understand that alpaca is a "wool" fibre, and in the "western" world is mainly processed and marketed by business whose main focus is on wool fibres. Alpaca is commonly blended with wool with alpaca representing 25 to 80% of the fibre. The following information is based on extensive research conducted by the wool industry.

Clothing Evolution 1950-2000.

During the 1950s formal tailored clothing represented the main clothing market. By the 1990s casual and sports/active clothing were of similar importance to formal tailored clothes. Within 20 years it is expected that casual clothes will dominate with formal tailored clothes representing a smaller proportion of the market than sports active clothing. There have been large changes in the way people travel (more cars, less public transport) and central heating is usual in homes, work places and in transport.

Clothing styles have changed with greater emphasis on easy care and wash and wear fabrics and consumers wear less underclothing resulting in outer garments being worn closer the skin. The emphasis on warmth in clothing is less but the emphasis on comfort greater. Some of these changes are advantageous for alpaca fibre while others are not. Of greatest concern is the issue of comfort in alpaca textiles.

Surveys of consumers in the big 6 consuming countries of Japan, Germany, Italy, France, Britain and the USA have indicated that the most important negative attribute about wool clothing was prickle discomfort. New product development in the wool industry (IWS 1993) focuses on comfort, softness, lightness in weight, ease of care, retention of appearance and colour. Growth markets are in the smart casual, semi formal, young casual and trans-seasonal markets.

Fibre diameter, fibre diameter variability and prickly clothing.

The wool and cashmere industries are very "sensitive" about production of prickly garments. The trade definition for cashmere, having a mean diameter of less than 20 µm, is to ensure no fibres in the fibre diameter histogram, exceed 30µm. Indeed, in Australia, cashmere classification generally ends at 18.5µm as Australian goats appear to have a greater variability and spread of fibre diameters. Definition of both fibre diameter and fibre diameter variability are essential to ensure cashmere retains its soft luxurious handle.

The Australian wool industry also regards prickle discomfort as a major impediment to the use of wool, especially in the USA market. Wool lots with over 5% of fibres exceeding 30µm are classed as prickly. Surprisingly this includes about 35% of wool with a mean fibre diameter of 21 µm and all wool lots with a mean fibre diameter of 24 µm and greater.

Considerable effort is now focussed on reducing the mean fibre diameter and diameter variability in flocks with mean wool fibre diameters of 21 to 23 µm (Dolling 1992). Italian spinners are known for their desire to purchase fine Merino wools with good handle and low CV%, usually less than 18%. This has enabled the production of fine even single yarns and smoother finishes to premium worsted fabrics.

Recent developments include the proposed use of measured *"spinning fineness"* to indicate wool sale lots which have similar spinning and weaving performance and are similarly ranked for fabric prickliness (Dolling 1993). Effectively spinning fineness uses the coefficient of diameter variability (CV%) to "adjust" the mean fibre diameter to better reflect the processing performance of wools.

Wools of greater CV% perform as though their mean fibre diameter is greater (Dolling 1993). At 22µm, for each increase in CV% of 5% spinning fineness increases approximately 1 µm (Table 1) but at 35 µm each increase in CV% of 5% increases spinning fineness 2µm.

Alpaca, with mean fibre diameters ranging up to 45 µm also has a high CV% of fibre diameter. Peruvian alpaca fibre has an average CV of about 28% (data based on 4500 samples studied by Pumayalla and Levva 1987). Thus almost all raw alpaca, except the very finest, has a considerable proportion of fibres greater than 30 µm.

As mean fibre diameter increases to 24 µm the % of fibres above 30 µm increases to about 20%. Increasing CV% from about 30% to about 40% increases % of fibres above 30 µm by about 4%. Alpaca garments and yarns are often brushed so that the softer brushed textiles are less likely to prickle and the fibres more likely to bend.

Table 1: Spinning fineness (µm) for various combinations of mean fibre diameter and co-efficient of variation (calculated from Butler and Dolling 1995). The calculations assume the CV% of typical Australian alpaca is 30%.

