WOOL PRODUCTION SCHOOL

April 3 - 5, 1992
Ukiah and Hopland, California

AMERICAN WOOL
PRODUCE IT WITH PRIDE

UNIVERSITY OF CALIFORNIA
Hopland Field Station

Hopland Field Station Publication 103

WOOL PRODUCTION SCHOOL

April 3 - 5, 1992
Ukiah and Hopland, California

Martin R. Dally
John M. Harper
Pamela J. Tinnin
Editors

UNIVERSITY OF CALIFORNIA

Hopland Field Station

Hopland Field Station Publication 103

WELCOME !

On behalf of the *University of California* and the *California Wool Growers Association*, I would like to take this opportunity to welcome you to the **Hopland Field Station Wool Production School**.

It is important to realize that wool is not just a by-product of the lamb industry. Wool is a valuable commodity that can increase the profitability of the sheep enterprise. However, wool must be produced, packaged and marketed as a quality product in order to enhance its market value.

The goals and purpose of this year's program are to increase producers' knowledge of wool production and to encourage the proper management of the wool clip. We hope that the information presented here will help you produce a higher quality and more profitable wool clip.

Martin R. Dally, Wool School Chairman
Department of Animal Science
University of California-Hopland Field Station

In Memory

The organizers of the Wool Production School would like to dedicate this program in memory of Floyd Johnson who passed away on January 12, 1992. Floyd was a lifelong resident and rancher in Mendocino County. His dedication to ranching, and especially to the sheep industry, was an inspiration to those who had the opportunity to work with him.

Floyd was a member of the California Wool Growers Association for 42 years. He chaired the California Farm Bureau's Sheep Committee for three years, and in this capacity represented the state at the American Farm Bureau commodity meeting. He was a past president of the Mendocino County Wool Growers and was very active in promoting the sheep industry.

Floyd's leadership on many issues confronting the livestock industry was unfaltering. He was persistent in getting to the heart of any problem and solving it. He was also very active in uniting the producers to support funding for the Animal Damage Control Program. He will be long remembered as the gentleman with the cocked back cowboy hat, friendly smile, and wonderful sense of humor.

Floyd will be truly missed, but for those of us that had the pleasure to know him, his loyalty, dedication, and enthusiasm for the sheep industry, he will never be forgotten.

ACKNOWLEDGEMENTS

The editors wish to thank a number of people for their interest and help with this school:

Rita Kourlis-Samuelson from ASI for educational materials and permission to use American Wool Mark. **Gary Markegard**, Livestock Advisor, U.C. Cooperative Extension in Humbolt County for moderating Saturday's session.

Nancy O'Ferrall, Administrative Assistant at the Hopland Field Station, assisted with numerous details of registration, arrangements and correspondence related to the school. **Suzanne Billups**, Mendocino County Extension Office Manager, proofed the majority of the manuscripts before final copy. **Lee Rossavick**, Agriculture Technologist, for computerized scanning of text and graphics.

The **Wool Production School** coordinating committee whose members, in addition to the editors, were: **Stephanie Larson**, Livestock Advisor, U.C. Cooperative Extension in Sonoma and Marin Counties; **Robert Timm**, Hopland Field Station Superintendent; **Eric Bradford**, Chairman, U.C. Davis Animal Science; **Ed Price**, U.C. Davis Animal Scientist; **John Hays**, Animal Resources Supervisor and **Bob Keiffer**, Principal Superintendent of Agriculture.

All of the speakers who participated and also contributed papers to these Proceedings are responsible for the success of this school, as well as a valuable document with current information on wool. This document will be useful to many people interested in American wool production.

We thank **Mendocino College** for the use of its facilities. We also acknowledge the financial contributions of the **California Wool Growers Association, Hopland Field Station, U.C. Davis Department of Animal Science**, and **Mendocino County Cooperative Extension.**

M.R.D.
J.M.H
P.J.T
Hopland, California
April, 1992

TABLE OF CONTENTS

SHEEP BREEDS AND THEIR WOOL

John M. Harper
Livestock/Natural Resources Advisor
Mendocino & Lake Counties

The sheep belongs to the Genus *Ovis* which is closely related to the Genus *Capra*. The sheep and goat have been closely associated during man's history and it is sometimes difficult, particularly with fossil evidence, to distinguish between the two species. The goat, however differs from sheep in several respects. Sheep typically have wool fibers in its coat and through domestication have been more narrowly specialized for wool and meat production. Some types of sheep, such as the Barbary of North America, really belong to a group intermediate between sheep and goats.

When considering breeds of sheep it is important to realize that each breed has evolved from the emphasis placed on production and the region where that production occurs. Worldwide there are four major types of sheep production:

Fine wool production
Dairy production
Mountain or range sheep production
Lowland lamb production

Fine wool production is mainly found in the semi-arid plains of Australia, South Africa, South America and Asia. It is based on large scale herding of Merino sheep or their close relatives. Although referred to as fine wool production, the wool varies in fineness and meat production is not the primary source of income.

Dairy production is widespread on mountainous land in Southern and Eastern Europe, Northern Africa and Asia. Recently, there has been small-scale interest in sheep dairying in the U.S. With the exception of France, in Europe, Asia and Africa it is based on small scale peasant farming or communal tribal ownership of a wide variety of native sheep types. Wool, meat and pelt production are other important products.

Mountain or range sheep production is found primarily in Northern Europe and North

America. The size of these flocks vary considerably and are usually complementary to lowland systems, supplying lambs to be finished in feedlots as in the southwest United States or on grass and arable crops as in Britain and Northern Europe. Wool production is usually second in importance only to meat production.

Lowland lamb production systems are found in temperate or coastal areas suitable for grass production like New Zealand, Northern Europe and North America. Most flocks are self-contained with the main product being young lamb marketed at the end of the grass growing season. Wool production is an important but usually secondary in terms of income.

