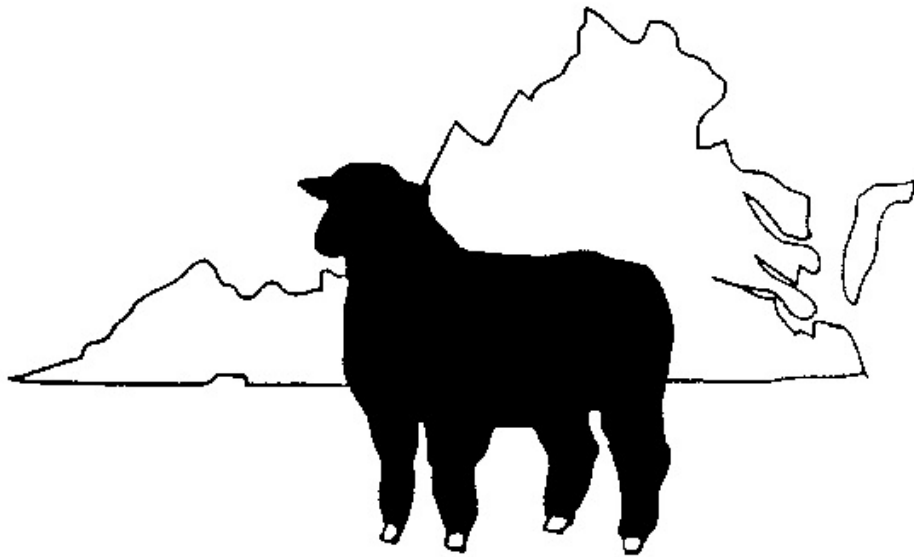


Proceedings

2015

***VIRGINIA
SHEPHERDS' SYMPOSIUM***



January 9 - 10, 2015

***AUGUSTA COUNTY GOVERNMENT CENTER
VERONA, VIRGINIA***

Sponsors

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Culpeper, VA 22701
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Virginia Farm Bureau – Spencer Neale
PO Box 27552
Richmond, VA 23261
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Virginia Sheep Industry Board
c/o Mike Carpenter
261 Mt. Clinton Pike
Harrisonburg, VA 22802
540-209-9143

Virginia Sheep Producers Association
Dept of Animal & Poultry Sciences
Virginia Tech
Blacksburg, VA 24061
540-231-9163

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2015 VA Shepherds' Symposium
Presented By
Virginia Sheep Producers Association

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Friday, January 9

- PM** *Augusta County Government Center*
- 4:00** Virginia Sheep Industry Board Meeting
(Open to the public)
- 6:00** Virginia Sheep Producers Association
Board Meeting (Open to the public)

Saturday, January 10

- AM** *Augusta County Government Center*
- 8:15** Registration and Commercial Exhibits
- 9:00** “New Research and its Application to
Dealing with Parasites”
Dr. Scott Bowdridge – West Virginia
University

CONCURRENT SESSION I

- “Lamb Market Situation and Outlook”**
Dr. David Anderson – Texas A & M
University
- “Keeping and Using Flock Records”**
Dr. Scott Greiner – Dept. of Animal &
Poultry Sciences, Virginia Tech
- “Timely Management Strategies for the
Flock”**
Dr. Mark McCann – Dept. of Animal &
Poultry Sciences, Virginia Tech
Dr. Scott Greiner – Dept. of Animal &
Poultry Sciences, Virginia Tech

CONCURRENT SESSION II

- “Determining the Value of Your Wool”**
Dr. Rodney Kott – Montana State University
- “Marketing Opportunities for Your
Wool”**
Dr. Rodney Kott – Montana State University
- Roundtable Discussion – Opportunities
for Virginia**

PM

- 12:00** Virginia Sheep Producers Association
Annual Meeting

*Roy Meek Outstanding Sheep Producer
Award Presentation*
- 12:15** Lunch – *will be provided*
- 1:00** “Report from American Sheep Industry
Association”
Mr. Bob Leer – ASI Executive Board-
Region II Director, Indiana
- “American Lamb Board & Your
Checkoff Dollars”**
Mr. Leo Tammi – Director-American Lamb
Board, Mt. Sidney, VA
- “Lambing Time Management: Keys to
Success”**
Dan Hadacek, DVM – Ashby Herd Health
- “Keys to My Sheep Operation: Producer
Panel & Virtual Tours”**
Coordinated by John Benner, VA
Cooperative Extension, Augusta County
Featured Producers:
John Sponaule, Grottoes, VA
Sonny Balsley, Lyndhurst, VA
David & Kitra Shiflett, Grottoes, VA
Leo Tammi, Mt. Sidney, VA

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If you are a person with a disability and require any auxiliary aids, services, or other accommodations for this symposium, please discuss your accommodation needs with Scott Greiner at (540) 231-9159 at your earliest convenience.

PRE-REGISTRATION INFORMATION

Received by January 5, 2015

SATURDAY SYMPOSIUM

- _____ **\$25.00 FULL REGISTRATION**
(includes lunch, breaks, and materials)
- _____ **\$10.00 YOUTH FULL
REGISTRATION** (includes lunch,
breaks, and materials)
- ===== **TOTAL**



ON-SITE REGISTRATION

After January 5, 2015

SATURDAY SYMPOSIUM

- _____ **\$30.00 FULL REGISTRATION**
(includes lunch, breaks, and materials)
- _____ **\$15.00 YOUTH FULL
REGISTRATION** (includes lunch,
breaks, and materials)
- ===== **TOTAL**

VIRGINIA
SHEPHERDS' SYMPOSIUM
PRE-REGISTRATION

DEADLINE – JANUARY 5, 2015

Complete separate form for each participant only
if different addresses.

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

DAYTIME PHONE _____

E-MAIL _____

FAX _____

✦ Credit cards are not accepted this year ✦

Please return with payment for registration (make
check payable to VSPA) no later than January 5
to:

Virginia Sheep Producers Association
Dept of Animal & Poultry Sciences
Virginia Tech
Blacksburg, VA 24061
Phone: (540) 231-9159
Fax: (540) 231-3010

LOCATION:

*Augusta County Government Center
18 Government Center Lane
Verona, VA*

The Virginia Shepherds' Symposium is open to all sheep
producers from the Mid-Atlantic Region. It provides in-
service training opportunities for extension personnel,
educators and other professionals in sheep and related
agribusiness industries. Youth are an important segment
of the sheep industry and are invited to attend.

MOTEL RESERVATIONS:

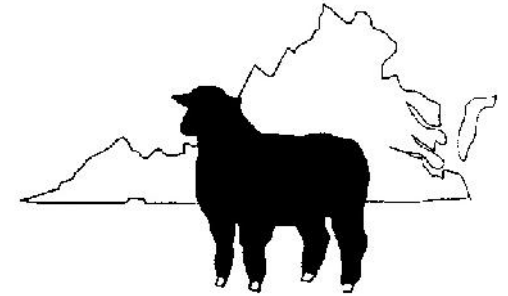
Local lodging is available.

For a complete list, please visit:

<http://www.visitaugustacounty.com>

MOTEL RESERVATIONS ON YOUR OWN

**VIRGINIA SHEPHERDS'
SYMPOSIUM**



January 9 - 10, 2015

*Augusta County Government Center
Government Center Lane
Verona, Virginia*

*Pre-Registration Deadline
January 5, 2015*

Sponsored by:



Virginia Tech • Virginia State University

FRIDAY, JANUARY 9

- 4:00 PM Virginia Sheep Industry Board Meeting (open to public)
- 6:00 Virginia Sheep Producers Association Board Meeting (open to public)

SATURDAY, JANUARY 10

AM Augusta County Government Center – Verona, VA

8:15 Registration & Commercial Exhibits

9:00 “New Research and its Application to Dealing With Parasites”
Dr. Scott Bowdridge, West Virginia University

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“Lamb Market Situation and Outlook”
Dr. David Anderson, Texas A&M University

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PM

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Mr. Leo Tammi, Director- American Lamb Board, Mt. Sidney, VA

1:45 “Lambing Time Management: Keys to Success”
Dan Hadacek, DVM, Ashby Herd Health

2:30 “Keys to My Sheep Operation: Producer Panel & Virtual Tours”
Coordinated by John Benner, Virginia Cooperative Extension, Augusta County

Featured producers:

John Sponaugle, Grottoes, VA
Sonny Balsley, Lyndhurst, VA
David & Kitra Shifflet, Grottoes, VA
Leo Tammi, Mt. Sidney, VA

Virginia Shepherds' Symposium
January 10, 2015
Augusta County Government Center
Verona, VA

Program Overview:

Friday, January 9

4:00 pm **Virginia Sheep Industry Board Meeting (open to public)**

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Saturday, January 10 *(all activities at Augusta County Government Center)*

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David & Kitra Shifflet, Grottoes, VA; Leo Tammi, Mt. Sidney, VA

Early Registration Deadline: January 5, 2015 (registrations also taken on-site day of program)

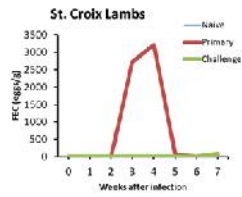
For registration information visit <http://www.vtsheep.apsc.vt.edu> or contact Dr. Scott Greiner, Department of Animal & Poultry Sciences, Virginia Tech, phone (540) 231-9159, email sgreiner@vt.edu

New Research and its Application to Dealing With Parasites



Scott Bowdridge
West Virginia University

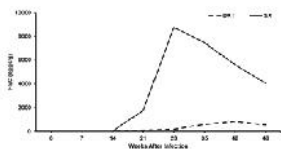
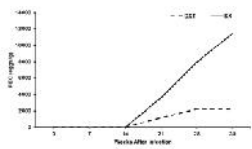
What does parasite resistance look like?



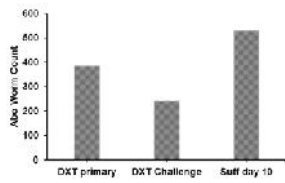
10 days after *Haemonchus* infection



Parasite resistance from heavier muscled sheep?



Worms in the sheep



- Can Texel be used as terminal sires while maintaining parasite resistance in resulting progeny?
- How much Texel is needed?
- Crossbreeding as an anthelmintic?

Things that we forget about when conducting parasite resistance research!

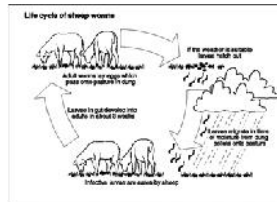
- St. Croix sheep are great but...
- Texel sheep are great but...
- Grazing animals will be exposed to constant reinfection
 - Threshold of resilience
- Grazing management
- Selective deworming
- Nutrition of the animals



“WU-style” grazing management

- Avoidance grazing
- Sheep are graze paddocks for 1-3 days
- Minimum rest period of 56 days
- Requires intermittent mowing to maintain forage quality

LABOR INTENSIVE!!!!!!!!!!!!



What happens to FEC when you graze lambs like this?

2010 – 52 weaned lambs (Suffolk/Merino/Dorset)

4 treatments

- Control
- Dewormed at weaning (moxidectin)
- Supplemented with corn/barley (1% bw)
- Deworm + Supplementation

What happens to FEC when you graze lambs like this?

	Post-weaning management system				P-value
	Control	De-wormed	Grain	De-wormed + grain	
Initial live weight (kg)	20.5	18.3	18.7	21.0	0.6588
Final live weight (kg)	22.4	20.9	20.4	23.2	0.6446
Total gain (kg)	1.9	2.6	1.6	2.3	0.6007
Initial FAMACHA score	2.8	3.3	3.1	3.0	0.5575
Final FAMACHA score	3.2	3.0	2.9	3.0	0.9052
ADG (kg.day ⁻¹)	0.03	0.04	0.02	0.03	0.6007
Strongylid FEC	4194b	1705a	4580b	3071ab	0.0093

What happens to FEC when you graze lambs like this?...and increase protein?

- Increase protein level in 2011 to 16%CP using corn and soybean meal
- Same:

4 treatments

- Control
- Dewormed at weaning (moxidectin)
- Supplemented with corn/SBM 1%BW
- Deworm + Supplementation

What happens to FEC when you graze lambs like this?...and increase protein?

2011

	Post-weaning management system				P-value
	Control	Dewormed	Grain	Dewormed + grain	
Initial live weight (kg)	22.41	20.41	22.68	24.14	0.3455
Final live weight (kg)	22.00ab	21.25b	24.27ab	27.97a	0.0312
Total gain (kg)	-0.2c	1.1b	1.9b	4.2a	0.0091
Initial FAMACHA score	3.5	2.9	2.8	3.1	0.2917
Final FAMACHA score	4.0a	3.3a	3.1b	2.6b	0.0014
ADG (kg.day ⁻¹)	-0.01c	0.02b	0.03b	0.06a	0.0111
Strongylid FEC	1837b	628a	1994b	537a	<0.0001

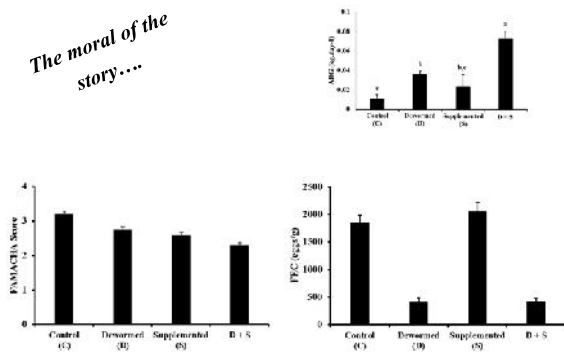
What happens to FEC when you graze lambs like this?...and increase protein?

2012

	Post-weaning management system				P-value
	Control	Dewormed	Grain	Dewormed + grain	
Initial live weight (kg)	22.82	22.85	22.97	20.78	0.7687
Final live weight (kg)	23.72	26.35	25.22	25.36	0.7195
Total gain (kg)	0.9b	2.3b	2.0b	4.8a	<0.0001
Initial FAMACHA score	2.5	2.5	2.6	2.6	0.9892
Final FAMACHA score	2.1	1.5	2.1	1.5	0.1362
ADG (kg.day ⁻¹)	0.01c	0.04b	0.03b	0.07a	<0.0001
Strongylid FEC	1908b	91a	2227b	237a	<0.0001

What happens to FEC when you graze lambs like this?...and increase protein?

The moral of the story....



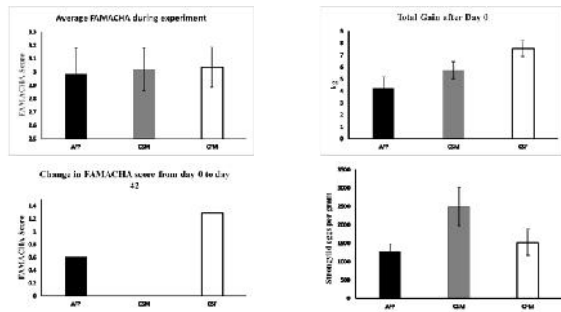
Can protein supplementation have any effect on FEC of grazing lambs?

"WVU-style" grazing

- Two types of protein that are available to ruminants
 - Rumen degradable protein
 - Plant derived, alfalfa
 - Rumen by-pass protein
 - No degradation in rumen, absorption occurs in small intestine
 - Fish meal
- Will adding more rumen by-pass protein affect FEC and growth?
 - Diets formulated to be 19% crude protein
 - 1.) Alfalfa pellets (70% rumen degradable, 30% by-pass)
 - 2.) Corn/SBM (60% rumen degradable, 40% by-pass)
 - 3.) Corn/SBM/FM (30% rumen degradable, 70% rumen by-pass)

Can protein supplementation have any effect on FEC of grazing lambs?

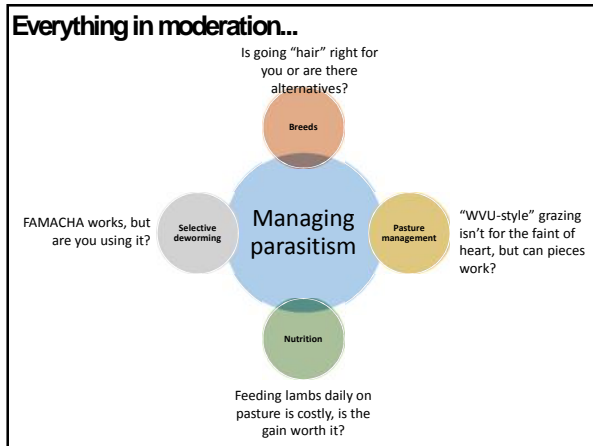
"WVU-style" grazing



Rumen by-pass protein can affect FEC and promote growth in grazing lambs

Feed	\$/lb	Lb consumed	Total cost of feed	kg of gain	\$/kg gain
AFP	\$0.46	349	\$160.45	5.8	\$2.77
CSM	\$0.48	296	\$141.90	6.4	\$2.22
CSF	\$0.41	285	\$145.45	7.8	\$1.86

- Fish meal is a mess to deal with from a producer and researchers perspective
- FM has a lot of oil!
- Is FEC reduction caused by higher oil?




Lamb Market Outlook

Virginia Shepherd's Symposium

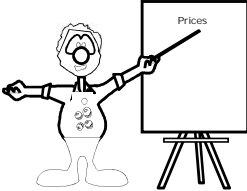
January 10, 2015

David P. Anderson
Professor and Extension Economist
Livestock and Food Products Marketing

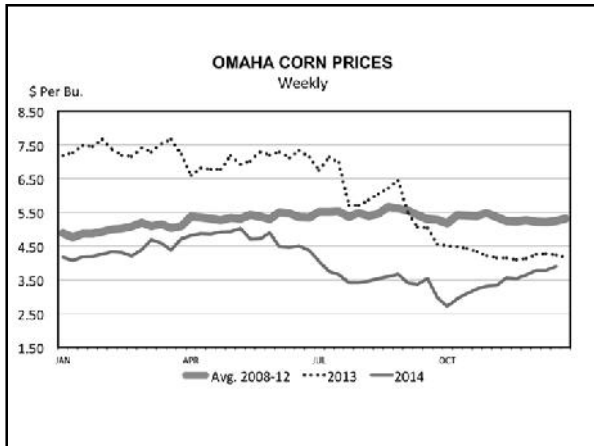


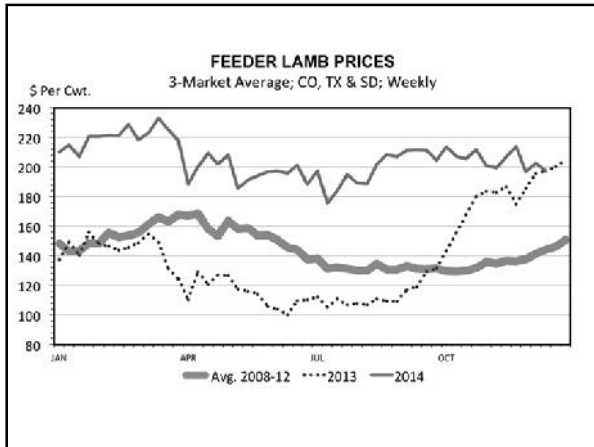
Overview

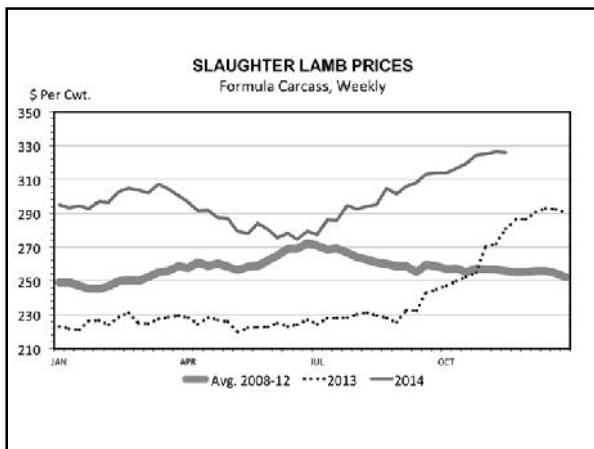
- Price Recovery
- Supplies
- Meat Demand

