Alpaca Fiber Quality and Analysis

Chris Lupton

Texas AgriLife Research The Texas A&M System San Angelo

Alpaca Information Day

Petersburg, VA January 17, 2009

Overview

- I. Background and current research interests.
- II. Recent cooperative studies with alpacas.
- II. Animal fiber metrology.
- IV. Genetic tools that are being used to improve alpaca fiber quality and production.

Current research objectives

1. Develop and evaluate *near-infrared reflectance spectroscopy* and *automatic image analysis* for more rapid, less expensive, objective evaluation of animal fibers.

2. Use objective measurements to improve fiber and / or meat production, quality, and income to producers through improved selection, nutrition, management, and marketing efficiency.

 Near-infrared reflectance spectroscopy for measuring clean yield and fiber properties of greasy wool and mohair.



 Comparison of Texas Rambouillet with Australian Merino F1 crosses



 Using a portable automatic image analysis instrument (the OFDA2000) to measure fiber characteristics at the farm or ranch



 Rambouillet ram and Angora billy goat central performance tests





 Genetic selection to improve the use of goats to manage juniper



 Genetic selection to develop a more profitable dual-purpose (fine wool and meat) sheep. The Texas Rambouillet Superior Genetics Cooperative Breeding Program / National Sheep Improvement Program.





II. Recently completed alpaca research projects

- Fiber characteristics of Huacaya alpacas in the United States
- Angus McColl, Yocom-McColl Testing Laboratories, Denver.
- Bob Stobart, University of Wyoming, Laramie.
- Chris Lupton, Texas AgriLife Research, San Angelo.
- 23 fiber characteristics, BW, n=585
- Small Ruminant Research, 63, 3:211-224.

Recently completed alpaca research project

- Determine the effects of age, location, nutrition, and season on fiber production, fiber quality, and body weight of intact alpaca males.
- Ruth Elvestad, Olds College, Alberta Canada
- Chris Lupton, Texas AgriLife Research, San Angelo

Location of Research Sites in Canada and USA



Current projects with alpacas

- Gastrointestinal parasite epidemiology and control in alpacas.
- Effects of management practices on alpaca fiber production.
- Stephan Wildeus et al., Virginia State University, Petersburg



Current long-term, low intensity project with alpacas

• Evaluation of alpaca castrates as guard animals for sheep and Angora goats



Another recently funded project with alpacas

 Evaluation of two objective methods (the SAMBA System and NIRS) for measuring luster in Suri alpaca fiber, comparison with subjective assessment, and correlation with other physical properties.
A. McColl and C. J. Lupton.

III. Alpaca fiber metrology

"Current technology"





Sampling

From live animals

From shorn fleeces

From accumulations (bags or bales)

Sampling

- Mid side, best single indicator
- Random (core or grid) sample from part of (e.g., saddle) or whole fleece
- Random (core or grab [manual or machine]) sample from packages of fiber



Figure 1. Five (normally) distinct fleece components

Yocom-McColl's alpaca mid-side diagram





Neck, side, and britch samples for fiber diameter and medullation



Core & grab sampling bales





Core sampling bales





Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, % (AB, LSY, CWFP, SDY)
- Vegetable matter content, % (VMB, VMP)
- Average staple length, SD, mm, and CV, %
- Average staple strength, SD, N/ktex, CV, %, POB (and % tip, middle, and base breaks).

Fleece and fiber characteristics that can be measured or calculated (contd.)

- Average fiber diameter, SD, microns, CV, %
- Comfort factor, % fibers < or = to 30 microns
- Spinning fineness, microns
- Average fiber curvature, SD, deg/mm, CV, %
- Resistance to compression, kPa
- Medullated fibers (med, kemp and total medullation, ASTM), or total medullated fibers, flat fibers, and objectionable fibers, % or number / 10,000 (IWTO). Also AFD, SD, and CV of medullated fibers.

Fleece and fiber characteristics that can be measured or calculated (contd.)

- Dark fibers (in white fleeces or vice versa), number / 10,000 or number / unit weight.
- Color, tristimulus values, brightness or yellowness.
- Luster.
- Fibers per unit area of skin.

Relative commercial importance of raw specialty animal fiber traits (McGregor, 2006).

Trait	Scoured	Top/noil	Yarns	Cloth
Mean fiber diameter	****	****	****	****
Comfort factor	-	-	*	***
CV of fiber diameter	-	_	**	**
Clean yield	****	_	_	_
VM (amount and type)	***	***	**	**
Staple strength/ POB	**	*	_	_
Mean fiber length	**	***	**	**
CV of fiber length	**	**	*	*
Dark fibers	*	*	*	***

Relative commercial importance of raw specialty animal fiber traits (McGregor, 2006) contd.

Trait	Scoured	Top/noil	Yarns	Cloth
Medullated fibers	**	**	**	***
Fiber crimp	*	*	**	**
Color	*	-	-	**
Style and handle	-	-	**	**

* Some significance **** Highly significant

Sampling the staple

- Guillotine (2 mm) the base of staple (OFDA 100 or Laserscan).
- Guillotine elsewhere along the staple.
- Measure the whole staple (OFDA2000).
- Minicore the whole staple (2 mm).
- Measuring each type of sub-sample will give you a different result, but all are potentially useful.





Courtesy: Yocom-McColl Testing Labs, Inc.







Standard methodology

 American Society for Testing and Materials (ASTM)

 International Wool Textile Organisation (IWTO)
Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, %
- Vegetable matter content, %
- Average staple length, SD, mm, and CV, %
- Average staple strength, SD, N/ktex, CV, %, POB (tip, mid, base or fraction)

Alpaca fiber base

- Mass of clean, dry fiber with all impurities removed expressed as a % of the original "raw" or "greasy" alpaca fiber mass.
- Usually report the fiber base after adjusting for allowed moisture (12%), residual grease (1.5%) and ash (0.5%).

Vegetable matter base

 Mass of oven-dried scoured burrs, seeds, twigs, leaves, and grasses, free of mineral matter and alcoholextractable matter expressed as a % of the mass of the sample.

Presale Measurement Procedure



NIRS

 Allows us to quantify broad classes of compounds or individual compounds that contain different chemical bonds.
e.g., protein (in this case keratin), lipids (wool wax), cellulose and lignins (vegetable matter), and water.

 NIRS is also sensitive to particle size (potential for estimating AFD, SDFD, AC).