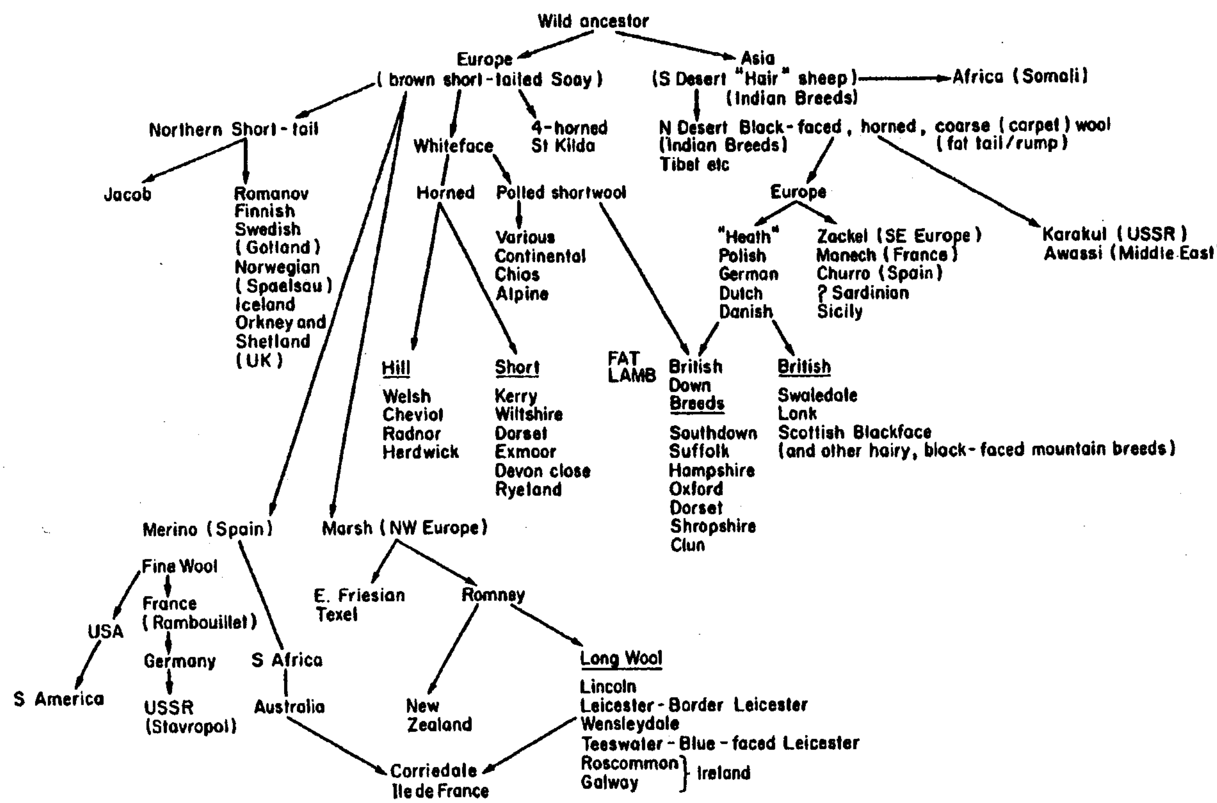


Figure 1 Classification & affinities of sheep. Source: Owen, 1976.

Figure 1 above, originally prepared by Dr. M. L. Ryder of the Animal Breeding Research Organization, Edinburgh shows graphically some functional and developmental significance of common groupings associated with the different breeds of sheep. It's clear that the groups are dominated by the Merino and its near cousins, and its importance reflects the traditional emphasis on wool. It also helps us to understand how sheep have evolved into the modern breeds we have today and to realize that the world has many more breeds of sheep than are found in the United States.

In the U.S. there are over 35 different breeds of sheep and the genetic diversity among these breeds is great. As an example, fiber produced from these breeds can range from fine wool to long wool to hair. Most of the breeds found in the U.S. are of British or European origin or have been developed from crosses of these breeds. In terms of commercial importance, however, there are fewer than 10 breeds at the present time in the U.S. The genetic diversity of the minor or recently introduced breeds should not be overlooked especially when we consider the future.

In classifying sheep breeds there are many options available. Often breeds are classified as ewe, dual purpose or terminal sire breeds. Since this proceedings covers wool production a classification based on wool type and fleece traits is most logical. Wool type is a descriptive term with five categories. They are: Hair - of little value, Carpet or Coarse wool - used mainly for carpets and mattress filling, although the finest wools in this category may be used for tweeds and also are popular among handspinners and weavers, Long wool - uses are similar to the carpet wools and are especially suited for hand spinning, Medium or Crossbred wool - used for wide range of materials including tweeds, lower quality worsted materials and a broad range of knitting yarns and Fine or Merino wool - destined for the best quality light weight worsted and woolen garments.

Fleece traits typically used in classifying breeds are: grease fleece weight, average fiber diameter (microns), yield and staple length. For a more thorough description of fleece grading and specific breed details of wool quality please see papers entitled *Wool Grading* and *Genetics of Wool Production* elsewhere in this proceedings. Table 1 on the following page summarizes the wool characteristics of most of the U.S. breeds of sheep.

Table 1 Classification of U.S. Sheep Breeds by Wool Characteristics

Breed	Country of Origin	Wool Type	Average Fiber Diameter (microns)	Grease Weight (lbs)	Staple Length (inches)
Barbados Blackbelly	Barbados	Hair	---	---	---
Booroola Merino	Australia	Fine	26-20	9-14	2.5-4
Border Leicester	England	Long	38-30	8-12	8-10
Cheviot	Scotland	Medium	33-27	5-8	2.5-5
Clun Forest	England	Medium	33-28	5-9	2.25-3
Columbia	U. S.	Medium	30-23	10-15	3-5
Coopworth	New Zealand	Long	36-30	8-12	8-10
Corriedale	New Zealand	Medium	31-24	9-14	3.5-6
Cotswolds	England	Long	40-33	10-14	9-10
Debouillet	U. S.	Fine	23-18	9-14	3-5
Delaine-Merino	Spain	Fine	22-17	9-14	2.5-4
Dorset	England	Medium	33-27	5-8	2.5-4
Finnsheep	Finland	Med. to Long	31-24	4-8	3-6
Hampshire	England	Medium	33-25	6-10	2-3.5
Karakul	Russia	Carpet	36-24	4-8	5-10
Katahdin	U. S.	Hair	---	---	---
Leicester	England	Long	40-33	10-14	6-10
Lincoln	England	Long	41-34	10-16	8-15
Montadale	U. S.	Medium	30-25	6-11	3-4
Navajo	U. S.	Carpet	40-28	4-8	2-6
North Country Cheviot	Scotland	Medium	33-27	5-10	4-6
Oxford	England	Medium	34-30	7-10	3-5
Panama	U. S.	Medium	30-24	9-14	3-5
Perendale	New Zealand	Long	38-30	7-10	5-10
Polypay	U. S.	Medium	33-25	6-10	3-5
Rambouillet	France/Germany	Fine	23-19	9-14	3-4
Romanov	Russia	Medium	35-28	3-5	2-3
Romney	England	Long	39-32	8-12	3-5
St. Croix	Virgin Islands	Hair	---	---	---
Scottish Blackface	Scotland	Carpet	36-28	8-12	8-12
Shropshire	England	Medium	33-25	6-10	2-3.5
Southdown	England	Medium	29-24	5-8	2-3
Suffolk	England	Medium	33-26	4-8	2.5-3
Targhee	U. S.	Medium	25-21	9-14	3-4.5
Texel	The Netherlands	Medium	33-28	4-8	2-3.5
Tunis	No. Africa	Medium	33-28	4-8	2-3.5

Sources: SID, 1988 and Briggs & Briggs , 1980.