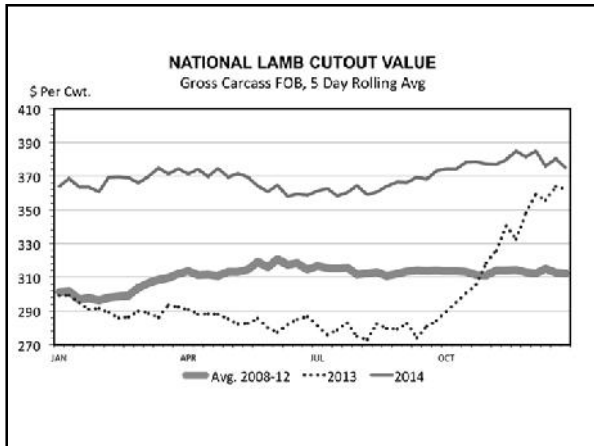


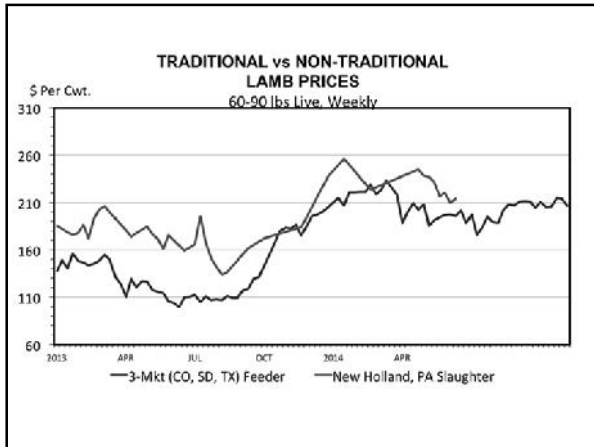
Recovery



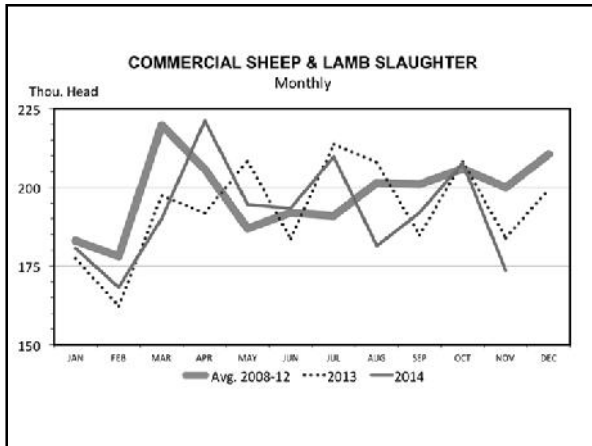


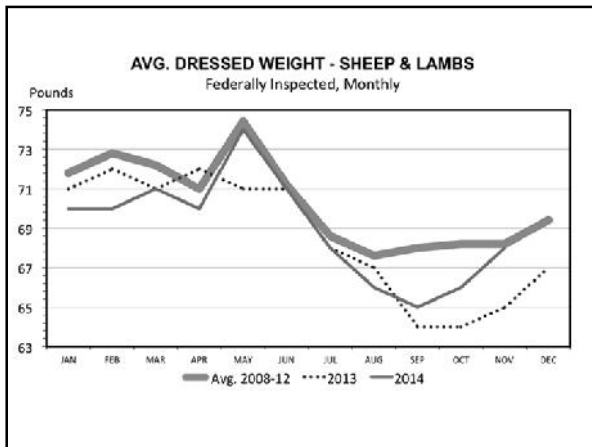


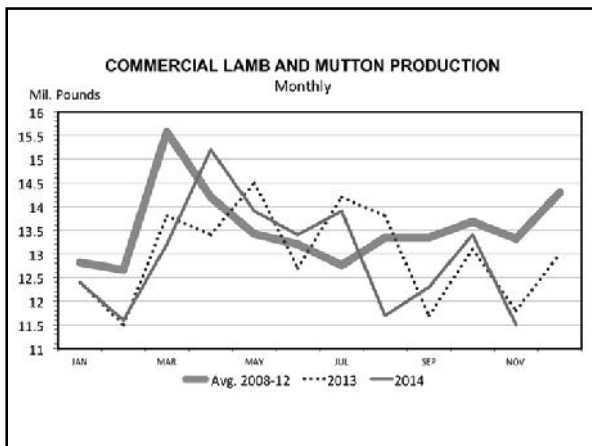


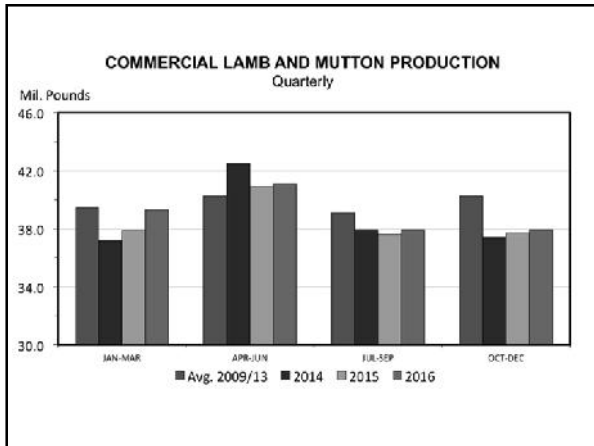


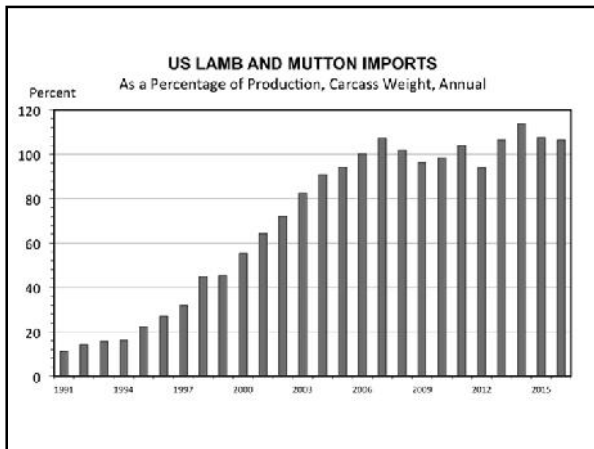
Supplies

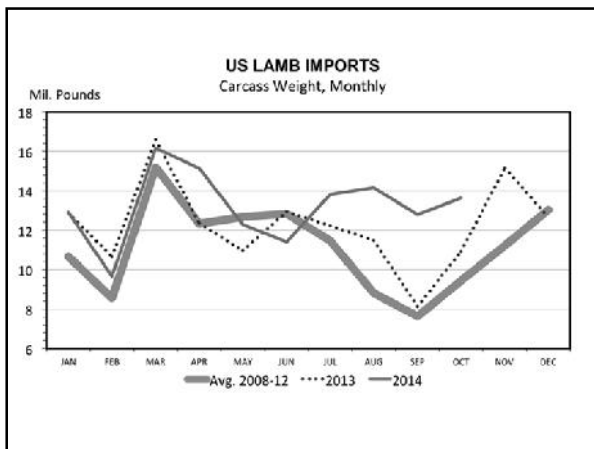




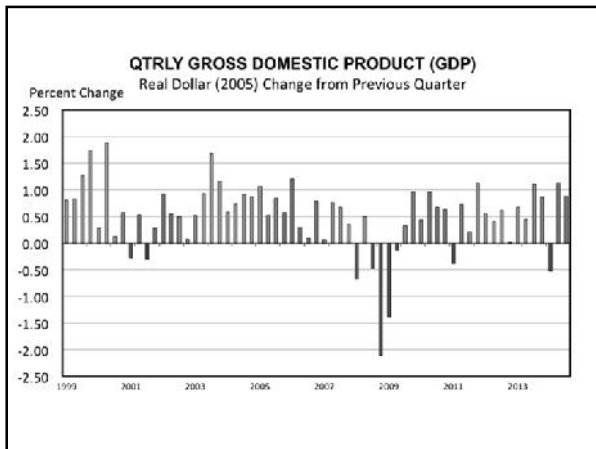


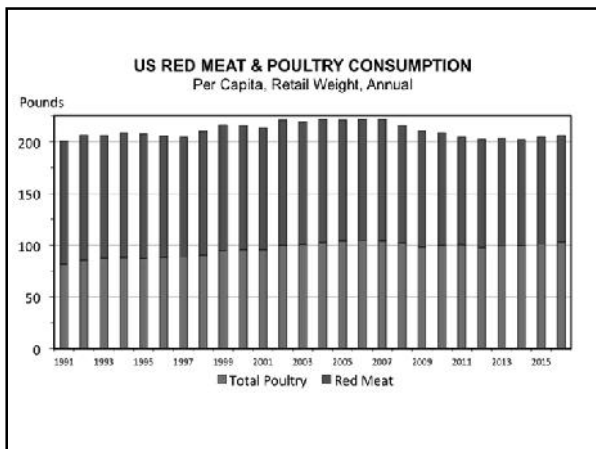


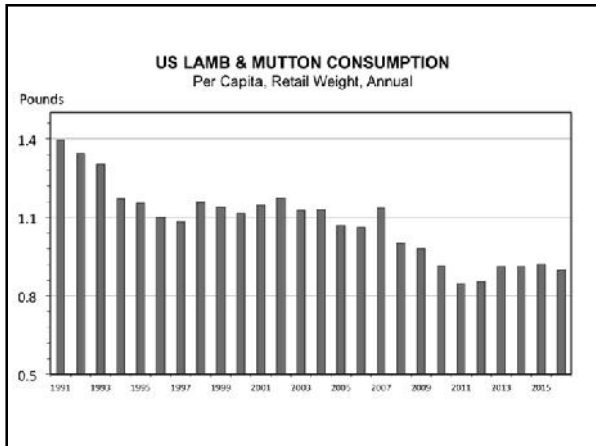


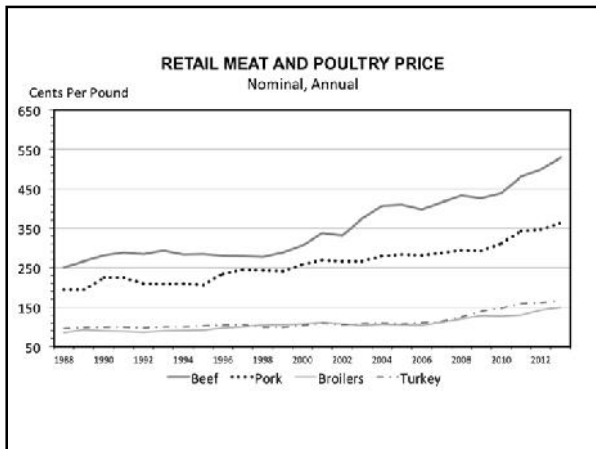


Demand









THANK YOU!

Keeping and Using Flock Records

Scott P. Greiner, Ph.D.

Extension Animal Scientist, Virginia Tech

Flock record-keeping is a vital component of a successful sheep enterprise. Most often we associate the term “records” with information related to production, such as identification, various weights, inventory, and health information. A more comprehensive definition would also include financial records, particularly those items related to enterprise expenses and income. The 2011 USDA National Animal Health Monitoring System (NAHMS) study reported that 86.7% of all sheep operations with 20 or more ewes kept records. The most typical production records taken included number of lambs born (89.2%), number of lambs weaned (77.5%), inventory (79.7%), breeding records (71.9%), and health/vaccination records (68.4%). Individual birth weights and weaning weights, however, were not frequently recorded (15.7% and 14.7%, respectively).

Records are a valuable tool for any sheep production enterprise as they are necessary for documentation and evaluation of many factors which impact profitability. In the absence of records, implementing changes in management that enhance the profitability of the flock either through increased income and/or controlling costs of production are very difficult. Since each sheep enterprise is unique, an operation's record-keeping system needs to be tailored to fit the needs of that particular flock based on its management practices, goals, and objectives. Hence, there are various ways that effective flock record-keeping can be achieved. The key is finding a system which is applicable, practical, and usable for your operation. Following are some basic guidelines which can be adapted to meet various record-keeping needs.

Animal Identification

Individual animal identification serves as the template for an effective record-keeping system. Individual identification allows for monitoring of basic flock performance parameters, and is a necessary component of quality assurance (identification of individual animals for health treatments, vaccination, etc.).

Ear tags- Ear tags are the most common and practical form of individual animal identification. There are many types and sizes of ear tags on the market, designed for various purposes. The ideal ear tags are those that have high retention rates, are easy to read, and easy for the shepherd to apply. Proper location of the ear tag in the ear is important for retention. The USDA Scrapie Identification Program requires most all sheep to carry an official scrapie tag upon leaving the flock of origin. Consequently, most producers utilize an official scrapie ear tag which also serves as their individual flock tag. Keep in mind that official scrapie tags can be customized to meet the needs of an individual flock (animal numbers can be specified). With any ear tag system, the individual numbers utilized can be useful as a flock management tool. For example, the tag number sequence can be designated to indicate year of birth (1501, 1502, etc. for lambs born in 2015; or similar). Similarly, tags differing in color can be used to designate different groups/breeds within the same flock. Note this customization can be used in conjunction with official scrapie tags. With regard to tag size, it is important to find a tag that is compatible with the size and age of sheep being tagged. Consequently, a common practice is to utilize a small lamb tag at birth followed by a second, larger tag

(such as a scrapie) tag applied at an older age (weaning). This system has multiple benefits, as each lamb will have two tags and maintain identity even if one tag is lost, and applying a larger tag enhances readability and also can be made compatible with scrapie identification requirements. Another common practice is to tag male and female lambs in different ears for rapid identification of gender when sorting or performing other management practices.

Tattoos- Tattoos are a viable form of permanent identification. While the identification is permanent, the challenge with tattoos is they are difficult to read as sheep must be caught. As a result, tattoos are best used as a compliment to ear tags in breeding stock. Tattoos can be applied to replacement ewe lambs, and will assure lifetime identification if done correctly. Tattoos are also commonly used in registered breeding stock.

Temporary Forms of Identification- Paint brands, chalks, and spray marks are all forms of temporary identification. All can be effective short-term, particularly for identifying a few individuals (animals receiving health treatment for example). A common use of paint brands or markings is to identify each ewe and her lambs with the same brand upon leaving the lambing jug. This is an excellent management tool, particularly in larger flocks.

Production Records

Basic flock records which should be kept to monitor flock performance include: ewe ID, sire ID, lamb ID, lamb gender, birth date, birth type, rear type, and any notes/comments (lambing ease, mothering ability, lamb vigor, etc.). Along with this, birth, weaning, and post-weaning weight records provide the opportunity to make selection decisions on these traits as well as provides guidance on management decisions.

Record-keeping systems for these traits come in many forms, including paper forms, notebooks or pocketbooks, electronic spreadsheets, and computer record keeping systems. Following are some sample templates for records sheets that can be printed and used on a clipboard or binder in the barn, or converted to electronic form. Shepherds can customize these templates to meet the needs of their flock, depending on the information desired and collected.

Lambing Record- The most basic form of record keeping, used to record basic information on each individual born in the flock.

Ewe Lifetime Record- Summary of a ewe's lifetime performance and includes information across multiple lambing seasons.

Health Record- Documents all health-related procedures performed on the flock either to groups or to individuals. Serves as the basis for quality assurance to observe withdrawal times prior to marketing or harvest.

Inventory Record- Simple record which records inventory numbers during the production cycle. For example, number of ewes exposed to rams and dates, marketing dates and information for lambs and breeding stock or culls, death losses, etc.

Weight Records

As mentioned earlier, weight records are needed for genetic improvement of growth. To effectively utilize weight records, they must be properly adjusted to remove the effects

of lamb age and sex, along with age of the ewe (weaning weight). The following provides basic formulas used to adjust weaning and post-weaning weights. Note that the weights of lambs should only be compared within contemporary group- a contemporary group is defined as a group of animals all raised together in the same environment and given the same opportunity to perform (born together, fed and managed together and of the same general age).

Lamb Adjusted Weaning Weights (45-90 days of age at weaning):

Adj. WW = ((actual WW- actual BW)/age in days) x 60 x WW adj. factor + actual BW
(*if BW not available omit BW from equation)

Lamb WW Adjustment Factors for Lamb Sex, Dam Age, Type Birth & Rearing

Lamb Sex	Dam Age	Birth/Rear Type					
		S/S	TW/S	TW/TW	TR/S	TR/TW	TR/TR
Ewe	1	1.13	1.29	1.38	1.40	1.51	1.80
	2 and over 6	1.08	1.19	1.29	1.28	1.38	1.54
	3 to 6	1.00	1.10	1.19	1.18	1.27	1.36
Ram	1	1.02	1.15	1.21	1.23	1.31	1.53
	2 and over 6	0.98	1.08	1.17	1.16	1.25	1.38
	3 to 6	0.91	1.00	1.08	1.07	1.15	1.23
Wether	1	1.10	1.25	1.33	1.36	1.45	1.72
	2 and over 6	1.05	1.16	1.26	1.25	1.35	1.50
	3 to 6	0.98	1.08	1.16	1.15	1.24	1.33

Lamb Post-Weaning Adjusted 120- day Weight (90-150 days of age):

Adj. PWW = ((actual PWW – actual WW)/(actual PWW age – actual WW age)) x 60 + Adj. WW

Computerized Record Keeping Systems

Many record-keeping systems can be converted from paper form to spreadsheet and database form. Additionally, there are several software packages available commercially that are designed for flock record-keeping. These programs can be used to collect and store records, as well as sort and summarize records. Many also calculate adjusted weights, and some also contain a component to store health records. Price on these programs is variable and can range from \$50 to \$250+, although several of the programs are available at no cost on a trial basis.

National Sheep Improvement Program

The National Sheep Improvement Program (NSIP) conducts the genetic evaluation for the US sheep industry. Through NSIP, across-flock Expected Progeny Differences (EPDs) are calculated for several economically important traits including growth, maternal, carcass, wool and parasite resistance traits. Producers enrolled in NSIP submit flock performance data electronically, and receive back EPDs on their animals for their traits of interest. EPDs provide estimates of the genetic value of an animal as a parent. Specifically, differences in EPDs between two individuals predict differences in performance between their future offspring when each is mated to animals of the same average genetic merit. Complex statistical equations and models use all known information on a particular animal to calculate its EPD. This information includes

performance data (i.e., weight records) on the animal itself, information from its ancestors (sire and dam, grandsire, great grandsire, maternal grandsire, etc.), collateral relatives (brothers and sisters), and progeny (including progeny that are parents themselves). In short, virtually all performance data that relates to the animal of interest is used to calculate its EPD. Additionally, genetic merit of mates is accounted in evaluating progeny information. The statistical analysis used for EPD calculation also accounts for the effects of environment (nutrition, climate, geographical location, etc.) that exist between flocks. Consequently, EPDs generated through the across-flock NSIP analysis allows EPDs to be compared on sheep from different flocks of the same breed. As a result, EPDs derived through NSIP are the best tool for genetic improvement as they a direct prediction of genetic merit. The cost for enrollment in NSIP includes an annual flock fee as well as a fee per ewe enrolled. For more details on NSIP visit <http://nsip.org/> .

Utilizing Records

The power of flock records is in their utilization as a flock management and evaluation tool. The following table outlines several important production and financial parameters which are related to profitability, and the records needed to assess those parameters.

Performance Parameter	Record(s) Required
Pregnancy Rate	Breeding inventory, lambing records
Lambs born per ewe lambing	Lambing records
Lambs born per ewe exposed	Breeding inventory, lambing records
Lambs marketed/retained per ewe lambing	Inventory, lambing records
Lamb death loss (at various stages)	Lambing records, inventory
Lamb WW, Post-WW (sale weight)	Weight records
Pounds of lamb weaned/sold per ewe lambing	Lambing records, inventory, weights
Pounds of lamb weaned/sold per ewe exposed	Lambing records, inventory, weights
Lamb ADG	Weight records
Feed costs per ewe	Inventory, expense records
Total costs per ewe	Inventory, expense records
Lamb cost of gain	Weight records, feed/other expenses
Profit/loss (total or per ewe)	Production, expense, income records

Note that several important benchmarks above integrate production and financial records. For details on expense and income record-keeping and their utilization see “Key Components to Making Money in the Sheep Business” presented at a previous Sheep Symposium and available at http://www.apsc.vt.edu/extension/sheep/programs/shepherds-symposium/2008/07_key_components.pdf

Summary

A fundamental component of enhancing profitability is making sound decisions, and having the ability to assess opportunities for cost control or revenue enhancement. This

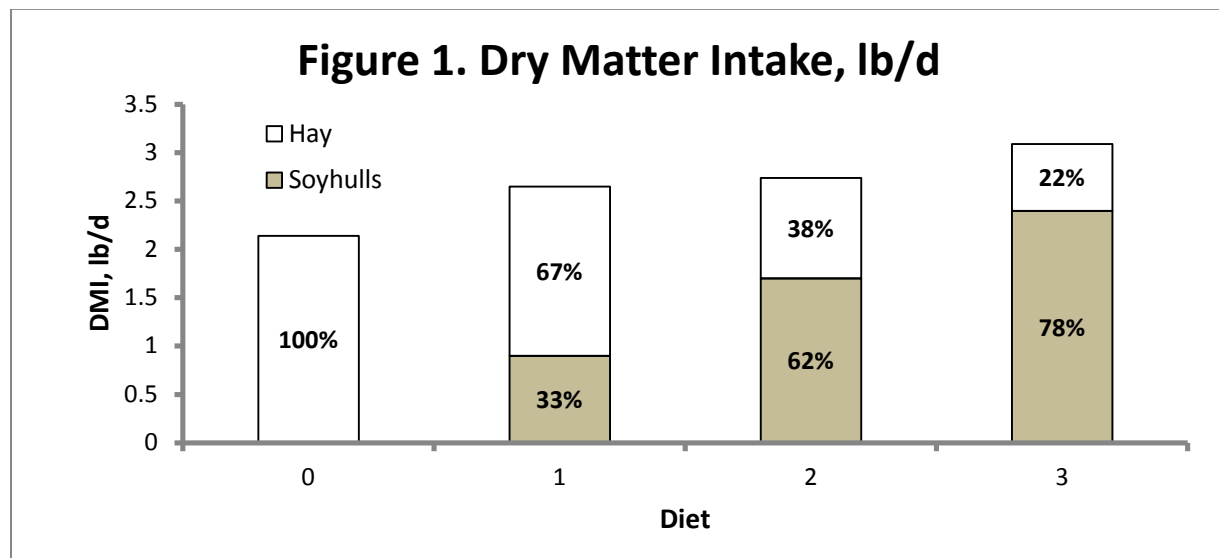
ability is dependent on flock financial and production data. The ability to make sound decisions is dependent on accurate records for income sources and costs of production, as well as basic production parameters for the flock. Essential records include both usage and costs associated with pasture and feed, health, breeding, facilities, and marketing. Essential production records include inventory, pregnancy and lambing rates, death loss, and marketing weights along with detailed receipts for income generated.

Associative effects of feeding varying levels of soyhulls to lambs consuming grass hay.

K.M. Ulmer, D.D. Harmon, S.J. Neil and M.A. McCann, Dept. of Animal and Poultry Sciences

Soyhulls are a popular supplement for sheep and cattle consuming a forage based diet. The low starch and high fiber content coupled with a price discount relative to corn, all contribute to its utility. Previous research has focused on low to moderate levels of supplementation produced gains similar to corn based rations. Additionally, soyhull supplementation has not resulted in the negative associative effects commonly reported with corn supplementation of forage rations. Recent high corn prices have increased pressure on livestock producers to potentially increase the level of soyhull supplementation to higher levels in an effort to support levels of performance while minimizing levels of corn.

The objective of this study was to compare the effect of varying levels of soyhull supplementation on the nutrient digestibility in lambs fed a basal diet of chopped grass hay. Eight St. Croix cross wether lambs (88 ± 8 lb) were housed individually, and randomly assigned to one of four dietary treatments. Lambs were fed a chopped grass hay free choice and supplemented at 0, 1, 2 or 3% (DM basis) of body weight in loose soyhulls. During each of the four periods, lambs were fed chopped hay twice daily and soyhull supplement once daily. Each period consisted of a 9-day adaptation followed by a 5-day collection. Each lamb was fitted with a total fecal collection bag during the adaptation period of each diet. Lambs were weighed prior to each adaptation period and the amount of soyhull supplementation adjusted for lamb weight and diet.



Daily DM intake increased as level of soyhull supplementation increased (Figure 1). This is an important result which indicates that soyhull supplementation did not have any negative effect on hay intake and adding the soyhulls increased DMI above the hay only treatment. Dry matter and nutrient digestibility results are presented in Table 1. Dry matter digestibility with increasing level of soyhull supplementation increased. The improvement in diet digestibility was most pronounced with the 1% treatment and the benefit in digestibility diminished at higher soyhull intake levels.