Diameter (µm)	Co-efficient of variation (%)				
	18	24	30	36	42
22.0	19.7	20.7	22.0	23.5	25.1
25.0	22.4	23.6	25.0	26.7	28.5
28.0	25.1	26.4	28.0	29.9	31.9
30.0	26.9	28.3	30.0	32.0	34.2
33.0	29.5	31.1	33.0	35.2	37.6
35.0	31.3	33.0	35.0	37.3	39.9
38.0	34.0	35.8	38.0	40.5	43.3
40.0	35.8	37.7	40.0	42.6	45.6

Technology is presently available which can measure fibre diameter distribution quickly and cheaply. Thus discerning buyers of alpaca fibre and alpaca animals should be able to take commercial advantage of the difference between mean fibre diameter and spinning fineness provided spinning fineness information is available.

Methods of Assessing Fibre Quality

As discussed earlier the major quality attributes of raw alpaca fleece have been defined by processors and markets for many years. They include, in order of importance:

- fibre diameter,
- fibre length,
- fibre colour,
- freedom from contamination (vegetable fault, man made fibres)
- degree of medullation.

To this list I have added fibre diameter variation.

There are three stages in assessment of fibre quality and each stage is equally important. Messing up one of these stages results in the whole exercise being a waste of time.

The stages are:

- in the shearing shed,
- in the laboratory, and
- in the office.

In the shearing shed.

There are five important steps to follow when shearing alpacas:

(i) Correctly read and record the ear tag number

This sounds simple but in a hectic shearing shed with lots of noise, people, animals and fleece moving about it is easy to forget to read the tag or to misread a tag. Near the end of a busy day when a visitor drops by and when you are a bit tired it is very easy to misread a tag. Ways to minimise errors are to read the tags yourself and double check any shearer, to bring in a list of tags expected at shearing and check the read tags against expected tag numbers, and concentrate (don't talk to anyone).

(ii) Accurately weigh the fleece parts

Before shearing you must obtain or borrow a set of accurate scales for weighing fleece. The scales must weigh up to 5 kg, with an accuracy of 50 g. The scales must be able to hold a large cumbersome fleece without tipping over. The scales need to be placed on a large and level surface to enable the operator easy access and a place to store record sheets, pens and sample bags. For electronic scales a power point or extension lead is required. Record the fleece weight immediately it is weighed.

There are many ways to incorrectly weigh a fleece so operators must ensure that the area near the scales is kept clean so the scales can operate freely without touching anything. Check frequently to ensure that the scales are zeroing or taring correctly and do not let the fleece hang off the scales.

(iii) Accurately sample the fleece

The current advice is to take a grid sample from the shorn saddle. The saddle is spread evenly over the fleece table and a sample is randomly drawn from at least 16 places representative of the entire fleece. Some people prefer to use a grid made of mesh (squares 10 cm x 10 cm) and take a sample from each square.

The final sample must weigh 50 g. The sample is accurately and clearly labelled by placing a label with the tag number inside a plastic bag which is then sealed. Remember, if you take a dud sample then you will get a dud result. Test laboratories only test the sample you supply. Make sure you and your money are not dudded!

(iv) Measure fleece length

Have a ruler to accurately measure the length of the fleece. Randomly take three staples from the saddle and measure to the nearest 0.5 cm. Record the length.

(v) Sort the fleece

The fleece parts need to be sorted or classed into the appropriate lines for sale. A marketing system is being developed for Australian alpaca fibre and the guidelines need to be carefully followed. It is likely that lines will be established for fibre diameter, colour, length, impurities and inferior fibre types. Use the measurement of fleece length to determine the length category for your main fleece lines.

In the laboratory.

It is necessary to send your fleece sample to a fleece testing service for determination of mean fibre diameter, fibre diameter variation, incidence of medullation and washing yield. There are a large number of other measurements which could be made but they are not relevant for farm use.

(i) Mean fibre diameter

Fibre diameter is easily measured with modern equipment. Fibre diameter is expressed as micrometers (µm). One micrometer is one thousandth of a centimetre and is often referred to as a micron.

The cheapest method of measuring mean fibre diameter is by the airflow method but mean fibre diameter can also be measured in laboratories with fibre diameter analysers (FDA), Laserscan or the optical fibre diameter analyser (OFDA).