In addition to the wool types and traits outlined, careful consideration should be given to follicle density, secondary to primary follicle ratio, and the average number of follicles per square inch when choosing a breed for wool production. Development of the wool follicles is covered in the paper entitled *Development of Wool Follicles* in this proceedings and the reader is encouraged to study that paper to fully understand why follicle parameters are important. Table 2 shows some of the follicle parameters for various sheep breeds.

In conclusion, choosing the right breed of sheep is the first step in producing high quality wool. When selecting a breed you should consider the animals ability to adapt to the environment where it will live. Knowing what type of wool that is in demand will help you decide on a particular breed. Knowledge of breeds and their wool types will help you in your selection or crossbreeding programs to produce a wool clip with pride.

Table 2. Follicle Parameters for Various Breeds of Sheep

Breed	Follicle Density	Secondary to Primary Ratio	Average Number of Follicles (inches^{2})
Merino	79.8	19.0	36800-60000
Corridale	30.0	11.0	14,800-19,400
Southdown	27.6	6.3	18,100
Suffolk	20.4	4.8	13,200
Perendale	15.3	5.4	NA
Romney	14.3	5.4	14,200
Boarder Leicester	15.8	4.4	10,300
Coopworth	12.4	5.0	NA
Lincoln	14.6	5.4	NA

Source: Ryder & Stephenson, 1968.

References

Briggs, H.M. and D.M. Briggs. 1980. Modern Breeds of Livestock, 4th ed. Macmillan Publishing Co., Inc. New York.

Owen, J. B. 1976. Sheep Production. Bailliere Tindall. Sussex, England.

Ryder, M. L. and S. K. Stephenson. 1968. Wool Growth. Academic Press. New York.

SID, 1988. Sheep Producers Handbook. Sheep Industry Development Program, Inc. Englewood, Colorado.

DEVELOPMENT OF WOOL FOLLICLES

Stephanie Larson
Livestock & Range Management Advisor
Sonoma & Marin Counties

The two types of follicles that produce fiber on the sheep are known as primary and secondary follicles. The primaries are the largest, and usually arranged in rows in the skin in groups of three. 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 secondary follicles are generally the smallest follicles and tend to grow finer fibers than the primaries. The fundamental difference between the two follicle types is that primaries have a bi-lobe sweat or sudoriferous gland which produces suint and an arrector pili muscle, whereas, secondary follicles have neither of these structures. Both types of follicles have sebaceous or wax glands. However, secondary follicle's sebaceous glands are smaller in size than that of the primary follicle. The sebaceous glands secrete a complex mixture of esters and some 30 different fatty acids, commonly referred to as wool grease. Yolk is a combination of the wool grease and suint. The glands and the muscle are known as accessories and always lie on the side towards which the wool fiber slopes. Figure 1 illustrates the structure of skin and wool fibers.

In the fetus, primary follicles start forming between 35 and 40 days after conception. They begin developing fibers approximately 80 days after conception, and by the 120th day all are producing fibers which are above the skin line. Secondary follicles commence developing about 80 days after conception and may be producing fibers as early as day one hundred. A large proportion of the secondary follicles will not start producing fibers until sometime after birth.

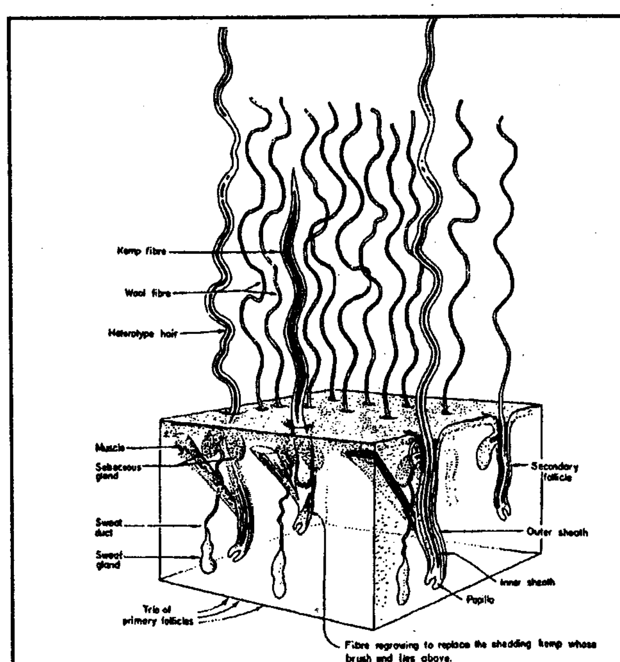


Figure 1 A wool follicle group showing 3 types of fiber and 2 types of follicle in the skin. Source: Wool Growth, 1968.

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:

Pre-Trio Period: Initiation of central primary (PC) wool follicles begins on the face and poll about 35 - 40 days after conception. This period is completed by 60 days after conception.

Trio Period: The trio period of primary follicle initiation begins on the fetal face around 63 days. The trio period differs from the initiation of central primary (PC) follicles in that the central primaries appear to initiate the lateral primaries (PL). Thus during the trio formation, small lateral primary follicles (PL) appear one on each side of each central primary (PC). Development of the sweat glands begins during this period which is completed 90 days after conception.

Post-Trio Period: The post-trio period covers the final stages in the initiation and development of the follicle group. Two major aspects of this period are: (1) the initiation of the secondary follicle subsequent development, and (2) the growth and development of the already formed follicles leading to the production of their fibers. This is known as the maturation stage of development. The post-trio period is the longest of the prenatal periods and occupies the remainder of the time until birth.

The number of secondary follicles initiated in this way appears to be about 5 or 6 times the number of primary follicles. This period brings the most rapid increase in follicle population and accumulates in the birth coat of the lamb on or about the 150th day of gestation. By the time of birth, the follicle group is essentially the same as the adult arrangement.

The density of primary follicles becomes less per unit area as the lamb becomes older. Since 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 majority of skin expansion has taken place and only a small decrease in primary follicle density is measured between 4 and 16 months of age.

The Secondary/Primary Ratio:

The ratio of secondary to primary follicles in a trio group has been found to be an excellent measure of the quality (density and fineness) of wool fiber production in sheep. The finer the fleece type, the higher the secondary:primary (S:P) follicle ratio is. For example, a Merino with a spinning count of 60- 64/70s will have an S:P ratio of 21.0 whereas a Suffolk with a spinning count of 56-58s will have an S:P ratio of 4.8.