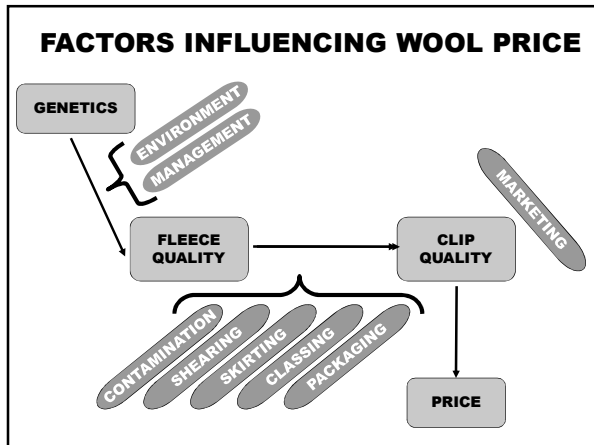
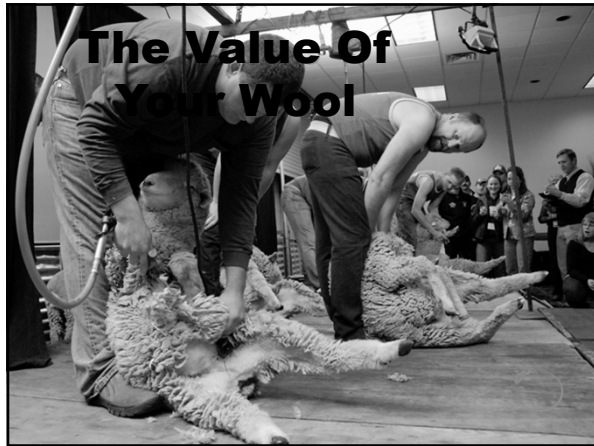
NDF and ADF digestibility exhibited a similar type of response to that of DM digestibility. However, contrary to DM digestibility, NDF and ADF displayed peak digestibility at the 2% supplementation level and a decline in digestibility at the 3% level. This would imply some loss in efficiency of digestion at the higher soyhull levels. Assuming hay DM digestibility of Diet 0, the estimation of soyhull DM digestibility was 76.0, 70.4 and 66.8 % for Diets 1, 2, 3 respectively.


In conclusion, supplementing grass hay with 1% of body weight in soyhulls resulted in the greatest improvement in both DMI and DM digestibility. Depression of NDF and ADF digestibility at the 3% supplementation level contributed to the small improvement in DM digestibility. Feeding levels of soyhulls greater than 2% of body weight would provide diminishing returns for the producer, as the digestibility of the feedstuffs is lower while DMI was higher.

Table 1. Diets Means of Nutrient Digestibility					
	Soyhull Diets				SE
	0	1	2	3	
DM Digestibility, %	56.6	62.97	65.4	66.4	1.0
ADF Digestibility, %	52.5	60.6	63.4	60.2	2.0
NDF Digestibility, %	59.1	63.5	65.5	63.6	1.6
CP Digestibility, %	65.7	65.5	64.1	62.3	0.9


An additional note of interest is that when corn gluten feed was similarly fed in a different experiment at a different time there was no decline in digestibility at the higher supplementation rate (Table 2).

Table 2. Diets Means of Nutrient Digestibility					
	Corn Gluten Feed Diets				SE
	0	1	2	3	
DM Digestibility, %	55.6	59.5	59.1	65.6	4.1
ADF Digestibility, %	50.3	48.2	50.0	50.6	7.1
NDF Digestibility, %	61.0	83.7	85.5	86.2	3.8
CP Digestibility, %	58.9	52.8	61.2	66.4	4.3





Wool Industry

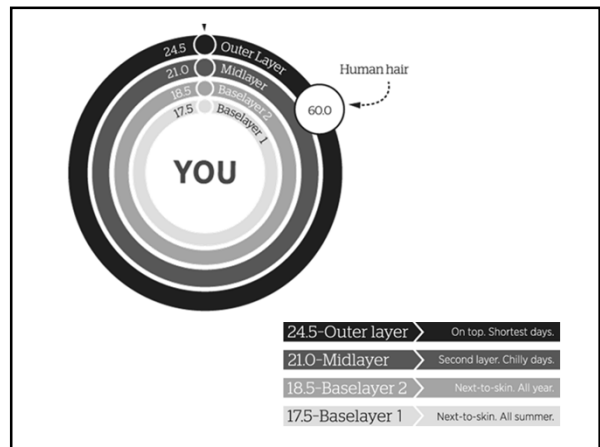
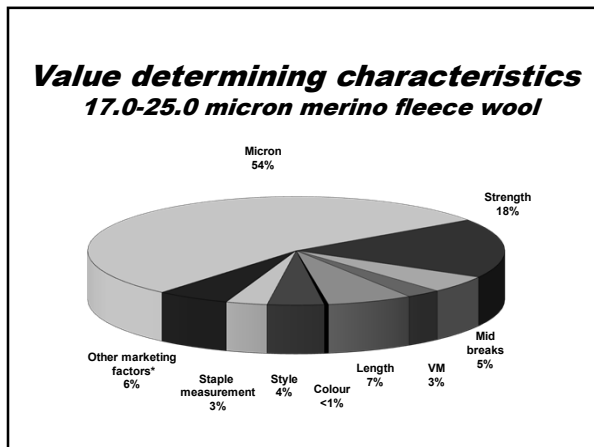


30 Years Ago

US was consuming majority of its domestic wool production and exporting much smaller amount.

Today

US is exporting a majority and consuming smaller amount.



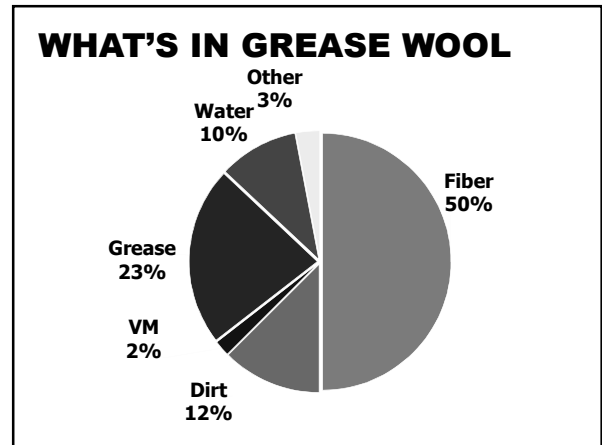
Finer weight garments require finer wool

Yarn diameter must contain a minimum of about 44 fibers

Fiber Diameter

Fine ← → **Course**

Finer wool is generally higher value

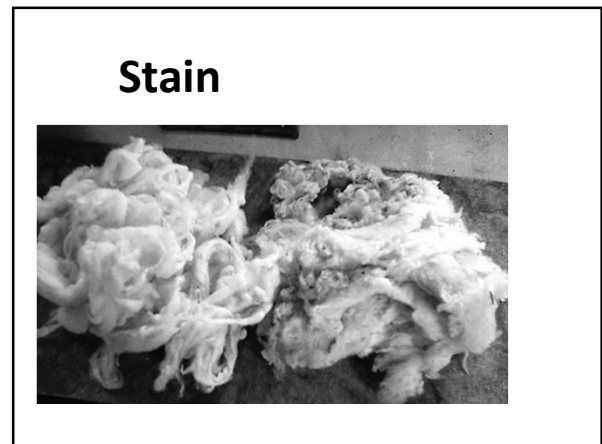
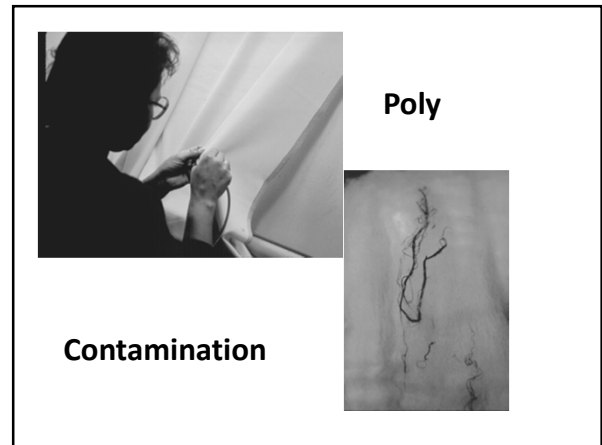
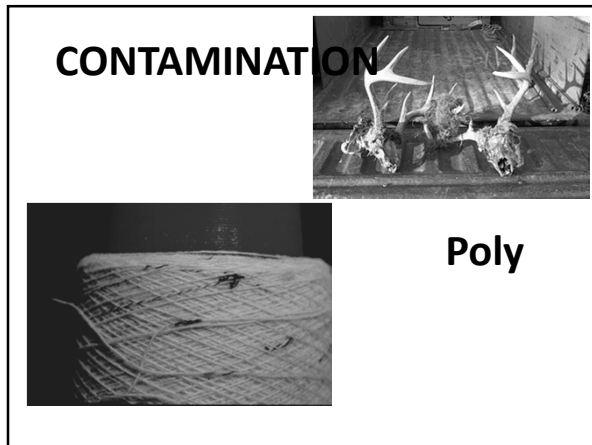
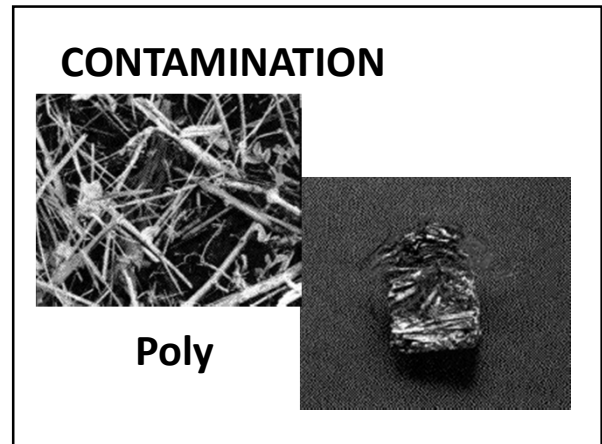
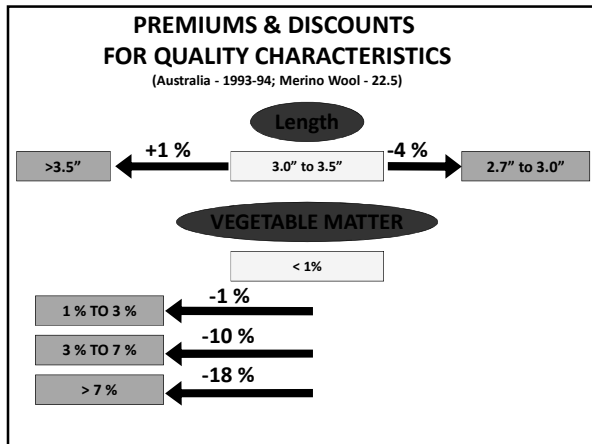


STAPLE LENGTH


Length premiums 2003/04

Discounts in the wool shown relative to wool measuring 80mm.
Discounts in medium wool shown relative to wool measuring 50mm.
Discounts in broad wool shown relative to wool measuring 100mm.

Defects



CONTAMINATION



Other

- Jute
- Sisal
- String
- Rags
- Cigarette Buts
- Blood


CONTAMINATION



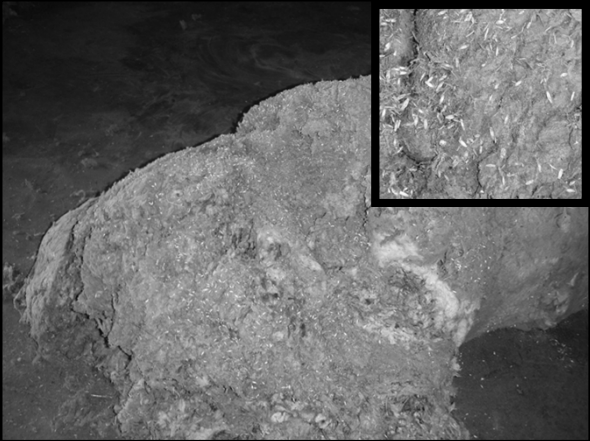
Paint Brands




Marking Chalk

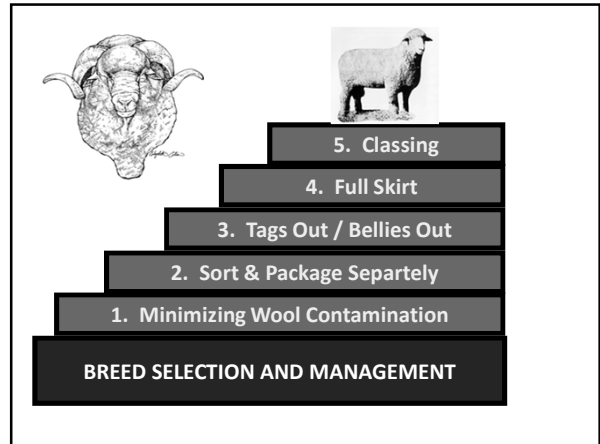


Skin Pieces




Colored Fiber





Grower Responsibility



- **Clean Shearing Board**
- **Pick bellies, topknots & locks (keep out of fleeces) and place in proper place**

Additional Skirting (depending on market)

→ Removing Excessive Contamination



- Any wool contaminated with hair from neck runner or britch
- Blood stain
- Skin pieces

Additional Skirting (depending on market)

→ Removing Excessive Contamination



- Short wool from Fleece edge and jaw (frib)
- Heavy stained wool from sweat points and rump
- Heavy VM contaminated wool from crows nest

Additional Skirting (depending on market)

→ Other Defects



- Stained wool
- Water stain
- Black Spots
- Paint Brands ??
- Damaged wool
- Other

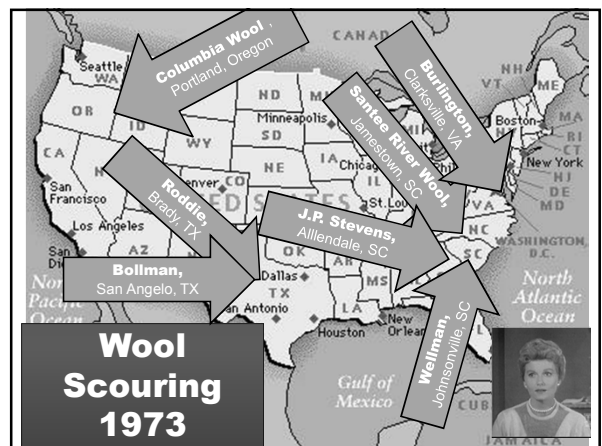
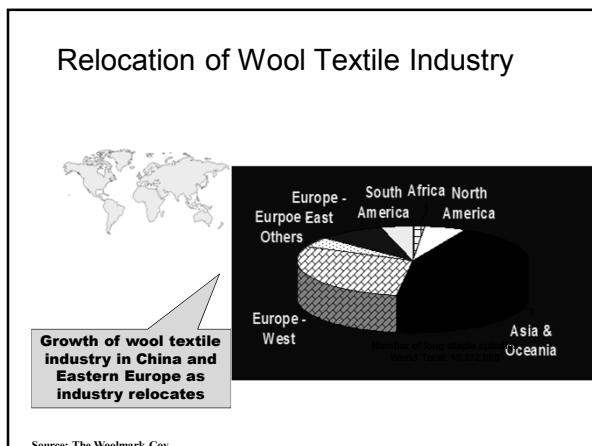
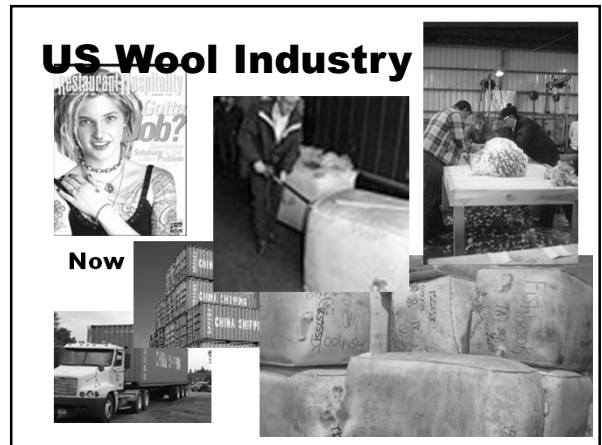
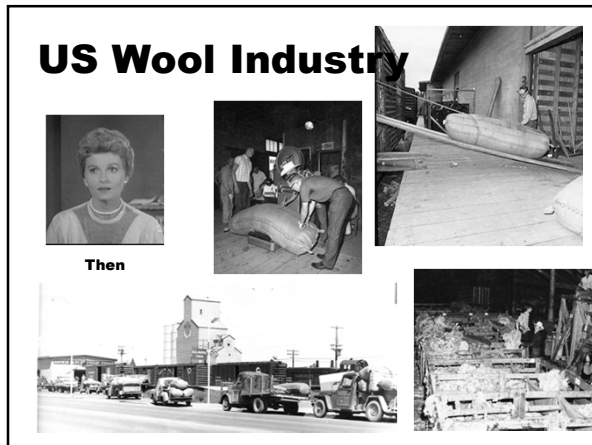
The Value Of Your Wool



A little extra effort at shearing can be extremely profitable



Neglect can easily create a product that has no value





Currently

-Majority of US wool clip is exported (In some years as high as 70 to 80 %)

The major importer of US wool by a large percentage is Asia and Pacific rim countries (mainly China and India)



Government Procurement

Military generally uses approx 20% of U.S. clip annually

Berry Amendment

Focus on finer microns

NO FINER FEELING. MERINO.COM

Increased demand for next to skin fabrics in knitting industry







Redevelopment of the Wool Knitting Industry In The US





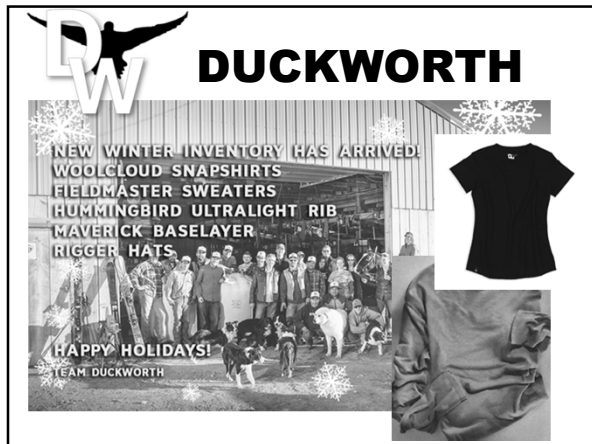


The rumors are true, a quality clip of wool is being produced in the USA. We traveled to Montana to investigate what the Lehfeldt Family has been up to for the last 100 years. What we found was an ultra fine fiber being produced by their Rambouillet Sheep. The fiber being produced is the last piece of our puzzle, a piece which will allow us to make a 100% USA garment. Sheep to Shak made entirely in the USA.




FARM TO FEET
100% AMERICAN





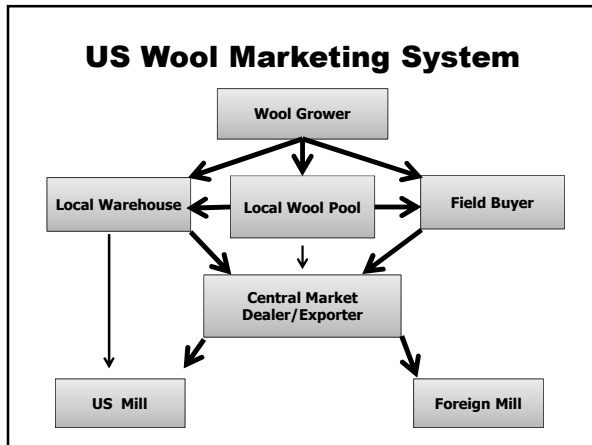
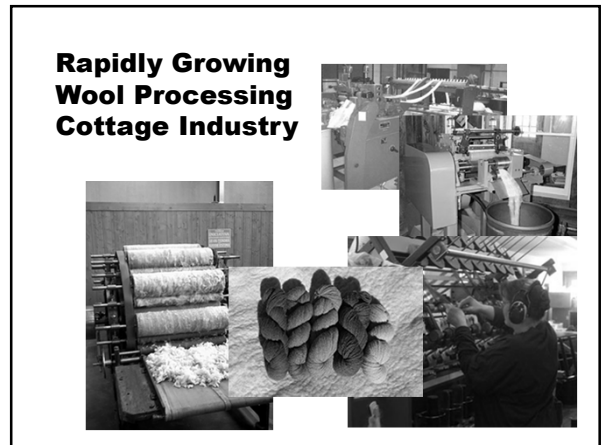
DW DUCKWORTH

NEW WINTER INVENTORY HAS ARRIVED!
 WOOLCLOUD-SNAPSHIRTS
 FIELDMASTER SWEATERS
 HUMMINGBIRD ULTRALIGHT RIB
 MAVERICK BASELAYER
 RIGGER HATS

HAPPY HOLIDAYS!
 TEAM DUCKWORTH



Minimum Lot Size
 Chargeurs Worsted (??,000 pounds)
 Bollman Woolen (??,000 pounds)

Rapidly Growing Wool Processing Cottage Industry



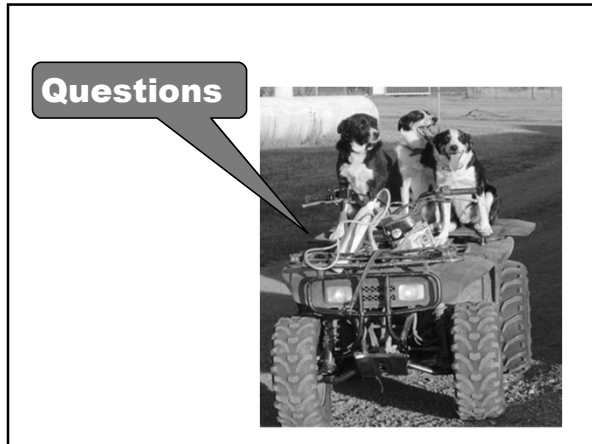
Consolidated Pool

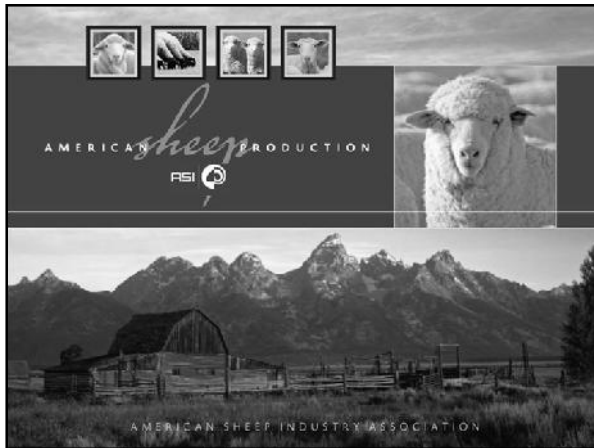
6 Delivery Sites



Individual Fleece Sales


WATERLOO SHEEP & WOOL FESTIVAL
 May 2-6th, 2014





2014 Farm Bill



- Sheep Production and Marketing Grant Program (to fund the National Sheep Industry Improvement Center)
- Livestock Indemnity Program
 - Includes cost-share for sheep killed by federally re-introduced or regulated predators
- Wool Fabric Provision Extended 5 years
- Country-of-Origin-Labeling for Lamb
- Disaster Programs High Priority



Open Export Markets


- U.S. freely traded lamb market yet most of world wont accept American lamb
- Markets closed in 2003 because of cattle BSE
- Requesting significant export market open prior to TPP
- Lamb companies show interest in Japan, China, Taiwan, Russia and European Union





FEI  AMERICAN *sheep* PRODUCTION 

U.S. Sheep Experiment Station

- June 17 – Secretary Vilsack recommended to House Appropriations to reprogram sheep station funds
 - Claiming lack of budget, however, the real reason is harassing lawsuits of Western Watersheds
- Only sheep research station in America would close by November



FEI  AMERICAN *sheep* PRODUCTION 

U.S. Sheep Experiment Station

- USDA refused to alert state or federal officials or industry
- Letters of support for station from ASI, congressional delegations of ID, MT, OR and WA, PLC and Idaho Governor, County Commissioners, University officials
- Station unique in location and ability to do research on rangelands similar to 70% of sheep production in US
- US House Appropriations rejected USDA request in July
- 2 Listening Sessions in August by USDA. Next industry will have to set plans for future of USSES and research

FEI  AMERICAN *sheep* PRODUCTION 

Domestic and Bighorn Sheep Conflict



- Region 4 Forest Service Framework
 - Agreement with Western Watersheds to avoid lawsuits
 - Identify sheep allotments and wild sheep viability
 - Will announce grazing decisions by Feb. 15 for sheep ranchers in Utah, Wyoming, Idaho and Nevada

FEI  AMERICAN *sheep* PRODUCTION 

Domestic and Bighorn Sheep Conflict – Cont.



