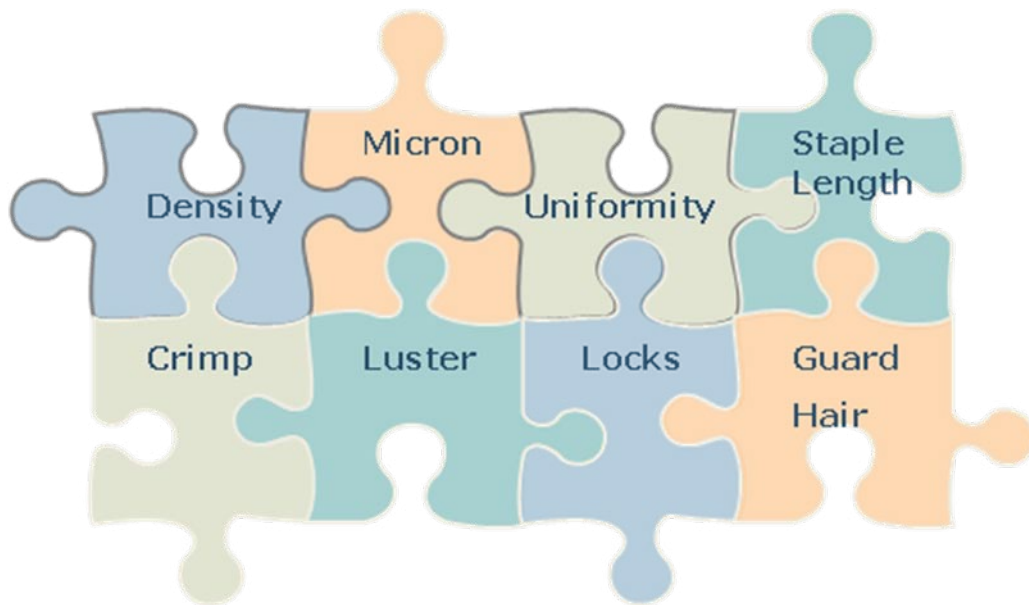


Alpaca Fiber for Profit Course

Module 3: Histograms & Follicular Skin Biopsies



Jim Tomaszek

Note: This material is presented as a support for the alpaca industry and is not verified by any administrative or authoritative body or AOBA at present

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Introduction: Alpaca Fiber for Profit

Question: What do you do with alpaca fiber?

Answer: We do what every breeder of livestock does – we selectively breed our alpacas for profit – through the sale of end products and/or services.

Question: With a limited fiber supply or demand, how do we sell our fiber for profit?

Answer: We come together, as partners rather than competitors to build appropriate sales & marketing channels for alpaca fiber. We breeders work in cooperation to educate the North American consumer as to the value of alpaca fiber as textiles.

Question: Where do we begin?

Answer: We begin with a complete understanding of alpaca fiber, its potential value, realistic market demands (current and potential), and selective breeding goals and strategies.

Question: What is your (North American Alpaca Federation ((NAAF))) role in this alpaca fiber for profit initiative?

Answer: NAAF is simply an alpaca marketing organization made up of fellow alpaca breeders dedicated to and focused on marketing and sales. NAAF's mission is to promote the North American alpaca to amplify the demand for the alpaca, its fleece and related end products through timely education and appropriate related strategies, in support of the individual alpaca owner/breeder.

NAAF's goals

Work cooperatively with any and all alpaca reputable alpaca industry resources to advance the alpaca industry in North America.

Offer marketing support to Independent Alpaca Businesses for marketing & education.

Develop and implement a comprehensive model for profit from alpaca fiber.

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Continue to attract new customers for sales of alpaca breeding stock.

Course Disclaimer:

This is module #3 of a 4 module series. The course is designed to flow from module #1 through module #4. If any information in this module does not seem to be defined properly, you will most likely find it in one of the previous modules.

The alpaca is a relatively new and exotic sight in pastures and backyards all over North America. Less is known about alpacas than perhaps any livestock animal in America. As we learn more about our rare alpacas both through research and experience - facts, theories, and speculation are sure to adjust accordingly.

Many 'how's and whys' of alpaca fiber are still hotly contested issues and some scientific research contradicts previous research. Study contradicts study. It is the intent of this module to attempt to separate opinion from responsible research, experience, and common sense. It is our sincere hope this module will evolve into a more refined and accurate knowledge base as you and others question this material, engage in lively discussion and contribute to improve this workshop.

This module is based on collective breeder experience, independent university studies, research conducted in Australia (CSIRO), articles written by Dr. Sumar, Ian Watt, Dr. Norm Evans, Mike Safely, Dr. Jim Watts (SRS), Mr. Villarone, Dianna Jordan (AFCNA), Robyn Kuhl (NAAFP), and many other sources.

Every attempt has been made to exclude irresponsible claims made by those who skew facts to favor sales of their own animals, breeding males or end product. *Note: Comparing alpaca to other fibers, as in "alpaca is seven times warmer than wool," still needs to be qualified. Just as a steak cooked to perfection can be a delight to the gourmet's palate, one burned to a crisp does not reflect a great steak at its best. A thick micron and dirty alpaca fleece mixed with long primaries and guard hair (the proper*

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term is 'Kemp'), then poorly processed can be thought of as the burned steak. It neither represents the standard nor reflects the potential.

Secondly, the alpaca comes from a diverse genetic background. While DNA studies show the domesticated alpaca to be the closest relative of the undomesticated vicuña, further studies reveals significant breeding history with the llama. As a result, there are many 'types; of alpaca, depending on its particular ancestry. This fact manifests itself in the alpaca's fiber, which comes in many varieties. While some styles will be in greater demand than others, dictated more by fashion than true worth, all styles of fiber have worth. It is up to us to carve out each niche market. In addition to creating an ever-growing supply and demand for fiber we must constantly educate the American public (as well as ourselves) on our harvests' value. To accomplish this we better be sure we understand the value of alpaca fiber ourselves. It is in the spirit of this challenge that this module was produced.

Note: NAAF remains neutral on the need for a North American alpaca breed standard.

This Fiber for Profit Workshop consists of 4 interrelated modules:

Module #1 – The Current & Potential Value of Alpaca Fiber

Module #2 – Alpaca Fiber Evaluation – The Objective & The Subjective

Module #3 - Histograms, Follicular Skin Biopsies & EPD

Module #4 – How to Make Money with Alpaca Fiber and the Value Chain

Each module relies on the others to present an understanding of alpaca fiber, its benefits and shortcomings, how it compares to like fibers, and how to measure it objectively to maximize profit. Module #4 will present case studies to show how at this time it is possible to pay for the upkeep of your herd with fiber sales. It is hard work, is very involved, and requires an industry focused on opening sales & marketing channels to attract an ever-growing alpaca breeder population as well as creating breeding and end product standards to ensure ever-growing revenue stream from alpaca sales and all potential end product revenue streams

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Section 1 – Measuring Alpaca Fiber

My arm is not a scale; my eye is not a microscope

Many of us spend a healthy amount of time evaluating our alpacas for ‘value.’ We investigate ‘bloodlines,’ championship, reserve and blue ribbon wins. We search through show data for the number of entries in a particular halter class. Some of us believe that the more an alpaca costs, the better it will be. Many of us agonize as to who to breed to whom next spring. Many of us pour through articles on animal husbandry and genetics articles looking for a way to stack the odds in our favor.

