ANIMAL FIBER METROLOGY

Chris Lupton

Texas AgriLife Research
The Texas A&M System
San Angelo

IRAQ AGRICULTURAL EXTENSION
REVITALIZATION GROUP

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SHEEP AND GOAT INDUSTRY IN TEXAS

Spanish explorers introduced sheep to the Southwest in the 1500s, and Spanish missions depended on the animals for food and clothing. The first Angora goats, known for the beauty and strength of their mohair, were brought to Texas in 1853 by Col. W.W. Haupt, pioneer of modern sheep ranching in Texas from 1857 to 1867. George Wilkins Kendall, who encouraged others with glowing reports of the industry’s future while improving his own flocks, was one of the first to crossbreed the coarse-wooled Mexican Churro sheep with the fine-wooled Merino variety brought by European settlers.

The land, climate, and vegetation of the Edwards Plateau area especially suited the raising of sheep and goats. After 1870, with new markets and abundant land, the industry boomed. Ranchers fought disease, predators, deadly plants, and droughts to build their flocks. Today Texas is the leading producer of sheep and goats in the nation, and San Angelo is the major market center for these animals and their wool. Research facilities such as the San Angelo Research and Extension Center, built in 1969 through the efforts of Gen. Earl Rudder, then president of the Texas A&M System, work for the industry’s continued prosperity.

(1974)
Animal fiber program

- Develop and evaluate improved procedures for measuring value-determining characteristics of animal fibers.
- Collaborate in research projects that require fiber production and quality to be quantified.
Animal fiber program

- Project Leader: Chris Lupton
- Research Associate: Faron Pfeiffer
- Research Assistant: Sue Engdahl
- Student Assistants: Eddie Swinney, Gary Henson, Kendra Franke (ASU)
- (Graduate students, ASU and TAMU)
- Plus administrative, secretarial, bookkeeping, and maintenance support from the unit and CS.
Species we work with

Muskox (qiviut), rabbit, dog, cattle, mice, et al.
U.S. animal fiber testing labs

- One commercial and 3 academic labs.
- Our AgriLife Research lab is well equipped and staffed.
- Consequently, there are plenty of opportunities for collaboration with AgriLife Research, USDA, ARS, and other scientists in academia on projects that have high national priority.
Total sheep and lambs, 1908 to 2009

Year (January data)

Number, thousands


1942, 56.2m

2009, 5.75m in U.S.
0.87 m in Texas
2008 data

- Sheep 82,330. Down 1% compared with 2007
- Angora goats 6500. Down 10%.
- Dairy goats 29,000. Up 6%.
- Meat goats 128,800. Up 5%.
Texas wool production and value, 1909 to 2009

[Graph showing Texas wool production and value from 1909 to 2009.]

Production, 1000 lb

Value of production, 1000$
Texas goat numbers

1,000,000 hd

Year

72 77 82 87 92 97 2002 2007

Meat
Angora

980,000
120,000

Plus ~20,000 milk goats
Animal fiber metrology

“Current technology”
Sampling

- From live animal
- From shorn fleece
- From packages (bags or bales)
• 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 packaged 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 are measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, % (WB, 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 are 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 are 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).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Scoured</th>
<th>Top/noil</th>
<th>Yarns</th>
<th>Cloth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean fiber diameter</td>
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<tr>
<td>Comfort factor</td>
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<tr>
<td>CV of fiber diameter</td>
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<tr>
<td>Clean yield</td>
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<tr>
<td>VM (amount and type)</td>
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<td>**</td>
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<tr>
<td>Staple strength/POB</td>
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<td>-</td>
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<tr>
<td>Mean fiber length</td>
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<tr>
<td>CV of fiber length</td>
<td>**</td>
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<tr>
<td>Dark fibers</td>
<td>*</td>
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Relative commercial importance of raw specialty animal fiber traits (McGregor, 2006) contd.