- Maps in 15 states show bighorn distribution overlap with domestic sheep allotments on public lands
 - Occupied habitat then 10% of sheep allotments on FS / 3% of sheep allotments on BLM
 - If potential habitat then impact is 23% of Industry



FEI  AMERICAN *sheep* PRODUCTION 



Domestic and Bighorn Sheep Conflict – Cont.

- Bi-Cameral letter of Congress in June to Secretaries of Agriculture and Interior addressing threat to industry
 - 37 members of Congress signed with all western states.
 - Requesting clarification of Forest Service/BLM Plans
 - Need to factually and transparently analyze risk of contact between domestic and bighorn sheep on federal lands

FEI  AMERICAN *sheep* PRODUCTION 



Domestic and Bighorn Sheep Conflict – Cont.

- Letter Recommends Framework change to:
 - Offer alternative allotments similar in forage amounts and types, capacity, water, ease of access, season of use and proximity
 - Place alternative allotment on rescissions schedule to fulfill NEPA requirements
 - No swap to alternative allotments until NEPA analysis fulfilled

FEI  AMERICAN *sheep* PRODUCTION 


Governors of Idaho, Wyoming and Utah


- Supports the requests of Congress and included requirement that alternative grazing be presented prior to risk analysis, otherwise the Framework provides a list for Western Watersheds suits.
- Also requires State agency role in the Forest Service Framework -- No swap to alternative allotments until NEPA analysis fulfilled
- Administration yet to respond

FEI  AMERICAN *sheep* PRODUCTION 

Sheep Genome Mapped


- International Team of Scientist completed mapping of sheep genome
 - Dr Noelle Cockett, Utah, contributed
- Will accelerate research on sheep traits:
 - Reproduction
 - Lamb growth
 - Wool quality
 - Milk yield
 - Disease resistance





FEI  AMERICAN *sheep* PRODUCTION 

Lamb Price Reporting


- Lamb program is entirely by regulation so USDA can implement updates without Congressional changes to the law.
 - Confidentiality
 - Imported lamb
 - Carcass trade
- ASI asked USDA to publish several changes for comment



FEI  AMERICAN *sheep* PRODUCTION 

LRP-Lamb

- 2012 sales periods were not always available due to lack of pelt reports some weeks and “circuit breakers” kicking in some weeks
- 2013 policy sales nearly non-existent as insured levels below a dollar per pound





FEI  AMERICAN *sheep* PRODUCTION 

LRP-Lamb


- In February, sales suspended by Federal Crop Insurance Corp.
- ASI's Sheep Venture Company submitted a new proposal to change and improve the plan of insurance.
- USDA/FCIC conducted formal review in June
- FCIC to possibly consider approval by end of summer. Notice will need to be given to companies before sales resume (60 days?)



FEI  AMERICAN *sheep* PRODUCTION 

Legislative Action Council

- In July 2013, Orwick contracted Jim Richards of Cornerstone Government Affairs as Washington, DC lobbyist.
- Jim worked for Joe Skeen (NM), Henry Bonilla of (TX) and covered sheep issues in House for a decade.
- Also contracted Northwest Natural Resources for strategy & mapping on wild sheep controversy



FEI  AMERICAN *sheep* PRODUCTION 

Legislative Action Council

- In May, ASI added lobby contract exclusively for legislative action on Bighorn issue
- All dues paid to ASI are used for lobbying in D.C.



FEI  AMERICAN *sheep* PRODUCTION 

Animal Rights still after Wildlife Services

- ASI led a letter to Congress with 169 county, state government, local and national agriculture and sportsmen groups to oppose any efforts to cut or eliminate USDA Wildlife Services.
- ASI led defeat of the Humane Society of U.S. sponsored amendment in June 2011 to gut Wildlife Services for any livestock protection. Vote was overwhelming at 284 – 132.
- 5 Airline and Airport organizations joined

FEI  AMERICAN *sheep* PRODUCTION 

Undercover Video by PETA on Shearing



- NBC online contacted sheep and wool industry July 3rd. Indicated video of abuse of sheep during shearing in CO, UT and WY
- ASI coordinated the crisis plan with those states and the support of Animal Ag Alliance in DC
- Press statement prepared and media coverage handled in CO and WY. Law enforcement actively involved in both states.
- One contractor/One shearer

FEI  AMERICAN *sheep* PRODUCTION 

H-2A Legislative Subcommittee





- ASI, WRA and MPAS coordinating on 113th Congress immigration reform legislation
- Codify the three year contract and annual visa with range livestock and range housing
- Codify special procedures
- Senate package includes special procedures industries which would be first time appearing in law.

FEI  AMERICAN *sheep* PRODUCTION 

Wool Superwash

- Huge success story for industry.
- A shrink-resist treatment line that makes wool products machine washable and dryable without shrinking meeting Total Easy Care standards.
- Use in commercial and military products.
- This line exceeded its production projections by more than 40% in the first year.
- ASI and Sheep Venture Co. making loan payments

FEI  AMERICAN *sheep* PRODUCTION 

Let's Grow Efforts

- Focus on management efficiency.
- 3 Webinars presented with great participation.
- "We need to maximize efficiency of lambs born and lambs/wool shipped every year to be profitable much less grow production."

www.growourflock.org

FEI  AMERICAN *sheep* PRODUCTION 

Let's Grow Efforts – New Loan Program

- ASI and NLP Sheep Loan Fund offering new loan program for flock expansion
- \$50,000 minimum loan – fixed rate and fixed at five years
- Must be used to purchase breeding animals

Call -- 800-237-7193 

FEI  AMERICAN *sheep* PRODUCTION 

Young Entrepreneurs & Grow Our Flock

- Both new programs of ASI funded with wool money.
- 3 Webinars presented with great participation.
- “We need to maximize efficiency of lambs born and lambs/wool shipped every year to be profitable much less grow production.”



www.growourflock.org

FEI  AMERICAN *sheep* PRODUCTION 

Grants for Projects and State Mentors


- Over \$20,000 in grants to assist states with new sheep producers.
- Several multi-year grants funded such as sheepSD and 3 state ethnic lamb production (OH, MD, ME)
- ASI to fund \$500,000 in fiscal year 2015 for Grow Our Flock and research initiatives to support the American Lamb Board industry roadmap.

www.growourflock.org

PEI  AMERICAN *sheep* PRODUCTION 

ASI Website Update

- Responsive
- Drop Down Menus
- Includes SIN
- Shop Online
- Photo Gallery





PEI  AMERICAN *sheep* PRODUCTION 

www.sheepusa.org


Your One Stop for Industry Information...



- Access to educational materials
- Up-to-date information on current issues
- Digital version of the *Sheep Industry News*
- Market Reports
- Industry Contacts


PEI  AMERICAN *sheep* PRODUCTION 

ASI Market App

- Provides wool and lamb markets
- All reports come from USDA
 - 7 Auction Reports
 - National Reports
- Designed for iPhones & Androids
- Download from Apple's App Store or the Android Store
- More than 1,600 downloads to date



PEI  AMERICAN *sheep* PRODUCTION 



151 AMERICAN SHEEP INDUSTRY ASSOCIATION 
865-- **150 YEARS** --2015--

PEI  AMERICAN *sheep* PRODUCTION 

**OVER-WIDTH, OVER-HEIGHT, OVER-LENGTH,
OVER-WEIGHT, UNRESTRAINED & NO
BRAKES...**




THE GOOD 'OL DAYS

PEI  AMERICAN *sheep* PRODUCTION 

150th Anniversary in 2015

- ASI dates back to 1865
- Successor to the National Wool Growers Association
- Oldest National Livestock Association in the United States



FSI  AMERICAN *sheep* PRODUCTION 

**Sheep Heritage Foundation Fundraiser...
Call ASI office to order your family Heirloom**



Donation...
\$750 -- Blanket
\$1,000 -- Blanket with
2 Pillows
\$175 -- 1 Pillow
\$300 -- 2 Pillows

100% American Wool
176 of this Numbered Limited Edition Series

- Design implies the geography of the nation by the cut-out peaks, valleys, plateaus and hills in the horizontal stripe
- Interwoven strands represent weaving of wool

FSI  AMERICAN *sheep* PRODUCTION 

**2015 ASI Convention
January 28-31
Reno
Celebrating Our History**

FSI  AMERICAN *sheep* PRODUCTION 

**Q
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Lambing Time Management: Keys to Success

Daniel G. Hadacek, DVM

Ashby Herd Health Services, Inc.

Harrisonburg, VA

Pre-Lambing:

- Ewes vaccinated for clostridium C, D, & T
- Ewes crutched or sheared
- Feeding to prevent pregnancy toxemia {1/2 -3/4# corn or equiv./day}
- Feeding to prevent abortions {150mg OTC/ hd /day}

Lambing Area:

- Clean
- Dry
- Fresh air

Lambing:

- Sanitation is extremely important
- Provide gentle assistance if necessary {30 min w/no progress-check}
- Dip, Strip, Sip
 - dip navels -strip teats -lambs nurse
- Colostrum {2 oz [60cc] stomach tubed if not trying to nurse in 15min}
 - freeze extra colostrums (2 oz bags) for emergencies
- Cold weather: -lots of towels -heat pads, lamps, box -lamb covers
 - hypothermia: "comatose" temp<90 may need 10-20% dextrose I.P.
- Confine ewe and lambs: -single 1-2 days -twins 2-3days
 - community pen 4-5days

Lamb Processing:

- 1 mg selenium {1cc BoSE or 0.2cc MuSe}
- Clostridium C, D,&T *day 1 best for immune system response
- Tetanus antitoxin *****especially for banding -400 units {1.3cc for 1500 IU vial}
- Dock, castrate day 2-5 before moving to community pen
- Identify lambs {eartags, paint etc}

Pneumonia prevention:

- "Inforce" intranasal : BRSV is viral trigger for pneumonia
 - 1cc intranasal (1/2 bovine dose) use disposable Teat cannula
 - at birth or ASAP
- "One Shot" Mannheimia (pasteurella) Haemolytica vaccine
 - 1cc sub-Q (1/2 bovine dose)
 - 5 weeks of age Lambs
 - anytime rams, ewes *pre-lambing

Shepherd's Kit- you may want to have the following handy

- Clean towels or rags
- Disposable sleeves & lube (thawed cold packs)
- Dog chain collar or lamb snare
- Stomach tube and 60cc syringe
- Lamb covers, heat lamp, heat pad
- "Iodine" for navels
- Small rope halter




John & Pam Sponaugle
Sarah, Jeff, & Eli Ward
J.T. & Laura Begoon
Grottoes, Va

Origins

- Purchased first lambs in high school
- 1977 – purchased 10 Suffolk ewe lambs from Ansel Luxford
- 1979 – purchased farm in Grottoes and first stud ram Luxford 79 N240 at Eastern Stud Ram Sale
- Bloodlines include:
 - Luxford, Nichols, Buckeye Acres, and George Brothers
- 1992 Midwest Stud Ram Sale Reserve Grand Champion Ram

Today

- 110-125 ewe lambs
- 75 acres
- Feeds and Forages include
 - Corn and barley
 - Barley/wheat/pearl millet (2x rate)
 - Orchardgrass and alfalfa have been part of mix through the years



Breeding Philosophy

- “Structurally correct productive sheep”
- Heavy focus on moderate frame lambs
 - That can compete with frame sheep in the show ring
- Ewes
 - Feminine, calm, good mothers
- Rams
 - Good ewes behind him
 - High growth, heavy muscle



Lambing Season

- 4×6 or 5×5 lambing jugs
- Shear before lambing
 - Reduces complications
- Some spring lambs
- Some late fall lambs for spring shows







Genetics/ET Program

- Embryo Transfer
 - Flushed 5 ewes = 72 good embryos
 - Receipts
 - Synchronized to allow for ET
 - most received 2 embryos
 - 25 embryos frozen for next year
- If using fresh semen
 - AI once
- If using frozen semen
 - AI twice



Parasite Control and Health Program

- Worm ewe in lambing jug (albendazole)
- Worm during pasture turn out (moxidectin)
- Worm once during summer
 - And/or at breeding
- Lambs brought in to farm are wormed using ivermectin
- CD&T
 - Give ewes twice before weaning
 - And before ewes lamb

Forage and Feed Program

- Ewes
 - 0.5-1lb grain prior to and after lambing
- Lambs typically weaned 55-70 days of age
 - Weaned lambs are introduced to feed
- Ewes are backed down off feed before lambs are 55 days old



Marketing

- Online marketing of show lambs
 - Sold 40-50 head through online sales
- Fall replacements sales – online and during fall
- Value Added Sales
 - Performance test



Greatest Challenges facing Sheep Producers

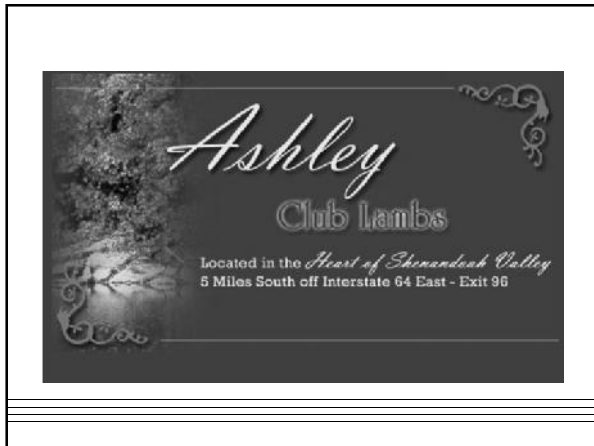
- Wildlife interaction & predation out West
- Average age of sheep producer is increasing

But:

- Most valuable part of being a sheep producer is the friendships and relationships established with fellow producers through the years


Thank you!






Ashley Club Lambs

- 150 ewes
- A few wethers
- Hamp x Suffolk Cross, Speckled
- Main Market:
 - Show lambs
 - Breeding ewes
 - East Coast, Indiana, Pennsylvania
- Showing lambs since age of 10



Ashley Club Lambs

- 119 acres – hay and pasture
- Orchardgrass and clover
- Barn
- 3 converted horse stalls
- 9 lambing pens



Lambing Seasons

- Start breeding mid-May through Nov.
- Market Oct. –born lambs to N.C. market

- Suffolk, Hamps
 - Synchronize PG 600 + CIDR
 - 5 ewes to a ramb
 - 2014 – 90 synchronized 63 bred

Lambing Jugs



Lambing Pens/Barn



Breeding Philosophy

- Meet market needs
 - Show criteria
- Suffolk × Hamp – growth advantages
- NO ONE BUCK CAN DO IT ALL
- Buck needs to have:
 - Longevity, style and appearance
 - Growth, wide top, long loin
- Lease or Own? – It depends



Supplements

- 2 lbs grain a day
 - Cracked corn with protein pellet and molasses
- Free choice minerals
- Hay
- Creep feeders



Parasite Control/Health Program

- Used to worm every 3 months
- Now:
 - Worm at pregnancy check
 - Cydectin, Valbazen – open ewes
 - Check eyelids
- CD&T given also given at pregnancy check
- Lice medication given after shearing
- Foot Scald

Marketing Program

- Show Circuit = primary market
- North Carolina
- Virginia
- East Coast




Industry Challenges

- Markets:
 - Prices need to stay relatively high short to long term
- Education
 - Check-off supported programs to promote benefits of lamb to consumers




Thank You!






Ridgeview Acres




David & Kitra Shiflett
Grottoes, VA




Origins

- 1975
 - 4-H Lamb Show Project
 - Suffolks
 - Dorsets
- 2015
 - 400 ewes
 - 900-1100 head of lambs before taking to market



Ridgeview Acres

- 500 acres crops (including double cropped acreage)
- 150 acres pasture (sheep)
- 2 poultry houses
- 32 jug Lambing Barn
 - Houses 100-125 pregnant ewes
- Suffolk & Dorsets and Commercial Flocks

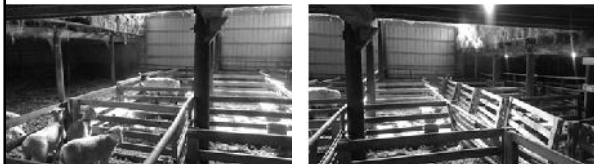


Ridgeview Philosophy

- Focus on breeding ewe lambs that need only low inputs
- Dorsets
 - Easy keeping, mothering ability, prolificacy, milk
- Suffolks
 - Faster growing, high yielding lambs
 - Heavy muscled, long loined and big legged

Lambing Season

- 70-60% Ewes lamb in the spring
- 30-40% Ewes lamb in the fall
 - 100 ewes lambed this fall
 - CIDRS used for these lambs
 - Used to produce lambs for club market



Methods of Grafting a Lamb



Feeds/Forages

- Barley/Rye haylage
- Corn Silage
- Corn/Soybeans/Barley
- 80 acres Fescue Hay



Health/Parasite Program

- Birth: Dip navels
- Two weeks of age: lambs given CD&T
- Weaning: CD&T booster

- Dewormer: Extra-Label Cydectin annually
- Spot check and treat/cull

Marketing

- Primary Market
 - Majority of flock is focused on producing lambs for the restaurant trade in N.C.
- Secondary Markets
 - Club Lambs
 - Purebred Lambs



Challenges to Sheep Industry

It depends

- Where is your operation?
 - Coyotes
 - Pasture availability
 - Marketing (limited in many areas)



Thanks you!



Shamoka Run Farm

Leo Tammi

Shamoka Run Farm is, in many ways, a typical modest family farm in Augusta County. Judy and I moved here 34 years ago. I was raised on a small diversified farm with one or two milk cows, hogs, sheep and mostly poultry. (An immigrant peasant's dream)

Early on, I learned to farm the land for what it is best suited. These steep and rocky soils are best suited for forage production.

We raise about 500 Polypay ewes on 300 acres of owned and rented land. Polypays are distinctive for their strong maternal characteristics. About 240 acres are hay and pasture. We raise replacement ewes. We sacrifice market lamb characteristics as we select for criteria that produces a brood ewe--moderate size, prolificacy, fertility, milking ability, hardiness. Ours is a forage passed system. We expect our ewes and lambs to perform on pasture. So, much of our management emphasizes forage production. Our ewes with newborn lambs go out on pasture with high quality forage. We produce many of our own replacements, including rams. On the occasion that we introduce another ram, it would need to come from another forage based production system. We sell most of our sheep (except culls) and lambs as private treaty.

Sheep do not require large capital expenditure for facilities. Our handling facility is simply a chute and cutting gate. Our primary working barn is a pole barn. It is a multi-use facility as we assemble and disassemble structures as the seasons demand. As the hay comes out we set up lambing jugs and use that space for lambing. We replace a number of solid panels in the working chute with swinging door panels to create a facility for shearing.

If you want to test your animal husbandry skills--raise sheep. Animal health concerns are a major test. We vaccinate for the major claustridial diseases especially enterotoxemia C and D and tetanus. Controlling internal parasites is our major constraint. I have been floating fecal samples for 25 years and have watched as all the anthelmintic classes have lost their efficacy. I used to think if an animal was sick, you should give medicine. That logic has gone a long way to creating the terrible situation we are in now. We worm strategically, at lambing and weaning. Beyond that, we try to worm only when needed increasing refugia in the pasture.

I have long preached production efficiency of forages. We stockpile forages for winter and summer grazing. Brassicas are a great alternative in the winter. Now we manage our forages with the production efficiency goal of keeping our animals alive. We leave much more residue, longer periods between grazing and try to create "safe pasture". Multi species grazing has worked well for us in the past. We are also looking at using alternative forages that suppress

parasitism such as lespedeza. For several years we have been working native grasses into the program.

Predators, including internal parasites, are our major production constraint.

I have to say this: The infrastructure of the sheep industry is failing. We are at risk of becoming a cottage industry. Lamb may be the most popular meat in the world, but our consumption is less than a pound per capita per year. We are a small segment in a monstrously large meat industry. We are neglected by the pharmaceutical industry. Other nations are using products, especially anthelmintics, that we can't get. That has market implications.

Nationally, the lamb market is dominated by fewer yet larger buyers. We in the East, however are well positioned to survive much market turmoil as we target direct marketing and the ethnic market. Best case? Our ability to grow grass in Virginia and the Southeast can give us advantages. If we can solve the parasite problem.

