Alpaca fleece length attributes for processing and the relationship with assessment in the show ring

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About the Author

Dr. Bruce McGregor, *B.Agr.Sc.(Hons), Ph.D., Advanced Cert. Textile Technology*, has had a long career in improving the production, fibre quality, processing and comfort properties of rare natural animal fibres including alpaca, superfine wool, cashmere and mohair. His work has included detailed studies of animal fibre production and quality, fibre marketing, textile quality and processing. Bruce investigated the farm productivity and fleece quality of Australian alpacas during the 1990s and initiated alpaca processing studies during the early 2000's. His scientific publications on fibre quality of Australian alpacas have been cited over 100 times.

Recently Bruce was the leader for the Cooperative Research Centre for Sheep Industry Innovation program on next generation wool quality. The focus aimed to improve the next-to-skin comfort properties of wool textiles. This collaborative work led to the development of testing protocols for the wool comfort meter, analysis of extensive garment wear trials and the development of decision support tools for textile designers and manufacturers using new laboratory equipment, fibre and textile testing.

Bruce has published over 150 scientific research papers plus 100's of technical bulletins and advisory publications. He has travelled widely to countries that produce rare natural animal fibres so he could understand the environmental, social and technological conditions in these regions. This includes six trips to South America to study alpacas and alpaca processing, and many trips to China and Europe to study textile processing.

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Abbreviations and definitions

AWTA: Australian Wool Testing Authority

Carding: the mechanical process that disentangles, cleans and mixes fibres to produce a continuous web or sliver suitable for subsequent processing

Clean washing yield: the percentage by weight of clean fleece in a raw greasy fleece (% w/w)

IWTO: International Wool Textile Organisation which sets the international rules regarding fibre measurement methods and trading rules

Medullated fibres: fibres which have a hollow or a partially-filled central canal running either as a continuous or in a fragmented form along their length. Most medullated fibres present in alpaca are guard hairs which are removed by dehairing.

MFD: mean fibre diameter (μm)

μm: a unit of length called micrometer equal to one thousandth of a mm (often referred to as micron)

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Executive Summary

There is currently debate amongst alpaca breeders, particularly those actively involved in showing, and especially for those who exhibit Suris, regarding the relationship between show ring rules and commercial processing requirements for fibre length. To provide insights to these questions five approaches were taken:

- Textile processing research knowledge was briefly summarised;
- Interviews were conducted with 10 alpaca processors on their requirements;
- A summary of raw alpaca fibre marketing requirements was made;
- Measurements were made on the fibre length of commercial alpaca tops;
- Information on length effects on mohair auction prices was summarised;
- Research findings on fibre length Australian alpacas was summarised.

The evidence provided in this report can be summarised as follows:

1. It has been clearly demonstrated in detailed and extensive research around the world that fibre length is a critical physical property which affects textile processing and textile quality.
2. Commercial practice for 150 years has been to separate animal fibre based on the raw staple length prior to sale and processing. During this fibre preparation, fibre of similar length is put together to create processing lots. The categories for fibre length conform to the requirements of the processor and the processing route.
3. The Australian alpaca industry developed fibre handling codes of practice during the 1990s and early 2000s which clearly indicated that the maximum preferred lengths of shorn alpaca were 15 cm and that overgrown fibre had lower or no commercial value.
4. The current Alpaca Fleece Classing Code of Practice shows a maximum accepted length of 14 cm with longer fibre categorised as overgrown.
5. The survey of processors of Australian alpaca indicated a maximum preferred length of 15 cm. One New Zealand processor has a specially designed textile mill which can handle up to 20 cm length fibre but the range for this processing is 12.5-20.0 cm. Several mini-mill operators have processed alpaca longer than 17 cm but only one or a few fleeces at a time and sometimes this is unsuccessful, however most mini-mill operators want fibre no longer than 15 cm.
6. Fibre length in processed international alpaca tops indicate that only 5% of the fibre is longer than 15 cm and less than 1% is longer than 17 cm.
7. The average length of fibre grown on the mid-side by Australian alpacas will most probably average 15 to 17 cm in a 12-month shearing interval.
8. Delayed shearing will increase the weathering effect of UV sunlight reducing fibre length, reducing fibre strength, increasing processing waste and making white fibre more yellow.

The concept of defining the rules for the show ring to align with what processors require has been implemented in other industries. Based on the present report, the proposed rule changes appear to be generous to those wanting little or no control on fleece length.

If the AAA want show ring animals to exhibit what processors want then an objective length of 15 cm would be a much clearer rule for exhibitors and stewards to apply than an elapse of time between shearings rule. The evidence from the annual growth of Suri fibre is that even 14 months elapse between shearing would produce average fleece lengths of greater than 19 cm, while 18 months growth would be closer to 22 cm.

1. Introduction

There is currently debate amongst alpaca breeders, particularly those actively involved in showing, and especially for those who exhibit Suris, regarding the relationship between show ring rules and commercial fibre requirements.

Since the current Board of the Australian Alpaca Association were elected, the focus has been to ensure that the alpaca industry has a viable future, and the commercialisation of the industry can be successful. Consequently, the Board recently endorsed various changes to the Showing Rules with the key rationale being to align what is awarded in the show ring with what textile mills require for processing. These changes included one to reduce the fleece age of Suris in the show ring to 18 months for first fleece and 14 months thereafter (effective from 2019), followed by a further reduction to 14 months for all age groups effective from 2021. This staged approach and timeframe is intended to allow breeders time to adjust their breeding and shearing schedules.