(ii) Fibre diameter variability

Variation in fibre diameter around the mean diameter is measured by the standard deviation (SD). The smaller the SD the less the variation around the mean. SD tends to increase as the mean fibre diameter increases so a better measure of fibre diameter variability is the co-efficient of variation (CV%). CV% measures the variation in fibre diameter relative to the mean fibre diameter. CV% is calculated by dividing the SD by the mean fibre diameter and then multiplying by 100. For example, if the mean fibre diameter is 25 µm and the SD is 5 µm then:

$$CV\% = (5/25) \times 100$$
$$= 0.20 \times 100 = 20\%$$

The only economic methods of measuring CV% are in laboratories with FDA, Laserscan or OFDA. These modern machines are connected to computers and can easily measure, record and calculate the data from 5000 fibre measurements. The OFDA measures fibre diameters between 4 and 150 µm.

(iii) Incidence of medullation

The incidence of medullated fibres is measured by number (% of fibres examined) or by weight (% w/w).

The only economic method of measuring the incidence of medullation is by the OFDA. The OFDA records the diameter of medullated fibres, and can calculate the mean diameter of medullated fibres, the incidence of medullation by number and by weight. Histograms are also printed of the distribution of medullated fibres. Previously the projection microscope was used but this method cost about four times that of the OFDA. However the OFDA cannot accurately measure medullation of coloured fibres.

(iv) Washing yield

The fleece of alpacas contains impurities which include natural grease from the skin, dust, soil, dung, and vegetable matter like grass seeds. Some owners also apply coloured markers. The washing yield is calculated following a carefully controlled cleaning and drying procedure. A weighed greasy dirty fibre sample is converted into a clean dry sample and reweighed. A standard allowance is made for moisture regain and the washing yield is expressed as a percentage (%).

The use of the washing yield is to calculate the clean fibre production from an animal. For example, if the greasy fleece weighed 3.0 kg and the washing yield was 90% then the clean fleece production was 3.0 x 0.90 = 2.7 kg.

(v) Vegetable matter content (VM)

Special laboratories are required for determination of VM contamination. It is possible to determine the amount (%) and type of VM. Under most situations growers do not need to determine VM but selling agents need to determine VM. If VM exceeds 5% then special processing is required which can damage fibre characteristics.

In the office.

If test results are not carefully examined in the office then it is really a waste of time, money and effort taking the samples in the first place. The following issues are important:

(i) Interpretation of test results

When comparing test results to select and cull animals for breeding it is only valid to compare results between animals which have been grazed together in the same mob. Even then you may not be able to make a valid comparison. The test results are quite valid for selling fibre.

Why? Well there are a large number of environmental influences which can affect the fibre grown by alpacas. These environmental influences vary even over a small property.

For example soil types can vary over distances of 20 m resulting in different paddocks having different pasture growth, different mineral nutrition, and different levels of internal parasite contamination. Even within the same mob you must only compare animals of the same physiological state. That means compare pregnant females with pregnant females, compare tuis with tuis, compare healthy animals with healthy animals, compare animals shorn in November with animals shorn in November.

It is very silly to use "test results" to compare animals which have been brought in from another property or prepared for shows. You need to wait until all the animals (yes, yours and the new arrivals) have been shorn and then grazed together.

When buying alpacas ask the seller to provide details of all the animals grazing in the mob, so you can see the relative ranking of the animal you are interested in buying. If the seller says that they have only tested the animals they are selling then you know that they really don't understand the benefits of testing all their animals, you could suspect that they do not know the relative merits of the animal they are selling, but they may know the relative merit of the animal they are selling and they may be telling you a great big lie and be selling you a dud!

(ii) Graphing results

The simplest way of comparing animals is to graph the clean fleece weight against the mean fibre diameter. An example is shown in Figure 2. This example is based on a random selection of fleece measurement data collected during the first year of my study of alpaca fleece quality.