Near-infrared Reflectance Spectroscopy



NIRS Measurements

- Non-destructive and results available in less than two minutes.
- Currently, only being used commercially to replace one of the gravimetric tests (residual grease).

Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, %
- Vegetable matter content, %
- Average staple length, SD, mm, and CV, %
- Average staple strength, SD, N/ktex, CV, %, POB (tip, mid, base or fraction)



Length Measurement, contd.









Length & Strength Testing



Measuring Length





Staples in a Tray

Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, %
- Vegetable matter content, %
- Average staple length, SD, mm, and CV, %
- Average staple strength, SD, N/ktex, CV, %, POB (tip, mid, base or fraction)

Staple Strength Measurement

Average staple strength, SD and CV of staple strength, Position of break, and % tip, middle and base breaks



Strength Measurement, contd.





Fleece and fiber characteristics that can be measured or calculated (contd.)

- ✓ Average fiber diameter, SD, microns, CV, %
- Comfort factor, % fibers < / = to 30 microns</p>
- Spinning fineness, microns
- ✓ Average fiber curvature, SD, deg/mm, CV, %
- Medullated fibers (white and pastel fibers only), total medullation, flat fibers, and objectionable fibers, % or number / 10,000.
- Dark and medullated fibers and contaminants (in white fleeces), number / 10,000 or number / unit weight
- Resistance to compression, kPa
- Color, tristimulus values, brightness or yellowness

Instruments for measuring average fiber diameter

- Projection microscope (PM)
- Sirolan Laserscan (LS)
- Optical Fiber Diameter Analysers (OFDA 100 and 2000)
- Sirolan Fleecescan
- Airflow

Projection Microscope



Courtesy: Yocom-McColl Testing Labs, Inc.





Microprojection





Courtesy: Yocom-McColl Testing Labs, Inc.

One Micron Equals...

1/25,400 of one inch

or

1/1,000,000 of one meter

Sirolan LaserScan Sample



LaserScan Display

$\frac{300}{100}$	SIROLAN-LASERSCAN 13:50:55 Tue Apr 20, 2004 Operator: CF Calibration: 0404 .CL1 Count linit - 2000 File: Save Combine No Print: Long Short No File mane: SSU019 Ext: DAT Client;tion: SOCOC START MEXT COUNT < Log file OH > SHUPLE COMPLETED File exists, overwrite it ? YM	
ViewSonic		• • • •

Courtesy: Yocom-McColl Testing Labs, Inc.

OFDA 100 Optical Fibre Diameter Analyser



OFDA slide on stage







Sirolan Fleecescan













Texas	Agrid	cultura	l Expe	erimen	t Stati	on				
Date	:	13Feb07			Mean	=	27.3	u		
Sample I	D:	ALPACA			SD	=	6.6	u		
Descript	10n :	232	NO.		CV General en el	=	24.3	8		
Lot/Cile	nt :	ALPACA FAR	MS .		Sample Si	.ze =	5509			
5% of fi	: hrea 1	201			Spin line	ness=	27.3	u e		
Curve- 6	6 8 [43]	dea/mm	e mean.		Curve num	actor= ber -	20/5	8		
OFDA030:	2.14 Ca	1: D=5 412	1*WH -3	80. wV=	1 4680*wH	(+ 0 0	8 DkF	lach-	77 5	
cum.% mic co	ount	75 150	225	300 37	451	526	601	676	751	826
	•	·· I ···· ··· ··· ···	I		L					
100.0 1	0									
100.0 3	ō									
100.0 4	0									
100.0 6	1									
100.0 7	5									
99.8 9	6									
99.7 10	5									
99.5 12	12									
99.3 13	22									
98.9 14 98.3 15	45									
97.5 16	75	-								
96.1 17 1										
91.9 19 1	53									
89.1 20 2	207									
81.3 22 2	21									
76.4 23 2	263									
71.6 24 3	47									
59.0 26 3	59			_						
52.5 27 3	21									
40.1 29 3	38									
34.0 30 2	88									
28.7 31 2	38									
19.3 33 1	94		-							
15.8 34 1	43									
11.0 36 1	22									
8.8 37 1	04									
6.9 38 5.2 39	49									
4.3 40	60									
3.2 41	33									
1.9 43	26									
1.4 44	12									
0.8 46	9									
0.7 47	9 =									
0.5 48	6									
0.3 50	5									
0.2 51	31									
0.1 53	31									
0.1 54	0									
0.1 55	1									
0.1 57	1									
0.1 58										
0.0 60	1									

Standard Deviation (SD)

- Statistical measurement of the variability in a sample
- 68% of the fibers fall with in +/- one SD of the mean or average
- Smaller the number, the more uniform the sample

Standard Deviation (SD)

- Example:
- MFD=20 microns
- SD=4.0 microns
- CV=(4.0/20.0)*100=20%
- Assume "normal" distribution then:
- 68% of all fibers measured are between 16 and 24 microns
- 95% of all fibers measured are between 12 and 28 microns

Curvature

- Is a measurement of the fiber crimp. Does not indicate the type of staple crimp (i.e., uniform staple crimp (like most fine wools) or crinkle (like cashmere).
- Is correlated with Bulk and Resistance to Compression
- Generally, worsted processors (lean yarns for fine suitings) prefer less crimp, woolen system spinners prefer more crimp (bulkier yarns for knitwear).



Curve Histogram



Fiber crimp

 Fiber crimp (visual or measured as average fiber curvature, AFC) is not an accurate indicator of average fiber diameter.

Curvature ranges

- Low: < 50 deg/mm, crossbred wool, mohair (~2 crimps per inch). Alpaca 15-55 deg/mm.
- Medium: 60-90 deg/mm, 21 micron Merino and Rambouillet wool (~4 crimps per inch)
- High: >100 deg/mm, 16-18 micron superfine Merino and Rambouillet wool (~7 crimps per inch)

Spinning fineness

 Used by textile processors, a better indicator of processing performance than MFD alone, particularly in spinning.