We agonize over terms like ‘zipper crimp versus French fry crimp,’ ‘lock structure’ and ‘degrees of luster.’ We cart our alpacas around the country and compete in halter and fleece shows, hoping to learn more as to the worth of our animals as they measured against others. If we win big, the judge was an expert. With a loss, the judge was incompetent.

Whether we return home with a fist full of ribbons or empty handed, we may still puzzle over the questions like ‘which herdsire should I breed my best dam to?’ or ‘am I truly improving my herd with my breeding strategies?’ Even if we take the championship at a show, how do we know this titleholder will produce improved offspring?

No matter what we read, see or feel, or if we win in halter or fleece shows, much of what we do we do on instinct, pre-conceived notion, mood, hearsay – and these are mostly opinions mixed with experience. We call this a *subjective* view. It can be an emotional view, a biased view, based on your impression. It is subject to illusion.

The counter view is the objective view. This is the scientific view; the measured view; the unemotional view. Facts. Statistics. Hard comparisons. What we see and judge visually and with our hand are subjective. We view the alpaca’s phenotype it’s external being. We look at conformation. We look at ‘indicators’ of fineness such as crimp and can visually compare on alpaca’s fiber to another and determine which fiber is finer; which is longer.

When we apply science and measure with tools, we begin to view the alpaca objectively. While I might say, ‘my alpaca is finer than your alpaca,’ and believe it and you say the same about yours, scientific measurement moves us from opinion to fact.

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What we measure is objective, and many of these ways to measure objectively help us understand the alpaca's genotype. And this truly does help us stack the odds for selective breeding for improved qualities in our herds.

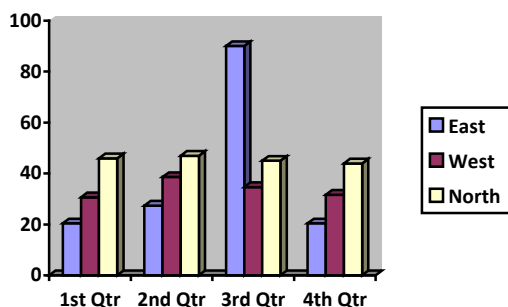
As expected with science and its greatest tool, mathematics, results are often displayed as complex formulas with strange terms. We often repeat these terms without fully understanding their meaning. We just know that an 'SD' of 4 is great and an AFD of 50 isn't.

The goal of this module is to remove the complexity and mystery from objective measurement to help us both understand the value of scientific alpaca measurement tools and to help us utilize them to accurately assess the value of our alpacas for certain traits and to also evaluate our breeding programs for accuracy and progress.

Section 2 – Basic Histogram Terminology

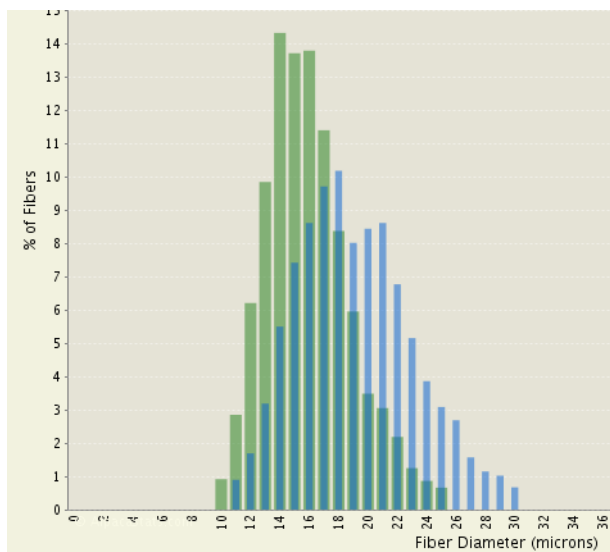
Most of us are familiar with charts and graphs. They offer us a visual representation of data. While the data may look like an unintelligible row of data, once we can see it in chart format, we can easily identify trends and sizes represented with lines and colors, bars, intervals and arrows and the like. Charts and graphs are a great way for us to comparatively view statistics.

'Histos' is a Greek word for something standing upright. The Empire State Building is a histos. So is this. Note the colored bars. Note the vertical numbering from 0 to 90. Note the horizontal labels (1st Qtr, etc). This chart offers us a comparison. We know from the base labels that we are representing something through quarters (usually means the 4 quarters of a year) and that the color chart to the right matches the bars with the cardinal directions, but we would need to label the vertical axis (0 – 90) to get any meaning from this.



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So a histogram is a graphical display of numerical data. A picture is worth a thousand words. Histograms help alpaca breeders evaluate each alpaca's fiber scientifically. Below I am evaluating the fiber characteristics of two male Huacaya.

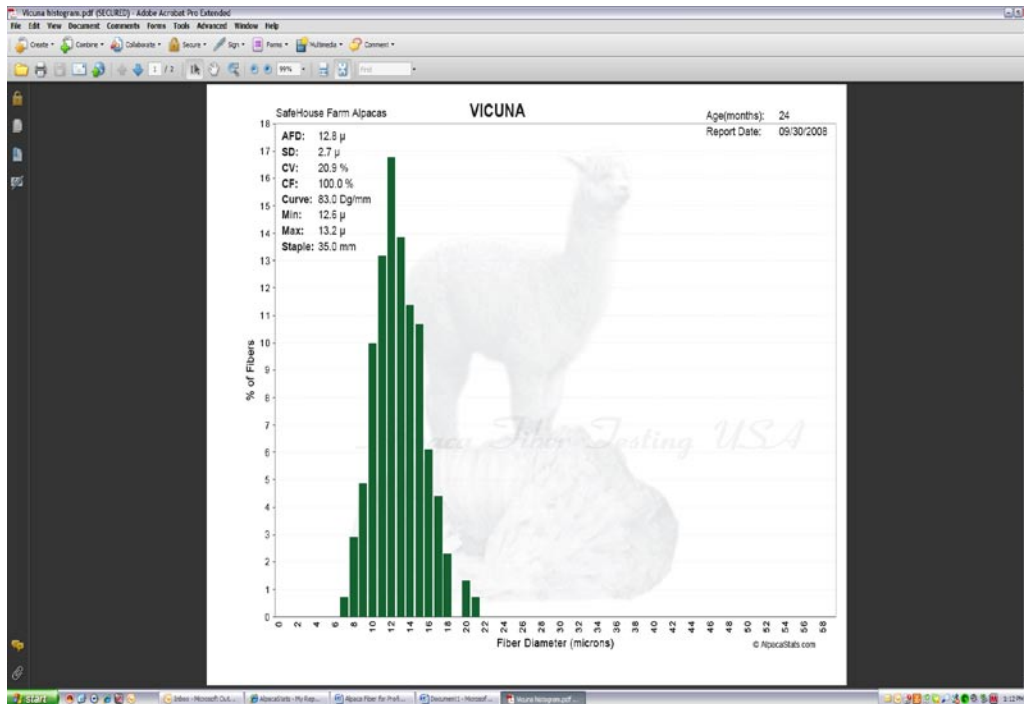


I am comparing the percentage of fibers on the vertical axis against the fiber diameter measured in microns. One male is in green, one in blue.