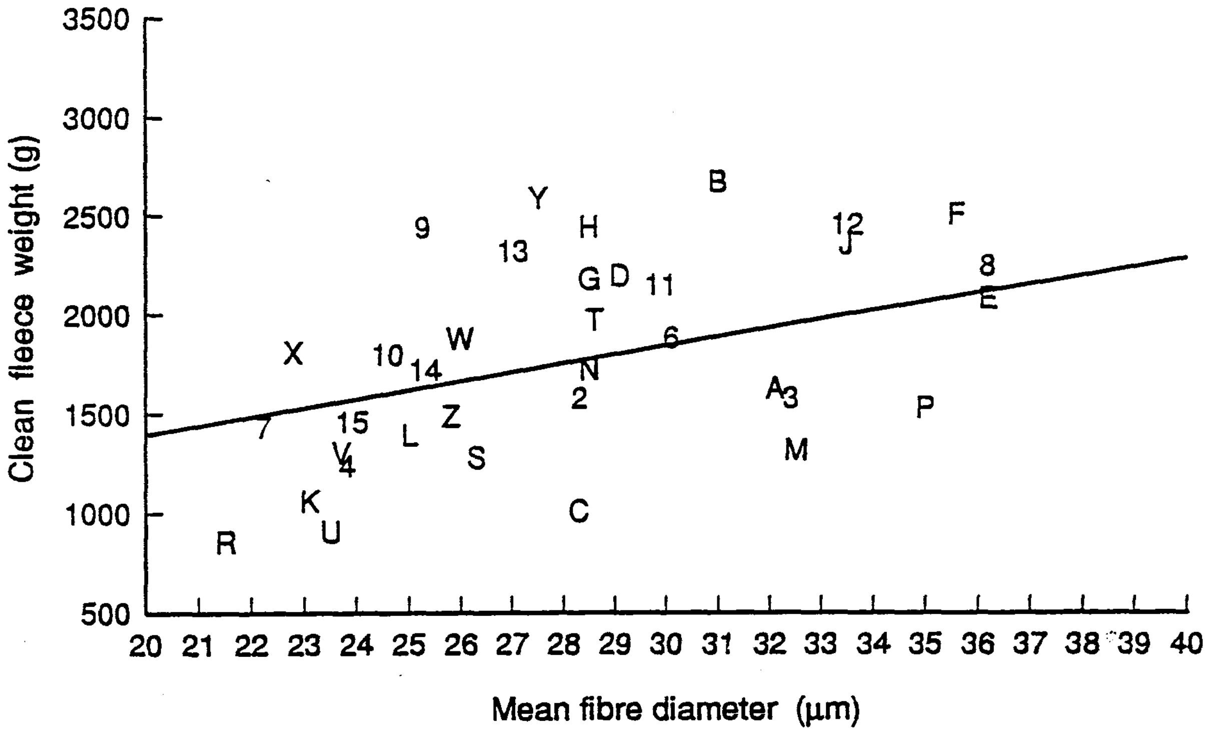

Figure 2: The relationship between clean fleece weight and mean fibre diameter based on a random selection of alpacas grazed in southern Australia (McGregor unpublished). Individual animals identified by letters or numbers.

Once the data has been graphed a line of best fit is fitted through the data. In this hypothetical example let us assume that several cull animals have already been excluded (animals 1, I and O) and that the fleece characteristics and live weight of the remaining alpacas are similar. Which are the best females? Which of these adult animals would you use and which animals would you cull?

- Which is the better animal, N, T, G, or H? Which is the better animal, 9, H, 12, or F?
- Which is the better animal, 7, W, G, or B?
- If you were going to cull 75% of these alpacas which 9 would you keep?

To make genetic progress more information is required. Genetic selection is briefly discussed later in this paper.

(iii) Keeping good records

Invest in a filing cabinet and other appropriate equipment to keep your records safe. Programs are available to store and process data on computer.

(iv) Interpretation of fibre diameter variability

The potential use of fibre diameter variability has been discussed in relation to spinning fineness. Ideally CV% needs to be reduced, not only to eliminate the coarse edge and the "prickle factor" but to reduce the mean fibre diameter and to improve the processing performance of the fibre. What is the ideal CV%? Well fine wool growers are aiming at 16 to 18%. Vicuna has a CV of 12 to 13% (Pumayalla and Levva 1987). These targets are too severe at current levels of production. Perhaps 20% is a more realistic target in the medium term.

Some people like to over interpret fibre diameter histograms, and read into the histograms all sorts of things. Apart from the data on CV% the only other information of any real importance is the shape of the histogram. While it may be ideal to see a perfectly symmetrical histogram this shape is rarely seen. It is impossible for the follicles to grow fibres 4 µm in diameter but they can grow fibres 50 µm in diameter.

Histograms usually have a short "tail" towards the greater fibre diameters, or in technical terms the distribution is skewed. I examine histograms to see if the fibre distribution is "bimodal" by trying to identify two peaks in fibre diameter distribution and to identify distributions with a very long tail. Some animals have one peak at say 22 µm, representing non medullated fibres, and a second peak at say 30 µm representing medullated fibres. The second peak predominantly represents fibres growing from primary follicles. Animals with bimodal histograms and long tails are undesirable in a breeding herd. See Figures 3 and 4 for examples from Australian alpacas of desirable and less desirable histograms (measurements made on the OFDA). In these histograms the distribution of medullated fibres is shown by the bolder darker bars.