Some Suri breeders have expressed the view that these changes are not “commercial” and questioned the assumption that fleece of up to 30 months growth is not “commercial”. Whilst, of course, small quantities of such fleece can be sold to niche markets, the Board remains of the view that the animals awarded top honours in the show ring should be those with the genetic ability to improve the national fleece herd, and for this reason need to be exhibited on regrowth as well as first fleece.

With the appointment of a new Showing & Judging Committee and to provide evidence to AAA members, the Board has commissioned this report on alpaca fibre requirements for processing in mechanised mills, and the relationship between textile processor requirements and the public exhibition and assessment of alpacas and fleeces in the Australian show system.

In relation to both alpaca fibre types, Huacaya and Suri, grown under Australian conditions, what do textile processing mills require in relation to raw fibre quality, particularly staple length? Is there a difference in requirement between mills in Australia and overseas, especially in Asia and Europe? How do these requirements compare with the fleece attributes of Australian alpacas in agricultural and industry Show events?

To provide insights to these questions five approaches are summarised:

1. A summary of textile processing research knowledge was made;
2. Interviews were conducted with 10 alpaca processors on their requirements;
3. A summary of raw alpaca fibre marketing requirements was made;
4. Information on commercial alpaca tops and from mohair marketing was sourced;
5. Australian on-farm alpaca research results were summarised.

This report is not about animal husbandry requirements and management needs of alpacas. Shearing alpacas is a known risk to animal welfare, as is heat stress in summer months, and owners need to prepare for and take appropriate precautions in the advent of adverse weather. There are many other aspects of husbandry which are excluded from this report including health management, nutrition and genetics.

2. Commercial processing requirements for raw alpaca fibre

2.1 Fibre processing practices and quality assurance

All textile students are taught that processing batches need to be uniform in quality and conform with the machinery requirements of the processor. For alpaca fibre, the textile equipment is essentially the same as that used for all animal fibres, which are predominantly wool. The equipment design has been engineered to very high standards based on experience over 200 years and improvements in technology. The basic mechanical actions are that of repeated actions of steel onto keratin fibres. The fibres experience up to 20 interactions with steel pins, often at high speed. The processing is basically engineering, physics, and fibre mechanics.

Modern factories are designed to operate with the minimum of staff. Thus, equipment is calibrated and set up to operate in a self-sufficient manner with the minimum of breakages and stoppages. Specialist alpaca processors have adjusted their equipment to optimise the processing efficiency in similar ways to the adjustments made by fine wool processors compared with medium and coarse wool processors. The processing of animal fibres other than wool is often referred to as specialty fibre processing, as special techniques, equipment or equipment settings are required compared with normal wool processing. Such descriptions have been provided for more than 60 years, for example by Mauersberger (1954), von Bergen (1963) and Watson and Buxton (1992).

The economics of textiles mills are based on optimising the production from equipment. The limiting step is often the spinning process, where production is measured in kg per hour and the biggest problem is when yarn breaks. Spinning frames are set up for specific lengths of fibre, ideally straight clean fibre, and the spinning operation inserts twist into the fibres. The more twists which are inserted the slower the production per hour. A typical commercial factory will have spinning frames with up to 100 spindles on each side and have many frames on a factory floor, all set up with the same settings. To ensure that there are minimum stoppages and associated wastage of fibre and cost, quality practices are followed from the initial fleece classing to fibre purchase, fibre blending and top making. A predictable and relatively uniform fibre length is an essential quality measurement to ensure efficient operation of the spinning equipment.

With the advent of mini-mills, which process single fleeces or small quantities of fleece, there is a little more flexibility in some parts of the process, as the operator is present to ensure the passage of the fibre. However, there are still fixed settings on most machines such as the settings of the rollers in the spinning frame. These settings determine the length of fibres which can be successfully spun, and outside these limits poor quality yarn with many faults will result.

2.2 Evidence from textile research in processing mills

Intensive research in many wool processing mills around the world has been undertaken to quantify the most important aspects of raw wool fibre quality in terms of processing and end-product quality. The relative importance of the raw fibre physical properties is summarised in Table 2.1 (Anon, 1973; Smith, 1988; Vinella, 1993; McGregor, 1997, 2012). There are two main methods used to spin rare natural animal fibres. The woollen system is used for shorter fibre lengths and requires the production of slubs. Different equipment is required for these processing lines. The worsted system is used for spinning longer fibres. As well as defining the processing route, fibre length affects the spinning performance of animal fibres and many yarn and fabric properties (Hunter, 1993) and the price of raw and processed animal fibres. Consequently, fibre length comes second after mean fibre diameter in importance as a fibre attribute.

Table 2.1. The relative commercial importance of attributes of raw specialty animal fibres (adapted from Smith, 1988; Vinella, 1993 and based on Anon, 1973; with additions and modification based on recent research McGregor and Postle, 2007, 2008, 2009; McGregor et al. 2015). Not all physical attributes are listed.