What I would like to see is more of both colored lines shifting to the finer (left side) of the graph (finer = \$\$\$\$\$ in general). I would also like to see the bars reaching higher than they are. Why? The farther to the left I move and the higher I move, the finer and more uniform the fleece will be. That can be worth big bucks.

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The histogram below is Vicuna fiber. Note how this graph is shifted left and is elongated vertically. Vicunas are known to be very fine and very uniform. This is what fine and uniform look like on a histogram.



Note the symbols on the top left corner of the above diagram. AFD, SD, CV, CF, Curve, Min, Max, Staple. The green bars are a graphical representation of those measurements. To understand our alpaca's fiber better, to measure its value against others in your herd, we need to understand these numbers – not in depth, just in high level. To be successful as a breeder, you better be able to evaluate your end product. Besides, potential customers will ask.

Take a deep breath and let's dig in.

Getting a histogram test is simple. You basically cut a fiber sample (the size of a man's thumb for the OFDA 2000 test and 2 square inches for the OFDA 100 test) from your alpaca, send it to the appropriate lab and your results are sent back within days or a few weeks either in the regular mail or by email.

Two examples of where to send them are online:

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Yocum Mccoll - <http://www.ymccoll.com/>

Alpaca Consulting Services (ACS) USA - <http://www.alpacaconsultingusa.com/>

(Thanks to Ian Watt of ACS for permission to use samples of his histograms for this module).

A. AFD – average fiber diameter

(also referred to as MFD – mean fiber diameter)

For many breeders this seems to be the ‘be all end all’ statistic. We call it ‘micron madness.’ While it is a key statistic in alpaca fleece evaluation, it does not give the whole picture of an alpacas worth.

If the tested alpaca is ill, the fiber will be finer since most of the energy the alpaca has is being channeled to fight the illness.

If the alpaca was tested in the dead of winter, the test result will show up finer than normal since the alpaca is channeling most of its energy to keep warm.

If the alpaca has been over eating and has been on a high protein diet, this number may be very high and could be reduced if the alpaca is fed a balanced diet.

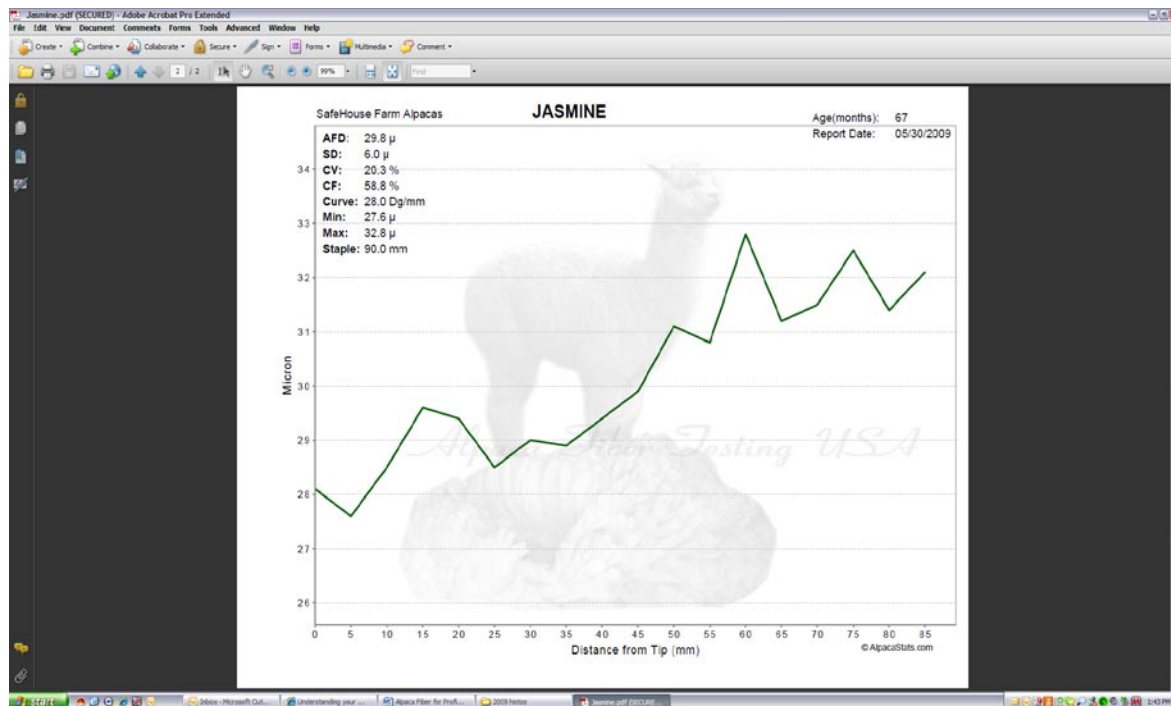
Note how the environment and nutrition play a big part in fiber testing. There may be some truth in the adage, ‘figures don’t lie, but liars figure.’ Most of us sample fiber in the spring, during shearing.

Also note that some tests of AFD are measured at only one point while others take measurements along the entire fiber. No alpaca has a perfectly uniform fiber diameter – it changes due to health, nutrition and environment, as well as from pregnancy, nursing and other factors.

Also note that, in general, a sample is taken from one spot on the alpaca’s blanket. The AFD therefore only reflects a sampling of one area – the side of the blanket. While there are other methods to sample fleece, this method seems to be the standard for now.

The following is a graphical representation of a fiber sample where the micron diameter is measured along the fiber and not from one single location. It is called the Average Fiber Profile.

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Note the wide variation of fiber from less than 28 microns to nearly 33 microns. This is a sample of a year's growth on a pregnant dam. The left side of the graph represents shearing day the year before and the right side represents the tip of the fiber sample, furthest from the body.