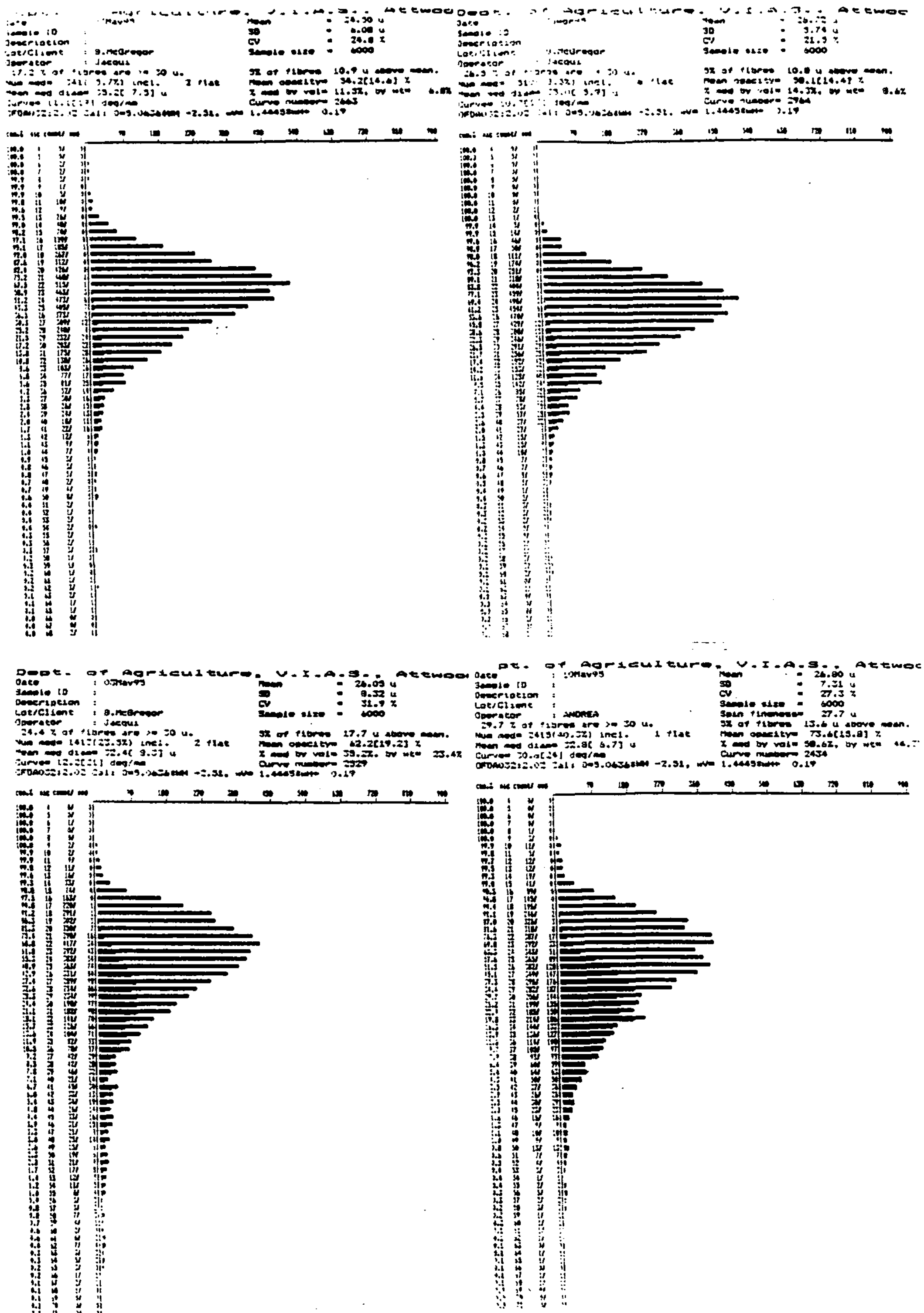

Figure 3: Examples of desirable and less desirable fibre diameter distribution histograms for measurements of alpaca fibre made on the OFDA. In these histograms the distribution of medullated fibres is shown by the bolder darker bars.