- SF=0.881*MFD*(1+5*[CVD%/100]²)^{1/2}
- For a given MFD, spinnability \uparrow as CV \downarrow

Coarse Edge Micron (CEM)

- The number of microns above the MFD that contains the coarsest 5% of fibers
- Another statistic used by textile processors
- Smaller = more uniform
Degrees of medullation (ASTM nomenclature, med, kemp, medullated fiber)



Microprojection





Dark and medullated fibers and contaminants (especially polypropylene) in white fleeces



OFDA 100 - Opacity



Medullation (IWTO [OFDA100] nomenclature)

- Total medullated fibers
- Flat fibers
- Objectionable fibers
- Units: per 10,000 or %
- AFD, SD of medullated fibers
- White and pastel fibers only

Texas Agricultural Experiment Station Date : 18Nov04 Mean 22.50 u Sample ID : 0241 SD = 5.64 u Description : S CV = 19.1 % Lot/Clint :: TAMU Sample size = 3627 Operator ::PP Spin finenesse 28.3 u Sk of fibres 10.6 u above mean. Confort factor= 63.6 % Num med= 929 (2561/10K) inc offlat.482obj/10K Mean opacity= 66.6[16.1] % Mean med diame 35.0 [5.4] u % med by vol= 35.7k, by wt= 23.8% Op num/10K>= 80 82.1001 :2561 2396 2225 1980 1668 1337 943 496 229 110 Obj/10K Obj/10K := 0 502 100 :150 :200um File.198 Curve number = 2397 Aime: num 243 Mm 87515.2] deg/mm Curve number = 2397 Aime: num 243 Mm 87515.2] deg/fmm Curve 1.4708 WH - 0.06 D, DKPLa51 CFDA3012.12 Call: 10 = 5.1.337 WH - 2.69, WH - 1.4708 WH - 0.06 D, DKPLa5N 000.1 0 0 0 010.2 1 0 0 10 02.2 2 0 381 433 409 54 03.3 1 0 2 0 04.3 1 0 0 14708 WH - 0.06 D, DKPLa5N 05.3 100 10 0 14708 WH - 0.06 D, DKPLa5N 05.4 10 0 14708 WH - 0.06 D, DKPLa5N 05.5 10 0 <t< th=""><th></th></t<>			
Date : 18Nov04 Mean = 29.50 u Sample ID : 024L SD = 5.64 u Description : S CV = 19.1 % Lot/Clent : TAMU Sample size = 3627 Operator : FF Spin fineness= 28.3 u S3 of fibres 10.6 u above mean. Comfort factor 63.6 f Mum med 929 (2561/10K) inc 0flat, 48200j/10K Mean opacity 66.6 [16.1] % Mean med diam 35.0 5.10 3.15 0.200 un Flat/10K = 0 >50 5.10 3.150 >200 unt 422 6 3 0 0 0 0 0 0 0 0 0 Curve 23.9 [23] deg/mm Curve number = 2397 Aleg: num 23.5 Mrs. 20.5 5.12 5d= 0.561 0.01 Mis 26.6 5.21 blow = 0.401 0.315 upc 0.201 0.315 0.0 0 0 OFDA03012.12 C Call : D=5.1397 VMH - 2.69, 10.91 WH - 2.69 U.533 upc 0.201 0.735 0.0 0 Out. 100.1 D=5.130 VMH - 2.69 U.533 upc 0.201 0.735 Op.0 1 0 0 0 0 Op.0 1 0 2.12 C Call : D=5.1397 VMH - 2.69 U.533 upc 0.501 0.515 0.56 U.533 upc 0.535 U.50 U.533 upc 0.535 U.50 U.533 upc 0.535 U.533 u	Texas Agricultural Experiment Station		
Sample 1D : 024L SD = 5.64 u Description : S Lot/Client : TAMU Sample size = 3627 Operator : FP u above mean. Comfort factor = 63.6 % Num med giam 35.0[5.4] u Spin fineness = 28.3 u S\$ of fibres 10.6 u above mean. Comfort factor = 63.6 % Num med giam 35.0[5.4] u % med by vol= 35.7% by vt= 22.80 Op num/10K= 80 82.100: 2561 2396 2225 1980 1668 1337 943 496 229 110 Obj/10K= s0 >50 s100 s150 s200um Flat/10K = s0 >50 s100 s150 s200um (482 6 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Date : 18Nov04 Mean = 29.50 u		
Loc/Clint: : TAMU Sample size = 1021 ° Operator: :PP Spin fineness= 20.3 u St of fibres 10.6 u above mean. Comfort factor= 63.6 % Num med 29(2561/10K) inc 0flat, 42200j/10K Mean opacity= 66.6 [16.1] % Mean med 29(2561/10K) inc 0flat, 42200j/10K Mean opacity= 66.6 [16.1] % Mean med 29(2561/10K) inc 0flat, 42200j/10K Mean opacity= 66.6 [16.1] % Mean med 29(2561/10K) inc 0flat, 42200j/10K Mean opacity= 66.6 [16.1] % Mean med 29(2561/10K) inc 0flat, 42200j/10K Mean opacity= 66.6 [2001] % Op num/10K= 80 82100: 2561 2396 2225 1980 1668 1337 943 496 229 110 (16.1) % Op num/10K= 80 82100: 2561 2396 2225 1980 1668 1337 943 496 229 100 (17.0) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Sample LD : $0.24L$ SD = 5.64 u Description : S CV = 19.1 %		