Note that accurate records of illness, pregnancy, delivery, nursing, and even stress from the spring/summer show circuit can be matched to the timeline of this graph. In addition to micron, this graph can give one an excellent record of health and nutrition.

So AFD is merely one factor necessary to assess an alpaca's value and status.

B. Standard Deviation (SD)

Technically, this number measures the number of fibers within one standard deviation of the mean (arithmetic average). Yeah, right.

Imagine it is your job to find the average income of families living on two specific streets. On street one there are 20 families and they all happen to make \$20,000 per year. The average income is easy to compute – it's \$20,000 per year. The average is very representative of each family – in fact it is a perfect match for each

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family. Street two as only two houses. The family in the first house is very wealthy. Their household income is one million dollars per year. The family breadwinners on the second block are out of work and have been for over a year. When we average the income on this block we get \$1,000,000 plus \$0 and divide by 2. This gives us \$500,000. The out of work family laugh when they hear this average income of the block. So do the millionaire family. The average in this case is not very indicative of either household. This is because there is such a small sample (2 houses) and a big difference in income. We say the second average is highly deviated – or skewed. It doesn't really give us a reliable indicator of the facts.

This happens often with statistics. We hear it a lot in the media when we sample voter satisfaction. They say things like 'this sample has a plus or minus 3% error).

If we apply this to micron measurements, what if your alpaca's fiber is 19 microns for each fiber? Then an AFD of 19 means something. But if $\frac{1}{2}$ your alpaca's fiber is 10 microns and the other $\frac{1}{2}$ measures 40 microns, the AFD is 25. This is not a good representation of an average since you will feel the 40 microns and not the 10.

The last example shows a high deviation. Statisticians always include a standard deviation number with the average. The lower the SD, the less the deviation and the more representative of uniformity of measurement around the average.

From experience, an SD of 5 or less is an excellent number. It means there is a high degree of uniformity in the fleece. So an AFD of 19 with an SD of 4.9 is great. But an AFD of 15 with an SD of 23 is not so hot. Why? Poor uniformity.

From our histograms we can see that the less spread out the green bars are, the better – high uniformity. The more to the left the peaks are and the higher they are, the better – very fine. All this can be understood by an experienced histogram reader in a flash. This is much better than reading line after line of numbers.

Note – when comparing one alpaca's SD to another, it is only valid within the same micron range. If the alpacas have wildly different micron counts, comparing SD is like comparing apples to oranges.

So how do we compare two alpacas with different AFDs?

C. Coefficient of Variation. (CV)

CV is defined as a formula to assess uniformity within a tested fiber staple. It is a statistic which relates SD and AFD displayed as a percentage. The lower the number, the better uniformity the sample will have. A CV around 20 is excellent. Often times a cria will have a high CV and as it ages (primary and secondary fibers mature). One can

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compare different alpacas with different AFDs using the CV to say 'based on these samples, alpaca one and two are both uniform or not.'

D. Comfort Factor - CF

One of the statistics in your histogram report will be the percentage of fibers greater than 30 microns. It is at this 30 micron number where sensitive skin begins to react to these robust fibers 'pricking the skin.' At 30 microns a fabric will begin to annoy its wearer. Experience shows that if the amount of fibers at or above 30 microns is greater than 5% of the entire fleece, this is not a soft feeling fleece (or yarn). So if your histogram comes back with Fibers > 30 = 1%, this is a great number. The Comfort Factor (CF) is measured by subtracting the % of fibers > 30 from 100. In our example above, the CF is 100 – 1 or 99%. Pure luxury.

E. Curvature

This statistic is picking up steam as a valuable measurement. The curvature number relates to amplitude (wave height) of Huacaya crimp. A high curvature number indicates a higher frequency crimp and low numbers reveal a lower frequency crimp with higher amplitude. What some call 'zipper crimp' will have a high curvature number and the style called 'French Fry crimp' will have a lower curvature number.

F. Fiber length (stretched and unstretched) & Fiber Growth Rate

Fiber Length and growth rate metrics can help you determine several things. Fast growing fiber (if fine, uniform, etc) means you will have more product to sell at shearing time. There is also evidence that fast growing fiber is in general brighter than slow growing fiber since the fiber scales in fast growing fiber will be longer and smoother and thus reflecting available light better. The greater the difference in length between an unstretched fiber and a stretched one, the deeper the crimp the fiber most likely has. So an alpaca that looks to have short fiber may have deeper crimped fiber and indeed be carrying more fleece weight than an alpaca whose straight or less deeply crimped fiber makes it look 'blown up and dense.' These are critical statistics to keep track of.

Note; Not all of the above metrics are available from all vendors.

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Section 3 – Follicular Skin Biopsies

Note: Alpaca skin biopsies are currently performed primarily by Dr. Norm Evans, DVM and Ian Watt (Alpaca Consulting Services USA). Both gentlemen are highly regarded in our industry and have years of pointed experience in virtually all aspects of alpaca analysis, management, nutrition and husbandry. While technique and metric numbers and importance of certain metrics differ, both methods bring value to a breeder and both are highly recommended. While cost varies between \$250 - \$300 as of this writing (2010) many of us use our biopsy results to rate our alpacas and evaluate and make key breeding decisions with them.

A skin biopsy is a peek under the blanket to evaluate the fiber producing engine of our alpaca. This test is capable of getting much closer to revealing the genotype of the alpaca than the phenotype-driven histogram. Like the histogram sample, a skin biopsy is a sampling technique.

To perform a skin biopsy, a core of skin 10mm in diameter, roughly the size of a pencil's eraser is extracted from a specific spot on the side of the alpaca. All the fiber is shaved from the spot and the sharp circular punch is lightly pressed into the skin and twisted. The sampling point will bleed, but dabbing it with a clean cloth will stop the bleeding quickly. A shot of lidocaine or equivalent can be administered to mask the pain and antiseptic can be administered and the sample point monitored for a few days for any sign of infection. It should be noted that the use of an anesthetic can swell the sample and so affect the reliability of the test results if injected intradermally but not if injected subcutaneously.

Quite a few breeders feel squeamish about having these tests done. It is not any more traumatic to the alpaca than having its teeth ground. And it gives critical results with regards to density and primary and secondary fiber statistics. Many of us would not think of purchasing a herdsire or even breeding to one without skin biopsy results.

The sample is put into a bottle of buffered formalin to preserve it and sent to a laboratory where it can be analyzed microscopically to produce several key statistics. These results are valuable tools for your alpaca breeding, buying and selling toolkit. The metrics include:

- Accurate and meaningful density figures. Density is measured in follicles per square millimeter. There is a strong correlation between high density, uniformity and fineness. An alpaca can supply only so much of its energy

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into fiber production; relatively short thick fibers or longer fine fibers. If its skin happens to be densely packed with uniform follicles, the alpaca's fibers will most probably be fine, the staples or locks well structured and uniform.