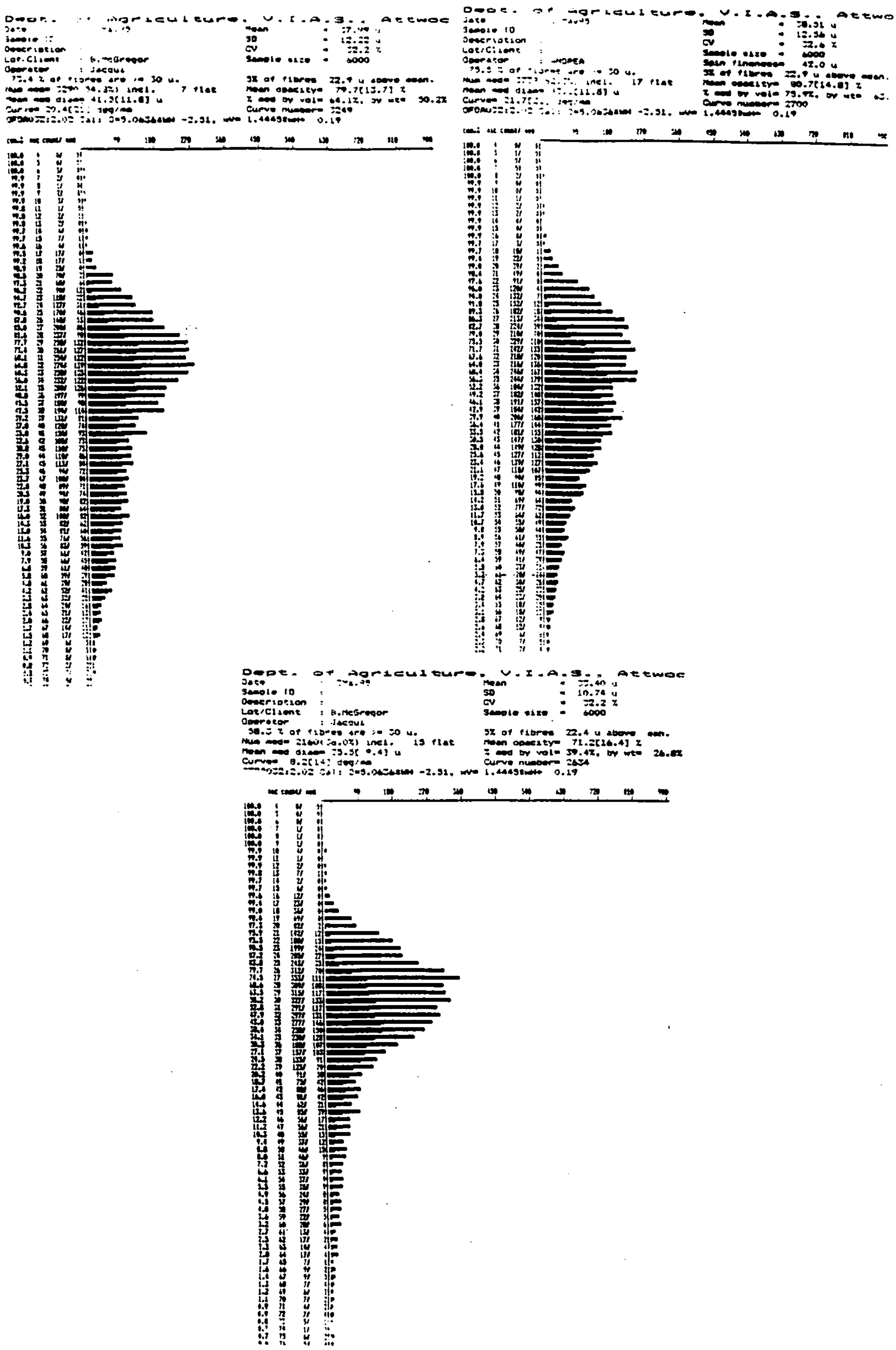

Figure 4: Examples of undesirable fibre diameter distribution histograms for measurements of alpaca fibre made on the OFDA. In these histograms the distribution of medullated fibres is shown by the bolder darker bars.