Operator : FP Spin fineness 23.3 u St of fibres 10.6 u above mean. Comfort factor 63.6 % Num med 929(2561/LOK) inc 0flat, 4820bj/JOK Mean opacity 66.6 (l6.11 % Mean med diame 35.0 (5.4] u % med by vole 35.7%, by ve 23.8% Op num/10K= 80 82100: 2561 2396 2225 1980 1668 1337 943 436 2229 110 Obj/10K = 0 550 >100 >150 >200um Flat/LOK = 0 550 >100 >150 >200um 482 0 0 0 Curve= 32.9[23] deg/mm Curve number = 2397 Atoms: new X05 Mm 20.515.21 540 650.63 Mm 28.615.21 blse 6.0010.63 K mm 6.601 6.33 Lge 0.2016.73X OFDA03012.12 Cal: D=5.1397*WH -2.69, wV= 1.4708*WH + -0.08, DkPlash= 70.5 cm.X mic count/ med 54 109 163 210 227 320 381 433 400 544 100.0 1 0/ 00 3 22/ 01 0 2/ 01 1 0/ 01	Lot/Client : TAMU Sample size = 3627		
5% of fibres 10.6 u above mean. Comfort factor= 63.6 % Num med 929(2561/10K) inc oflat, 4820bj/10K Mean opacity= 66.6[16.1] % Mean med diam= 35.0[5.4] u % med by vol= 35.7K, by wt= 23.8% Op num/10K>= 80 82.100: 2561 2296 2225 1980 1668 1337 943 496 229 110 0bj/10K= s0 >50 >100 >150 >200um Flat/10K= >0 >50 >100 >150 >200um 482 6 3 0 0 C Urve number = 2397 Alog:nam 235 No.95.51 St 0.551 0.4] Nim 28.4(5.2] bleb 0.60 0.01 0.31 St 0.400 0.31 St 10 -0.07 0.0 CUrve 235 No.95.51 St 0.551 0.4] Nim 28.4(5.2] bleb 0.60 0.01 0.31 St 0.400 0.31 St 10 -0.07 0.7 X OFDA030:2.12 Cal: D=5.1397*WH -2.69, wV= 1.4708*wH+ -0.08, DkFlash= 70.5 cum.X mic count med 54 109 103 216 272 320 381 433 400 544 100.0 1 0/ 0 100.0 2 0/ 0 100.0 2 0/ 0 100.0 2 0/ 0 100.0 2 0/ 0 100.0 1 0/ 0 100.	Operator : FP Spin fineness= 28.3 u		
Num mede 929 (2561/10K) inc 0flat, 48200/10K Mean opacity 66.6(16.1] % Mean med diam 35.0[5.4] u % med by vole 35.7k, by vt= 23.8% Op num/10K>= 80 82100: 2561 2396 2225 1980 1668 1337 943 496 229 110 Obj/10K = 30 .50 .100 .515 .200um 0bj/10K = 30 .550 .100 .515 .200um 0 0 0 0 0 0 0 0 0 482 6 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0curve= 32.9[23] deg/mm Curve number = 2397 Along: nam 2435 Mrs 28.5[5.2] 54 0.561 0.61 Mine 28.6[5.2] bide 0.001 0.81% sml= 0.201 0.71% OFDN030 2.12 Cal: D=5.1397*WH -2.69, wV= 1.4708*wH+ -0.08, DkFlash= 70.5 Curv. a mic count/ med 54 109 163 218 272 328 314 435 400 544 100.0 1 0/ 0 100.0 2 0/ 0 100.0 3 2/ 0 00.0 3 2/ 0 00.0 3 2/ 0 00.0 3 2/ 0 01.0 4 0 02.1 1 3/ 0 03.3 11 3/ 0 04.3 13 05.1 10 06.3 11 07.0 1 08.4 17 09.3 10 2/ 0 09.3 10 3/ 0 00.1 10 01.1 0 02.1 10 03.1 13/ 0 04.1 0 05.1 10 05.1 0 05.1 0 <	5% of fibres 10.6 u above mean. Comfort factor= 63.6 %		
Op num/10kx= 80 02:.100: 2561 2396 2225 1980 1660 1337 943 496 229 110 Obj/10kx= s0 s50 >100 >150 >200um Flat/10kx= s0 s50 >100 >150 >200um Vurve= 32.9[23] deg/mm Curve number = 2397 Aleng: nam 235 Mm 295.512 sto .0561.0.8 Min= 28.615.2 blabe .0001 0.835 mi= 2051 0.73X OPDA03012.12 Cal: D=5.1397*WH -2.69, wV= 1.4708*wH + -0.08, DkFlash= 70.5 cunx.is mic count/ med 54 109 100 107 100 107 100 107 100 107 100 107 100 107 100 107 100 107 100 107 100 107 100 107 100 107 100 107 101 107 102 107 103 21 104 21 105 217 106 107 107 107 108 107 109 107 100 107 101 107 102 <td>Num med= 929(2561/10K) inc Oflat,482obj/10K Mean opacity= 66.6[16.1] %</td>	Num med= 929(2561/10K) inc Oflat,482obj/10K Mean opacity= 66.6[16.1] %		
Obj/10K= 0 50 510 150 2000 m Plat/10K= 0 50 100 150 2000 m 482 482 69 0	mean med diam = $55.0[5.4]$ u s med by Vol = 55.7 , by Wt = 23.8 Op num/10K5 = 80.82.100: 2561 2396 2225 1980 1668 1337 943 496 229 110		
482 6 3 0	Obj/10K= >0 >50 >100 >150 >200um Flat/10K= >0 >50 >100 >150 >200um		