STRUCTURE OF THE FIBER

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

Epicuticle:
The epicuticle is a thin outer membrane covering the cuticle protecting the wool fiber from deterioration 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 surround the wool fiber and are more prominent on fine wools than on coarse wools. A one-inch length of wool fiber may contain up to 2,000 overlapping scales. These scales are very small and comprise only two percent of the fiber's structure. The scales are a major factor involved when wool fabrics shrink during washing, and the 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 gives wool its ability to be bent back upon itself more than 20,000 times without breaking. Wool's ability to absorb up to 30 percent of its weight in moisture vapors is another property of the cortex.

Medulla:
The medulla, or central core, is found primarily in medium and coarse wools. Medullation is believed to result from incomplete keratinization and is not desirable in wool production. Kemp are fibers which have over 65 percent of their diameter medullated. Kemp fibers lack strength and crimp and don't accept dye as readily as true wool fibers. Figure 2 shows a cross sectional representation of a medullated fiber. A true wool is non- medullated.

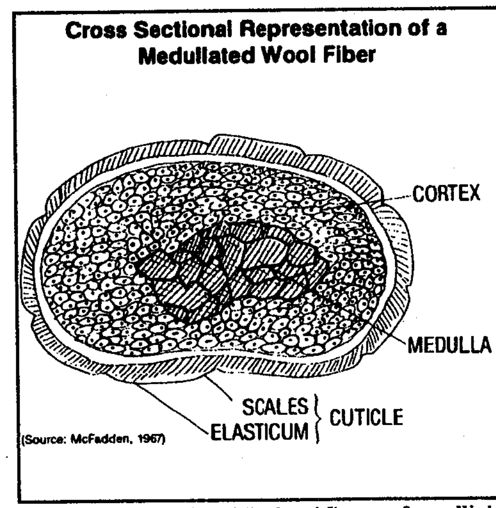


Figure 2 Cross section of a medullated wool fiber. Source: Wool Science, 1968.

Reference
American Sheep Producers Council, Inc. 1982.
National Wool and Pelt Workshop, November 15-18, 1982, Denver, CO

McFadden, W. D. 1967. Wool Science. Pruett Press. Boulder, CO

Ryder, M. L. and S. K. Stephenson. 1968. Wool Growth. Academic Press. New York

SID, 1988. Sheep Producers Handbook. Sheep Industry Development Program, Inc. Englewood, CO

The Wool Bureau, Inc. 1982. Wool-From Fiber to Fabric. The Wool Library Volume 1. New York

NUTRITION AND WOOL PRODUCTION

Dan Brown
Department of Animal Science
University of California - Davis

INTRODUCTION

Interest in wool production and quality naturally rises and falls with the price of wool relative to other sheep products such as meat, milk and pelts. Given the present wool price situation and outlook worldwide, it is probably not worthwhile to make major changes in management (including nutrition programs) that favor wool growth, yield and quality if they will reduce lamb productivity or increase costs substantially. Fortunately, many of the nutritional factors that improve wool production also improve sustainable lamb production. Conversely, decreases in staple growth and fiber diameter can be an indicator of nutritional problems which reduce lamb productivity and ewe health as well. The purpose of this paper is to provide sheep producers with the understanding they need to evaluate: 1) what changes in wool are telling them about the nutritional status of their animals and 2) the value of new products, ideas and techniques suggested to them by salesmen, professors and farm advisors.

ENERGY EFFECTS

The synthesis of wool requires energy beyond that needed to maintain an animal of similar size that is producing no wool. Similarly, an animal producing 20 pounds of wool each year needs more energy to do it than an animal that produces only 10 pounds of wool. The absolute amount of energy needed, however is so tiny compared to all of the other physiological tasks that a ewe carries out over the course of the year (See Figure 1), we rarely see an energy requirement listed just for wool.

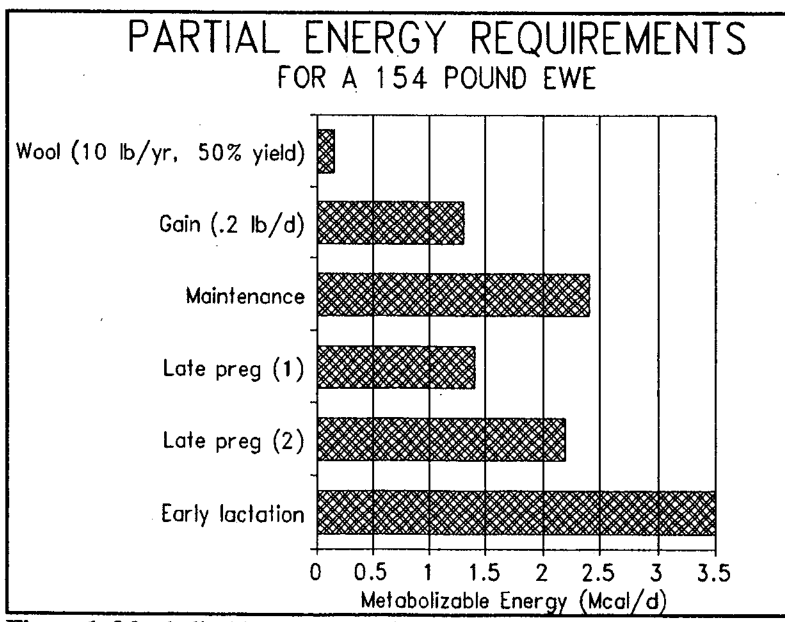


Figure 1. Metabolizable energy requirements for several physiological functions

The amount of energy needed for wool is too low to be detected experimentally because the **variation** in the amount of energy used for maintenance, growth, etc. is larger than the increment needed for wool. An estimate of the wool energy requirement is usually calculated from the energy in the wool divided by the estimated fractional efficiency of energy to produce wool. Nutritional requirement tables usually just list a maintenance requirement that includes the amount needed for wool synthesis. For all practical purposes, reduced wool growth, tenderness or breaks due to energy deficit are rarely observed unless the feed supply fails to meet maintenance requirements (in the case of a dry, open ewe) or the requirements for maintenance plus the sum of other functions in more productive ewes. This often happens in range systems because of seasonal periods on low quality feed and in productive intensive systems because of the demands imposed by lactation.

PROTEIN EFFECTS

Protein needs for wool production are a more complex topic of discussion than energy requirements. We could construct a diagram for protein similar to the one we made for energy (See Figure 2) which would show that the daily protein requirement is small relative to other functions (although a bit more prominent than the wool energy requirement).