Figure 3 shows four histograms from Australian alpacas. The example on the top left has a mean fibre diameter of 24.5 μm, CV 24.8%, and medullation incidence of 6.8% w/w and the example on the top right has a mean fibre diameter of 26.7 μm, CV 21.5%, and medullation incidence of 8.6% w/w. Both these histograms have good shape. The example on the bottom left has a mean fibre diameter of 26.1 μm, CV 31.9%, and medullation incidence of 23.4% w/w and the example on the bottom right has a mean fibre diameter of 26.6 μm, CV 27.3%, and medullation incidence of 44.3% w/w. Both these histograms have poorer shape with longer tails (coarse edge). The animal on the bottom left shows a slight tendency for bimodal distribution.

The three histograms in Figure 4 all have poor shape with long tails. The example on the top left has a mean fibre diameter of 38.0 μm, CV 32.2%, and medullation incidence of 50.2% w/w and a tendency for bimodal distribution, the example on the top right has a mean fibre diameter of 38.5 μm, CV 32.6%, and medullation incidence of 63.9% w/w and the example at the bottom has a mean fibre diameter of 33.4 μm, CV 32.2%, and medullation incidence of 26.8% w/w.

Where to test?

Fibre Testing Services using the OFDA are available in Victoria from:

- Victorian Institute of Animal Science, telephone (03) 9217 4365
- Melbourne College of Textiles, telephone (03) 9389 9228

Airflow and Laserscan testing are available from the Australian Wool Testing Authority, Sydney and private suppliers. In other States growers should check with their local Department of Agriculture for fibre testing services.

Survey Of Australian Alpaca Fleece Quality

Preliminary data from the first year of the research project "Productivity and marketing improvement of the Alpaca fibre industry in Australia" are given in Table 2. Midside mean fibre diameter ranged from 24.3 to 30.2 μm and mean CV% ranged from 23.3 to 26.2%.

We are currently evaluating the relationship between midside and whole fleece measurement. On all properties the mean fibre diameter of the pieces line was about 10 μm greater than the midside fibre diameter.

Table 2: The mean and range in alpaca fibre characteristics of samples taken during November 1994 from the midside of alpacas grazing four properties in southern Australia (Total number of alpacas = 184, number of data in medullation analyses = 76).

Fibre measurement	Property 1	Property 2	Property 3	Property 4
Fibre diameter (μm)	30.2	25.7	26.9	24.3
range	19.9-43.9	19.8-33.0	19.9-41.0	19.3-31.6
Co-efficient of variation (%)	23.3	26.2	24.7	25.2
range	16.3-32.6	20.2-39.0	18.4-35.2	19.4-32.5
Medullated fibre diam (μm)	34.6	32.1	33.2	30.8
range	29.0-43.0	26.6-36.0	29.6-38.6	25.0-33.0
Medullated fibre (%w/w)	31.7	24.5	36.5	26.2
range	1.7-73.6	4.5-70.9	10.6-87.8	5.2-98.5
Washing yield (%)	91.3	91.2	88.0	87.2
range	72.3-98.0	84.0-96.6	82.9-94.3	78.0-94.8

Management and Environmental Effects on Alpaca Quality

The objective of this section of the paper is to briefly mention some of the management and environmental effects on alpaca quality. There are five major management and environmental effects which can be manipulated by producers to influence fibre quality and production. Some management and environmental effects offset or counter act benefits gained by other management effects. The effects are live weight, nutritional manipulation, flock type, flock structure and genetic selection.

Live weight.

As alpacas grow and become heavier they generally grow coarser fibre. If producers wish to produce fine alpaca a production system needs to exclude heavy animals which produce coarse fibre. For example, a producer may wish to exclude all alpacas producing fibre 28 μm or stronger.

Live weight, age and alpaca fibre diameter Many commentators have concluded that alpaca fibre diameter increases as alpacas age. This concept is not reliable under all conditions. Under conditions of good nutrition, age and mean live weight of alpacas are reasonably correlated with each other, but under poor nutritional conditions leading to alpacas loosing live weight, live weight is much more likely to account for more variation in fibre diameter than age.

Live weight loss naturally occurs when animals graze dry mature pastures in Australia and in Peru. Live weight loss would occur if animals were grazed at too high a stocking rate, during droughts, during lactation if nutrition is poor or if severe internal parasitism occurred.