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<tr>
<td>Medullated fibers</td>
<td>**</td>
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<tr>
<td>Fiber crimp</td>
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<tr>
<td>Color</td>
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<tr>
<td>Style and handle</td>
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</table>

* 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.
Standard methodology

- American Society for Testing and Materials (ASTM)
- International Wool Textile Organisation (IWTO)
Fleece and fiber characteristics that are 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)
Clean fiber base

- Mass of clean, dry fiber with all impurities removed expressed as a % of the original “greasy” 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 alcohol-extractable matter expressed as a % of the mass of the sample.
Presale Measurement Procedure

Weights shown in the chart are typical examples of the weights of the samples, subsamples and test specimens which occur in a pre-sale test.
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
• Non-destructive and results available in less than two minutes.

• Currently, only being used commercially to replace one of the gravimetric tests (residual grease).
X-ray instrument for estimating clean yield
Fleece and fiber characteristics that are 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/ktx, CV, %, POB (tip, mid, base or fraction)
Length Measurement, contd.

Grid sampling

Average staple length, SD, and CV of staple length
Length & Strength Testing

Measuring Length

Staples in a Tray

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<td>%, POB (tip, mid, base or fraction)</td>
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Staple Strength Measurement

Average staple strength, SD and CV of staple strength, Position of break, and % tip, middle and base breaks
Strength Measurement, contd.

Agritest Staple Breaker 2 ↔

ATLAS
Fleece and fiber characteristics that are measured or calculated (contd.)

- **Average fiber diameter, SD, microns, CV, %**
- **Comfort factor, % fibers ≤ 30 microns**
- **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**
Fiber diameter measurement

- 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

Courtesy: Yocom-McColl Testing Labs, Inc.
LaserScan Display

Courtesy: Yocom-McColl Testing Labs, Inc.
OFDA 100
Optical Fibre Diameter Analyser
OFDA slide on stage
Sirolan Fleecescan
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).
Frequency
Amplitude

Angle of curvature, °/mm

Large angle, small crimp

Angle of Curvature, °/mm

Small angle, bold crimp
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.

- \[ SF = 0.881 \times MFD \times (1 + 5 \times \left[ \frac{CVD\%}{100} \right]^2)^{1/2} \]

- For a given MFD, spinnability ↑ as CV ↓
Coarse Edge Micron (CEM)

- The number of microns above the MFD where the coarsest 5% of fibers lie
- 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
μm

Number of fibers
OFDA2000 bonus measurements: staple length and staple profile. But, limited accuracy, since measuring greasy, unconditioned samples.
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.
Histogram and staple profile

OFDA 2000 REPORT: SORTED BY TAG
alpaca 2004 (16 Records)

- EarTag: 051L
- Micron: 22.9 mic
- SD: 4.7 mic
- CV: 20.6%
- CF: 92.7%
- SF: 22.2 mic
- CRV: 28.8 Dg/mm
- SDC: 20.5 Dg/mm

- Staple Len: 100.0 mm
- Min Mic: 21.8 mic
- Max Mic: 24.7 mic
- Finest Point From Tip: 15.0 mm
**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.
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 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
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.
I. Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

• Near-infrared reflectance spectroscopy for measuring clean yield and fiber properties of raw wool and mohair.
NIRS Programs

- Monitoring juniper consumption in free-ranging goats.
- Monitoring algae growth.
- Measuring “energy content” of cattle manure from feedlots.
- Estimating average fiber diameter directly on Angora goats.
- Estimating protein and energy content of forages and feeds.
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Using automatic image analysis (OFDA2000) to measure fiber characteristics on the ranch
The SAMBA System (AIA) for measurement of fiber luster
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Comparison of Texas Rambouillet with Australian Merino F1 crosses
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Rambouillet ram and Angora goat central performance tests
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

• Genetic selection to improve the use of goats to manage juniper
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- 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.
Long-term, low intensity project with alpacas

- Evaluation of alpaca castrates and dogs as guard animals for sheep and Angora goats
Nutrition effects on fiber properties

• Numerous projects being conducted by Dr. Whitney...juniper, distillers dried grains, etc. in sheep and goat diets.
• All have a fiber component.
Animal fiber program

• We recognize the great need to increase sheep and goat numbers before excessive infrastructure is lost.

• Develop technologies and / or animals capable of increasing producers’ income.
Service work for breeders

- Provide measurements on individual animal fleeces and technology that permits producers to compete better in world markets.
- Small scale scouring.
Questions?