Unfortunately, this Figure 2 diagram is not and can never be a reliable picture of what is going on as is Figure 1. The simple reason for this is that animal tissues (including the tissues that make wool) do not require protein! What animals actually require are specific amounts of the essential amino acids that proteins contain. (Animals also need enough of a mixture of non-essential amino acids and surplus essentials to make their own amino acids to complement the essentials.)

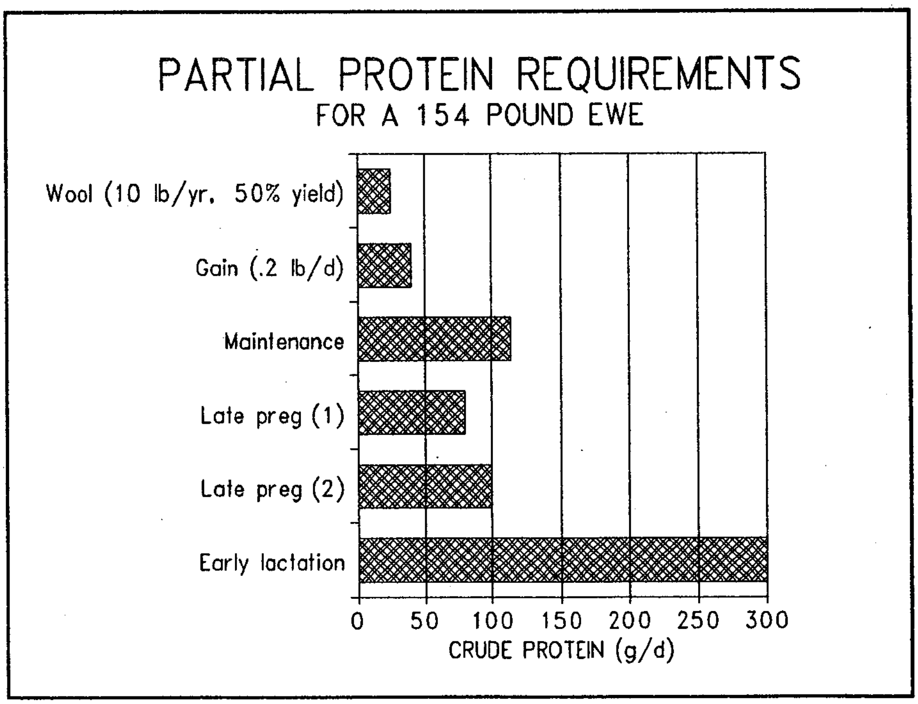


Figure 2. Protein requirements

Each tissue requires a different mixture of amino acids to make the proteins characteristic of that tissue. For example, the cells that secrete wool have an outrageously large requirement for amino acids containing the element sulfur. Wool protein is almost 10% cystine and some individual wool proteins are 24 and 29% cystine. Fortunately, sheep can make some of its own cystine out of methionine (another sulfur containing amino acid). Unfortunately, sheep can not make methionine (it is therefore an essential amino acid). No wonder nutritionists consider the sulfur amino acids to be the "first limiting nutrients" for wool production when energy is adequate.

To make matters a bit more interesting, the protein that sheep digest is not the protein that they eat. Sheep have a rumen full of microbes that consume the feed protein and turn it into the microbial protein and polypeptide which the sheep actually digest. Therefore, the amount of protein the animal gets usually depends on the yield of protein-rich microbes that exit the rumen. The quality (In the narrow view of the wool secreting cell, quality means sulfur amino acid content.) of the protein depends on the amino acid content of the particular microbe populations produced.

What is nice about this arrangement is that the microbes can convert low quality proteins to moderate quality proteins. This permits the production of lamb from forages and other feed resources that cannot support swine, poultry or human populations.

Unfortunately for wool production, microbial protein is only about 3.6% sulfur amino acids and wool, of course is much higher. Furthermore, those sulfur amino acids are needed for functions other than wool. The percentage of sulfur amino acids in milk and meat are not nearly as high as those in wool, but a great deal more meat than wool is deposited on a growing lamb each day and a great deal more milk protein than wool protein is secreted by a ewe each day of lactation.

Attempts to deliver more microbial protein to the sheep by increasing the percent protein in the diet above 8 or 9% usually do not increase wool production because the amount microbial protein produced stays about the same. Attempts to increase the % sulfur amino acids delivered to the sheep gut by adding them to the diet do not work either, since they are all converted to microbial protein with its characteristic amino acid pattern. Attempts to increase microbial protein output by increasing microbial yield by increasing energy intake can be successful, but usually result in a fat ewe with attendent reproductive and metabolic problems. It is generally not economically feasible to feed a high energy feed in order to increase wool production.

What can one do to maximize the wool productivity of sheep with the capacity to produce more wool than microbial protein can support? One must sneak high quality protein or methionine past the microbes into the lower gut. That way, the microbes do have a chance to reduce the sulfur amino acid content of the supplementary proteins before the sheep can absorb the constituent amino acids.

How might this difficult process be carried out? Some protein supplements (fish meal, blood meal, feather meal) contain components that are not particularly soluble in the rumen, but can be digested by the sheep in the lower tract. Other supplements which would normally be degraded in the rumen (methionine salts, casein, etc.) can be artificially protected by combining them with formalin, glutaraldehyde, tannins, etc. Both the natural and artificially protected supplements are the so-called "bypass" or escape protein products.

Evaluation of these bypass protein sources depends on the value of expected response (increased lamb gain, increased wool production, etc.) and the price of the supplement. Beware bypass protein products which result in the bypass of proteins which are inferior to microbial proteins. Beware also of proteins that are so well protected that they are not only insoluble in the rumen, but cannot be digested by the sheep either.

NUTRITIONAL STRESS AND WHAT TO EXPECT ON YOUR RANCH

Annual patterns: Match seasonal nutrient supply to animal needs

Animal: Animals differ somewhat in nutrient partitioning.

Productive systems: Highly productive systems that combine accelerated lambing with multiple births pose special nutritional demands for all functions and will compromise wool production and quality.

Maternal handicap: (see *Physiological and Environmental Effects on Wool Production* in these proceedings) Underfeeding may cause delayed or reduced development of secondary follicles and may reduce lifetime wool output and quality. This will probably not be a permanent noticeable effect for most of the breeds used in California. The detrimental effects of underfeeding on reproduction, growth and range condition are all much more important.

References

Black, J.L. and P.J. Reis. 1979. Physiological and Environmental Limitations to Wool Growth. CSIRO. Sydney.

National Research Council. 1981. The Nutrient Requirements of Goats. National Academy of Sciences. Washington, D.C.

National Research Council. 1985. The Nutrient Requirements of Sheep. Sixth Revised Edition. National Academy of Sciences. Washington, D.C.