Curve= 32.9[23] deg/mm Curve number = 2397 Along new 235 Mnc 20:51:23 de 0.610.03 Him 28.6(5.2) bide 0.001 0.33 Lige 0.2010.71X OPDA030:21:2.12 Cal: D=5.1397*NH +2.69, wV= 1.4708*wH+ -0.08, DkPlash= 70.5 cun.X mic count/ med 54 109 163 218 272 326 381 433 400 544 100.0 1 0/ 100.0 2 0/ 99.9 5 4/ 99.9 5 4/ 99.8 6 7/ 99.9 5 4/ 99.3 10 2/ 99.3 11 3/ 99.3 11 3/ 90.6 17 0 13 2/ 90.6 17 0 14 2/ 90.7 12 1/ 90.6 17 0 15 2/ 15 1 3/ 12 2/ 13 2/ 12 2/ 13 2/ 14 2/ 15 1 3/ 16 2/ 16 2/ 16 2/ 17 1 3/ 16 2/ 17 1 3/ 16 2/ 17 1 3/ 17 1 3/ 18 2/ 18 2/ 19 2/ 19 2/ 10 1 2/	482 6 3 0 0 0 0 0 0		
Altog Hum 25/10/12 0.10 0.01 0	Curve $32.9[23]$ deg/mm Light $235 = 2397$		
Cum.X mic count/ med 54 109 163 218 272 326 381 435 490 544 100.0 1 0/0 0 100.0 3 2/0 0 99.9 5 4/1 1 99.9 4 2/ 0 99.4 9 3/ 0 99.3 10 2/ 0 99.3 10 2/ 0 99.3 10 2/ 0 99.3 10 2/ 0 99.4 9 3/ 0 99.4 9 3/ 0 99.5 8 4/ 0 99.5 8 4/ 0 99.6 1 5/ 0 99.7 11 5/ 0 99.8 8 18 7/ 1 98.8 18 7/ 1 97.9 21 32/ 0 97.9 21 32/ 0 97.9 21 32/ 0 97.6 27 333/ 12 97.6 27 333/ 12 97.7 15 13 10 3 36 266/ 27 97.6 27 33/ 12 97.7 15 13 10 4 36/ 32 97.7 6 97.7 6 97.7 6 97.7 6 97.7 6 97.7 6 97.7 7 97.7 5 97.7 6 97.7 6 97.7 6 97.7 7 97.7 6 97.7 6 97.7 6 97.7 7 97.7 6 97.7 6 97.7 6 97.7 7 97.7 6 97.7 6 97.7 7 97.7 7 97.7 6 97.7 6 97.7 7 97.7 7 97.7 6 97.7 7 97.7 7 97.7 7 97.7 6 97.7 7 97.7 7 97.7 7 97.7 6 97.7 7 97.7	A Gright nume easy mine easy mine easy mine easy mine easy is a gright of the easy mine easy mi		
100.0 1 2 0/ 0 100.0 2 0/ 0 99.9 5 4/ 0 99.8 6 7/ 0 99.8 6 7/ 0 99.8 7 3/ 1 99.8 6 7/ 0 99.8 7 3/ 1 99.8 6 7/ 0 99.1 13 2/ 0 99.0 15 1/ 0 99.0 15 1/ 0 99.0 16 1/ 0 99.0 16 1/ 0 99.0 16 1/ 0 99.0 16 1/ 0 99.3 111 70 1 90.3 114 2/ 0 99.3 12 12 1/ 0 99.3 12 1/ 0 99.3 12 1/ 0 91.8 32 1/ 0 91.9	cum.% mic count/ med 54 109 163 218 272 326 381 435 490 544		
100.0 2 0 99.9 4 2/ 0 99.9 4 2/ 0 99.9 5 4/ 1 99.9 5 1 1 99.9 5 1 1 99.4 9 3/ 1 1 99.3 10 2/ 0 1 99.3 11 3/ 0 1 99.1 13 4/ 0 1 99.0 14 2/ 0 1 99.1 13 4/ 0 1 99.0 14 2/ 0 1 99.0 14 2/ 0 1 99.0 15 1/ 0 1 91.0 14 2/ 0 1 92.0 14/ 1/ 0 1 92.1 13/ 0 1 1 92.2 13/ 1 0 1 93.2 13/ 1 1 <t< td=""><td></td></t<>			
00:00:0 3 2 0 99:9 4 6 7/ 0 99:6 7 3/ 0 0 99:3 10 2/ 0 0 99:3 11 3/ 0 0 99:3 11 3/ 0 0 99:1 13 4/ 0 0 99:1 13 4/ 0 0 90:1 14 2/ 0 0 90:0 15 1/ 0 0 90:1 14 2/ 0 0 90:0 15 1/ 0 0 91:0 17 0 0 0 92:0 15 1/ 0 0 91:0 16 1/ 0 0 92:1 32/ 0 0 0 97:0 22 3/ 0 0 0 91:8 2 11// 0 0 0 92:5 32 <td< td=""><td></td></td<>			
99.9 5 4/ 1 99.8 6 77 0 99.5 8 4/ 0 99.5 8 4/ 0 99.5 8 4/ 0 99.3 11 3/ 0 99.3 11 3/ 0 99.3 11 3/ 0 99.1 13 4/ 0 99.0 16 1/ 0 99.0 16 1/ 0 99.1 13/ 0 0 90.1 16 1/ 0 90.8 18 7/ 1 90.8 18 7/ 1 91.8 24 17// 2 87.0 25 29// 3 18.7 34 17// 2 19.8 24 17// 2 19.7 26 29// 3 11.7 34 120// 12 13.9 40// 28//	99.9 4 Z/ 0		
00.6 7 3y 1 00.5 8 4/ 0 00.3 10 2/ 0 00.3 11 3/ 0 00.1 14 2/ 0 00.1 15 1/ 0 00.1 15 1/ 0 00.1 16 1/ 0 00.1 15 1/ 0 00.1 16 1/ 0 00.1 17 0 01.1 14 2/ 0 02.2 13/ 1	99.9 5 4/ 1 P 99.8 6 7/ 0 ■		
90.2 0 3/ 0 90.3 10 3/ 0 90.3 11 2/ 0 90.3 11 3/ 0 90.3 11 3/ 0 90.1 13 4/ 0 90.0 15 1/ 0 90.1 16 1/ 0 90.2 16 1/ 0 98.8 18 7/ 1 98.8 19 10/ 0 98.8 19 10/ 0 98.8 12 14/ 0 98.8 18 7/ 1 98.8 18 7/ 1 98.8 18 7/ 1 97.0 21 32/ 0 97.2 22 34/ 28 37.4 128 37.4/ 28 36.4 12 50/ 70 25.9 32 20.4/ 90 7.7 77 87 16/	99.6 7 3/ 1		
99.3 10 2/ 0 99.3 11 3/ 0 99.2 12 1/ 0 99.0 14 2/ 0 99.0 16 1/ 0 99.0 16 1/ 0 98.0 18 7/ 1 98.4 18 7/ 1 98.5 20 11/ 0 98.6 18 7/ 1 98.7 21 12/ 0 98.8 18 7/ 1 98.6 18 7/ 1 98.7 26 29/ 3 91.8 24 17// 2 77.0 25 29/ 3 18.7 24 17// 2 72.6 27 333 18/ 27 28.5 2 204/ 9	99.4 9 3/ 0		
99:2 12 17 0 99:0 14 27 0 99:0 16 17 0 98:9 16 17 0 98:9 16 17 0 98:9 16 17 0 98:9 16 17 0 98:9 16 17 0 98:9 16 17 0 98:9 18 7 1 98:9 19 107 0 98:9 21 327 1 97:9 22 737 1 97:0 22 737 1 97:0 22 737 1 97:0 22 737 1 97:0 22 737 1 97:0 22 737 1 97:0 24 24 12 93:0 120 14 25 72:6 29 42 32 93:0 1364 129 14 <	99.3 10 2/ 0 99.3 11 3/ 0		