Outstanding Sheep Producer Award Recipients

- 2013 – Laura Begoon, Rockingham County
- 2012 – Sonny and Ashley Balsley, Augusta County
- 2011 – Leo Tammi, Augusta County
- 2010 – Bobbi Hefner, Highland County
- 2009 – Mac Swortzel, Augusta County
- 2008 – David Shiflett, Augusta County
- 2007 – Doug Riley, Augusta County
- 2006 – Mike Carpenter, VDACS
- 2005 – Jim Wolford, Wythe County
- 2004 – Martha Mewbourne, Scott County
- 2004 – David Redwine, Scott County
- 2003 – Martha Polkey, Loudoun County
- 2002 – Carlton Truxell, Augusta County
- 2001 – Corey Childs, Clarke County
- 2000 – John Sponaugle, Rockingham County
- 1999 – Bill Stephenson, Page County
- 1998 – Gary Hornbaker, Clarke County
- 1997 – Bruce Shiley, Clarke County
- 1996 - Weldon Dean, Rockingham County
- 1995 - Bill Wade, Augusta County
- 1994 - John Henry Smith, Russell County
- 1993 - Robin Freeman, Chesapeake
- 1992 - Courtland Spotts, Pulaski County
- 1991 - Ted Bennett, Halifax County
- 1990 - Clinton Bell, Tazewell County
- 1989 - Rex Wightman, Shenandoah County
- 1988 - Tim Sutphin, Pulaski County
- 1987 - Zan Stuart, Russell County
- 1986 - J. W. Riley, Augusta County
- 1985 - John Bauserman, Fauquier County
- 1984 - Roy Meek, Pulaski County
- 1983 - Jonathan May, Rockingham County

*For the Propagation of SHEEP,
and increasing the Quantity of
WOOL.*

T

HOUGH Sheep are the most beneficial Creatures we can raise, they affording us both Food and Raiment, yet there is no dumb Creature taken so little Notice of in *Virginia* as they; there being but very few People here that take Care to sow any Thing for Winter Pasturage for them, or provide or give them any other Food than a few dry Blades in the Winter. And as Wool is a Commodity greatly wanting in this Colony, I hope it will not be taken amiss if I here give the Readers my Opinion how to manage their Sheep to have more in Number, with finer Wool, and larger Fleeces, than is at present got from the common Flocks.

First. Make choice of a likely large Ram Lamb, that has the finest and longest Wool,

Useful Information for Wool Producers

compiled for addendees of the
2015 Virginia Shepherds' Symposium
January 10, 2015

wards, for the Ewes having Lambs before they have their Growth is a great Disadvantage to the Breed of our Sheep.

Virginia's wool producers in 2015 are a diverse lot—owning flocks of a few animals to hundreds, with wool types from fine wools to dual-coated primitive breeds, hobby flocks to full-time sheep farmers. These shepherds market their wool with the same diversity. Some take all or part of their clip to finished products entirely by hand, some use the abundance of custom mills to scour, card, spin, dye, and knit or weave their fiber, some bale at the farm and haul their clip to the wool pool.

These producers do have common aspirations: to improve the quality and value of their flock's fiber, and their operation's profitability.

In addition to this Symposium's sessions on wool production and marketing, the Virginia Sheep Producers Association's Wool Outreach Fund Committee offers to producers this booklet of wool production information. We hope you find useful information from our speaker, Dr. Rodney Kott, from this booklet, and from your fellow shepherds at the symposium, to help advance your farm goals.

Virginia Wool Outreach Fund Committee

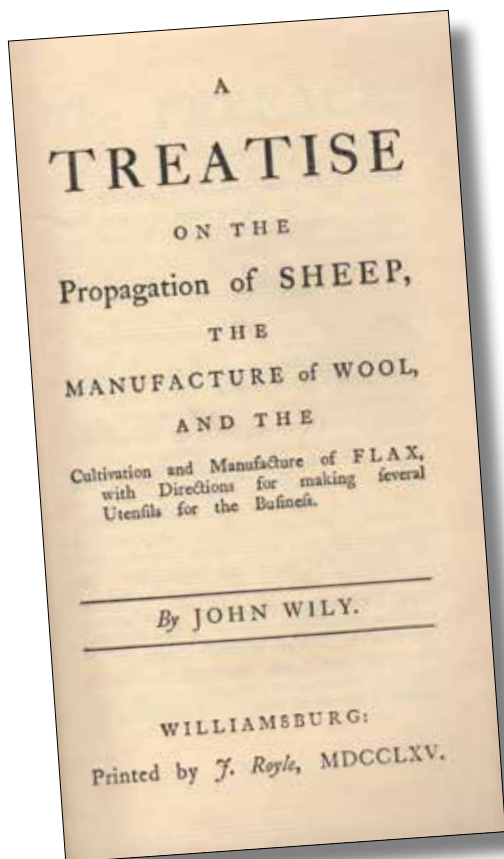
Martha Polkey, CHAIR

Robin Freeman, Naomi Smith, Cathie Shiff, Patti Price

Publication of this booklet was funded by the Wool Outreach Fund.



Kevin Ford, hand shearing a ewe.



Cover: The first page of an early reference for Virginia shepherds, published in 1765. Reproduction from archivees at Colonial Williamsburg.

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- 4** Selection for Fiber Improvement in Your Flock. *Compiled from the SID Sheep Production Handbook and Montana Farm Flock Sheep Production Handbook*
- 5** Effects of Nutrition on Wool Production and Quality. *Compiled from the SID Sheep Production Handbook*
- 6** Effects of Environmental Conditions on Wool Quality. *Taken from Sheep and Wool Science, Production and Management, by M. P. Botkin, Ray A. Field, and C. LeRoy Johnson, Department of Animal Science, University of Wyoming*
- 7** Biological Development of the Wool Fiber. *From the SID Sheep Production Handbook*
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- 21** A Timeline for the Ewe and Her Lambs. *Martha Polkey*

Evaluating Wool on the Live Animal

by Paul E. Briggs, published in *The Marker*, publication of the Natural Colored Wool Growers Association

Evaluating the wool or fleece on the live animal is difficult for many people. Most of us are used to looking at shorn fleeces with the cut side out, compared to the weathered side out when evaluating the fleece of a live animal.

There are three times when you must evaluate a fleece on the live animal:

- when purchasing replacement animals away from your farm,
- when evaluating fleeces in your own breeding program, and
- when you are an official sheep judge.

First, evaluating a fleece is very important when selecting replacement rams and ewes away from your ranch. In some cases you will not be able to evaluate the fleece of the animal until after the animal is purchased and shorn.

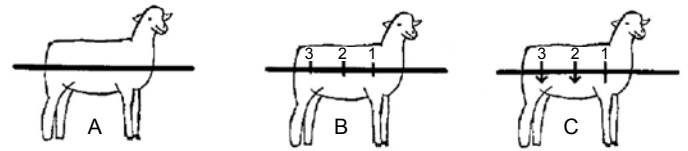
Second, if you raise a wool breed of sheep you can save yourself time and energy by a pre-evaluation of your potential replacements before shearing. You can pick out your top-end animals and cull animals with obvious faults, thus spending more time evaluating fleeces from your top group.

Third, if you are a sheep judge, you must be knowledgeable about the breeds you are judging. It behooves you as a judge to know the wool scorecard standards adopted by the different breed associations. Judging or evaluating fleeces in the show ring shouldn't be any different than evaluating fleeces at home; however, the animal has been fitted for the show ring and the fleece has been adulterated by trimming. Fitting will affect staple length, uniformity of staple length, yield, and even density, which makes it more difficult to compare fleeces.

The best time to evaluate a fleece on or off the animal is when they are yearlings with a full 12-month fleece. Fleece traits are highly repeatable; therefore, selections made at 16 months of age can be a good indicator of future wool production. Evaluating aged ewe fleeces is difficult because of the differences in the physiological state of the animals and its effect on wool production. Barren ewes will have better fleeces than ewes that have raised lambs.

Now, to start analyzing the fleeces. Looking at the animal from the side, draw an imaginary horizontal line halfway between the top line and underline of the animal (see above). This should put your line at approximately the middle of the side.

Figure B shows three locations in which the fleece should be examined: Point 1 is on the shoulder, point 2 is in the middle



of the side just past the last rib, and point 3 is on the face of the leg about the stifle or britch. Now, with both hands, make a wide split in the wool to look at the fleece, working from point 1 to point 3.

Look at and estimate the following criteria: fiber diameter or grade, uniformity of fiber diameter, staple length, character, yield, and density.

Fiber diameter or grade. Compare the animal you're evaluating with the grade of wool that its breed should be producing. The average of the three points should correspond with the range of diameters or grades representative of the breed.

Uniformity of fiber diameter. Both breeds and individuals within a breed will vary in fiber diameter uniformity. Breeds such as the Merino and Rambouillet, for example, should be uniform from front to rear. Columbias and Targhees are not quite as uniform from front to rear. Fiber uniformity is very important and animals that vary more than 5 microns from shoulder to britch should not be kept as replacement stock. The finest fibers are found on the shoulder and the coarsest fibers are located on the britch.

One way to judge the uniformity of a fleece is to closely examine the number of crimps per inch. For example, if the staple on the shoulder has 11 crimps per inch and the britch has only 5 crimps per inch, there is a high probability that the fleece is not very uniform. This method is only used to compare fiber diameter uniformity within a fleece and not between fleeces.

Staple length. Staple length and uniformity of length play a major role in determining the value of wool. Each grade of wool has a minimum length to be classified as staple, French combing or clothing wool.

Character. Character refers in general to the overall appearance of the fleece. This includes crimp, color, handle and lock formation. Crimp, the natural waviness of the



Parting the fleece.

wool fiber, is an important characteristic. Well-crimped wools usually possess a high tensile strength. Wools lacking in crimp have a tendency to break during processing. Uniformity of the crimp throughout the length of the staple is very desirable and is a trait worth selecting. Color is very important, especially if white or pastel shades of fabrics are to be made. Bright wools (genetics is key here) are more valuable and take up dyes more uniformly than discolored wools.

Yield. Yield is the amount of clean wool that is obtained from grease wool after scouring and is expressed as a percentage. If all animals being evaluated have been run together since their last shearing the depth of dirt penetration and amount of yolk are a good indicator of yield.

Density. Density refers to the closeness or compactness of the fibers in a fleece. The more fibers per square inch, the denser the fleece. There are two ways to check for density on the live animal:

- When you part the fleece the amount of skin exposed is an indicator of the fleece density or, in other words, the less skin you see, the denser the fleece.
- The density can be evaluated by grabbing a handful of wool and squeezing it.

By doing this at point 1, 2, and 3 as seen in the illustration, you'll be able to get a feeling for how dense the fleece is when compared to other animals' fleeces. Wool having a shorter staple length will feel denser, therefore you should consider this when comparing animals with different staple lengths.

Two other factors you should consider in evaluating fleeces on the animal are belly wool and kemp.

Belly wool. Belly wool is wool that grows on the belly and is often uneven, tender, and shorter than wool from other parts of the body. Belly wool should be limited to the belly region. If belly wool is seen on the sides of the animal, it is a serious fault. When looking for belly wool, start at point 2 in Figure C and go down the fleece toward the belly until you see the belly wool and compare this point with where belly wool starts on other sheep.

Kemp. Kemp is an opaque fiber that lacks strength, elasticity and crimp. The fiber is medullated (hollow) and considerably coarser than other fibers in the same staple. Kemp fibers do not readily absorb dyes, therefore, wools containing kemp are limited to their end use. If a fleece contains kemp it is most prevalent in the britch wool. Kemp is acceptable on carpet wool breeds such as Scotch black faces and Drysdale. If kemp is found on a fine-wool sheep the animal should be culled.



Fiber Test Results: What They Look Like

by Martha Polkey

Testing fiber samples from individuals in your flock provides objective measurement of fleece characteristics, which you can use in selection of replacements to advance the quality and quantity of your clip.

Fleece samples were taken from the sides of the animals on the day before shearing, using hand shears, trimming as close to the skin as the electric shears would do, do get a realistic staple length measurement. Taking samples from side and britch area (or side, britch and shoulder) would provide a more comprehensive evaluation of the fleece (but not as comprehensive as core sampling and entire fleece).

The figures at right display the test results from an optical fiber diameter analyzer (OFDA) for individuals in a flock, with data on multiple characteristics. Plugging this data into a spreadsheet allowed the producer to sort columns according to characteristics such as micron count, comfort factor, and staple length, and then rank animals.

Glossary of abbreviations used in OFDA 2000 reports

Mic Ave	Average fiber diameter of the testes sample expressed in microns
SD Mic	Standard deviation of fiber diameter expressed in microns
CV Mic	Coefficient of variation of fiber diameter expressed as a percentage (= [SD Mic ÷ Mic Ave] x 100)
CEM	Coarse edge micron. The number of microns above the average diameter where the coarsest 5% of fibers lie.
< 15%	The percentage of fibers finer than 15 microns
CF%	Comfort factor; the percentage of fibers equal to or less than 30 microns
SF Mic	Spinning fineness; it represents "spinning quality" and is calculated from CV Mic and Mic Ave
SL mm	Average relaxed staple length expressed in millimeters
Min Mic	The finest point along the staple expressed in microns
Max Mic	The coarsest point along the staple expressed in microns
FPFT mm	Finest point from the tip of the staple expressed in millimeters. The tip of the staple is at the left-hand side of the staple profile
MFE mic	Mean fiber ends; the average fiber diameter of the fiber ends (tip and base) expressed in microns
SD along	The standard deviation of fiber diameter measured along the staple, expressed in microns
CRV Dg/mm	Average fiber curvature expressed in degrees per millimeter, an estimate of crimp
SDC Dg/mm	Standard deviation of fiber curvature expressed in degrees per millimeter

Skirted fleece weights at shearing and visual characteristics were added to the data from the test, and other data on individuals (number of lambs born to mature ewes, comparison of sire and dam statistics to test results for progeny) was evaluated by the shepherd.

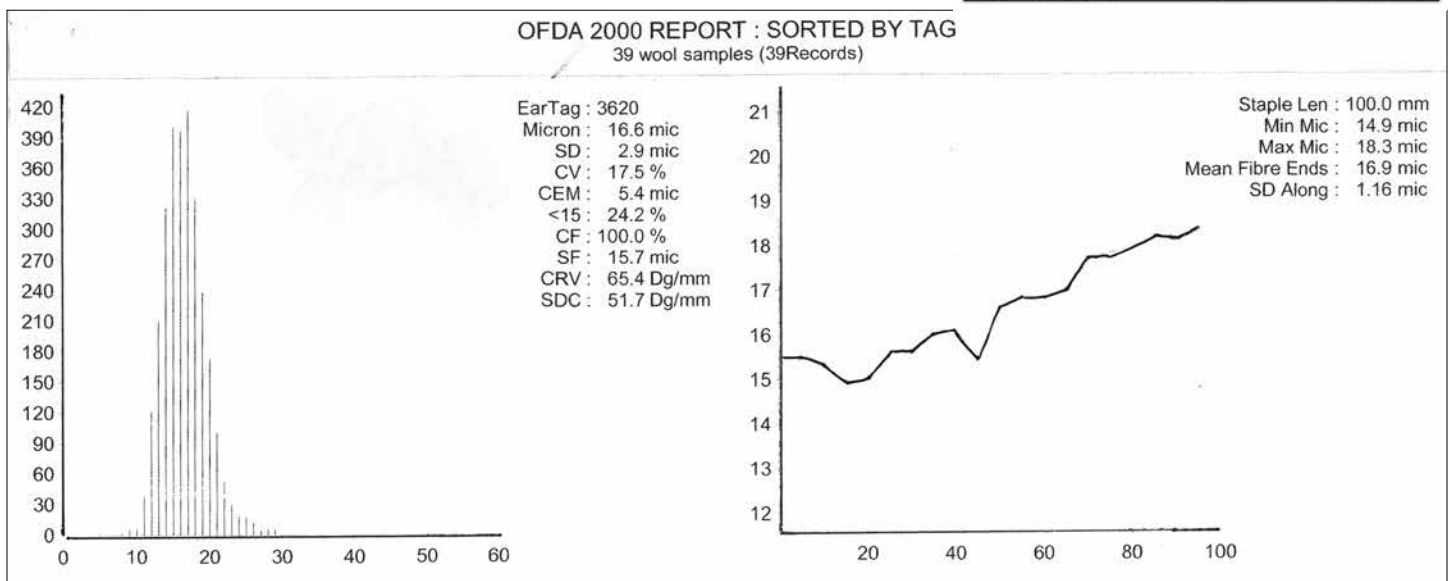


Results were used to identify replacement ewes and potential replacement rams, make culling decisions, plan breeding programs and set goals for future flock improvement—as well as to market fleeces to handspinners.

The analyses shown here were done at the Bill Sims Wool and Mohair Research Laboratory, Texas A&M Agrilife Research, 7887 U.S. Highway 87 North, San Angelo, Texas 76901-9714, 325-653-4576. The price per sample tested is \$3.



Above right: the OFDA. At right: Go ahead, watch the marketing video of the manufacturer at http://www.ofda.com/Natural_fibres/Ofda2000.html!



Above are graphs of the fiber measurements for a mature ram. The narrowness of the fiber distribution (at left) is a visual representation of the uniformity of the sample. Below is a portion of a table of a group of fleece sample results. A producer can render these data in a spreadsheet, and sort to classify characteristics of flock individuals as part of a flock improvement plan.

Mic Ave	SD Mic	CV Mic	CEM	<15 %	CF %	SF Mic	SL mm	Min Mic	Max Mic	MFE Mic	SD Along	CRV Dg/mm	SDC Dg/mm
21.9	4.0	18.4	7.6	3.3	95.4	20.9	80.8	20.1	23.7	21.3	1.11	75.5	55.0
20.0	4.0	20.2	8.0	6.8	98.7	19.3	35.0	18.7	21.7	19.7	1.27	73.5	58.5
19.1	4.4	23.1	8.5	13.4	97.9	18.9	40.0	18.1	19.8	19.4	0.53	75.1	56.5
27.6	5.2	19.0	9.1	0	72.4	26.4	90.0	25.4	29.3	27.0	1.19	76.6	55.4
19.8	3.2	16.2	6.1	2.8	99.2	18.6	80.0	18.7	21.3	19.0	0.82	84.8	64.0
21.3	3.6	17.1	6.8	1.3	97.7	20.1	90.0	20.1	22.6	21.2	0.80	94.1	61.6
24.0	4.0	16.8	7.3	0.6	94.5	22.6	100.0	22.2	25.8	23.1	1.03	93.8	63.9
22.8	4.1	18.0	8.1	0.6	95.2	21.7	90.0	20.6	26.3	21.5	1.64	69.1	46.9
23.5	3.9	16.5	7.2	0.6	95.7	22.1	80.0	22.1	25.3	22.6	1.00	77.1	56.8
24.7	4.3	17.5	7.6	0.7	91.1	23.4	70.0	23.4	26.0	23.9	0.76	98.5	64.7
26.0	4.1	15.9	7.7	0	86.8	24.3	70.0	24.7	26.8	25.0	0.62	82.6	64.8
22.9	3.6	15.7	6.4	0.7	97.1	21.4	85.0	20.1	24.3	20.6	1.42	90.9	62.0
23.3	4.6	19.9	9.2	0.5	91.9	22.4	80.0	22.0	25.7	23.3	1.01	65.5	47.9
21.3	3.4	15.8	6.4	1.3	99.0	19.9	70.0	19.8	22.5	20.1	0.82	101.5	70.9
21.7	4.4	20.3	9.2	1.5	95.2	21.0	85.0	19.9	22.4	21.1	0.76	64.3	48.3
20.6	3.5	17.2	6.4	2.4	98.2	19.4	90.0	19.1	22.8	20.0	1.09	54.8	38.4
24.1	4.6	18.9	8.3	1.0	91.9	23.1	95.0	20.0	28.5	24.6	2.43	76.6	53.9
19.4	3.1	16.0	5.9	3.5	99.5	18.1	75.0	17.8	20.7	18.7	1.03	105.5	74.0
23.2	3.7	16.1	7.0	0.4	96.4	21.8	85.0	22.2	25.0	23.0	0.67	79.3	56.5

Selection for Fiber Improvement in Your Flock

Compiled from the *SID Sheep Production Handbook* and *Montana Farm Flock Sheep Production Handbook*

Selection is the most important tool you have to improve your wool clip and production efficiency. Many desirable wool traits are highly heritable, and so effective selection methods will lead to permanent gains not only in quantity but also in quality of stock and wool produced. Bottom line: Determine the economic importance of wool in your sheep operation and apply selection pressure accordingly.

Because the amount of selection that can be practiced for any single trait is limited, give emphasis to the traits that are most valuable and in which the most progress can be made. Pounds of wool, staple length and fiber diameter are the basics commonly included in selection programs.

Heritability

Estimates of heritability, which give the proportion of observed variation due to genetic construction, are useful in determining the relative progress you can make in selection to improve various traits. In sheep, estimates of heritability have usually been obtained from relationships among relatives. Estimates are available for a large number of traits, but many are based upon relatively small numbers under varying conditions and therefore are quite variable. In general average heritability estimates over 40 percent have been classified as highly heritable, those from 20 to 40 percent as moderate, and those under 20 percent as low. See the table below for heritability estimates.

Genetic correlations show the relative change in one trait associated with selection for another trait, and in general, for wool traits these are positive correlations—for example, selection for higher grease or clean fleece weight alone will result in increased fiber diameter and staple length, and vice versa. There are some exceptions to the positive correlations in

Heritability of Wool Traits	
Characteristic	Range of heritability (%)
Face cover	35–55
Skin folds	20–50
Grease fleece weight	30–60
Clean fleece weight	25–60
Staple length	30–65
Fiber diameter	20–60
Variability of diameter	30–90
Yield	30–40
Crimp	20–50
Luster	20–30
Fiber density	20–60

wool traits: selection for finer fiber may reduce fleece weight, and skin folds are negatively correlated with staple length, but positively related to fleece weight.

That brings us back to selection for the traits that are economically important: higher grease and clean weights, longer staple length within the grade of wool you are

producing, and gains in fleece density and uniformity of length and fineness. Voilà, a more valuable clip.

Breeding practices for obtaining the most rapid improvement in wool production are identical to those that apply to other traits:

- Identify individual sheep.
- Use objective and direct measures whenever feasible.
- Adjust for environmental effects such as age, type of birth, age of dam, or year effects, or select within like groups.
- Reduce generation intervals (defined as the speed with which each generation is replaced—ideally with superior animals), especially on the male side.
- Select only for the most important traits and maximum selection differentials (for example, annual clean wool weight of selected sires minus the average clean weight of the group from which the sires were selected).
- Emphasize selection of rams.