RAW FIBRE PHYSICAL ATTRIBUTE	RELATIVE PROCESSING SIGNIFICANCE			
	Scoured	Top/noil	Yarns	Cloth
Mean fibre diameter	****	****	****	****
Clean washing yield	****			
Vegetable matter contamination (amount and type)	***	***	**	**
Mean fibre length	**	***	**	**
Incidence of medullated fibres		**	**	**
Mean fibre diameter variability			**	*
Fibre length variability		**	*	
Resistance to compression (crimp)		*	**	**
Incidence of cotts	**	**		
Degree of staple tipiness	*	*		
Style and handle			*	*

******** Highly significant, ***** Some significance.

Consequently, there are many attributes of raw alpaca fibre which are of commercial importance during textile processing. Some raw fibre attributes are of great importance in early and latter (spinning) stage processing while others are only of importance in early stage processing. The difficulty for commercial producers is that they have to produce a fibre that will please all stages of the industry from the early stage processor right to the consumer and make a profit at the same time. The relative importance of different raw fibre attributes depends on the defined end use for which the fibre is destined. These raw fibre attributes are commercially significant as they directly affect: the speed of processing, processing yield, quantity of waste products, yarn quality, dyeing performance, visual attributes, handle attributes, fabric properties, cost of product and appeal to customer. Fibre length is important for all stages of processing.

3. Interviews with alpaca processors on their requirements for fibre length

3.1 Interview method

A semi-structured telephone interview was conducted with 9 Australian alpaca processors and email communication was undertaken with a New Zealand processor. The processors all processed Suri and were asked the following questions:

1. Do you process raw Suri alpaca fibre?
2. If yes, what are the preferred staple lengths which you advise growers/industry?
3. If overlong Suri fibre is processed, what are the problems/issues which must be managed?
4. If overlong Suri fibre is sent to you for processing what do you do?
5. Are there other fibre quality issues with the processing of Suri fibre compared with processing other fibre?

The semi-structured approach allowed discussion of other issues which were mentioned by processors and provided a more relaxed approach. Sometimes issues were discussed in a different order to that listed above as the processor mentioned them early in the interview.

3.2 Responses from alpaca processors

The identity of the processing mills and their responses are summarised in Table 3.1. Processing mills ranged in size and capability from larger plants with large commercial equipment, such as Design Spun in New Zealand and Cashmere Connections in Victoria, to the more numerous “mini-mills” located in each State.

3.2.1 Preferred Suri staple length

Almost all of the mills (8 out of 10) expressed a preferred or optimal Suri staple length within the range 8 to 15 cm. The largest processor Design Spun, which has adapted its mill to process alpaca, had two preferred length ranges with the longest being fibre from 12.5 to 20 cm. They want relatively uniform staple lengths. One processor with a woollen processing system designed for shorter fibre had, as would be expected, a shorter preferred length of 6.5 to 7.5 cm. This plant cannot process long staples. Fibre of the Gods reported that they had not had any problems with overlong fibre but their experiences had only been with two lots of maximum lengths of 17 to 19 cm, which were successfully processed.

3.2.2 What are the issues with processing overlong Suri?

The most frequent issue identified in processing overlong Suri was the wrapping of long fibre on the equipment. This causes the fibre to not transfer to the next piece of equipment, which is usually another roller. The consequences being that the equipment must be stopped, the fibre cut off and wasted, equipment can be damaged and time is lost. Several processors reported that longer fibres resulted in yarn spinning faults and faulty yarn. Overlong fibre may need additional washing to remove soil and dirt contamination. Overlong fibre is more likely to become entangled during processing.

Some processors reported that they can process small quantities of fibre longer than their preferred length, but careful attention must be paid to the processing lot.

Table 3.1. Feedback from a survey of textile processors who process Suri alpaca fibre.

Processor	Location	Preferred Suri staple length	Other comments
Cashmere Connections, Trisha Esson	Bacchus Marsh, Victoria	12 cm	Can take some up to 15 cm but want average at 12 cm. Long fibre wraps on card rollers and will not transfer to next rollers. Fibre must then be cut off. Long fibre leads to a lot of wastage and lost time. Tight Suri locks do not open easily and will be ejected as waste. Equipment is best slowed down to process 100% Suri to ensure even fibre flow and keep the slivers together. Can use equipment to chop up long fibre but do not obtain even material and multiple passes are required so increase the cost.
Design Spun, Peter Chatterton	Napier, New Zealand	12.5 to 20 cm or 7.5 to 15.0 cm	Alpaca fibre is more difficult to deal with compared with wool, mohair, cashmere and possum. It has taken some years to optimise the processing of alpaca including the alterations to numerous machines. Have two preferred lengths to keep fibre length variation to a minimum. Can handle 20 cm Suri but only if the blend does not contain lots of short fibre. Fibre longer than 20 cm cannot be processed in the plant.
Rosabella Threads, Peter Tatum	Merritts Creek, Queensland	6.5 to 7.5 cm	As a woollen plant we cannot handle long fibre. The biggest problem for us is that the length is too long, even with shearing once each year. Very hard to have pure Suri go through the card. An important issue is the restricted supply of commercial quantities of appropriate alpaca fibre in order to operate the plant.
Adagio, Nadine Hulme	Orange, New South Wales	9.0 to 11.0 cm	Can process fibre in the range of 7.0-14.0 cm. Outside the preferred range results in increasing yarn faults. Longer fibres cause multiple undesirable faults as our equipment is set up for our preferred length. Farmers need to schedule shearing of alpacas for optimal staple length to fit the requirements of mills. Suppliers of alpaca and Suri get "thoroughly disappointed" when they learn that their overlong fibre is rejected. One third of suppliers bring in overlong alpaca as they miss annual shearing, which is a complete waste. The biggest challenge then is to manage the expectations of people who do not shear to the required length. It can take 30-40% more time to process pure Suri. Some suppliers bring in full mixed fleeces and so the rejected coarse pieces and short necks can amount to more than can be processed.