92.0 1 13 4/ 0 92.0 15 1/ 0 92.0 15 1/ 0 92.0 16 1/ 0 92.0 16 1/ 0 92.0 16 1/ 0 92.0 16 1/ 0 92.0 16 1/ 0 92.1 32/ 0 - 92.2 13// 0 - 92.3 118/ 1 - 92.4 111/ 2 - 92.5 23// 1 - 92.6 23// 1 - 92.6 23// 1 - 92.6 23// 1 - 92.6 23// 1 - 93.1 22 33// 12 93.4 314 20 - 93.5 32 16// 10 93.7 71/ 53 16// 93.7 71// 54	99.2 12 1/ 0		
99.0 15 1 / 0 98.9 17 6 / 0 98.8 18 7 / 1 98.8 19 10/ 0 98.7 21 32/ 0 97.9 21 32/ 0 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 80.7 26 27/ 33/ 81.7 24 27/ 28 73.8 31.80/ 70 7 18.7 33 18/ 60 97.7 38 81/ 60 97.7 38 55/ 51 6.2 39 42/ <td>99.1 15 4/ 0 ■ 99.0 14 2/ 0 ■</td>	99.1 15 4/ 0 ■ 99.0 14 2/ 0 ■		
78.9 10 10 10 98.8 18 7 1 98.4 18 7 1 98.4 18 14/ 0 97.9 21 32/ 0 97.0 22 73/ 1 91.8 24 171/ 2 87.0 25 220/1 3 80.7 26 24/4 2 63.4 28 374/4 25 53.1 29 340/ 25 72.6 224/ 9 340/ 73.3 120/ 90 90 74.3 120/7 90 90 75.3 120/7 90 90 77.3 38 15/7 10 77.3 38 120/7 90 77.7 38 15/7 10 77.7 38 5/7 11 80.7 25 22/4 22 22.3 42 24/7 22 23.9 22/4	99.0 15 1/ 01 99.0 16 1/ 01		
98.8 18 7/ 1 98.6 19 10/ 0 98.6 19 10/ 0 97.9 21 32/ 0 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 97.0 22 75/ 1 98.0 72.6 29/4 9 72.6 29/4 9 28 36.4 28 374/ 28 37 73 10/7 10 92.5 204/ 9 10 93.81 90 97 18.7 33 180/ 97 19.7 38 160 9.4 36/4 32 2.9	98.9 17 6/ 0■		
98.3 20 14/ 0 97.0 21 32/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 22 73/ 1 97.0 25 229/ 3 80.7 26 27 333/ 12 53.1 29 340/ 28 374/ 28 72.6 27 73/ 28 374/ 28 73.3 1250/ 70 70 70 70 23.9 33 189/ 97 71 73 71 74 77 78 55/ 51 60 77 74 74 77 64 7.7 38 55/ 51 77 74 74 77 6 0.5 42/ <td>98.8 18 7/ 1 P 98.6 19 10/ 0 P</td>	98.8 18 7/ 1 P 98.6 19 10/ 0 P		
77.0 21 32/ 0 95.0 23 118/ 1 91.8 24 171/ 2 87.0 25 229/ 3 80.7 25 229/ 3 81.7 26 273.33/ 12 63.4 28 374/ 25 36.4 31 250/ 28 72.6 27 33.1 12 63.4 31 250/ 28 36.4 31 250/ 28 36.4 31 250/ 28 36.4 31 250/ 29 23.9 32 204/ 90 23.9 33 189/ 97 15.1 35 16/ 80 77 38 55/ 51 6.2 39 42/ 40 3.9 41 36/ 32 71.7 38 51/ 5 7.7 71/ 5 6 9.42 24/ <t< td=""><td>98.3 20 14/ 0</td></t<>	98.3 20 14/ 0		
95.0 23 118/ 1 91.8 24 171/ 2 87.0 25 229/ 3 80.7 26 294/ 9 72.6 27 333/ 12 63.4 28 374/ 25 53.1 29 340/ 28 43.8 30 266/ 52 364.1 250/ 70 29.5 32 204/ 90 23.9 33 189/ 97 18.7 34 129/ 79 15.1 35 116/ 89 91.9 6 81/ 60 9.7 37 71/ 58 5.1 40 42/ 42 2.3 421 32 9.41 36/ 32 9.5 7.7 78 12.2 45 11/ 13.9 41 36/ 0.5 48 9/ 0.5 48 9/	97.0 22 73/ 1		
87.0 25 229' 3 80.7 26 294/ 9 72.6 27 333/ 12 63.4 28 374/ 25 73.8 29 340/ 28 43.8 30 266/ 52 36.4 12 50/ 70 29.5 32 204/ 90 23.9 33 189/ 97 15.1 35 116/ 89 9 14.9 681/ 60 9 42/ 32 55 9 42/ 40 42/ 10.9 46 5/ 51 11.9 681/ 40 42/ 13.0 41 36/ 32 2.3 42 42/ 42 2.4 224/ 22 42 2.5 50 7 7 1.7 74 19/ 10 1.2 45 11/ 10 1.5 10 10	95.0 23 118/ 1		
80.7 26 294/ 9 72.6 27 333 12 63.4 28 374/ 25 53.1 29 340/ 28 36.4 31 250/ 70 20.5 52 204/ 90 23.9 33 189/ 97 15.1 35 116/ 89 11.9 36 81/ 60 9.7 37 71/ 58 7.7 38 55/ 51 6.2 39 42/ 42 2.9 42 24/ 42 2.3 43 21/ 19 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7 6 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 1/ 1 0.1 52 0/ 0 0.3 9/ 8 1	87.0 25 229/ 3		
63.4 28 374/2 28 53.1 29 340/28 28 36.4 31 250/70 20.5 32.9 23.9 33 189/97 79 15.1 35 116/89 11.9 36 81/60 9.7 37/71 71 7.7 38 55/51 6.2 39 42/40 3.9 41 36/32 2.9 42 24/22 2.3 43 21/1 1.2 45 11/1 0.3 40 42/2 2.3 43 21/1 1.2 45 11/1 0.4 5/7 5/7 1.2 45 11/1 0.3 49 3/2 0.3 49 3/2 0.4 5/7 1 0.1 52 0/2 0.2 50 2/1 0.3 49 3/2 0.4 5/7 0/0 0.5 <td>80.7 26 294/ 9</td>	80.7 26 294/ 9		