Owen, J.B. 1976. Sheep Production. Bailliere Tindall. London.

Reynolds, L.L. and D.L. Brown. 1991. Assessing dairy potential of Western white-faced ewes. J. Anim. Sci. 69:1354-1362.

SID. 1988. SID Sheep Production Handbook. Sheep Industry Development Program, Inc. Denver.

GENETICS OF WOOL PRODUCTION

Gary D. Snowder
USDA-ARS, U.S. Sheep Experiment Station
Dubois, ID

INTRODUCTION

Domestication of sheep has resulted in significant genetic changes over time. The average fleece in the United States in 1810 averaged 2 lb, compared to 8.5 lb today. Much of this improvement has been in recent times as man came to an understanding of genetic principles. Improvement in quantity and quality of wool and lamb production became permanent with the application of effective selection methods. There is, yet, much potential for genetic improvement of wool production and wool quality.

The potential for genetic improvement of wool is dependent upon genetic variation in wool characteristics among and within breeds. The greater the genetic variation, the greater the potential for improvement. However, selection criteria must be based upon reliable estimates for genetic parameters. The number of traits to be selected upon must be limited if rapid genetic progress is desired. Therefore, it is important that traits for which the greatest progress can be made and, that are the most valuable are emphasized in selection. This paper will identify these traits and factors contributing to their genetic variation in wool production and discuss the results of relevant selection experiments.

UTILIZING BREED DIFFERENCES

Only a very small proportion of the over 450 breeds of sheep in the world can be considered as specialist wool producing breeds. Wool from these breeds can be divided into two broad categories related to end use: apparel type wools and carpet type wools. Apparel type wool is generally of less than 30 microns in fiber diameter.

Table 1 identifies wool characteristics of a sample of North American breeds and imported Australian Merino rams. Within North American there are large differences among and within breeds in wool. Importation of the Merino breed has increased the available genetic variability. The superiority in fleece weight and yield of the imported Merino rams is based upon the high degree of selectivity of the rams; such individuals may represent the top 10% for wool characteristics.

Table 1. Fleece Characteristics of Breeds of Sheep

Origin/Breed	Avg. Grease Fleece Weight (lb)	Avg. Fiber Diameter (microns)	Clean Wool Yield (percent)
North American Ewes[a]			
Columbia	10-15	23-30	45-55
Corriedale	9-14	24-31	45-55
Dorset	5-8	27-33	50-65
Finnsheep	4-8	24-31	50-70
Hampshire	6-10	25-33	50-60
Polypay	6-10	25-33	50-60
Rambouillet	10-15	19-23	45-55
Suffolk	4-8	26-33	50-60
Targhee	9-14	21-25	45-55
Australia Rams[b]			
Fine Wool Merino	36	21	76
Strong Wool Merino	40	24	78

[a] Source: SID Sheep Production Handbook, 1988.
[b] Average values for yearling rams available in the United States as either live or via frozen semen. Information obtained from commercial publications.

Caution should be exercised in using exotic breeds, such as the Merino. Adaptation of exotic breeds to foreign environments is critical and must be identified. The use of an exotic breed to improve one trait may be at the expense of another trait. For example, improvement in wool production may be offset by a decrease in reproduction, lamb survival, carcass merit, disease resistance or longevity. Several universities and research locations are currently evaluating the use of Merinos in crossbreeding schemes to provide such information.

Genetic progress can be achieved by utilization of breed diversity in the quantity and/or quality aspects of wool production. Three alternatives may be considered:

a) introduce superior exotic breeds and utilize them as pure breeds, generally by grading up,
b) systematic crossing of breeds for hybrid vigor and complimentarity of

traits, and

c) develop a new synthetic breed from a crossbred foundation.

SELECTION AND GENETIC PARAMETERS OF WOOL TRAITS

Within-flock selection programs require estimates of three parameters: heritability of individual traits, and phenotypic and genotypic correlations between pairs of traits. Heritability is defined as the proportion of phenotypic variation in a quantitative trait that is due to additive genetic effects. Heritability estimates over .40 are considered high, those from .20 to .40 are moderate. The relative progress of selection is related to heritability, thus the fastest progress may be made in traits with high heritability. Correlations indicate relative changes in traits, other than those under selection, for the lifetime of selected animals (phenotypic correlation) and in future generations (genetic correlations).

Heritability. Estimates of the heritability of significant wool traits are presented in Table 2. Grease fleece weight, fiber diameter and clean wool yield are considered as major determinants of economic returns for apparel wool producers. Fortunately, these traits, as well as most wool traits, are moderately or highly heritable.

Table 2. Heritability Estimates for Wool Traits

Trait	Average h^2
Grease fleece weight	.35
Clean fleece weight	.25
Yield	.40
Fiber diameter	.40
Staple length	.55

Source: SID Sheep Production Handbook, 1988.

Selection Response. Increased fleece weight has been selected for in different flocks and breeds. McGuirk (1983) summarized seven studies related to wool selection. All selection programs were successful in increasing average fleece weights over the control populations. Annual rates of progress in fleece weight varied between .85 and 1.66% per year. The more rapid rates of gain were observed in single character (fleece weight) selected flocks than in multi-character selected flocks.

Plateauing of selection responses for fleece weight has been observed after 2 to 3 generations (McGuirk, 1983). Plateauing of selection response can be due to several things (Rogan, 1984): a) inbreeding depression, b) genetic drift in the random bred control flock c) loss of additive genetic variation in the selected flock or d) genotype by environment interactions which restrict the expression of superiority of the selected line. Cessation of the rate of progress in the selected lines was found to be due to environmental limitations (nutrition); and the rate of response returned to its earlier levels after improved environmental conditions. Genetic improvement of fleece weight has been shown to continue over 30 years in a closed Merino line, averaging .68 percent annual increase in superiority over the nonselected control line (McGuirk, 1980). After 27 years (9.6 generation) of selection for yearling fleece weight in Romney sheep, fleece weight increased about 2.2 lb (1.2% per year), equivalent to 2 phenotypic standard deviations (Blair, 1986).

Correlated Responses. Indirect responses to selection are attributed to genetic correlations. Genetic correlations among wool traits are generally positive (Table 3). Selection for increased grease or clean fleece weight will result in increased fiber diameter and staple length. In some circumstances an increase in fiber diameter may not be desirable even if fleece weight is improving.

Table 3. Genetic Correlations Among Fleece Characteristics

Traits	Grease Fleece Weight (GFW)	Clean Fleece Weight (CFW)	Yield (Y)	Fiber Diameter (FD)	Staple Length (SL)
GFW	--	.71	-.18	.20	.19
CFW	--	--	.52	.18	.41
Y	--	--	--	.08	.42
FD	--	--	--	--	.02

Source: Averages of four Merino selection studies as reported by Rogan, 1984.