Processor	Location	Preferred Suri staple length	Other comments
Boston Fine Fibres, Tanya Boston	Queanbeyan, New South Wales	8 to 15 cm	If longer than 15 cm fibre wraps and binds to rollers. Some 18 cm fibre can be processed if very careful. Tight locks need to be pulled apart to reduce fibre loss. We have no time to do fibre cutting which is very time consuming.
Great Ocean Road Woollen Mills, Nick Renters	Ecklin South, Victoria	9 to 15 cm	Can process 6 cm fibre but short fibre causes problems as it is very slippery and slivers do not hold together. Longer than 15 cm does not draw properly with resulting thick and thin places. Can produce rovings for hand spinning from overlong fibre.
Wool2Yarn, Alasdair Chew	Mornington, Queensland	No longer than 15 cm	No problems processing Suri if no longer than 15 cm. Longer than 15 cm wraps around rollers. Can cut longer staples but this produces a bad product with inconsistent length. Overlong Suri is a waste of product. Vegetable matter contamination is a major problem.
Fibre Naturally, Gayle Herring	Macclesfield, Victoria	15 cm	Have processed small amounts of 28 cm long, but not all fleeces at this length will process. Long fibre will wrap around rollers, so additional cleaning is required and machine can be damaged. Opener can break long fibres which leads to reduced yarn quality and increased fibre shedding. Suri with tight ringlets is a problem
Fibre of the Gods, Hazel and Michael McKown	Toodyay, Western Australia	Must be longer than 5 cm	Had no problem processing any fleece and not had the problems reported elsewhere with overlong fibre. Have processed up to 17 cm Huacaya and 19 cm Suri. Most fleeces now shorn annually. When shearing interval is more than one year the fleeces get damaged staple tips and overlong fleeces need more careful washing.
Echo Beach Mills, Anne Harwood	Mt Barker, South Australia	No longer than 15 cm	The diameter of the rollers determines that 15 cm is the longest fibre to process as 17.5 cm will build up on rollers. If overlong fibre is consigned it is returned to grower. “Overlong fibre is the last thing I want to see”. There is more fibre entanglement after 12 months growth. Vegetable matter is also a great problem. Grower can cut overlong fibre. Suri is more difficult to handle and requires more time and effort to obtain a good product.

3.2.3 Dealing with overlong Suri fibre

Two processors reported using equipment for chopping up long fibre. Both processors said the end results of chopping are unsatisfactory with uneven material and increased costs. Several processors reported that overlong Suri was rejected.

Several processors said they told their farmer suppliers that the long fibre was worthless. One reported that their suppliers get “thoroughly disappointed” when they learn that their overlong fibre is rejected. Two processors said that overlong fibre is a waste of product. One said that “Overlong fibre is the last thing I want to see”.

3.2.4 Other issues identified with the quality of Suri fibre

Three processors identified the tight ringlet locks (curls) in Suri fibre as being difficult for the machinery to open easily and the tight locks may be ejected as waste. Tight locks may be pulled open by hand, but this is an undesirable activity.

Two processors specifically mentioned vegetable matter contamination as a serious problem. Some processors reported slowing down their equipment in order to successfully process Suri.

Some suppliers bring in full fleeces which contain acceptable fibre mixed with undesirable coarse and short fibre.

Fibre with more than a year’s growth will have damaged staple tips. Overlong fibre may need additional care with washing to remove the build-up of soil and dirt.

4. Alpaca marketing requirements

4.1 Introduction

There is a very long history of preparing animal fibre before sale as the essential first step in the quality assurance process (Barnard, 1958; Henderson, 1965; Pearse, 1965). Since at least the 1860's wool sorting, which today is called wool classing, has stressed the importance of removing fault lines and of placing like fibre with like fibre. The main aim of wool sorting is to ensure all the fibre in a lot is of similar quality. This means the fibre in a lot has similar fibre diameter, similar length and other important properties such as the absence of vegetable matter contamination and stains. This approach was taken to extremes so that by the 1960's Australia had about 6000 lines for wool sales. While it is always easy to see apparent differences in quality, in reality, many of the small differences were of limited commercial importance. Processors usually combined many of these lines before processing. Today, most Australian wool is sold in about 100 main lines.

The wool, mohair, cashmere and alpaca fibre industries in Australia have developed Codes of Practice for the preparation of fibre before sale. There have also been training courses developed for alpaca producers and for the training of wool classes proficient in classing alpaca fibre. These alpaca fibre standards are based on our extensive experience with the requirements for wool classing and are informed by advice from alpaca processing companies in South America. By 2012 the first industry standards for the preparation of Australian alpaca were agreed to as a Code of Practice with the Australian Wool Exchange (AWEX). This Code of Practice has been updated for 2016-2018 (AAA, 2016).