33.1 27 3447 52 36.4 31 2507 70 29.5 32 204.9 90 23.9 33 1897 97 18.7 34 1297 79 15.1 35 1167 89 11.9 36 817 60 9.7 77 75 77 38 557 51 10 427 9.7 37 717 58 51 6.2 39 427 435 5.1 40 427 40 3.9 41 366 32 9.42 24 24 22 2.3 43 21/1 10 0.42 45 11/1 10 0.43 49 37 2 0.44 57 5 1 0.5 48 9/ 8 0.3 49 37 2 0.43 57 0/ 0 0.1 <t< td=""><td>63.4 28 374/ 25</td></t<>	63.4 28 374/ 25		
36.4 31 250/ 70 23.9 33 189/ 97 18.7 34 129/ 79 18.7 35 116/ 89 11.9 36 81/ 60 9.7 77 75 77 7.7 38 55/ 51 6.2 39 42/ 43 5.1 40 42/ 40 3.9 41 36/ 32/ 2.9 42 24/ 22 2.3 43 21/ 19 1.7 41 16/ 35 1.2 45 11/ 10 0.3 49 3/ 2 0.4 24/ 22 2 0.5 48 9/ 8 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.1 54 1/ 1	335.1 29 340/ 20 43.8 30 266 52		
23.0 23 180/ 97 18.7 34 129/ 79 15.1 35 116 89 11.9 36 81/ 60 9.7 71/ 58 6.2 39 42/ 42/ 3.9 41 36/ 32 2.9 42 24/ 22 2.3 43 21/ 19 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7/ 6 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.0 56 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0	36.4 31 250/ 70		
18.7 34 1297 70 15.1 35 116 89 11.9 36 817 60 9.7 37 717 58 7.7 38 55/ 51 6.2 39 42/ 40 3.9 41 36/ 32 2.9 42 24/ 22 2.3 43 21/ 19 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7/ 6 0.3 49 3 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.0 55 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0	23.9 33 189/ 97		
11.9 36 81/ 60 9.7 37 71/ 58 7.7 38 55/ 51 6.2 39 42/ 40 3.9 41 36/ 32 2.9 42 24/ 22 2.3 43 21/ 19 1.7 44 19/ 15 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7/ 6 0.5 48 9/ 8 0.3 12/ 1 1 0.1 51 2/ 1 0.1 51 2/ 1 0.1 53 1/ 1 0.1 53 1/ 1 0.1 53 1/ 1 0.1 54 1/ 1 0.0 55/ 0/ 0 0.0 56/ 0/ 0 0.0 57/ 0/ 0	18.7 34 1297 79 15.1 35 116/ 89		
7.7 38 55/ 51 6.2 39 42/ 45 5.1 40 42/ 40 3.9 41 36/ 32 2.9 42 24/ 22 2.3 43 21/ 19 1.7 44 19/ 15 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7/ 6 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.1 53 1/ 1 0.1 53 1/ 1 0.1 54 1/ 1 0.0 56 0/ 0 0.0 57 0/ 0			
6.2 39 42/ 40 3.9 41 36/ 32 2.9 42 24/ 22 2.3 43 21/ 19 1.7 44 19/ 15 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7/ 6 0.5 48 9/ 8 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.1 53 1/ 1 0.1 53 1/ 1 0.1 53 1/ 1 0.1 54 1/ 1 0.0 56 0/ 0 0.0 57 0/ 0	7.7 38 55/ 51		
3.9 41 36/ 32 2.9 42 24/ 22 3.3 41 19/ 15 1.7 44 19/ 15 1 1.2 45 11/ 10 10 0.9 46 5/ 5 1 0.7 47 7/ 6 1 0.3 49 3/ 2 1 0.1 54 1/ 1 1 0.1 52 0/ 1 1 0.1 52 0/ 0 0 0.1 53 1/ 1 1 0.0 56 0/ 0 0 0.0 56 0/ 0 0 0.0 57 0/ 0 0	6.2 39 42/ 35 5.1 40 42/ 40		
2,3 43 $21/$ 19 1.7 44 $19/$ 15 1.2 45 $11/$ 10 0.9 46 $5/$ 5 0.7 47 $7/$ 6 0.5 48 $9/$ 8 0.3 49 $3/$ 2 0.2 50 $2/$ 1 0.1 51 $2/$ 1 0.1 52 $0/$ 0 0.1 52 $0/$ 0 0.1 53 $1/$ 1 0.1 53 $1/$ 1 0.1 54 $1/$ 1 0.0 55 $0/$ 0 0.0 57 $0/$ 0	3.9 41 36/ 32		
1.7 44 19/ 15 1.2 45 11/ 10 0.9 46 5/ 5 0.7 47 7/ 6 0.5 48 9/ 8 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.1 53 1/ 1 0.1 54 1/ 1 0.0 55 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0			
0.9 46 5/ 5 0.7 47 7/ 6 0.5 48 9/ 8 0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 52 0/ 0 0.1 53 1/ 1 0.1 54 1/ 1 0.0 55 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0	1.7 44 19/ 15 5		
0.7 47 77 8 0.5 48 97 8 0.3 49 37 2 0.2 50 27 1 0.1 51 27 1 0.1 52 07 0 0.1 53 17 1 0.1 54 17 1 0.1 54 17 1 0.0 55 07 0 0.0 56 07 0 0.0 57 07 0			
0.3 49 3/ 2 0.2 50 2/ 1 0.1 51 2/ 1 0.1 53 1/ 1 0.1 54 1/ 1 0.0 55 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0	0.5 48 9/ 8		
0.1 51 2/ 1 0.1 52 0/ 0 0.1 53 1/ 1 0.1 54 1/ 1 0.0 55 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0			
0.1 52 07 0 0.1 53 17 1 0.1 54 17 1 0.0 55 07 0 0.0 56 07 0 0.0 57 07 0	0.1 51 2/ 1		
0.1 54 1/ 1 1 0.0 55 0/ 0 0.0 56 0/ 0 0.0 57 0/ 0	0.1 52 0/ 0		
0.0 56 0/ 0 0.0 57 0/ 0			
	0.0 56 0/ 0		
0.0 58 0/ 0			