In Peru the average live weight of female alpacas in peasant communities is about 45 kg (Bryant et al 1989) while alpaca farmed in high input systems in Peru and New Zealand have live weights of 56 to 73 kg (Davis et al 1991). Live weight gains in New Zealand are much higher than is normal in South America and the fibre diameter of adult alpacas is 1.3 to 3.1 µm greater and the fibre diameter of crias 6.0 µm greater than is reported from South America.

Nutritional Manipulation.

As just mentioned there are a number of ways in which alpacas can experience poor nutrition resulting in live weight loss. On Australian farms managers have two main methods of manipulating the nutrition of live stock.

Stocking rate influences quality and production of fibre, mohair, milk, and meat by affecting pasture availability, pasture growth rate, pasture composition and internal parasite infection. San Martin and Bryant (1989) suggest that the stocking ratios of alpaca:sheep would be 1:1 and llama:sheep 1.5:1. These ratios would need to be used to compare animals of similar physiological state, that is for comparison of reproducing animals or for comparison of growing animals.

Supplementary feeding of energy is usually provided in droughts, dry summers, at weaning and during late pregnancy and lactation. Energy supplementation directly reduces live weight loss or results in live weight gain and therefore affects fibre diameter. Generally the costs of feeding energy supplements far outweigh the direct benefits of increased fibre production. Supplementary energy is definitely indicated before the welfare of the animal is at risk (droughts, pregnancy) and large benefits can arise when energy is fed to lactating females during droughts.

During the pasture growing season in southern Australia supplementary feeding of protein and non-protein nitrogen is not usually warranted as pastures contain more than 18% crude protein (dry matter basis). Research results in Australia and the USA have shown that when sheep and fibre goats graze growing pastures the costs of feeding protein supplements far outweigh the benefits in terms of increased financial return (McGregor 1990).

Flock Type.

Many wool producers maintain specialist flocks of wethers and some wool growers only have wether flocks. Why is this so? The main reasons are related to management and labour. Breeding flocks are subject to major nutritional stresses in autumn and winter which results in reduced wool quality and tender low strength wool. Wether flocks are less susceptible to such stresses. Wether flocks also require no labour at lambing!

Running wethers is a cheaper and easier way to be introduced to alpaca production, it requires less labour and by instituting rigorous culling and replacement management wethers could always be producing alpaca fibre with fibre diameters less than 28 µm.

Flock Structure.

Flock structure refers to altering the proportion of different classes of livestock, such as more younger animals and less aged animals. In term of fleece quality it is best to manage the breeding females to ensure high rates of reproduction and cull older less productive females with poor quality fleeces. One of the reasons why relatively little fine baby alpaca fleece is produced in Peru is that peasant communities don't mate female alpacas until 3 to 4 years of age, thus increasing the relative production of coarser adult fibre. In high input systems it is possible to mate females at 1 year of age (Bryant et al 1989) thereby reducing the number of older females required and increasing the relative production of fine alpaca fibre.

Genetic Selection.

It is clearly possible to change alpaca characteristics by genetic selection and/or changing alpaca strains. This topic is covered in more detail in other Alpaca Association proceedings (Ponzoni 1993, Tuckwell 1993).

Genetic Selection It is possible to select for finer alpaca fibre with reduced CV%, for less medullated fibres and heavier clean fleece weight as these traits are all heritable. Breeders need to be aware that these traits are correlated which means that changes in one trait will affect another trait.

Breeding indexes and progeny testing are required to fully evaluate potential males and to provide weighting of various traits prior to selection to ensure that your objectives can be reached. One of the objectives of our current research project is to provide data for the development of genetic data and breeding indexes.

Strain Selection Australian breeders can now purchase Chilean, Peruvian, Huacaya and Suri alpacas and llama and llama x alpaca cross animals. There is also variation within strains and opportunities exist for crossbreeding between strains to select the animals most suited to Australian conditions.

CONCLUSIONS

Farmers wishing to produce quality alpaca have clear directions for breeding and management of animals. The future evolution of the textile market requires more comfortable clothing. Within the Australian population good quality alpacas are available. The methods for on farm assessment of fibre are relatively simple but must be carefully followed if benefits are to be obtained. Much needs to be learnt about the influence of management and environmental influences on alpaca fibre quality under Australian conditions but practical guidelines have been given. An exciting future awaits breeders developing alpacas adapted to Australian conditions using the genotypes now available.

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