In South America, alpaca processors traditionally purchased unsorted mixed fleeces. The processors employed teams of trained sorters to separate the alpaca fibre into various lines prior to processing. One consequence of this approach was that the raw unsorted fleeces had a very low commercial value as there had been no quality assurance taken immediately following shearing. In recent years, many alpaca producing cooperatives began training staff and producers to follow the sort of guidelines we have for fibre classing. This has two benefits, firstly it increases the value of the fibre sold to processors and secondly, the quality of the fibre is improved as coarse, hairy and stained fibre is not mixed with better qualities of fibre.

4.2 Australian alpaca raw fibre classing standards

There was much discussion regarding appropriate raw alpaca fibre classing standards during the establishment phase of the Australian alpaca industry. In the 1990's the fledgling Australian Alpaca Cooperative Ltd struggled with the large variation in raw fibre quality (personal communications 1996 with present author).

4.2.1. Fleece standards for length in 2001

By 2001 the following classing lines for staple length and cast lines were used.

Huacaya
Length: AAA 70-140 mm;   AA 40-70 mm

Cast Lines
Heavy Vegetable Matter (VM)
Cott (COT)
Overgrown (OG)
Tender (TDR).

Suri
The quantity of Suri received by the Cooperative was low, and much of it was overgrown. Producers were strongly urged to shear their Suri's before the fibre exceeded 175 mm, otherwise the fleece will be overgrown, and of no commercial Value.

Length
AAA 100 – 175 mm
AA 70 – 100 mm.

4.2.2. Fleece standards for length after 2001

From November 2001 the length categories were redefined as follows.

Length categories
"A" 120 - 150 mm
"B" 80 - 120 mm
"C" 60 - 80 mm
"D" less than 60 mm
"O" (overgrown) more than 150 mm.

4.3 Development of the first National Code of Practice for Clip Preparation of Australian Alpaca Fibre

Knox and Lamb (2002), along with industry partners, developed fibre classing standards following extensive consultation with the AAA and Australian alpaca growers. Their general approach mirrors that used in the wool and mohair industries. The standards adopted were to be used in the then proposed national education of alpaca fibre classers and the Code of Practice for Clip Preparation of Australian Alpaca Fibre.

4.3.1 The object of fleece preparation

Alpaca fleece shows considerable variation between animals, between different parts of the fleece, even within a single staple of a fleece. Preparing a fleece during shearing accomplishes several goals:

- Processors can use Australian fibre with confidence, and with predictable outcomes;
- Australian fibre will develop a reputation as the world's best;
- Producers will gain the maximum financial reward for their clip.

To achieve these goals:

- Fibre should be combined into industry approved lines;
- All lines should be free of contamination while containing the appropriate colour,fineness and length variation;
- Producers should use suitable packaging material.

4.3.2 Line descriptions

The following descriptions, with a focus on staple length, were to be used to describe lines.

Breed: unless otherwise stated any description will refer to Huacaya. Suri will be denoted by the prefix S.

Length: the actual length parameters placed on each line will vary according to the industry requirements. Generally, it would be expected that the majority of a clip shorn at a 12-month interval would go into the AAA line. However, producers should consult with the organisation that will take the fleece prior to shearing for specific length requirements. The following guidelines are to be used:

AAA – Good average length, suited to worsted processing.
AA – Short line. Significantly shorter than AAA
A – Very short carding length line.
OG – Overgrown fleece, too long to go into AAA line.

Cast Lines: Fleeces which have a fault in them should be described accordingly. Small quantities of cast fleeces should be "Bulk classed" or packaged together and described in documentation for rehandling. **Some organisation may request that cast lines are not delivered at all.**

Descriptions:
All tender fleece - TDR
All cotted fleece - COT
Skirtings - PCS (only extra strong legs, bellies and aprons).
Overgrown - OG (excessively long fleece). May be No Commercial Value (NCV)
No commercial value NCV (do not dispatch as not wanted)
Heavy vegetable matter - VM (may be NCV).

These issues were widely discussed at AAA National conferences, such as in:

- Canberra (Morgan, 1994);
- Queensland (Holt, 1996);
- Sydney (Pearce, 1997);
- Fremantle (Knox, 1998);
- Adelaide (Knox, 1999);
- Canberra (Knox, 2000);
- Noosa (Williams, 2002).

During this period the maximum preferred upper length varied between 14 cm to 16 cm, but was most commonly 15 cm.

Pearce (1997), the Managing Director of an Australian textile processing company making a variety of yarns including alpaca yarns, was very clear regarding fibre length. He said: “Ideal length specification for worsted use is 100-150 mm staple lengths, giving a mean top length of 85 mm.” He also said that fibres much above 180 mm in length are not suitable for normal processing as even the presence of very small amounts of long fibre will render a batch unsuitable.

Williams (2002), a very experienced wool broker who was handling the Australian alpaca fibre for the alpaca co-operative said overgrown fibre creates a problem. He said it was uncertain whether the overgrown fibre could be scoured and that excessively long fleeces may have to be thrown out.