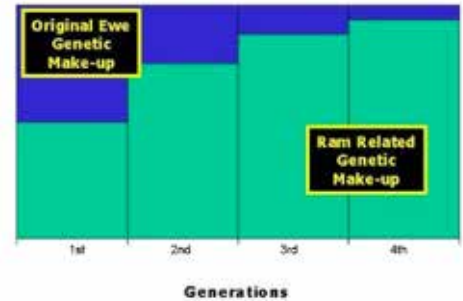
The ram

The greatest impact of selection on sheep performance can be made through ram selection. Small producers who feel that their sheep flock is not large enough to justify purchasing a quality ram should consider renting one, or purchasing one in partnership with another producer before using a poor quality ram. Remember, it does not take too many pounds of lamb and wool to justify using a good quality ram, instead of an average one.

Careful selection of rams can benefit the producer in two ways. It contributes to the production efficiency of every lamb and to the genetic improvement of economically important traits in the herd. Since relatively large numbers of ewe lambs are needed for replacements and often detailed production and genetic records are not available (increasing the role chance plays in the selection process) genetic progress through ewe selection is limited. In most sheep flocks 80 to 90 percent of the genetic progress comes from ram selection and only 10 to 20 percent comes from the selection of ewes.

Performance testing of rams is a method of objectively evaluating body weight gain, fleece quality and production of

Importance of the ram in a selection program



individual rams a common environment. But since you won't find such tests in the mid-Atlantic, as a producer you can look to good breeders, breed associations, go West for performance tested rams, or resort to an artificial insemination program using performance-tested rams.

Sheep Improvement Program

Incorporated in 1987, the National Sheep Improvement Program (NSIP) is a computerized, performance-based program for genetic selection. NSIP is designed to help purebred sheep producers identify the best genetic stock for their breeding programs. NSIP also gives breeders reliable information that they can use to advertise and sell their breeding stock. Wool breed groups that currently participate in NSIP include Border Leicester, Columbia, Coopworth, Dorset, Hampshire, Polypay, Rambouillet, Romney, Suffolk, Targhee and White Suffolk.

The methodology calculates performance and expresses it as flock expected progeny differences (FEPD) for each individual animal in the flock for each trait selected. Expected progeny differences (EPD) for an animal estimates how well its offspring compare to the breed average. Wool traits currently evaluated are fleece weight, staple length, fiber diameter, fiber diameter coefficient of variation (a measurement of uniformity), and fiber curvature (a measure of crimp).

An example of small flock producers collaborating to improve flock genetics was detailed at the 2014 American Sheep Industry Convention. Kreg Leymaster, of USDA's Agricultural Research Service, discussed the cooperative breeding program, the Mount Rushmore Consortium, initiated by a half-dozen Polypay breeders in the upper Midwest, who engaged two geneticists in the design and execution of a breeding program to increase the rate of genetic gain in their flocks—pooling their sheep numbers to gain the genetic diversity essential for an effective program. Having settled on common selection objectives, they established a breeding program to carefully select sire lines, planned matings to create genetic linkages, and carefully collected data to advance flock performance. The cooperative members gather once a year to transfer rams in an established pattern among the farms for the next round of breeding.



You can find out more about the NSIP and its results at nsip.org.

Are Australians serious about wool quality? Here a judge prepares to assess a Merino ram's fleece uniformity—yes, on the belly wool.

Effects of Nutrition On Wool Production and Quality

Compiled from the SID Sheep Production Handbook

Growth of the wool fiber is generally a continuous process that is regulated by genetics, nutrition, animal physiology and environmental factors. Potentials for wool production and wool quality are determined genetically. The degree of realization of that potential is a function of the level and consistency of nutrition and of environmental variables. Consequently, growth of the wool fiber may be altered by any interference with or lack of nutrient support for this process. Seasonal variations in wool growth are associated with length of day as well as availability and quality of feed/forage. More rapid growth has been measured during the season when days are longest. Wool growth may also be affected by age, temperature, physiological processes (e.g., lactation, parturition) and hormone therapy.

The effect of nutrition on wool production begins in utero while the fetus is nourished by maternal blood. The amount of wool grown by a sheep is determined by the number and size of fibers produced by the primary and secondary wool follicles (structural units in the skin of the animal). Primary follicles emerge in the fetal skin by the ninetieth day of gestation; secondary follicles develop from that time through the early postpartum period. Prenatal follicular development follows the rate of growth of the fetus and seems to set wool growth potential. Further maturation of follicles and production of wool fibers after birth are closely associated with the nutrition and growth rate of the lamb. The well-fed lamb may produce wool fibers from about 80 percent of the follicles at one month of age, whereas a poorly fed lamb may require 6 to 12 months before all follicles become functional. Feeding practices that do not restrict the birth weight or early postnatal growth of lambs will provide adequately for the initiation and maturation of wool follicles. This development is necessary if maximum wool production is to be achieved.

Wool production and quality in adult sheep is greatly affected by quality of feed/forage, its nutrient content, and its consistency of supply. Elevated feed intake (especially protein) can increase fiber diameter, lengthen and strengthen the staple, and increase the amounts of grease and scoured wool. Probably the most limiting nutritional factor in range sheep production is an insufficient amount of energy in the diet due to the lack of forage availability, low digestibility, or a poor balance of other nutrients that depresses intake. Variation in feed intake can sequentially increase and decrease the cross-sectional area of wool fibers by as much as fourfold. The small cross-sections (constrictions) are weak points causing "tender" wool or distinct "breaks" in the wool fibers. Tender wool

usually results from a sudden and severe reduction in feed consumption brought about by drought, snow cover, illness, or lack of water. However, consistent marginally low nutrition usually will support growth of wool that is lower in quantity (lower fleece weights), but high in desirability (fine with adequate strength) for the wool trade. The critical dietary protein level for maintaining fiber fineness, staple length, amount of crimp, and fiber strength appears to be near 80 percent of the NRC recommended requirements. Below this level, production and quality are adversely affected.

See next pages of this booklet for a portion of the chapter on wool development from the SID Sheep Production Handbook for a more detailed discussion of wool development and production.

Effects of Environmental Conditions on Wool Quality

Taken from Sheep and Wool Science, Production and Management, by M. P. Botkin, Ray A. Field, and C. LeRoy Johnson, Department of Animal Science, University of Wyoming

I. Nutrition - most important

A. Minerals and vitamins

1. Sulfur-containing amino acids - cysteine and methionine
 - a. Important in the chemical structure of wool
 - b. Feeding excess has not increased wool growth
2. Copper
 - a. Deficiency results in harsh, nearly crimplless, steely wool
 - b. Copper metabolism is closely related to dietary levels of molybdenum and sulfate.
 - c. Zinc – deficiency results in growth of steely wool

B. Protein – wool is pure protein with high cysteine content

1. Optimum level – 10 percent
2. Post-ruminal infusions of methionine and cysteine have been shown to increase wool growth dramatically
3. Need to develop method to avoid ruminal degradation of methionine and cysteine

C. Energy

1. Wool growth increases with increases in energy provided diet contains 8-10 percent protein
2. Wool growth more closely related to energy than protein levels
3. Due to price of high-energy feeds, may not be profitable

II. Physiological State – degree of competition between wool growth and other body functions is directly related to the production states of sheep. Last 6 to 7 weeks of gestation and first 6 to 8 weeks of lactation are the most critical

- A. Demands must be met from body reserves and/or increased feed intake
- B. Competition for nutrients by lambs may reduce wool growth in two ways

1. Ewes raising singles shear 10-20 percent lighter fleeces than dry ewes. Ewes raising twins shear an additional 4 percent less
2. Determines whether or not lambs reach their genetic potential for density (secondary/primary follicle ratio)
 - a. Supply of nutrients to the fetus during late gestation has been shown to affect the extent of initiation and probable degree of branching of secondary follicles. This is permanent
 - b. The degree to which these follicles mature to produce fibers is affected by the level of nutrition of the lamb during early life. This inhibition of maturation may be either permanent or only a delay in the process
- C. Single- versus twin-born lambs
 1. Twins produce 2 to 5 percent less wool during their lifetimes than singles
 2. Reduction due to lower density and smaller size
 3. Selection for increased fleece weight tends to discriminate against twins
- D. Age
 1. Maximum fleece weights occur in 2- to 4-year-old sheep with an approximate 4 percent per year decline thereafter
 2. The effects of age on wool production should probably be ignored except when comparing fleeces in the selection of lambs for replacements
- E. The price of wool and the price of feed determines economic feasibility of increased nutrition during late gestation and early lactation

III. Diseases and Parasites – primarily external parasites

- A. Compete for nutrients
- B. Reduces fiber diameter and may cause breaks in wool

IV. Soil Type

- A. Feeds may have calcium-phosphorus imbalances and/or deficiencies and trace mineral deficiencies
- B. Alkaline soils cause abnormal weathering of the tips of fleeces
- C. Some soils tend to discolor fleeces

V. Season

- A. Photoperiod (day length) – grow coarser, longer fibers and therefore more wool in summer than winter
- B. Physiological state (e.g., pregnancy, lactation)
- C. Adaptability of breed – genetic-environmental interaction in different climates and weather situations
- D. Quantity and quality of feed – particularly in grazing situations
- E. Temperature – has a major effect on competition for nutrients and degree of circulation of blood, and therefore nutrients, to the skin

For Winter Pasturage for your Sheep, fow Wheat, Rye, Clover, or Timothy, for them to feed on when the Earth is free from Snow; and fow large Patches of Turnips, to feed them with in snowy Weather, when they have not the Opportunity of getting any green or moist Food. You should take Care to dig your Turnips when your Earth is clear of Snow, and keep them in a Cellar, or Cave made for that Purpose, until you have Occasion for them; then take them out and wash them, and lay them in a clean Trough, and there with a Spade, or some cutting Utenfil, cut and chop them to Pieces; then lay them in long Troughs, for your Sheep to feed on. Oats or Pease is exceeding good Food for Sheep in the Winter; and sometimes wet the Oats, and throw a little Salt amongst them, for I look upon Salt to be very

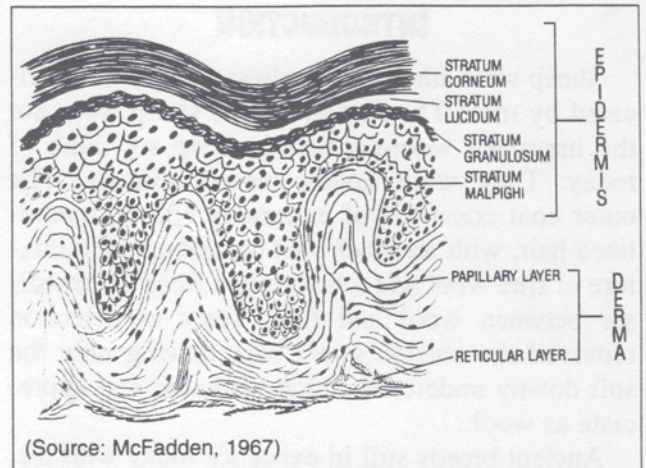
Excerpts from A Treatise on the Propagation of Sheep and the Manufacture of Wool, 1765, Williamsburg, Virginia.

serviceable to all Kind of Stock. In the Winter Season, have a good tight Roof for your Sheep to lie under; the Sides to be open, for the Benefit of the Air; have the Shelters often cleaned, and the Dung carried away; and give them fresh Litter. You should take Care not to let your Pasture be eaten down about the Time of your Ewes yeaning, but to procure some good Grazing to turn your Ewes on just before their yeaning, which will occasion them to have a Plenty of Milk for the Lambs, and will prevent there being so great a Loss of them as is common where the Ewes have only dry Food to feed on. If any of your Ewes yean whilst the Earth is covered with Snow, that they have not the Opportunity of grazing, you should supply the Defect by giving them a greater Plenty of Turnips. If any of your Ewes refuse to take their Lambs, put the Ewe and Lamb in a close House, and tie a Dog in the same Place, and they will own the Lamb immediately.

BIOLOGICAL DEVELOPMENT OF THE WOOL FIBER

■ Structure of the Skin

Wool and hair fibers are outgrowths of the integument or skin. Sheep skin is 1-3 mm thick and consists of an outer layer, the epidermis, and a much thicker layer, the dermis, which extends down to the muscle layer (Figure 1). The dermis is also known as the corium. Beneath the skin is a rather loose layer of connective tissue known as the tela subcutanea. Underlying this layer is the panniculus adiposus, a layer of subcutaneous fatty tissue.



(Source: McFadden, 1967)

Figure 1. Histological Drawing of Skin.

■ General Development of Individual Skin Follicles

The structure of the wool follicle is best understood if its development is followed in vertical sections of the skin of the unborn lamb and then between birth and up to 12 months of age. The two types of follicles that produce fiber on the sheep are known as primary and secondary follicles (Figure 2). The primaries are usually the largest, and usually arranged in rows in the skin in groups of trios. The secondaries are the most numerous and lie to one side of the primaries. The primary trio with its associated secondary follicles constitutes the follicle group, which is the basic unit of wool production.

The secondaries, being usually the smallest follicles, tend to grow finer fibers than the primaries. The fundamental difference between the two follicle types is that primaries have a sweat gland (sudoriferous gland) and an arrector pili muscle, whereas secondary follicles have neither of these. Both types of follicles have sebaceous (wax or grease) glands. The glands and the muscle are known as accessories and always lie on the side towards which the wool fiber slopes.

In the fetus, primary follicles are formed first (by 100 days), and the secondaries are formed later. All of the primaries have been formed and are growing fibers by the time the lamb is born. Although all or almost all of the secondaries are developed (initiated) before birth, many do not mature (produce fiber) until after birth. Most fol-

Notes

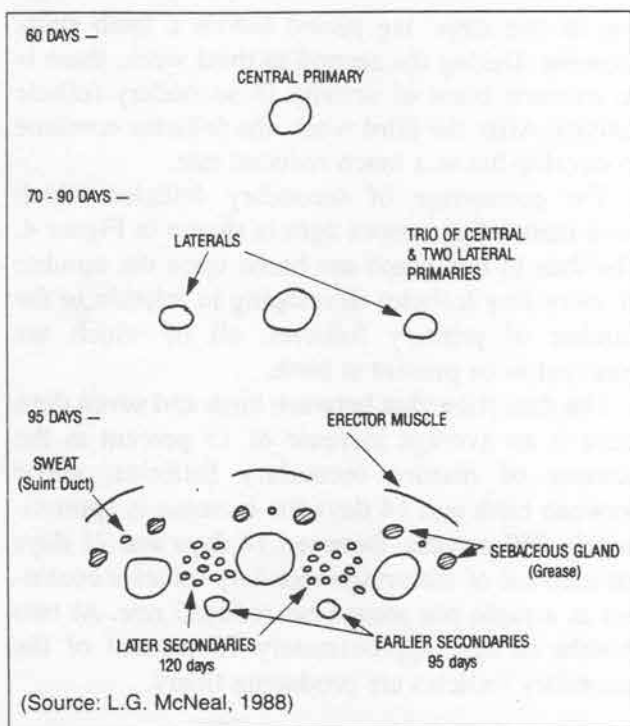


Figure 2. Stages in the Development of a Follicle Group.

licles are producing a fiber by about one month after birth.

■ Development of the Follicle Population

The sequence of initiation and the spatial arrangement of the different follicle types is an important feature in the development of the follicle population. The basic unit of measurement of follicle development and population is the trio group. This group of three primary follicles with varying number of secondary follicles develops prenatally and is normally classified into three different periods of development:

1. The Pre-trio Period of Central Primary Follicle Initiation
2. The Trio Period of Primary Follicle Initiation
3. Post-trio Period

Pre-trio Period

Initiation of central primary wool follicles begins on the face and poll about 35 to 40 days after conception. The follicles next appear on the neck, limbs, shoulder, and britch and by 54 to 55

days, central primary follicle precursors (anlagen) are found in these areas. Lastly, between 54 and 63 days, the anlagen appear over the back, midside, and withers. After 60 days of prenatal life, all of the skin is covered.

The average duration of the pretrio period of development is approximately 15 days. This 15-day period is fairly uniform in different regions of the fetal body.

Trio Period

The trio period of primary follicle initiation begins on the fetal face around 63 days. The trio groups are present in all regions of the body by about 75 days and completed in all regions by about 90 days after conception. The trio period differs from the initiation of central primary follicles in that the central primaries appear to initiate the lateral primaries. Thus, during the trio formation, small lateral primary follicles appear on both sides of each central primary.

It is during this period that the sweat glands of primary follicles appear. During the latter stages of trio initiation, sebaceous gland rudiments are formed in association with central primary follicles. The trio period lasts about 15 days in any one region of the fetus. It begins as early as the 55th day of gestation but usually commences on or about the 75th day. It is completed by the 90th day of prenatal life.

Post-trio Period

This period covers the final stages in the initiation and development of the follicle group. Two major aspects of this period are: (1) initiation of the secondary follicle anlagen, and (2) growth and development of the already formed follicles leading to the production of their fibers. This is known as the maturation stage of development to distinguish it from initiation. The post-trio period is the longest of the prenatal periods and occupies the remainder of the time until birth. Following completion of the primary trios, initiation of the secondary follicle anlagen starts at about 90 to 99 days in the different regions of the prenatal lamb. This activity is almost complete at birth.

The number of secondary follicles initiated in this way appears to be about five or six times the number of primary follicles. But it varies in differ-

ent locations on the body, being lower on the poll and limbs. There are also differences among breeds.

This period brings the most rapid increase in follicle population and culminates in the birth coat of the lamb on or about the 150th day of gestation. By the end of this prenatal period, as many as eight derived secondaries may be associated with the original secondary, and nine fibers may use a single hair canal to reach the surface of the skin. By the time of birth, the follicle group is essentially the same as the adult arrangement. However, most secondary fibers do not emerge from the follicle until after birth. Another phenomenon which occurs at birth or shortly thereafter is the shedding of the fibers from the primary follicles. This shedding occurs first in the central primary follicles and then in the lateral primaries. The increase in area of the trio group covers an indeterminate time but is usually complete by the time the animal is 12 months old.

The density of primary follicles becomes less per unit area as the lamb increases in age (Figure 3). Because all the primary follicles are fully developed before birth, the decrease is a direct result of skin expansion accompanying growth. The greatest decrease in follicle density takes place between birth and one month of age. By the time the lamb is four months of age the major increase in skin expansion has taken place and only a small decrease in primary follicle density is measured between four and 16 months of age.

During the first week after the lamb is born, little activity takes place in follicle development. This period of inactivity is slightly longer than the usual

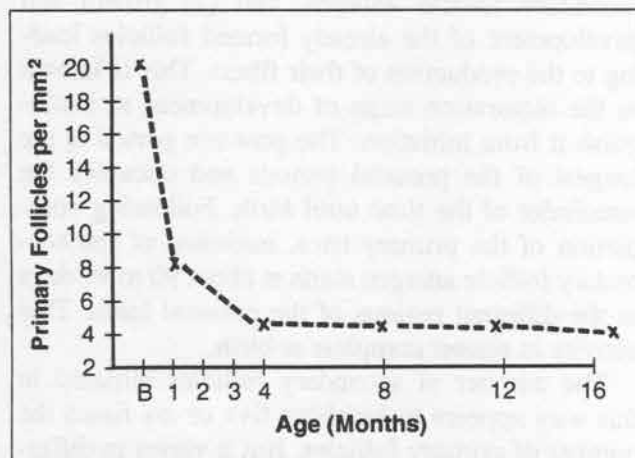


Figure 3. Density of Primary Follicles at Various Ages.

one to two days' lag period before a lamb starts growing. During the second to third week, there is an extreme burst of activity in secondary follicle activity. After the third week, the follicles continue to develop but at a much reduced rate.

The percentage of secondary follicles which have matured at various ages is shown in Figure 4. The data in this graph are based upon the number of secondary follicles developing in relation to the number of primary follicles, all of which are assumed to be present at birth.

The data show that between birth and seven days there is an average increase of 15 percent in the number of mature secondary follicles, while between birth and 14 days the increase is approximately 250 percent. Between 14 days and 21 days the increase of maturing secondary follicles continues at a rapid but somewhat reduced rate. At two months of age, approximately 75 percent of the secondary follicles are producing fibers.

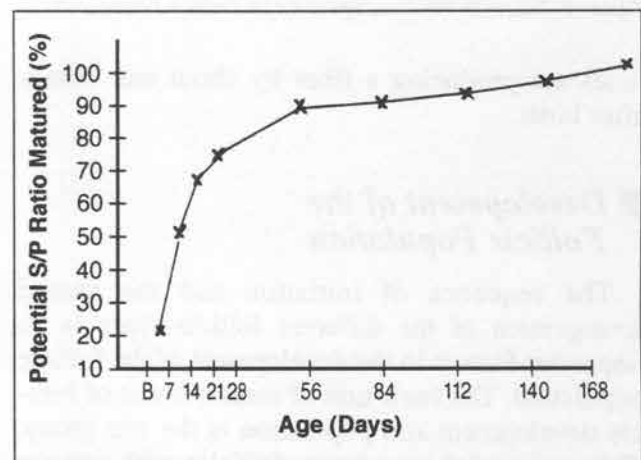


Figure 4. Progressive Percentage of Secondary/Primary Follicle Ratio at Various Stages.

The Secondary/Primary Ratio

The ratio of secondary to primary follicles in a trio group has been found to be a useful indicator of the quality (density and fineness) of wool fiber production in sheep. It is commonly referred to as the S/P ratio. This relationship is not constant among breeds of sheep as shown in Table 1.

Table 1. Follicle Density, S/P Ratios, and Range of Average Fiber Diameter in Different Breeds of Sheep

Breed	Mean No. of Follicles/mm ²	S/P	Average Fiber Diameter Range (µm)
Fine Merino	71.7	19.1	19-20
Medium Merino	64.4	21.0	21-22
Strong Merino	57.1	16.5	23-26
Corriedale	28.7	10.8	25-31
Southdown	27.8	6.3	24-29
Dorset	18.5	5.4	26-32
Suffolk	20.4	4.8	26-33
Romney	22.0	5.5	32-39
Border Leicester	15.8	4.4	30-38
Lincoln	14.6	5.4	34-41
Cheviot	14.6	4.5	27-33
Wiltshire	11.4	3.3	26-31

Source: Adapted from *Wool Handbook*, Von Bergen, 1970, and *Directory of U.S. Sheep Breeds*, ASI, 1992.