17.8

Staple Profile (OFDA2000 only)

- Fiber diameter measured along the staple
- Left side tip, right side base of staple
- Can see how MFD changes during the growing season.



Figure 7. Histogram and typical staple profile for an alpaca

Figure 8. Histogram and typical staple profile for very uniform alpaca



Staple profile (contd.)

FPFT – Finest Point From Tip

Used to indicate where the MFD is the smallest and most likely to break during processing MFE – Mean Fiber Ends MFD at the ends of the staple **Relationship to comfort factor?** Minimum and Maximum MFD along staple **Excellent for selection purposes** % fibers < 15 microns

Staple profile (contd.)

- Drastic changes in diameter can cause a weakness in the staple strength and can impact processing ability (breaks).
- Use the information to make management decisions to grow sound fiber
 - Shearing in relationship to parturition, lactation, etc.
 - Supplemental feeding strategies

Airflow (WIRA)



- Measures flow of air through fiber sample.
- Indirect measurement of AFD.
- Does not measure SD, CV, curvature, or medullation.
- Very few, if any, calibrated for alpaca.
- Medullation affects accuracy of measurement.

Resistance to Compression



Colorimeter

Tristimulus values Whiteness Yellowness Brightness





Luster

- Goniophotometer. Single fibers, slow, expensive.
- Opacity (OFDA 100) and NIRS.
- SAMBA Hair System. Very promising.



Of great interest to breeders (but not the textile industry)

- Body weight
- Fleece weight

Fiber density (fibers per unit area of skin)

Fibers per unit area

- Traditionally determined using histological / staining methods. Not particularly accurate and requires removal of multiple skin samples using a trephane.
- However, skin sections capable of revealing additional information.



Fibers per unit area

- Alternatively, and less invasively, a known area can be shorn from the mid-side.
- Knowing staple length, clean weight, average fiber diameter, and density of alpaca fibers, can calculate fibers/unit area.

Accuracy of objective measurements

 Don't get carried away with the second number after the decimal place!!

95% confidence limits

- Fiber base (clean yield): 1 to 2%
- VM Base: 0.1 to 2%
- MFD: 0.2 (15 micron) to 0.9 (40 micron)
- Staple length: 5 mm
- Staple strength: 6 N/ktex

IV. Genetic Evaluation of Fiber Traits in Alpaca



Genetic improvement of alpaca

Is usually geared towards:

- Increased production (per animal or per unit of BW).
- Increased production (per unit of land base).
- Improved quality (decreased fiber diameter and medullation, for example, so that a unit amount of fiber is worth more).

Genetic improvement of fiber production

Conventional

- Define breeding objectives
- Select measurable, heritable trait(s) that exhibits variation among individual animals.
- Apply maximum selection pressure (mainly from male side).
- Reduce generation interval

Genetics Theory (Simplified)

Genetic improvement per year =

Heritability (h²) X Selection differential

Generation interval

Genetic tools available in the U.S. for improvement of fiber production

- A National Alpaca Improvement Program, The Ideal Alpaca Community, Mike Safley (OR) and Dave Notter (VA).
- Genetic Alpaca Improvement Network (GAIN), Wayne Jarvis, Holley, New York.





The most active program for genetic evaluation of U.S. sheep is:

National Sheep Improvement Program.
 ASI Program
 Genetic Evaluation Center at Virginia Tech

NSIP Clients

- Targhee (TA)
- Polypay (PP)
- Dorset (DO)
- Hampshire(HA)

Suffolk (SU) Katahdin (KT)

Columbia (CL)

- **Boer Goat (BO)**
- Romney group (Romney, Dorper, White Dorper, Coopworth)

Texas Rambouillet Nucleus Flock

• <u>In 2008</u>

- Kiko Goat (KI)
- Ideal Alpaca Community

Genetic Trends in Targhee Sheep





Genetic tools for improvement of fiber production

- Estimated breeding values, EBV (or estimated progeny difference, EPD)
- An EBV can be calculated for each measurable trait of an individual animal.
- The trait is adjusted for DOB, sex, BW, type of birth, etc. and expressed as a deviation from the mean for contemporary animals.

Genetic tools for improvement of fiber production

- Estimated breeding values, EBV (or estimated progeny difference, EPD)
- EBV is calculated as a function of the adjusted trait deviation, heritability of the trait, correlation between measured traits, and records of relatives.
- Within- and across-flock EBV's are calculated (the latter when sufficient genetic connections are present among flocks).

Genetics Theory (Simplified)

To design an effective alpaca breeding program and to be able to accurately predict progress, we must have:

- Accurate estimates of heritability, genetic and phenotypic correlations among traits, and phenotypic variation within traits.
- It is also important to have relative economic values for each trait (preferably long-term averages unless specific knowledge is available on what the future holds).

Heritability values

- h² > 0.40, high
- h² = 0.20-0.40, moderate
- h² < 0.20, low

Most alpaca fiber traits are moderate to highly heritable.

Heritability estimates for alpacas (Chavez, 1991; Ponzoni et al., 1999; and Wuliji et al., 2000)

Trait	h²
Grease fleece weight	0.21 - 0.83
Clean yield	0.37 - 0.67
Clean fleece weight	0.68 - 0.79
Mean fiber diameter	0.67 - 0.73
CV fiber diameter	0.90
Mean staple length	0.43 - 0.63
Live weight	0.27 - 0.69
Staple strength	0.16
Resistance to compression	0.69
Genetic Improvement of Alpacas

If concurrent selection for more than one trait is desired then several approaches may be considered.

- 1. Index selection in which each trait is weighted by its heritability and economic value.
- 2. Independent culling levels. Threshold level for each trait.
- **3.** Combination of 1 and 2.

Genetic correlations

- Favorable Fleece weight and staple length.
- Neutral Clean yield and staple length; fiber diameter and staple length.
- Antagonistic Fleece weight and fiber diameter.

- The tools are likely to prove very useful for:
- Identifying traits in young animals that cannot normally be measured until the animal matures e.g., a cria's genetic potential to remain fine.
- Detecting carriers of deleterious physical defects in animals that do not themselves exhibit the problem (e.g., Spider lambs).

- The tools could prove very useful for:
- Identifying animals with resistance to internal and external parasites, or potential for improved growth, for example.
- Other traits that are difficult to measure directly.

- The tools have already proven to be very useful in other species for identifying:
- Beef cattle bulls whose offspring will produce more tender meat.
- Dairy cattle bulls whose offspring will produce more milk.
- To name just a couple.

But, as an animal fiber metrologist, I feel obliged to point out to breeders that if a fiber trait is measurable, highly heritable, and economically important, then keep measuring it.

The fiber test is likely to be much less expensive than the DNA test.