- The ratio of secondary to primary fibers (S/P) tells us much about how many secondary fibers cluster next to the primary follicle. The higher this ratio, the more secondary fibers are present. This implies density, which implies fineness, uniformity, and so on.
- Sebaceous glands are currently a contentious issue at this time and more research is needed. One theory says these glands do not create nourishment to fibers, they provide a wax and they take up growth area for follicle development i.e. large glands cause fibers to go around them and so can contribute to cross-fiber. Another gives high levels of importance to these glands as sources of nutrition and healthy fiber.
- Neither secondary nor primary fiber medullation (air spaces within a fiber) can be seen with the naked eye. It takes a skin biopsy to reveal medullation albeit in a limited way.
- The fiber clusters (primaries along with the secondary fibers) shape also implies density and uniformity.
- The variation between the micron thickness of primary and secondary fiber populations can also give you a feel for potential handle – the lower the difference the more uniform, the better the handle. SD of primary and secondary fibers are a key indicator of uniformity.
- Co-efficient of Variation of Fiber Diameter (CVFD) is an indicator of the fiber variation in diameter within the sample. CVFD is highly heritable and is negatively correlated with staple strength, so an alpaca with a high CVFD usually has a lower staple strength.
- CV allows comparisons of like micron animals and nothing else – the 'loss' of staple strength is because of the fineness and not the CV per se. Furthermore, the biopsy report offers us a comparison between our own alpaca against any others that have been tested and the results published. This moves us from a purely subjective view - ribbons won visual inspection, etc, to an objective view - hard, measureable and comparable numbers.

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A. Benchmarking

Benchmark studies have been accumulated and numbers are available to determine elite density, S/P ratios and so on. We can begin to rank those super studs that win in the ring against the also-rans and also track these studs and dams performance capabilities for herd improvement through their progeny.

And we are seeing that our halter and fleece judges are indeed selecting the best of the best in most cases, for there is a high correlation between judges' choices of champions and the densest of alpacas. Whether these champions pass this on to their offspring though, is another matter. Progeny skin biopsy testing must be done.

B. Available Skin Biopsy Testing

There are two significant and accepted methods of testing currently available to us: (note: see appendices 2 for skin biopsies report examples.

1. Alpaca Consulting Services USA

Per Ian Watt:

The following definitions are designed to give a better understanding of both the details of a skin biopsy report and a means by which to utilize the information in making better informed, and more meaningful, selection and breeding decisions.

a) Mean Fiber Diameter (MFD):

The mean fiber diameter in a skin sample represents the diameter at a particular point of time – it is a “snapshot” of the fiber diameters at the time of skin sampling.

Prevailing environmental conditions, nutrition and general health and condition of the alpaca at sampling will affect the diameter of these fiber measurements.

In some alpacas the fiber follicles sit at an angle to the skin and therefore appear as oval shaped in the skin cross-sections. Suri appear to feature this particular trait more than Huacaya and in Huacaya, this trait tends to follow less dense counts.

To counter this structural formation, these fibers are measured across the smallest axis.

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b) Co-efficient of Variation of Fiber Diameter (CVFD):

The CV of fiber diameter in skin samples is an indicator of the between fiber variation in diameter within the sample.

The CVFD accounts for about 80% of the total diameter variation (that is both between and along fiber, variation) in most cases.

CVFD is highly heritable and is negatively correlated with staple strength, so an alpaca with a high CVFD usually has a lower staple strength.

c) Secondary: Primary Ratio (S: P):

The ratio of secondary to primary follicles is correlated with density – generally, the higher the ratio, the greater the follicle density of that animal.

Note: with regards to derived secondary fibers. These are fibers that grow as part of the secondary fibers. These fibers come out at the top of the secondary follicle sheath as they grow and begin their emergence somewhere along the secondary follicle's length. When slicing the slide material the biopsy procedure includes entering the sample's epidermis and exposing all of the derived secondaries - that is, we see one hair for each follicle sheath, and, as we know that each follicle grows only one fiber and that each of those derived follicles have their own, albeit a short, sheath, we can identify them easily. What we can't do as yet is label derived and secondary hairs per se.

d) DP: Ds Ratio (DP: Ds):

The DP: Ds ratio indicates the relative size of the two fiber (primary and secondary) populations. It is calculated as the mean fiber diameter of the primaries divided by the mean fiber diameter of the secondaries.

Primary follicles are generally larger in diameter than secondaries so the ratio is usually greater than 1.0. For an alpaca where the primaries are substantially larger than the secondaries, the ratio will be much larger, for example, 3.0.

For an alpaca where the variation is not great, the ratio will be closer to 1.0.

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It is possible to have an animal where the primary fibers are finer than the secondaries, which indicate a more homogenous fiber population and a ratio of less than 1.0.

Generally speaking, the closer to 1.0, the better the uniformity between primary and secondary fibers and the finer the fleece. This ratio then becomes an important selection point of difference between animals under consideration for inclusion into a breeding program.

e) Follicle Density:

This is probably the major characteristic because it governs the diameter of fibers and thus the total fleece weight.

The higher the density of follicles in the skin, the lower the diameter and the higher the fleece weight, assuming staple length is conserved.

Two significant errors arise in its measurement however:

The skin biopsies shrink during fixation and processing for measurement. This is corrected for, on the assumption that a 1cm biopsy was taken from un-stretched skin at the time of collection or sampling, and

Samples from young animals always have higher densities than they ultimately will end up with as mature alpacas. The expansion of skin (which causes a lowering of density counts) increases with age and body condition and must be borne in mind when comparing alpacas of differing ages and sizes.

The OFDA 2000 Report.

When appropriate, an OFDA 2000 test will be done on the fleece sample snipped from the biopsy site as an addendum to the skin sample report.

When data is available, average daily growth rates for the staple is calculated and the crimp/cm (in Huacaya) is also counted.

A new measurement called “**stretch percentage**” is provided to indicate the amplitude of the crimp in the staple (not relevant in Suri).

A low stretch (under 10%) indicates a shallow amplitude, between 10 and 15% indicates a moderate amplitude and a stretch of over 15% indicates deep amplitude and is usually associated with moderate crimp/cm counts.

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When talking about staple length, it is very important to establish whether the measurements being talked about are relaxed or stretched as two animals may have identical staple lengths but, when stretched, they vary by as much as 15 to 20% which reflects greater fleece weight from the same density.

2. Dr. Norm Evans, DVM Skin Biopsy Report

Per Dr. Evans,

Some breeders have requested information on how to use the results of fiber biopsies. The results of your biopsies, when coupled with the histogram, should give good direction to your breeding program if you wish to follow it.

The useful tools you get are 1) Density, 2) Secondary to primary ratio, 3) Sebaceous gland presence and density, 4) Secondary fiber medullation, and 5) Fiber cluster shape, symmetry, or infrastructure, and 6) Micron variation of the secondary and primary fibers.