The alpaca staple length issue was not discussed at industry conferences in 2004 and 2006 perhaps implying that the industry knew the requirements of the processors.

4.4 Current AWEX Code of Practice

In 2012 the Australian Alpaca Association came to an agreement with the Australian Wool Exchange (AWEX) in regard to a Code of Practice for the description of greasy alpaca and the codes for branding bales of alpaca fibre. The Code of Practice was updated in 2016 (AAA, 2016). Specifically, the Code of Practice defines the Suri fibre length categories as follows:

A: 100 – 140 mm

B: 75 – 100 mm

O: (over long) > 140 mm applicable to all fibre diameter categories.

Similar length categories also apply to Huacaya, with the exception that very fine fibre A length should be 90 – 110 mm, otherwise A length is 90-140 mm.

4.5 Implementation of clip preparation standards, concluding remarks

It is clear that for at least 24 years there have been clear guidelines regarding the separation of alpaca fleece based on fibre length. It is also clear that the maximum preferred length for fibre has been about 15 cm, although some processors and agents may have some small variation on this maximum length. This maximum acceptable length is similar to the annual growth of fibre. The standards have also clearly indicated that overgrown alpaca is to be separated from acceptable fibre and that overgrown fibre may have no commercial value.

A lot of effort has been invested in providing the Australian alpaca industry with professional advice, based on cumulative wisdom accumulated over 100 years by countless professionals within the wool textile industry. Ignorance of such advice does not mean that the advice is misleading or incorrect.

5. International evidence on fibre length properties of commercial specialty fibre

5.1 Processed alpaca tops

The length properties of some samples of processed alpaca tops produced in Peru are shown in Table 5.1. These samples for Huacaya and Suri provide evidence on what the actual practices are in relation to the processing of alpaca fibre. The length properties of kid mohair, which is another special animal fibre, and which has similar properties to Suri, are also provided in Table 5.1 for comparison. Table 5.1 also shows the mean fibre diameter of the tops.

The length measurement shown is the Hauteur, which is the official length measurement used by the Internatlonal Wool Testing Organisation (IWTO-17, 2004). Hauteur is the average fibre length of tops after processing. Tops are then used for making yarn. When Hauteur is measured, the length of the longest 5% and longest 1% of fibres is also reported as well as other measurements. The data in Table 5.1 provide objective evidence of what happens during the processing of alpaca fibre in Peru.

Table 5.1. Fibre length tests on alpaca tops from Peru and kid mohair tops from South Africa.

Product code	Mean fibre diameter (μm)	Average length Hauteur (mm)	Length of longest 5% of fibres (mm)	Length of longest 1% of fibres (mm)
Baby Suri	21.9	55.6	115	147
Suri SU100M	27.4	44.0	102	134
Suri SU 203M	25.9	67.4	-	-
Suri SU 205M	27.0	75.1	-	-
Royal baby alpaca	19.6	70.6	137	161
Huacaya 100 BL	22.4	74.1	140	170
Cape mohair kid	23.3	80.1	147	172
Cape weaving kid	25.6	99.7	155	171

Note: Weaving kid is especially selected for longer fibre length (Hauteur)

The Baby Suri Hauteur had an average length of 55 mm with 5% of the fibres longer than 115 mm and only 1% of fibres longer than 147 mm. Other Suri samples had Hauteur of length 44 to 75 mm. The Royal baby alpaca (Huacaya) had an average fibre length of 70 mm with 5% of the fibres longer than 137 mm and only 1% of fibres longer than 161 mm. Similar length measurements were seen in the other Huacaya sample with only 1% of fibres longer that 170 mm. For the typical kid mohair samples, the average length was greater at 80 mm while the specially selected longer weaving kid had an average length of about 100 mm. For both the kid samples the longest 1% of fibres were about 171 mm long.

There are a number of comments relevant to the data in Table 5.1. Firstly, the average fibre length for spinning is no greater than 100 mm even for especially long weaving kid, and for the alpaca samples no more than 75 mm.

Secondly, for spinning, a very low presence of longer fibres is tolerated, with the longest 1% of fibres about 170 mm in length. Put another way, for commercial processing and spinning perhaps 1 fleece in every 100 fleeces could be about 17-20 cm in length but that fleece needs to be mixed with another 99 fleeces whose average length is substantially less than 17 cm.

Thirdly, there is a wide range in fibre length present in these tops. Given the averages are in the range of 44 to 100 mm, there are some very long fibres and to offset these there are also lots of fibres shorter than the average. One of the reasons for the large range in fibre length is that many fibres are broken by the machinery during processing.

Factors which affect the Hauteur of wool have been investigated. Textile research has shown that mean fibre diameter, staple length, fibre strength, vegetable matter and clean yield account for approximately 80% of the variation in the mean fibre length in wool tops before spinning and in the amount of fibre wastage experienced during top making (Anon, 1988). The remaining 20% of the variation if fibre length of wool tops is explained by variation between processing mills, fibre diameter variation, crimp definition, fibre style (including the amount of tip damage and dust penetration) and other characteristics.