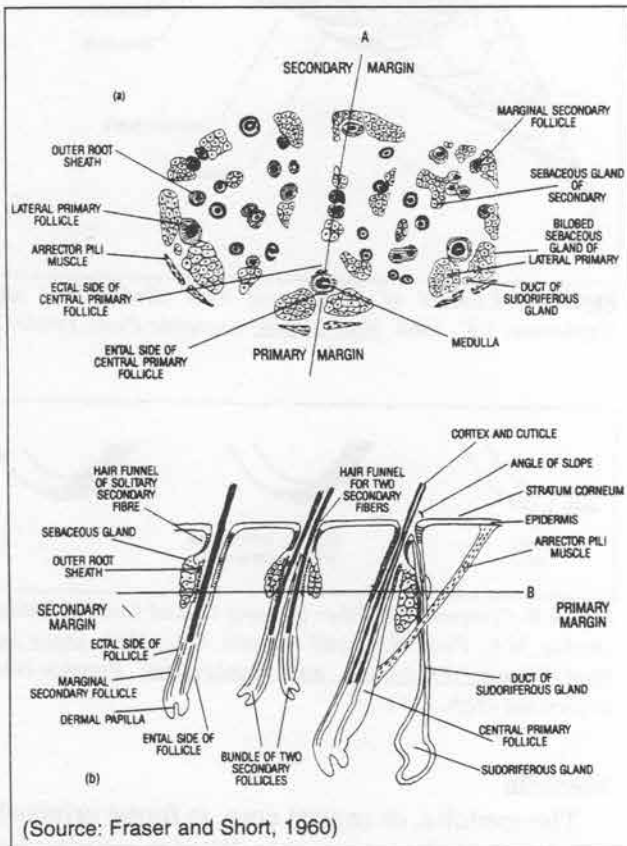


Figure 5. Diagram of a Follicle Group (a) in Transverse Section and (b) in Longitudinal Section.

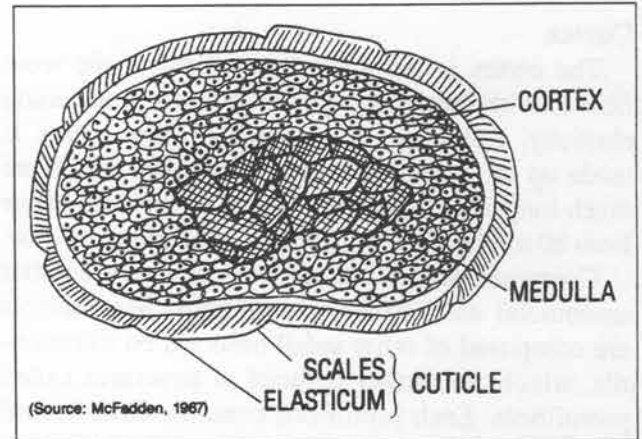


Figure 6. Cross Sectional Representation of a Medullated Wool Fiber.

Structure of the Fiber

All wool and hair fibers have a similar gross structure consisting of a thin outer layer, the cuticle, surrounding the cortex which in turn surrounds a central medulla in medullated fibers (Figures 5 and 6).

Epicuticle

The epicuticle is a thin outer membrane covering the cuticle (Figures 6 and 7). It measures approximately 1/100th of a micron (1 micron = 10⁻⁶ m = 1/25,400 of an inch). When the epicuticle maintains its integrity, it protects the wool fiber from deterior-

ration or damage due to chemicals and abrasion. The epicuticle also aids in giving wool its water-repellent property.

Cuticle

The cuticle makes up a protective layer of overlapping, flattened cells called scales. Scales encircling the wool fiber range in length from 10 to 30 μm and are approximately 0.5 to 1.0 micron thick. Scales overlap each other slightly and rarely more than two scale layers are found. The edges of scales on fine wools are more prominent than on coarse wools. Coarse wools tend to be smoother and more lustrous than fine wools. The protruding edges of the cuticular scales always point toward the tip of the fiber and are responsible for a differential directional friction effect which in turn produces the unique felting property of wool.

Cortex

The cortex is the major component of the wool fiber and imparts many special properties, including elasticity, resiliency, and durability. The cortex is made up of spindle-shaped cortical cells which are much longer than they are wide. Cortical cells range from 80 to 115 microns long and 2 to 5 microns wide.

Contained within the cortical cells are smaller anatomical units called macrofibrils. Macrofibrils are composed of other small units called microfibrils, which are further reduced to structures called protofibrils. Each protofibril contains three helical molecular chains.

Two types of cortical cells are found in the wool fiber: orthocortical cells and paracortical cells (Figure 7). In fine and many medium wools, the division is bilateral (Figure 8). Each type of cell has different chemical and physical properties. The paracortex is found on the inside of the curve of the crimp and the orthocortex is found on the outside of the curve. Because of this relationship between the cortical cells and crimp, it is believed that crimp is partially under the influence of the two types of cortical cells found in the fiber. The division of the ortho and paracortex is not similar in all breeds and genotypes of sheep (Figure 9).

The orthocortex is referred to as "soft" and has a higher affinity for dyes, whereas the paracortex is referred to as "hard" and exhibits less affinity for dyes.

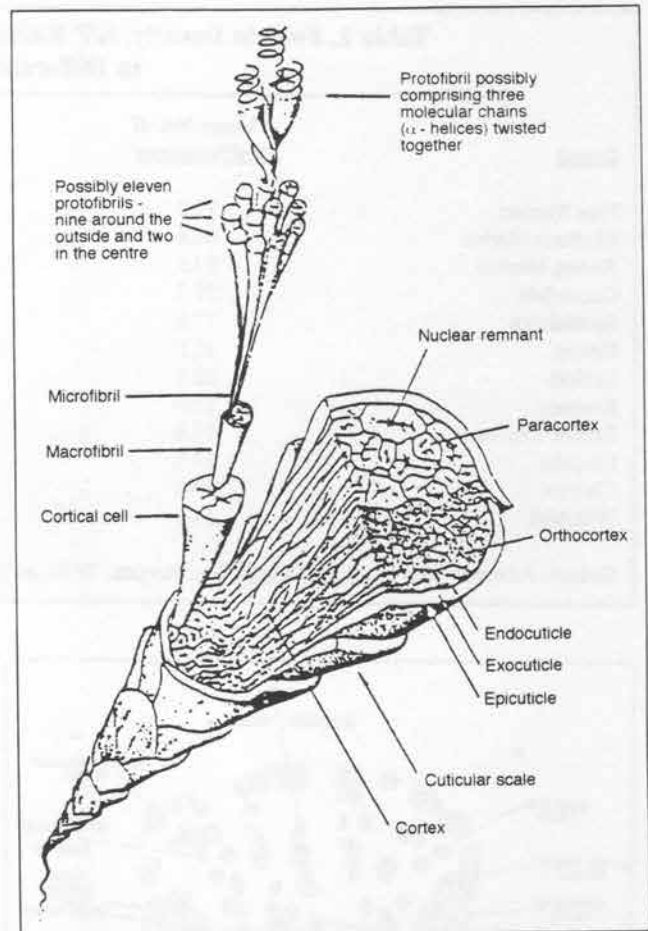


Figure 7. Example of Structure of Wool (Ryder, M.L. and Stephensen, S.K., 1968. *Wool Growth*, Academic Press, London.)

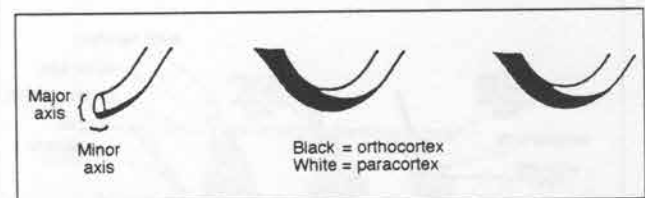


Figure 8. Crimped Wool Fiber Showing Typical Coil Formation. (Botkin, M.P., Field, R.A., and Johnson, C.L., 1988, *Sheep and Wool Science, Production, and Management*, Prentice-Hall, Englewood Cliffs, N.J.)

Medulla

The medulla, or central core, is found primarily in medium and coarse wools. Wool measuring less than 28 microns in diameter is unlikely to show medullation. Not all fibers coarser than 28 microns are medullated. Medullation is believed to result from incomplete keratinization (fiber cornification). Basically, the fiber is too wide for

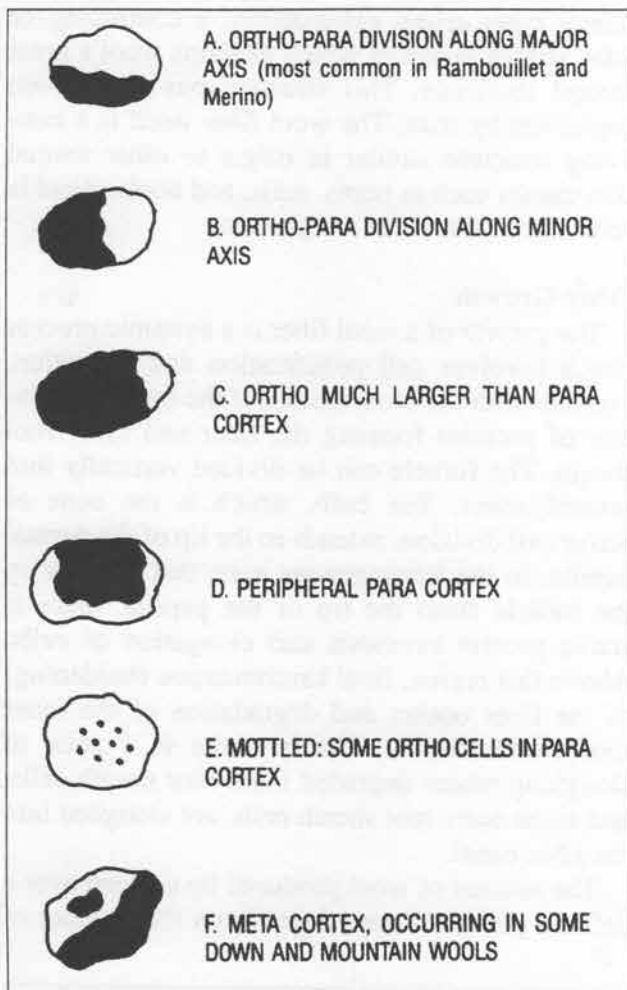


Figure 9. Some Typical Arrangement of Ortho-paracortex Segments.

the follicle to fill with keratin and a hollow or spongy core results.

In "kemp" fibers (coarsest fiber grown by sheep), the medulla occupies a major proportion (more than 60 percent or more of the fiber diameter when viewed in longitudinal section) of the fiber. By definition, the medulla of med fibers occupies less volume (less than 60 percent of fiber diameter). In some fibers, the medulla is narrow and not always continuous along the length of the fiber (Figure 10). It also has been found that during the winter months, when wool growth is slower than in other seasons, the medulla may not appear at all.

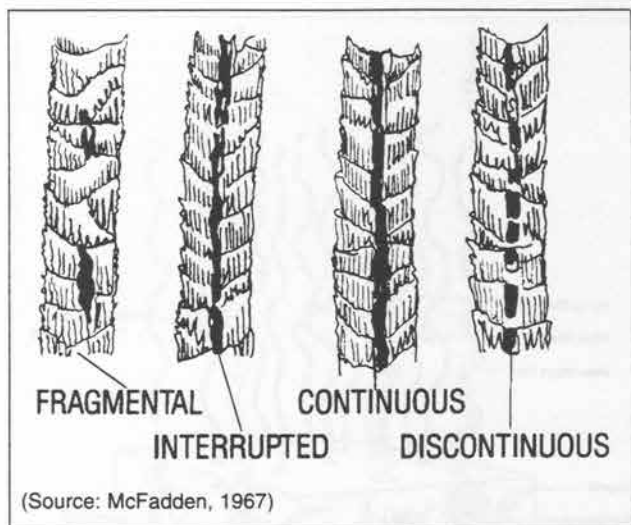


Figure 10. Types of Medullation Found in Wool.

■ Three Types of Fibers Produced by Sheep

Adult sheep produce three main types of fibers: (1) true wool fibers, (2) med fibers, and (3) kemp fibers (Figure 11). True wool fibers can grow from both primary and secondary follicles, depending upon the breed. Kemp and med fibers grow only in primary follicles. Primary and secondary follicles in young lambs can produce a variety of birthcoat fiber types.

This variation in the lamb birthcoat is related closely to the type of fleece that is later grown by the adult sheep.

Wool Fibers

The "true" wool fiber is the fiber and market commodity that is associated with the sheep industry. The main distinguishing features of wool are its lack of medullation and crimp, the degree of waviness. Most commercially produced wool falls into the range of 17 to 40 microns in average diameter. In cross section, wool fibers are somewhat elliptical in shape, increasingly so as diameter increases.

Med Fibers

Med (hair, gare, or heterotype) fibers are medullated and tend to be finer than kemp fibers. Med fibers are usually as long as "true" wool fibers but may lack crimp. These fibers are very difficult to detect with the naked eye.

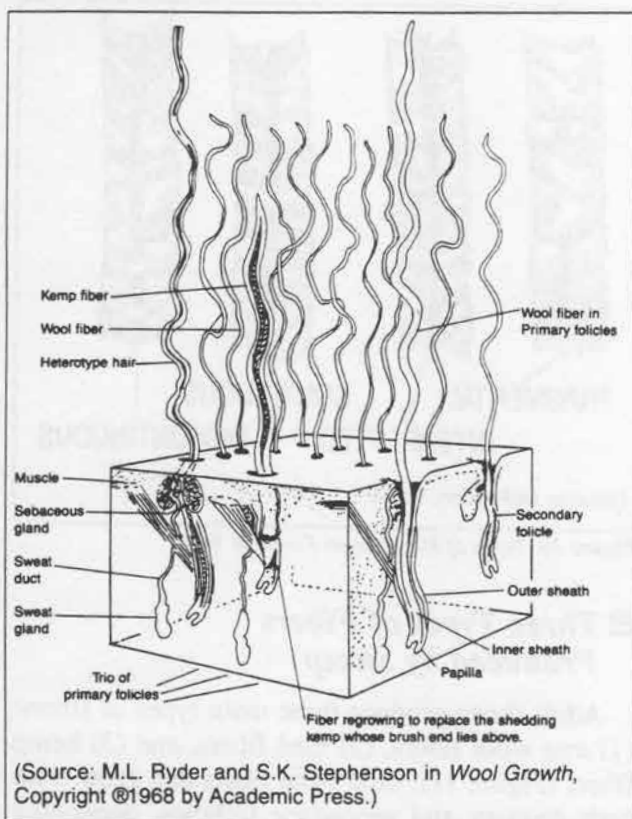


Figure 11. Dimensional Drawing Showing a Wool Follicle Group with the Three Types of Fiber and the Two Types of Follicles in the Skin.

Kemp Fibers

Kemps are the coarsest fibers grown by sheep and are typically shed seasonally. Kemp fibers tend to be short, chalky white, brittle, and do not appear to accept dyes well. Kemp is harsh to handle and is undesirable as a fiber grown by fine and medium wool sheep. It should be genetically selected against, unless it is an important characteristic of the sheep being bred, e.g., some carpet wool breeds. Also, kemp is essential in manufacturing tweed fabrics.

General Chemical and Physical Properties

Chemically, wool is composed of 19 different amino acids combined into keratin-type protein and linked in polypeptide chains (Figures 12 and 13). Nature has folded these chains back upon themselves in such a way that they act like coiled springs. This inner elasticity is in addition to the

fiber's outer crimp extensibility, a continuing or relay stretch potential which explains wool's great natural resilience. This structure has never been duplicated by man. The wool fiber itself is a non-living structure similar in origin to other animal skin tissues such as horns, nails, and hoofs. Wool is considered part of the integument.

Fiber Growth

The growth of a wool fiber is a dynamic process which involves cell proliferation and migration, together with the biosynthesis of the complex mixture of proteins forming the fiber and inner root sheath. The follicle can be divided vertically into several zones. The bulb, which is the zone of active cell division, extends to the tip of the dermal papilla. In the keratogenous zone that extends up the follicle from the tip of the papilla, there is active protein synthesis and elongation of cells. Above this region, final keratinization (hardening) of the fiber occurs and degradation of the inner root sheath begins. Finally, there is a zone of sloughing where degraded inner root sheath cells, and some outer root sheath cells, are sloughed into the fiber canal.

The amount of wool produced by a sheep over a defined period of time depends on the number of

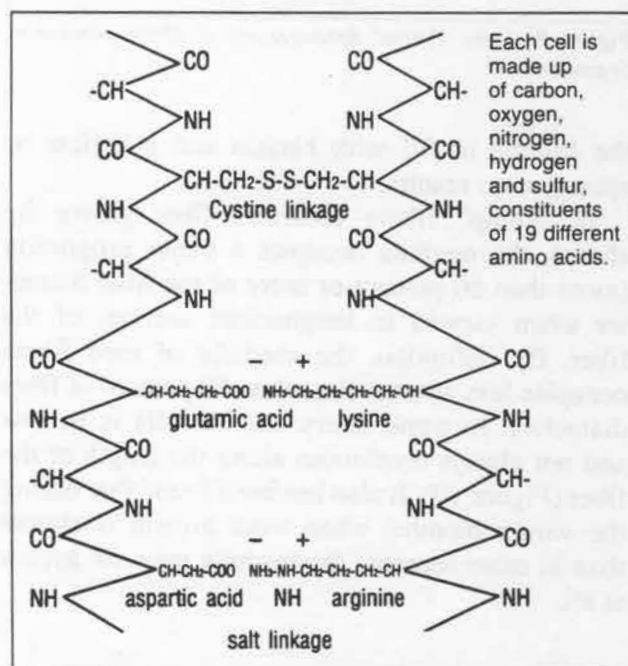


Figure 12. Diagrammatic Representation of the Chemical Structure of the Wool Fiber.

follicles actually growing a fiber and the rate of growth of each fiber, which in turn is related to nutrition, health, and numerous other factors. Rate of growth can be divided into two components, length and cross-sectional area.

Chemical and Physical Properties

The protein of the wool fiber has been given the name keratin. The chemistry of the wool fiber is not homogeneous within the fiber.

The main molecular chains of wool keratin are capable of assuming two different configurations, depending on whether or not the fiber is in a stretched state. Alpha keratin refers to the molecule in its relaxed state, while beta keratin is the designation of the molecule in the stretched state (Figure 13). Beta keratin is analogous to other fiber molecules, while the alpha type is uniquely associated with wool. There is no chemical difference between the two types. It is a property of beta keratin to reassume the alpha form when stress is removed from the fiber. Therefore, the mechanism of the unusual elasticity of the wool fiber is that of a molecular spring.

Action of Sunlight

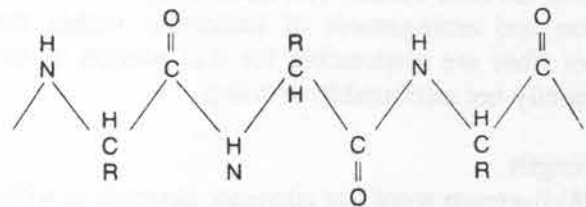
When exposed to ultraviolet rays in sunlight, a photochemical reaction occurs at the disulfide bond and elsewhere in the keratin molecule. A complex sequence of reactions is subsequently expressed by a browning or yellowing of the tips of the exposed wool. This accounts for the "frowzy" tip of cross-bred, medium wools which have little grease to filter out the ultraviolet rays of the sun.

Temperature Effects

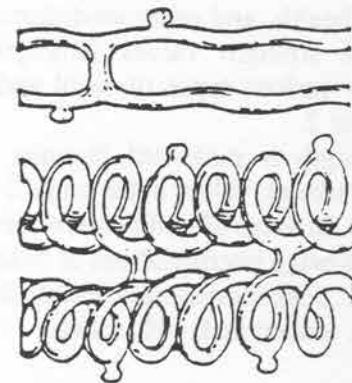
When wool is heated to 212 degrees Fahrenheit (°F) it becomes harsh but regains its soft handle when it picks up moisture. If 212°F is exceeded for any length of time, wool decomposes, acquires a yellow color and eventually turns brown. The extent to which the disulfide bond is affected may be determined by the release of ammonia and hydrogen sulfide. Although wool fibers are self-extinguishing, wool can actually be burned, but only with a very intense heat source. Grease wool burns more readily than scoured wool.

Moderately low temperatures have no effect on the wool fiber. However, under extremely low tem-

Amino Acids (the "building blocks" of wool)
Alanine, Arginine, Aspartic acid, Cystine, Glutamic, Glycine, Histidine, Hydroxylysine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Proline, Serine, Threonine, Tryptophan, Tyrosine, Valine.



These are linked up in polypeptide chains.



Chains are arranged in spring-action folds, or coils.

Figure 13. The Amino Acids in Wool.

peratures (i.e., liquid nitrogen), the fiber becomes very brittle.

Action of Water

When wool is immersed in water, water absorption causes the fiber to swell in both width and length. However, the percentage increase in diameter is greater than the percentage elongation in length. This is because water is not absorbed into the cellular portion of the fiber but rather is absorbed on the surface of the molecule.

Action of Acids and Bases

Because the wool fiber is composed of many amino acids (some of which are acidic and some of which are basic), it is "amphoteric" in its chemical reactivity, i.e., it exhibits both acidic and basic properties. Strong bases readily hydrolyze wool. Wool is more resistant to acids but will hydrolyze in concentrated acids or hot dilute acids.

Elasticity

The elasticity of the wool fiber is the result of two factors: crimp and molecular structure. Crimp in wool is influenced by the cellular arrangement within the fiber cortex. The basic chemical composition and arrangement of molecules within the wool fiber are responsible for that portion of the elasticity not attributable to crimp.

Strength

Well-grown wool has adequate strength to withstand the stresses and strains of manufacturing processes. The strength of wool fibers is influenced by nutrition, health, and other environmental factors. Relative strength values (strength/unit of thickness) for various types of wool and hair are shown in Table 2.

Staple strength is measured in units of Newtons/kilotex (N/ktex). Values in the range 2-100 have been recorded. In terms of traditional subjective estimates, the following interpretations of N/ktex values are acceptable: >30, increasingly sound; 20-30, part tender; 10-20, tender; and, <10, rotten.

Table 2. The Tensile Strength of Wool in Relation to Other Protein Fibers

<u>Fiber</u>	<u>Relative tensile strength percent</u>
Human Hair.....	100
Mohair.....	90
Long Wools.....	80
Camel Hair.....	75
Medium Wools.....	70
Merino Wools.....	62

Specific Gravity

Wool is among the least dense of textile fibers which permits the production of bulky fabrics of relatively low mass. The specific gravity has been determined at between 1.304 and 1.305. Naturally, medullated wools have a lower specific gravity than non-medullated wools.