1) Density is the number of follicles per square mm of skin. Based on about 2100 biopsies, the average for huacayas is about 40.25. About 300 Suris have averaged 39.5 follicles per sq mm. Superior breeding stock that seem to win in the show ring is 55-60+.

2) The secondary to primary ratio is the number of smaller micron desirable fibers to each primary fiber or guard hair in each fiber cluster. The average that I have seen on about 1800 huacayas is about 8.75 to 1. The average S/P on about 300 Suris is 8.75 to 1. It seems that near 10 to 1 is desirable for the perception of better fiber cluster in the show ring. I count 25 fiber clusters and average than number for the S/P average so it may not agree with the picture scan. While it does make sense that a larger S/P ratio of maybe 15 to 1 correlates to greater density, a large percentage of the most dense biopsies that I have evaluated have S/P ratios of 9 to 11 to 1 but with minimal connective tissue between fiber clusters. In going back 3 or 4 generations, I find the amount of connective tissue between fiber clusters seems to surface as a female trait which is passed on to the offspring whether male or female.

3) The sebaceous gland presence has not been mentioned until 2006. I have followed the progress of alpacas on fiber nutrients in my research for the past 5 years. I saw that some responded more rapidly than others. After the biopsies, I see that it is the ones with gland presence that responded better. After evaluating family lines, I see that these glands are appearing to be highly genetic. These glands provide a nutrition pathway to the fiber and are a very strong factor responsible for brightness and luster. When several judges started using this approach, looking for well nourished fleeces, I saw that I was headed in the right direction.

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4) Secondary fiber medullation was thought to be bad. In fact, some say that all alpacas with secondary medullated fibers should be eliminated from the gene pool. The fact is that would take 98% of the Huacayas and Suris from the United States gene pool. The average that I see on biopsy is about 40-50% secondary medullation. The judges are actually rewarding it in the ring because higher secondary medullation relates to more defined cluster structure which gives the fibers the perception of strength and form. The lower the number of secondary medullated fibers, the better the handle.

5) Fiber cluster shape, symmetry, structure, or infrastructure is highly genetic but can be destroyed by sickness or infection. Ideally, we want all clusters to have an even distribution of fibers. Clusters that uniformly have 9 to 11 fibers are preferable to having one bundle with 15 fibers beside a bundle with 8 fibers and another bundle with 11 fibers. This irregularity on the inside does not give the judges a good perception because of the irregularity on the outside. The fact is we can predict this before you ever select your breeding. Look for tight symmetrical clusters of the same size and shape on your biopsy rather than irregularly shaped clusters with uneven fiber numbers. Secondary fiber medullation is appearing to be a strongly passed prepotent male trait. I see several males at 3 years of age with secondary fibers that average 19 microns and primary microns that average 32 microns. In most cases, their offspring show the same wide variation. A male with secondary fibers that average 22 microns and primary fibers that average 27 microns is much more desirable in my mind at this time as far as passing desirable prepotent genetic traits regardless of the S/P ratio.

6) Micron size and variation of the secondary and primary fibers gets a lot of press. Most all opinions agree that it is highly desirable to breed toward primary and secondary fibers that are healthy and near equal in size as measured in microns. The primary fibers (guard hairs) are usually straight, much larger, and have a prickle factor that is unpleasant to human skin. The 250 X scan of your biopsy gives a good indication of the micron variation on your particular alpaca. I count and measure 100 secondary and 50 primary fibers (depending on the specimen density) and show a typical view on this scan. This calibration is usually rather close to the histogram results where many more fibers are evaluated. Both are to be used as tools in selecting breedings. Our goal is to breed in the direction that both fibers are acceptable in size and as near equal in size as possible. Micron size appears strongly genetic but can be altered by sickness, weather extremes, nutrition, and other factors. The average variation that I see to date is 7.9 microns and any thing under 5 to 5.5 microns seems very desirable and genetically strong.

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How do we use this info? You breed strong points to weak points in your selection process. To excel as a herd, some animals will simply not help to strengthen the gene pool. This is the reason for knowing the stats on the females as well as the males, if you really want to more rapidly potentiate your genetics. In about 30% of the cases, where both females and males are biopsied, the females actually have superior genetic characteristics to the males that they are bred to. Every farm that I visit seems impressed with how their crias are improved compared to previous years. This certainly is the case and we notice that the show ring is becoming much more competitive. Much of this success can be a compliment to breeder management in the selection of males utilized as well as to improved nutrition. Close observation of the programs enjoying much success have utilized the above tools in breeding selection.

The goal of the industry is to produce the **'finest fibered geldings in the world.'** I deal with 9-10 year old females that were 19 microns at 2-3 years of age, have had 6-7 crias, and are still at 19-20 microns. There are few males that are 7-10 years of age, have less than 5 micron variation between the primary and secondary fibers, and present strong, healthy fibers that have not coarsened. These are the genetics for the future rather than a blue ribbon winner in a class of 3.

Section 4 - Conclusions: Course Summary & Conclusions:

We must breed to a goal, to a direction. As we move toward this goal we will learn, we will adjust, we will improve our fiber and our end product profits.

There is little doubt that quantitative objective tools are critical to our success. Histograms, skin biopsies and evolving EPDs can and do help us improve our alpaca fiber and help us evaluate the results of our breeding programs.

A. The questions we should be asking:

'How do I select a herdsire to breed to my dams?' should be preceded by questions like, "What are my specific fiber goals?" and 'What do my dams need by way of improvement?' If your dams are fine, but not dense, perhaps breeding to a dense male is the right choice. If your dams are fine and dense but not uniform, perhaps breeding to a herdsire with a high S/P ration is the answer.

B. Breeding for Fiber for Profit:

1. NAAF recommends we breed for uniformity - fineness across both primary and secondary fiber populations which we believe will lead to reduced medullation in both populations and high fleece weight. Breed for an S/P

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ration of 15/1 or greater (but for uniform clusters in fiber number and cluster size).

2. NAAF recommends breeding a national alpaca herd that averages 25 microns or below and maintains this average into maturity will find commercially viable and lucrative textile markets.
3. NAAF recommends breeding for increased density, as more (quality) fiber on an alpaca increases the breeder's profitability. Breed for density of 60 follicles/ sq mm or better.
4. NAAF recommends breeding for increased uniformity (length, grade, color & character).
5. NAAF recommends breeders track regular progress – measure, monitor, analyze. You cannot manage what you cannot measure.

The above should come as no surprise to experienced alpaca breeders. Uniformity of fineness, fiber length, color on a robust and healthy alpaca will help us thrive as opposed to only survive in our highly competitive and diverse Fiber for Profit marketplaces.

Appendix 1 Histogram Report Example

A. Yocum MColl Histogram Report Example



TESTING LABORATORIES INC.