5.2 Mohair auction process for length categories

Both Australian Merino wool and mohair are sold to international processors using the auction system. At auction, the measurements of the main raw fibre physical properties are provided based on objective measurements provided by the Australian Wool Testing Authority using IWTO rules and including the classifications provided by certified wool classers. This allows the analysis of the importance of different physical properties on the prices of wool and mohair. There are no international marketing schemes for bales of raw greasy alpaca, so it is not possible to do such an analysis. Given the similarities between Suri alpaca and mohair, and the fact that both fibres use similar specialty textile processing techniques it is informative to examine the effect of fibre length on mohair prices.

A detailed study of the auction prices of over 1000 sale lots of Australian mohair found that the prices were based on rational decisions by buyers and processors. Over 98% of the variation in prices could be explained. Thus, the prices of mohair were predictable, were based on important measurable attributes and that prices were not all myth and magic. Mean fibre diameter was by far the most important physical property affecting the auction price but length was also important (McGregor and Butler, 2004).

Mohair had been visually assessed into length classes by Australian mohair selling agents: A, 12-16 cm; B, 10-12 cm; C, 7-10 cm; overgrown (OG), > 16 cm; Locks, < 7 cm. A length mohair received the highest prices. B length mohair was on average discounted by 7% and C length mohair was discounted on average by 48% compared with A length mohair. The discounts for B and C length mohair varied with the mean fibre diameter, being less if the mohair was finer and more if the mohair was coarser.

For overgrown OG mohair, the discount was 56% compared with A length mohair. Processors reported that this OG mohair had to be broken using machines and the additional cost, labour and lower quality product resulted in the OG fibre having a lower commercial value.

6. Fibre length of Australian grown alpaca

An intensive study of farm produced Australian alpaca was conducted during the 1990s by careful measurement of alpaca fleeces over 4 years. In the first year the shearing interval was standardised to 12 months (McGregor, 1999a, 1999b, 2006). The study included both Huacaya and Suri alpacas. The majority of shorn saddles had staple lengths for 12 months growth of between 7.5 and 15 cm. However, 13% of Huacaya fibre was not suitable for worsted processing (< 7.5 cm) and 20% was too long (> 15 cm). For Suri fibre 30% was too long for most worsted processors (>15 cm).

For Huacayas, average staple length was greatest at 2 years of age and then declined reaching a plateau from 5 years of age. In Suris, averge staple lengths were longest at 3 years of age and declined to reach a plateau from 5 years of age. The relationship between age of cria at shearing (Cria Age, years), staple length and Breed was:

Staple length (cm) = 5.2 + 9.27 × Cria Age + 3.23 if Suri

What this equation shows is that at 12 months of age, Huacaya had average staple lengths of about 14.5 cm, while Suri had average staple lengths of 17.7 cm. This average value for Suris was used for fleece standards up to 2001 (see Section 4.2.1).

With 20% of Huacaya and 30% of Suri fibre exceeding 15 cm in length, a substantial quantity of overgrown fibre was being harvested. Significant amounts of this overgrown fibre is fine fibre from the first shearing of tui aged alpacas. It is a significant waste to have this fine and potentially highest value tui alpaca fibre consigned to the "overgrown fibre" category. If overgrown fine fibre is going to remain a feature of the Australian industry then specific arrangements must be made for processing but as is shown earlier in this report, only one processor really has the capacity to process 15 to 20 cm fibre.

Measurements showed that shearing at 8 months of age would produce staple lengths of 12 to 13 cm. To maximise production of fine baby alpaca fibre of acceptable length for worsted processing, suitable management practices must be developed that allow cria to be shorn at approximately 8 months of age without endangering their welfare from cold stress. Implementing such a practice would lead to 3 shearings in 24 months and maximise the production of the most valuable fine fibre. Irrespective of such a development, all cria should be shorn prior to their staple length reaching 15 cm (which in this study was prior to 12 months of age).

Staple length also varies across the fleece of Australian alpacas (Aylan-Parker and McGregor, 2002) and is affected by nutritional management (McGregor, 2002). These subjects are outside the scope of the present report.

7. Effect of weathering on fibre length

Weathering refers to the degradation of the fibre that occurs during growth from exposure of the fleece to sunlight, water and air (Millington, 2006). Exposure of animal keratin fibres, such as alpaca, Merino wool and mohair, to UV light present in sunlight causes photo-bleaching, followed by progressive photo-yellowing. Latitude, altitude and climate all influence the extent of UV exposure (Godar, 2005). These effects can easily be seen on the staple tips of coloured alpaca where, for example, black fleeces have bleached yellowish staple tips. Weathering damage, to Merino wool for example, reduces quantities of wool that are harvested, reduces length in both raw and processed wools, reduces spinning performance and dyeing outcomes. The extent of weathering in Australian Merino wool was investigated by Jackson and Rottenbury (1994) who reported that raw wool given the best topmaking assessment had an average weathered area of 12% of the staple, for average topmaking lots the weathered area averaged 23% of the staple, and for inferior topmaking lots the weathered area averaged 28% of the staple.

Merino sheep whose fleece is protected from the effects of weathering have 10-15% more fleece harvested compared with similar sheep whose fleece is not protected (Wheeler et al., 1977). Weathering damages Merino wool fibre tips which become brittle and these brittle wool fibre tips are lost during early stage processing resulting in shorter processed wool fibre (Walls, 1963). As a consequence of weathering, wool is reduced in both length and strength. If weathering affected alpaca in this manner it is likely to result in reduced alpaca fibre length both before and following processing.