Moisture Relationships

Wool is the most hygroscopic of textile fibers and the moisture content of wool varies with relative humidity and the previous history of a particu-

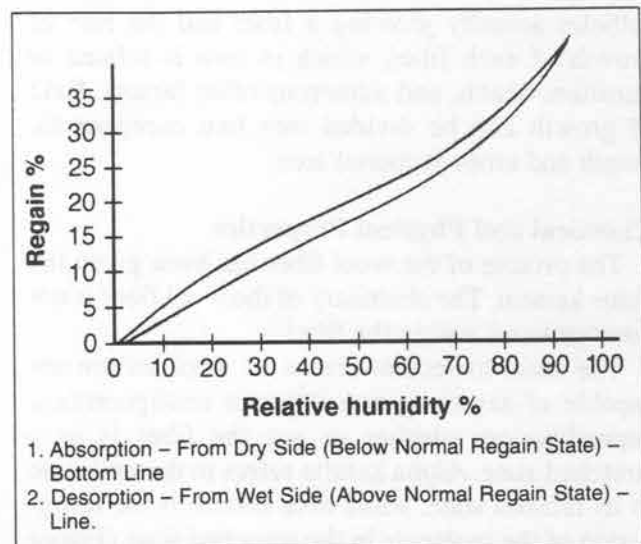


Figure 14. Relation between Relative Humidity and Regain for Wool at 77°F (25°C).

Wool moisture regain absorption and desorption are presented as functions of relative humidity. Absorption - From Dry Side (Below Normal Regain State) = Bottom Line. Desorption - From Wet Side (Above Normal Regain State) = Top Line. Source: Wool Research, Vol. 2 - Physical Properties of Wool, ©1955.

lar fiber (Figure 14). For example, a fiber that has previously been bone-dried will contain less water when equilibrated at a specific relative humidity than an identical fiber that was conditioned from a saturated state. The capability of wool to absorb and retain water (resulting in the evolution of a small amount of heat) contributes to the comfort of wool clothes, particularly on damp, cold days. Conversely, the ability of wool to lose moisture to a dry atmosphere (accompanied by heat absorption by the fibers) also contributes to garment comfort, particularly in warm weather.

Electric Properties

Wool is a poor conductor of electricity but an excellent producer of static electricity in the presence of low relative humidities. At high relative humidities, negligible static electricity is produced. Thus, wearers of wool garments and users of wool carpets in damp climates rarely experience the discomfort of static electricity discharge.

Thermal Qualities

Wool is an excellent insulator. Most people are familiar with the warmth of a wool garment. Actually the excellent thermal qualities of wool are due

to its physical properties when made into cloth. The crimp, bulk, and resilience of wool allow it to be knitted or woven into fabrics having numerous trapped air spaces which result in a structure of high insulating value. In cold weather, a thick layer of woolen cloth insulates the body against the cold air by means of the tempering effect of water absorbed on the fiber, while in warmer weather a light-weight, high-twist yarn construction allows for rapid wicking and subsequent evaporation of perspiration with its resultant cooling effect.

VALUE-DETERMINING CHARACTERISTICS OF WOOL

The value of wool is determined to a large degree by its suitability to specific end uses. Conversely, the relative value of different products that can be manufactured from wool has a direct influence on the price paid for the raw material. The price received for a particular grade or quality of wool is further determined by such factors as degree of preparation, and to a greater degree, by world and local supply and demand at the time of sale. This results in short-term, significant changes in wool prices. Despite this, the characteristics that determine wool value at any particular time remain

Table 3. Raw Wool Characteristics Prioritized for the Worsted Industry

Yield	MOST IMPORTANT
<u>Average fiber diameter</u>	
Quantity and type of vegetable matter	MAJOR
Average staple length	
Staple strength/position of break	
Color	
Colored fibers	
Variability of fiber diameter	SECONDARY
Variability of staple length	
Cotted or felted fleeces	
Crimp/resistance to compression	
Condition of staple tips	MINOR
Age/breed/type	
Style/character/handle	

* Primary source: Australian Wool Corporation

fairly constant. The relative importance of these characteristics has been determined by researchers and textile manufacturers. In general terms, the woolen system of producing yarns is more versatile and less demanding in terms of fiber properties than the worsted system. Consequently, the fiber, style, and fleece characteristics prioritized in Table 3 may be somewhat modified for the woolen segment of the industry. These properties, together with fleece weight, are the same wool characteristics that would be of interest to the sheep breeder.

■ Yield

Yield is normally quoted in terms of a percentage of clean wool fibers present (CWFP) in a greasy sample. By definition, CWFP is the weight of the wool base present in the raw wool, adjusted to a moisture content of 12 percent, an alcohol-extractives content of 1.5 percent, and a mineral matter content of 0.5 percent. Wool base is bone-dry, extractives-free, wool fibers. Prices paid to producers for grease wool are dependent upon yield. Often this value is subjectively assessed by the woolbuyer. However, there is an increasing trend for this important characteristic to be objectively measured at a commercial testing laboratory, enabling more accurate assessments. It is virtually impossible to evaluate a grease price without knowing the yield. Objective measurement minimizes the growers risk in marketing wool.

Table 4 shows that within an individual breed, a range of yield values is actually present. Thus, a major opportunity exists for producers to select for relatively high-yielding fleeces concurrent with selection for increased clean-fleece weight. It is not uncommon in the major-wool producing countries to find fine- and medium-wool fleeces yielding in excess of 70 percent. The genetic potential is already available in the U.S. and should be utilized to maximize returns from wool.

■ Average Fiber Diameter

Average diameter is the most important wool fiber property in the context of quality and value. For coarser wools, diameter has a rapidly decreasing affect on price. Diameter has a major influence on many loose wool, top-making, spinning, and

fabric properties. For example, as diameter increases, the harshness of loose wool increases while its propensity for felting decreases. In carding and combing, fiber breakage and noil production decrease as fiber diameter increases. The limiting yarn count (direct system) that can be spun from a particular batch of wool, yarn hairiness, and thickness all decrease as fiber diameter decreases. An increase in fiber diameter results in increased fabric harshness, as well as flexural rigidity and abrasion resistance, while fabric felting propensity, breaking strength, and pilling propensity decrease; resistance is unaffected.

The first U.S. grade standards for wool were introduced in 1926. These standards were based entirely on subjective, visual appraisal of average fiber diameter. Recognizing the limitations of this

method of quality assessment and with advancements in fiber sampling and objective measurement, the United States Department of Agriculture (USDA) developed and introduced a revised set of official standards for grades of wool in 1966. Assignment of grade is based on objectively determined average diameter and standard deviation (a measure of variability) of diameter. For each of 14 grades, the USDA specifies a range for average diameter and a maximum standard deviation. Samples having standard deviations greater than the specified maximum are downgraded to the next lower grade designation (Table 5).

It is interesting to note that the numbers used to express wool grade are the same as those used in the English Worsted Yarn Count System. When used to quantify yarn count, a number followed by the letter "s" represents the number of hanks (each 560 yards in length) of yarn that can be spun from one pound of top. At one time, it was theoretically possible to manufacture 64s yarn from 64s grade wool. Because of increased machine speeds and greater productivity, this is no longer practical in today's worsted industry. The double meaning of the symbol for count has been a source of confusion for many people involved with the U.S. sheep and wool industries.

The practice of using wool grades for production, marketing, and manufacturing is declining on an international basis. It seems likely that the use of specifications for grades of wool will also decline in the U.S. and ultimately will be replaced by a measurement of diameter (in microns) and variability (standard deviation, also in microns).

The range of average diameter for the major sheep breeds is listed in Table 4. While these are commonly accepted limits, it would not be unusual to find individuals of the breed producing wool that measures outside of these ranges. The breeder is advised to select and breed for uniformity of fiber diameter throughout the fleece. Even in fine wool breeds, there is a tendency for the britch wool to be coarser than the bulk of the fleece. This difference can be minimized by selective breeding. Generally, the bulk of a skirted, fine-wool fleece will be composed of one or two grades of wool. This tendency decreases as the average diameter of the fleece increases. It would not be unusual to find areas representing four or more grades in fleeces from cross-

Table 4. Sheep Breeds, Wool Diameter, Fleece Weight, and Yield Ranges*

Breeds	Range of Average Diameter (µm)	Range of Ewes Grease Fleece wt.(lb)	Range of Yield (%)
Border Leicester	38-30	8-12	60-70
Cheviot	33-27	5-8	50-65
Columbia	30-23	9-14	45-60
Corno	22-19	10-14	60-70
Corriedale	31-24	9-14	45-60
Debouillet	23-18	9-14	45-55
Delaine-Merino	22-17	9-14	40-50
Dorset	32-26	5-8	50-65
Finnsheep	31-24	4-8	50-70
Hampshire	33-25	6-10	50-60
Lincoln	41-34	10-14	55-70
Merino (superfine)	<18	6-9	60-70
Merino (fine)	19-20	6-11	60-70
Merino (medium)	21-22	9-13	65-75
Merino (strong)	23-26	11-15	65-75
Montadale	30-25	7-11	50-60
Oxford	34-28	7-10	50-60
Rambouillet	23-19	9-14	45-60
Romney	39-32	8-12	55-70
Shropshire	33-25	6-10	50-60
Southdown	29-24	5-8	40-55
Suffolk	33-26	4-8	50-60
Targhee	25-21	9-14	45-60
Texel	33-28	7-10	60-70

*Primary source: Producer Education and Research Council, American Sheep Industry Association

Notes

bred, medium, or long wool breeds of sheep. Consequently, these wools are more difficult to grade and sort.

■ Quantity and Type of Vegetable Matter

The vegetable matter base (VMB) of greasy wool is the oven-dry weight of scoured burrs, seeds, twigs, leaves, and grasses, free from mineral matter and alcohol-extractable material, expressed as a percentage of the sample of grease wool from which it was isolated. Vegetable matter is normally reported as vegetable matter present (VMP), which is the VMB adjusted to a moisture content of 12 percent, an alcohol-extractives content of 1.5 percent, and a mineral matter content of 0.5 percent. The American Society for Testing and Materials (ASTM) recognizes five major types of vegetable matter: bean burrs, spiral burrs, sand burrs, cockle-

burrs, and shives (a composite of small plant fragments and slivers).

The presence of an excessive amount of vegetable matter in raw wool is regarded as a defect and the wool is discounted accordingly. Discounts are justified by the extra mechanical and/or chemical processes to which the wool must be subjected in order to remove the plant parts, as well as the resulting weakness and brittleness of the fibers which cause excessive fiber breakage and waste in carding (see carbonizing, page 1154). The vegetable and non-wool content of major wool lines can be minimized by careful management and by skirting off bellies, topknots, cheek wool, and crutchings.

■ Average Staple Length

Staple length of wool is categorized into three classes: staple, French combing, and clothing (Table 6). There are no official USDA or ASTM specifications for length classes, and individual buyers may require lengths differing from those of Table 6. The length of wool fibers (which is highly correlated with staple length) determines primarily which system may be used to spin the fibers into yarn, i.e., worsted, woolen, and short-staple (cotton) systems.

Fine-wool sheep, in particular, have been

560 yds

handles for 1lb wool

Table 5. Specifications for Grades of Wool*

American Blood Grade	Grade	Range for	Maximum
		Average Fiber Diameter (µm)	Standard Deviation (µm)
Fine	Finer than		
	80s	under 17.70	3.59
	80s	17.70 to 19.14	4.09
	70s	19.15 to 20.59	4.59
64s		20.60 to 22.04	5.19
Half blood	62s	22.05 to 23.49	5.89
	60s	23.50 to 24.94	6.49
Three-eighths blood	58s	24.95 to 26.39	7.09
	56s	26.40 to 27.84	7.59
Quarter blood	54s	27.85 to 29.29	8.19
	50s	29.30 to 30.99	8.69
Low quarter blood	48s	31.00 to 32.69	9.09
	46s	32.70 to 34.39	9.59
Common	44s	34.40 to 36.19	10.09
	40s	36.20 to 38.09	10.69
Braid	36s	38.10 to 40.20	11.19
	Coarser than 36s	over 40.20	

*ASTM Standard Specification D 3991

Table 6. Staple Length Requirements by Grade

Grade	Length Class		
	Staple	French Combing	Clothing
64/70s	2-3/4" and longer	1-1/4" to 2-3/4"	Less than 1-1/4"
60/62s	3" and longer	1-1/2" to 3"	Less than 1-1/2"
56/58s	3-1/4" and longer	2-1/4" to 3-1/4"	Less than 2-1/4"
50/54s	3-1/2" and longer		Less than 3-1/2"
46/48s	4" and longer		Less than 4"
36/40/44s	5" and longer		Less than 5"

Notes

selected and bred to produce staples longer than three inches. The selection pressure on this trait should not be over emphasized, however, since exceptionally long wool provides no technical advantage to the manufacturer. In fact, production lots containing wool staples longer than five inches can cause serious problems in manufacturing. Most of the longer wools are combed into worsted-type yarns. However, some staple length wools are processed on the woolen system. There are no real mechanical limitations governing the length or diameter of fibers used to produce woolen textiles.

A highly significant linear relationship exists between the staple length of sound wools and average fiber length in top. In turn, fiber length in top has a major influence on spinning speeds, yarn count, yarn uniformity, and, ultimately, yarn quality. Thus, mean staple length is also a very important, value-determining characteristic of wool.

■ *Staple Strength/Position of Break*

Wool fiber strength is a major factor determining the strength of yarns. It also has an important effect on the percentage of short fibers (noils) formed and mean fiber length (hauteur) in top making. Low tensile strength in the form of "tender wool" and "broken wool" is the greatest contributing factor to fiber loss. The term "broken wool" is used when staples pull apart very easily and in a specific position. This type of fault is associated with stress-causing environmental influences such as changes in nutrition, the production status of ewes, severe weather, or diseases, all of which limit nutrient availability to the root bulb. In comparison, tenderness in wool is indicated when the overall strength is low and the staple breaks over a wider, indefinite area compared to a clean break.

Wool is discounted once a buyer determines subjectively that it contains breaks or is tender. The position of the weakness along the staple is also important in assessing price. Although objective measurement is possible, it is not commercially available in the U.S. at this time. Australian growers are receiving premiums for wools that have been tested for staple strength (and length) using the Automated Tester for Length and Strength (ATLAS) instrument.

■ *Color*

The lack of color in wool is of importance when the fibers are not to be dyed or are to be dyed to pastel shades. White wools offer a broad dyeing range without bleaching and are, therefore, more valuable to the textile industry. A high degree of whiteness can be obtained in a clip only by skirting out all the urine-stained and fecal-contaminated wool. Many spinners are now specifying minimum whiteness of the tops they purchase.

Production of colored wools is a specialized segment of the industry catering primarily to hand-spinners and weavers. This subject is discussed in a later section of the chapter.

■ *Colored Fibers*

The presence of colored fibers in white wool is extremely detrimental to value since it limits the utility of this wool to products that will be dyed to medium or dark shades. The source of these colored fibers—whether it is the sheep themselves (i.e., naturally pigmented, urine-, or fecal-stained) or from other species—is irrelevant from the point of view of the manufacturer. Lots containing an excessive number of colored fibers receive discounted prices. The presence of colored fibers is most critical and undesirable in bleached white, natural, and pastel shades. Even two or three colored fibers per square yard can be grounds for rejection of a fabric by a quality-conscious cutter. Colored fibers can be eliminated in white fleeces by selection, management, and wool preparation practices.

■ *Variability of Fiber Diameter*

Compared to average fiber diameter, variability of diameter has a relatively minor influence on spinning performance, yarn, and fabric properties. However, in the U.S. system of grading wool by diameter, an excessively high standard deviation of diameter requires a sample to be downgraded. This is a rare occurrence even in "choppy," poorly prepared wools. High variability of diameter may be indicative of low quality fine wool stock and/or poor blending practices prior to the manufacturing stage. In such cases, yarns and fabrics may be

excessively hairy and prickly. "Coarse edge" is a term used by the textile industry to describe the abnormal but significant presence in a fine wool clip of coarse (one and one-half times mean diameter) fibers. Levels in excess of 1.5 percent are reported to cause excessive "ends down" or disruptions of worsted spinning of "critical" yarn counts. This "coarse edge" results in a reduction of spinning efficiency and should be actively selected against. Prickle in fabrics worn next to the skin has been shown to be caused by fibers coarser than 30 μm . These fibers do not readily bend when pressed next to the skin, thus causing a prickling sensation.

■ *Variability of Staple Length*

This characteristic, though moderately genetic, is also related to staple strength, weak or tender wool, and/or poor shearing. Collectively, these factors contribute to length variability in top. Normally, top makers specify the coefficient of variation of fiber length in the top, because it has a small but significant effect on spinning performance and yarn properties. The producer can minimize length variability through adequate selection, management (skirt belly, leg, head, and other short wool), good shearing practices (no second cuts), and health maintenance practices (healthy sheep produce sound wool). Wool with coefficients of variation of staple length less than 12 percent are considered to have very good uniformity.

■ *Cotted or Felted Fleeces*

Cotted or felted wool arises when loose fibers bind with other fibers in the fleece to form a felted mass. Fine fibers having abnormally low crimp are particularly susceptible to this fault and animals exhibiting uncharacteristically low crimp levels should be culled. Cotting can also cause severe problems in long wool breeds. Cotted and matted fleeces are discounted because, like tender wool, they are wasteful. When carded and combed, these fleeces produce an excessive amount of card waste and comb noils because fibers break when torn apart in processing.

■ *Crimp*

Crimp and fiber diameter are usually highly and inversely correlated. Subjective assessments of wool fineness are usually influenced more by crimp than by actual diameter. Nevertheless, visual appraisal of crimp frequency and definition still forms an important part of buying strategy in the U.S. The influence of crimp in processing, yarn, and fabric properties is poorly understood and controversial. Low-crimp wools tend to entangle and felt during the scouring process. Excessive nepa production in carding and combing may be associated with excessive fiber crimp. Crimp is highly correlated to resistance to compression and bulk, properties that are sometimes measured to give an indication of crimp. Producers should cull animals with uncharacteristic (too little, too much) crimp for corresponding grade.

■ *Minor Characteristics*

Weathered fiber tips break in carding and are removed as either card waste or noilage in combing. In either case, the yield of top is reduced. Excessively weathered tips can be associated with an inadequate amount of protective wool grease or excessive exposure to rainfall, alkaline soils, and sunlight in fleeces that lack density. However, it has been shown that fine-wool sheep with tippy fleeces tend to be lower yielding and more prone to fleece rot in higher rainfall areas.

When most of the other value-determining characteristics are known, the age/breed/type characteristics of the sheep are of only minor importance. If, on the other hand, only age/breed/type information is available, it at least provides a general indication of the ranges that may be expected for the more important fleece and fiber properties.

Handle is closely related to average fiber diameter. Style and character are both characteristics of uncertain definition for which no objective measurement techniques currently exist. Style is dependent upon vegetable matter content, staple strength, tip damage, color, crimp, alignment of fibers in the staple, and dirt penetration. Character is related to style and in particular to crimp definition, regularity, and configuration of the staple tip. These are terms best understood and used by wool buyers. Attempts are being made to measure these elusive characteristics using image analysis technology.

A Timeline for the Ewe and Her Lambs

The Ewe

DAYS 0-7 →

Greatest risk of embryo loss due to heat and humidity stress

DAYS 30-90 →

Critical period for placental and mammary gland development. Reduced fetal growth, birth weights, vigor, and lower milk production result from poor nutrition at this time. Macro- and micro-mineral supplementation is vital. Impairment cannot be made up for later.

DAY 60 →

Booster vaccination (following pre-breeding vaccine) protects ewe against chlamydia and vibriosis abortions

DAYS 100-BIRTH →

Nutritional demands of fetuses place greatest demand upon ewe

DAY 120 →

Vaccination against respiratory, clostridial diseases and tetanus stimulates high level of antibodies in colostrum, (forming by about day 136). Periparturient rise of internal parasite egg production: deworm to protect lambs.

BIRTH →

Colostrum production ceases; 24-36 oz available to lambs.

DAYS 21-28 →

Maximum milk production attained. Maximum production requires maximum nutrition. Feed best hay, match grain amounts to number of nursing lambs.

DAY 60 →

Many ewes producing less than half of the amount of milk they produced at peak production.

The Lambs

0 DAYS FROM
CONCEPTION

10

20

30

40

50

60

70

80

90

100

110

120

130

140

150

OR BIRTH

10 DAYS AFTER
BIRTH

20

30

40

50

60

70

80

90

100

← **DAYS 20-24**

Embryos implanted in uterine wall

← **DAY 35**

First primary fiber follicles form

← **DAYS 60-63**

Most primary fiber follicles formed; lateral primary follicles begin to form

← **DAYS 90-100**

Secondary wool follicles begin forming

← **DAYS 100-BIRTH**

70% of fetal growth occurs

← **DAY 120**

Fetal lambs immunocompetent: capable of forming some antibodies

← **BIRTH**

Antibody-rich colostrum (received within 24 h of birth) provides passive immunity for up to 10 weeks; primary follicle fibers shed

← **DAYS 7-14**

Lambs begin eating creep feed; some rumen function by day 14; 250% increase (from birth) in growth/maturity of secondary follicles

← **DAYS 28-42**

Lambs convert from high-milk, low-feed to low-milk, high-feed diet

← **DAYS 42-56**

Rumen becomes fully functional; lambs vulnerable to coccidiosis (add coccidiostat to feed)

← **DAY 60**

75% of secondary follicles growing fiber; lambs vulnerable to high parasite loads (deworm)

← **DAY 70**

Disease immunity of lambs, gained by colostrum, depleted (vaccination vital)

← **DAYS 91-98**

In vaccinated lambs, antibody titers peak; booster of vaccine at this period "confirms" to immune system that antibody production is important

If you would like to join a network of Virginia wool producers, and participate in future educational and marketing initiatives, please fill out the form below, copy and send or email to Martha Polkey (address below).

Name _____

Farm name _____

Address _____

City, state, zip _____

Phone _____

Email _____

Website _____

AREAS OF INTEREST

- Cooperative marketing
- Cooperative production value-added wool products
- Virginia Make It With Wool competition
- Wool Handling School
- Wool Classing School
- Wool speakers
- Other: _____

VSPA WOOL OUTREACH FUND COMMITTEE

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