Phone (303) 294-0582 * Fax (303) 295-6944

540 West Elk Place * Denver, CO

80216-1823 USA

<http://www.ymccoll.com/>

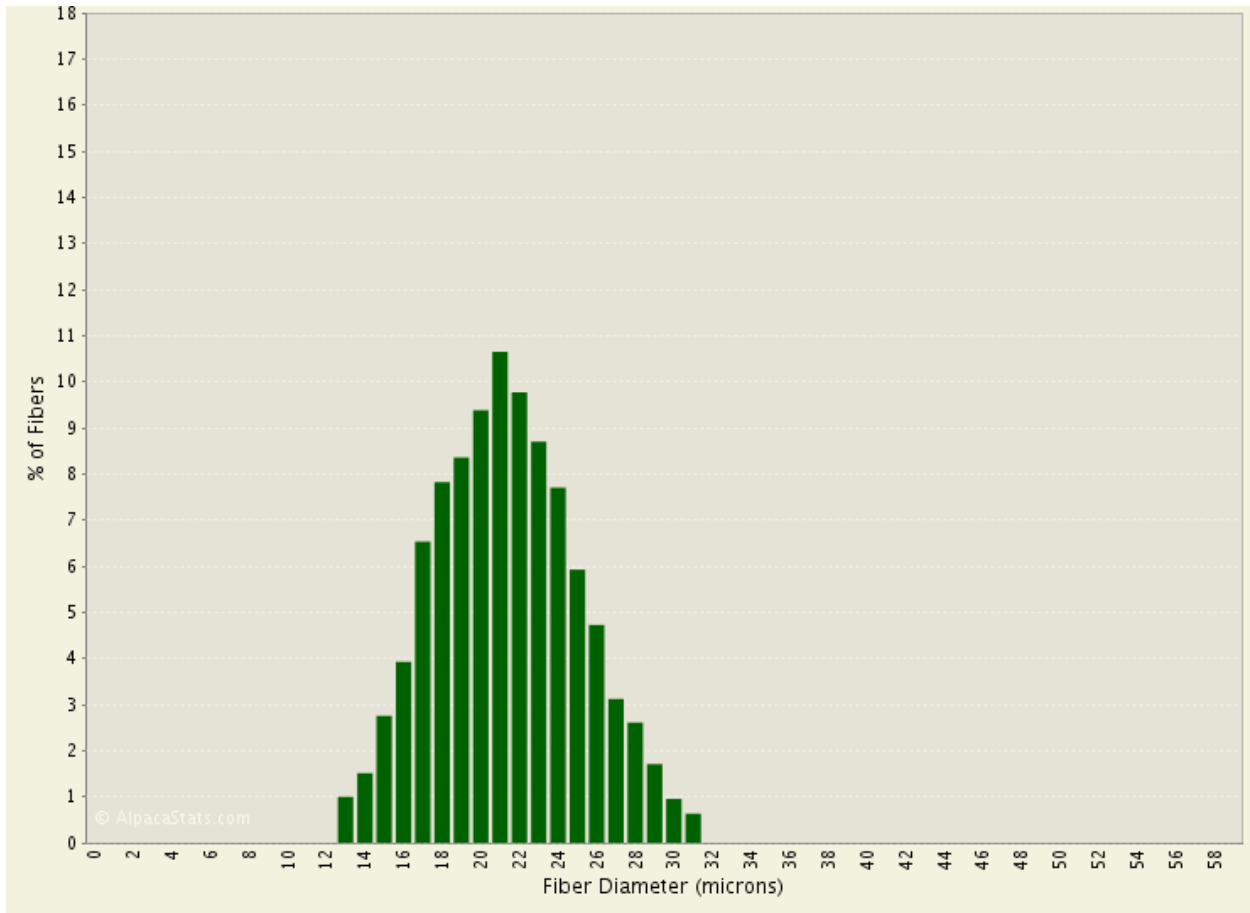
ymccoll@ix.netcom.com

B. Alpaca Consulting Services, USA Histogram Report Example

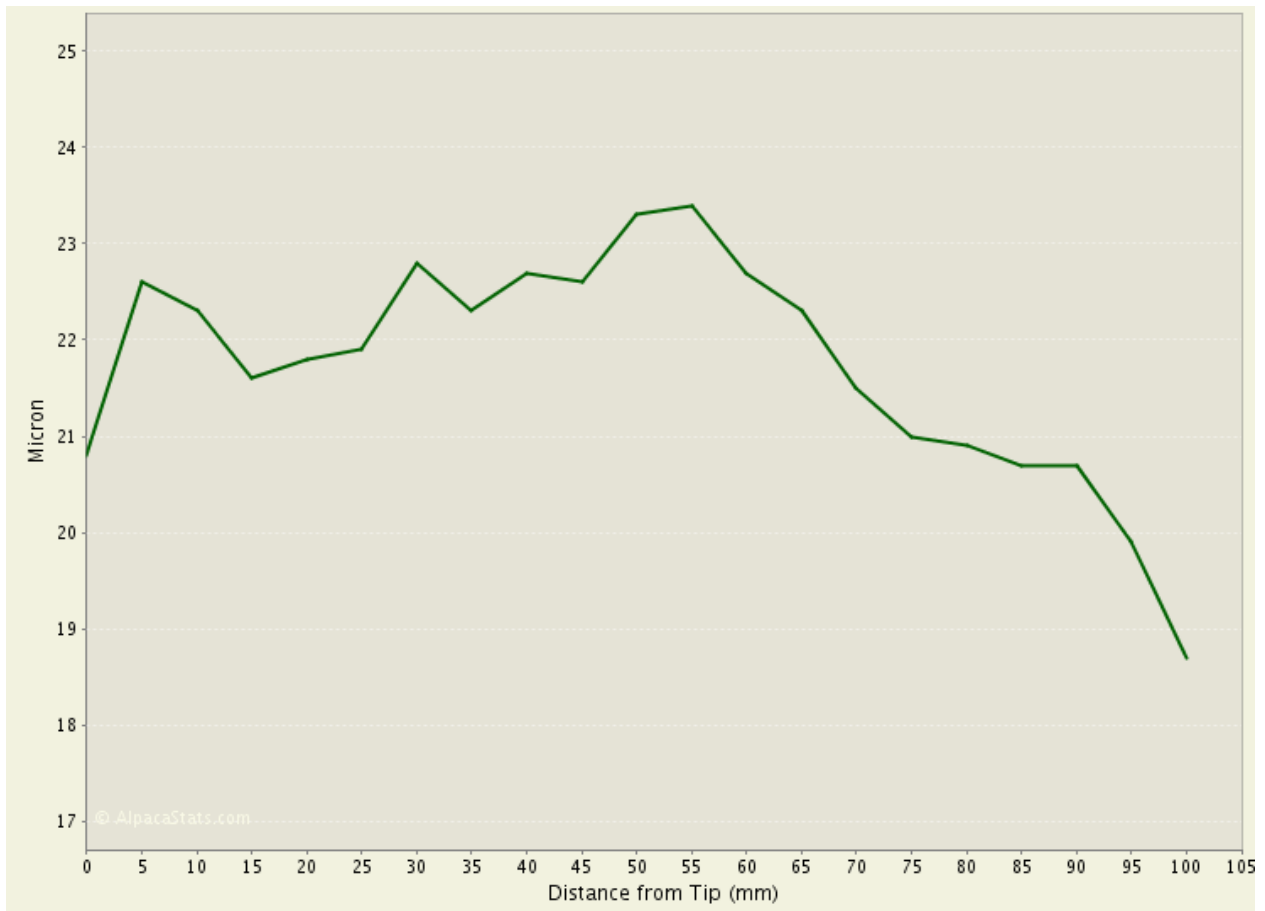
Report Date	05/01/2009	Min(micron)	18.7
AFD(micron)	21.47	Max(micron)	23.4