The effects of weathering on the dyeing properties of wool can extend up to 30 mm from the tip of fine wool samples (Holt et al., 1990; Holt et al., 1994), and associated with photo-bleaching can lead to “tippy dyeing”. Schreiber (1990) found that most wool produces uneven, “skittery dyeings” if auxiliaries designed to overcome tippy dyeing are not used.

Suri alpaca fleeces generally do not exhibit the compact blocky staple tip structure found in fine Merino wool, partly a result of lower densities of skin follicles, and also the long staple length. This more open staple structure may possibly result in the effects of weathering on the dyeing properties of Suri alpaca extending further than 30 mm from the tip of the fleece. For example, with South African mohair, a fleece with a similar low skin follicle density and fleece structure as Suri alpaca, weathering damage extends deep down the staples, and to the staple root with kid mohair (Louw and van Wyk, 1958). Weathering occurs with cashmere, with up to a 6-fold variation in the extent of weathering between sources. Increased weathering in cashmere reduced fibre strength, increased the yellowness and reduced whiteness of white cashmere (McGregor, 2016).

Weathering does affect Australian alpaca as has been shown in unpublished research. Altitude has a very large effect, where UV radiation increases by about 4.0% per 300 m increase in altitude (Godar, 2005). The nature of the ground surface also affects the amount of UV reflection (albedo) with sand reflecting 5-25% and green grass and farmland 2-4% (Godar, 2005). There are large differences between the altitude of pastures grazed by alpacas in Australia, from near sea level up to greater than 1500 m.

Delaying the shearing interval for Australian alpacas for more than 1 year will significantly increase the likelihood of increased exposure to UV light and lead to greater weathering damage. It is likely that some of the reports of fibre breakage and other issues mentioned during the survey of processors (Table 3.1) relate, in part, to effects of and variation in the extent of weathering found in Australian alpaca fibre. Increased weathering of alpaca will most likely reduce fibre length, reduce fibre strength, increase processing waste and resulted in make white fibre becoming more yellow in colour.

8. Implications for Show ring standards

The evidence provided in this report can be summarised as follows:

1. It has been clearly demonstrated in detailed and extensive research around the world that fibre length is a critical physical property which affects textile processing and textile quality.
2. Commercial practice for 150 years has been to separate animal fibre based on the raw staple length prior to sale and processing. During this fibre preparation, fibre of similar length is put together to create processing lots. The categories for fibre length conform to the requirements of the processor and the processing route.
3. The Australian alpaca industry developed fibre handling codes of practice during the 1990s and early 2000s which clearly indicated that the maximum preferred lengths of shorn alpaca were 15 cm and that overgrown fibre had lower or no commercial value.
4. The current AWEX Code of Practice indicates staple lengths up to 14 cm being acceptable, otherwise fibre longer than 14 cm is classed as overlong.
5. A comprehensive survey of processors of Australian alpaca in 2018 indicated a maximum preferred length of 15 cm. One New Zealand processor has a specially designed textile mill which can handle up to 20 cm length fibre but the range for this processing is 12.5-20.0 cm. Several mini-mill operators have processed alpaca longer than 17 cm but only one fleece at a time and sometimes this is unsuccessful, however most mini-mill operators want fibre no longer than 15 cm.
6. Fibre length in processed international alpaca tops indicate that only 5% of the fibre is longer than 15 cm and less than 1% is longer than 17 cm.
7. The length of fibre grown on the mid-side by Australian alpacas will most probably average 15 to 17 cm in a 12-month shearing interval.

The concept of defining the rules for the show ring to align with what processors require has been implemented in other industries. For example: carcass competitions conducted in abattoirs and judged by butchers; Merino fleece competitions evaluated using AWTA tests and market prices. Based on the present report, the proposed rule changes with shearing intervals of greater than 12 months appear to be generous to those wanting little or no control on fleece length.

If the AAA want show ring animals to exhibit what processors want then an objective length of 15 cm would be much clearer for exhibitors and stewards to apply than an elapse of time between shearings definition. The evidence from the annual growth of Suri fibre is that even 14 months elapse between shearing would produce average fleece lengths of greater than 19 cm, while 18 months growth would be closer to 22 cm.

9. Other comments

For there to be a controversy regarding the commercial issues surrounding the acceptable lengths of alpaca fibre for processing indicates a substantial loss of industry knowledge, substantial ignorance of the underpinning knowledge for alpaca textile production and an absence of effective industry training. A search of the AAA external internet site indicates that almost all of the technical evidence provided to the AAA over the past 3 decades, including the proceedings of national conferences, is absent from the public record. Provision of such information has been identified as important components of attracting investment into the alpaca industry in Strategic Plans developed in 2002 and 2007. It would appear that some in the industry are unaware of or want to ignore objective information provided by experienced professionals and/or to waste time and resources "reinventing the wheel".

Furthermore, a number of issues other than the preferred fibre length were raised by processors during the interview survey (Table 3.1). These include issues with other fibre physical properties such as vegetable matter content and the presence of overtight ringlets in Suri fleeces. These issues are also relevant to rules for showing of fleeces and animals.

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