Indirect selection, the selection for a trait that is correlated with a more desirable or economically important trait, can be beneficial. Obviously, clean wool is the end point of the production system and would be a preferable selection trait, but calculating clean wool is an expensive process. The high genetic correlation between grease and clean fleece weight (.71) suggests that simple and inexpensive measurement of grease fleece weight and selection for it would result in a high efficiency of selection for clean fleece weight.

Estimates for genetic correlations between fleece weight and reproduction are not in agreement (Table 4). Breed variation and/or estimation procedures may explain this disparity of estimates. However, observed correlated responses in reproductive rates from long term selection studies may be more reliable. Selection for clean fleece weight over 20 years in Merino sheep resulted in no difference between the selected and control lines for number of lambs born or weaned (Turner et al., 1972). A slight improvement in number of lambs born and weaned was observed after selecting for grease fleece weight in Romney sheep over 24 years (8.5 generations) (Blair et al., 1985). Long term selection for fleece weight has not been reported to have a significant diverse affect on reproductive performance in ewes.

Table 4. Genetic Correlations of Grease Fleece Weight with Yearling Weight and Ewe Reproductive Traits

Trait	Breed	
	Rambouillet[a]	Merino[b]
Yearling weight	.03	-.11
Number of lambs born	-.14	.34
Number of lambs weaned	-.10	.34

[a] Shelton and Menzies, 1968
[b] Turner and Young, 1969

The genetic association between fleece weight and body weight has been reported between .14 and .24 but is generally reported as low but positive. Long term selection for fleece weight decreased body weight slightly in Merinos (McGuirk, 1983), but increased 3.3 lbs over 21 years in Romney ewes (Blair, 1986).

INHERITANCE OF UNDESIRABLE WOOL CHARACTERISTICS

There are several inherited traits which adversely affect a fleece's market value. The occurrence of most of these traits is at a very low level and are therefor, not often seen. A few of the more common inherited defects are:

colored fleeces
pigmentation in wool
hairy britch
felting lustre mutant

The appearance of an occasional "black sheep" in a white wool flock is due, in most cases, to a single recessive gene. A black sheep is homozygous for the recessive gene and should be culled, as well as the sire and dam.

Pigmentation of wool, grey to black patches, is common in most breeds. A single recessive gene causes the presence of more than one large area of pigmented wool. The inheritance of one or several black spots on a white fleece appears to be different, and its heritability remains unknown (Turner and Young, 1969). Culling is recommended for sheep with pigmented fleeces.

The britch area is one of the coarsest fiber areas on a sheep. Occasionally animals are identified as having a hairy britch. This occurs when the proportion of one or several different types of fibers (coarse or guard hairs or kemp) increases. Several factors may influence the expression of a hairy britch, including sex, age, nutrition and inheritance. Hairy britch is moderately heritable; therefor, reduced by selection.

A felting lustre mutant animal has a light yellow fleece devoid of crimp with a distinct lustre, from which it has derived its common name of 'silky'. The fleece mats and often sheds over time. Inasmuch as the mode of inheritance is simple dominance each new occurrence in a ordinary flock represents a mutation.

GENETIC ENGINEERING

Recent technological advances in biological sciences has developed a whole new field of genetics: genetic engineering. Genetic engineering is the manipulation of an organism's genome to control expression of genes, including the insertion of new genes from another organism. Transgenic animals and plants have recently been developed with improved efficiencies for growth and production.

It has been proposed that wool production may greatly benefit from genetic engineering technology (Rogers, 1990). Genetic engineering may improve the availability and composition of amino acids necessary for wool growth by a) creating a transgenic animal more efficient at partitioning amino acids, b) modifying rumen bacteria to synthesize essential amino acids and c) creating transgenic plants, such as alfalfa, to provide essential amino acids that are absorbed in the hindgut. A short discussion on the potential for improving wool production may be helpful for producers to understand the possible application of new genetic technology.

Transgenic Sheep. Transgenic sheep have been produced by double gene insertion with the biological ability to absorb cysteine, a sulphur amino acid essential for wool fiber development, at the rumen wall. Prior studies have shown that wool production increases with absorption of cysteine.

Australian scientists are currently working on developing transgenic sheep that have two new genes modifying the tricarboxylic acid (TCA) cycle to increase the amount of glucose produce in the body. Increasing glucose improves the availability of amino acids for wool growth.

Engineered Rumen Bacteria. Since sheep obtain most of their amino acids from protein synthesized by rumen microflora, and not directly from the plant community, the aim is to modify the genetic makeup of the rumen bacterial species with the capacity to synthesize protein which is richer in amino acids tailored to the animal's requirements. Current work related to rumen bacteria is attempting to improve the efficiency of rumen cellulose digestion (Hespell, 1985).

Engineered Forage Plants. Genetic manipulation of forage plants is another way to improve the availability of amino acids. Rogers (1990) identified three criteria to the success of this approach. First, a gene which encodes a protein with the appropriate amino acid must be found. Second, the protein must be relatively resistant to rumen degradation. Third, the gene must be highly expressed in the leaves and stems of pasture species.

A gene has already been identified in the pea which encodes for a low-molecular-weight protein (pea albumin 1 or PA1) rich in cystine and found to be resistant to rumen degradation. PA1 was successfully introduced into tobacco and clover but expression in the leaves must be improved upon (Higgin et al., 1989).

The future prospects for improving wool by genetic engineering are certainly fascinating. Transgenesis in sheep, plants and rumen bacteria are all contemporary major projects. Speculation on the application of genetic engineering has evolved into decisive research and development. The range in ways which wool growth could be improved might be extended as efficiency and methods of genetic engineering are improved upon.

IMPLICATIONS FOR COMMERCIAL WOOL PRODUCERS

The data summarized here have shown that wool characteristics are moderately to highly heritable, and will respond to selection. Gains in wool production are unlikely to be associated with major undesirable effects on other production characteristics, such as reproduction.

In breeds where wool is relatively unimportant as an economic source, selection for increased fleece weight should remain an unimportant breeding objective. Selection emphasis given to fleece characteristics should reflect its relative economic importance. Improvement programs for wool producing breeds should continue to select for increased wool production, while maintaining fiber diameter. The recommended procedure is to select rams on fleece weight with independent culling levels for fiber diameter, while selecting ewes on fleece weight.

Selection for improving fiber diameter is expensive and should only be considered when the mean fiber diameter of a flock is close to an economic threshold for wool pricing resulting in a significant increase in the average value of the fleeces.