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SD(micron)	4.12	Stretched Length(mm)	122
CV(%)	19.17	Unstretched Length(mm)	110
CF(%)	97.78	Growth Rate(mm/day)	0.35
Staple Length(mm)	105.0	Crimp/cm	2.5



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1. Specifics on taking a sample

Alpaca Name:

Sex: Male Female Gelding

Huacaya or Suri

Color:

Age (at time of sampling) in months:

Location (state) of alpaca for majority of past year:

Age of sample in days:

Notes:

Samples should be no less than the size of a man's thumb

Samples must be cut as close to the skin as possible

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Samples must be sent in a clear plastic baggie with the alpaca name on a piece of paper inside the baggie

Sample must be dry

Enclose a check with the samples and send them to

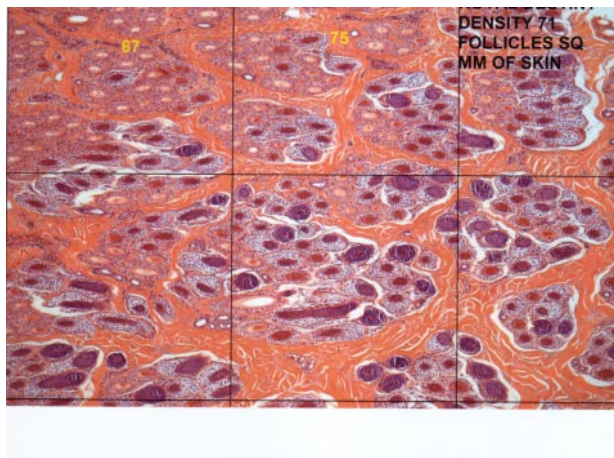
Alpaca Consulting Services USA

1540 San Bernardo Creek Road
Morro Bay CA 93442
805 772 1774

email: ian@alpacastats.com

Appendix 2 Skin Biopsy Report Example

1. *Dr. Norm Evans, DVM*



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2. Alpaca Consulting Services, USA

Fleece type, color and age at testing: Huacaya, White, 22 months

Date of test: 3 August 2009

Follicle density: 63.42 /mm²

Mean Fiber Diameter: 21.33 micron **Standard Deviation:** 3.98 micron

Co-efficient of Variation – Fiber Diameter (CVFD): 19 %

Secondary:Primary ratio (S:P): 10.9 : 1

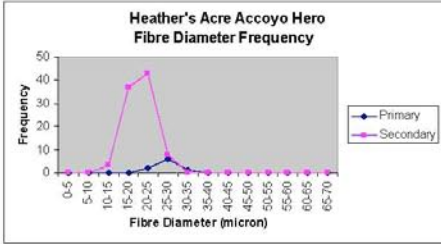
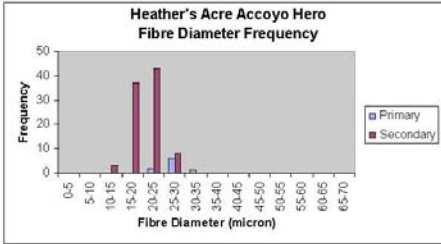
Mean Fiber Diameter Primaries (Dp): 28.48 micron **Standard Deviation:** 2.77 μ

Mean Fiber Diameter Secondaries (Ds): 20.54 micron **Standard deviation:** 3.25 μ

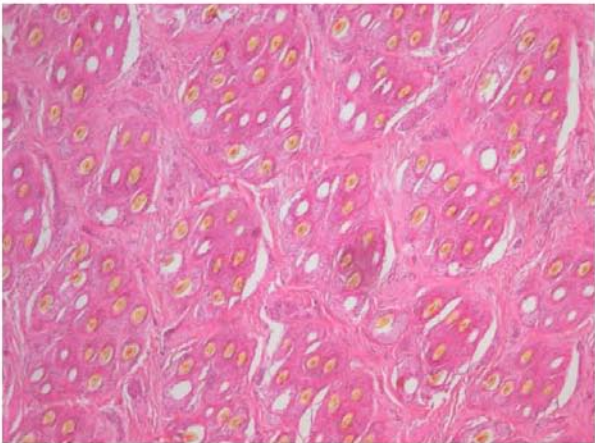
Dp:Ds ratio: 1.39

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Fiber Diameter Frequency Histogram:

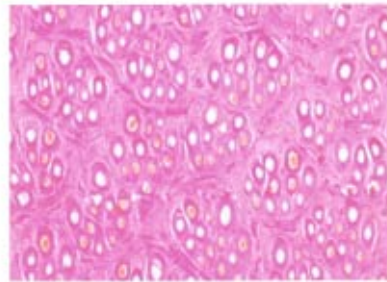


Micrograph of skin section:

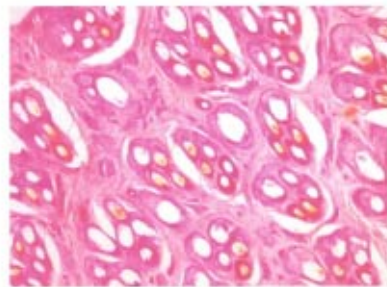


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Appendix 3 Skin Biopsy Comparison



DENSITY 58.51
MFD 23.6
SD 4.78
CV 20
S/P 11.9/1



DENSITY 32.33
MFD 30
SD 8.5
CV 28
S/P 8.1:1

Note the differences between the results of the top skin biopsy results and the bottom one. The top picture shows excellent density (many small white dots) while the bottom picture reveals fewer and thicker dots – this alpaca is only about ½ as dense as the alpaca pictured above it. Micron count, standard deviation, CV and secondary/primary fiber ratios are all inferior to the top pictured alpaca.