Potential use of exotic breeds and genetic engineering may be of benefit to wool production. Producers should be cognitive of future developments in these areas.

References

Blair, H.T., D.J. Garrick, A.L. Rae and G.A. Wickham. 1985. Selection responses in New Zealand Romney sheep 2. Selection for yearling greasy fleece weight. New Zealand J. Agric. Research 28:267.

Blair, H.T. 1986. Responses to 27 years of selection for yearling fleece weight. Proceedings: Third World Congress on Genetics Applied to Livestock Production. Lincoln, Neb. Vol. XII:215

Hespell, R.B. 1985. In: Biotechnology and Recombinant DNA Technology in the Animal Production Industries. R.A. Leng (Ed.). University of New England Publishing Unit, NSW, Australia. pp 95-100.

Higgins, T.J.V., P.A. O'Brien and D. Spencer. In: The Biology of Wool and Hair. G.E. Rogers (Ed.) Chapman and Hall Publishing. pp 441-445.

McGuirk, B.J. 1983. Genetic selection for wool production. In: Sheep Production. W. Haresign (Ed.). Butterworths, London. pp 545-566.

McGuirk, B.J. 1980. The effects of selection for increased fleece weight. Proc. Australian Society Anim. Prod. 13:171.

Rogan, I.M. 1984. Selection for wool production. Proceedings: Second World Congress of Sheep and Beef Cattle Breeding. Editors: J.H. Hofmeyer and E.H.H. Meyer.

Rogers, G.E. 1990. Improvement of wool production through genetic engineering. Trends in Biotechnology. 8:6-11.

SID, 1988. Sheep Producers Handbook. Sheep Industry Development Program, Inc. Engelwood, CO.

Shelton, M. and J.W. Menzies. 1968. Genetic parameter of some performance characteristics of range fine wool ewes. J. Anim. Sci. 27:1219.

Turner, H.N. and S.S.Y. Young. 1969. Quantitative Genetics in Sheep Breeding. Cornell University Press. Ithaca, NY.

Turner, H.N., E. McKay and F. Guinane. 1972. Response to selection in Australian Merino sheep IV. Reproduction rate in groups selected for high clean wool weight. Aust. J. Agric. Research 23:131.

THE EFFECTS Of DISEASE AND PARASITES ON WOOL GROWTH

Frederick A. Groverman, DVM
Cotati Small Animal Hospital

INTRODUCTION

Normal growth of wool fibers may be altered by disease or deleterious effects of internal parasites. Similarly the result of external parasitic irritation may destroy normally grown wool fibers. Systemic disease has a variable effect on growth and quality of wool. Internal parasitic infections may produce a shorter, finer diameter fiber which reduces the yield of the fleece, but is seldom severe enough to cause a break in the fiber. Immunity and host-parasite relationships have an impact on disease and parasite proliferation resulting in altered wool growth.

DISEASE

In general, acute disease states that are stressful enough to produce high fever and/or result in prolonged periods of inappetence result in cessation of wool growth. A number of diseases may reduce wool fiber growth abruptly enough to cause a "break" in the fleece. Those causing high fever such as foot rot, sore mouth, pink eye, blue tongue, BVD, RS virus, or any systemic infection, and infections or conditions decreasing appetite or interfering with the process of grazing or eating will result in a break in the fiber that will appear in two to six weeks after the insult. Any of the above diseases may also be mild enough that fiber diameter is reduced and length of staple is affected without stress to break the fiber. A fleece with such a break may be nearly useless for spinning. Mycotic dermatitis and fleece rot primarily affect the skin and fleece itself, but have little direct effect on wool growth.

FLY STRIKE

Fleece rot may be a predisposing factor in the attack by the primary blowfly *Lucillia*. Fleece rot is a complex chain of reactions. Water must penetrate to the skin level and an insoluble protein needs to be present for bacterial growth. Low suint content and high wax/suint ratio on the other hand, favors resistance to fleece rot. In severe fly strikes, if animals survive, there may be enough stress to cause a break in the wool, otherwise fly strikes commonly account for less than a 10% reduction in fleece weight.

EXTERNAL PARASITES

Losses in wool weight and character are caused by infestations from the sheep ked, and biting and sucking lice. Keds suck blood and stain the fleece with their feces and because they puncture the skin, they cause blems in the leather. Other damage done by external parasites appears to be limited to the reaction of the host to the presence of the parasite.

Resultant itching and rubbing may cause reductions in clean fleece weight by up to 14%.

INTERNAL PARASITES

The extent of damage by internal parasites to wool growth and quality is more complex and harder to predict. Nose botts, liver flukes and gastrointestinal parasites, including protozoa may all affect fleece weight and quality. In artificially produced infections of liver fluke, wool growth was decreased by 20-39% at 6-12 weeks after infection. Subsequent growth was reduced 20-25% 12-24 weeks after infection, accompanied by clinical signs and death. Different parasites have different effects. *Trichostrongylus* has its greatest effect when nutrition is poor, while *Haemonchus* produces its greatest effect when nutrition is best. There is a synergistic effect of severe clinical disease when coccidia and *Nematodirus Battus* combine. The latter parasite has been recently identified in Oregon.

A number of studies of artificial infections of gastrointestinal nematodes produce varying results of depression in wool growth. Depending on the study, reductions in wool growth ranged from 10 to 59%. Live body weight gain and wool growth are not always comparable. One conclusion was that the greatest effect of worm infection would be exerted on that part of the body growing most rapidly at the time of greatest infection, resembling the effect of a lowered nutritional level. Artificial infections in previously uninfected sheep have shown that gastrointestinal parasites can reduce wool growth by as much as 59% over a short period, without clinical disease or reduced feed intake.

Early studies in the 1930's before the presence of more effective wormers showed monthly treatments produced fleece weight responses of no more than 10%. In one study in monthly treated compared with untreated sheep, live weight gain was greater in the first year, the same in the second year and less in the third year, whereas wool production was greater in each successive year by 44%, 23%, and 13%. The researchers suggestion was that parasitism in the weaner year may produce permanent damage to wool producing ability, or that continuing exposure to larval intake leads to reduced wool production, but with little effect on live weight. The effects of gastrointestinal parasite infections on wool production seem to be less in adult non-reproducing sheep with prior experience (resistance) of infection than weaners.

Variations in immunity in the producing ewe with a parasite load and exposure to parasite laden pastures make a more complex prediction of fleece growth and quality. There is a temporary partial loss of immunity to parasites which occurs during lactation. It has been shown that a rise in worm egg counts occurs in lambing ewes 2 weeks before to 8 weeks after lambing. The depressing effect of parasites on wool growth is greater in the lambing ewe than non reproducing sheep. Wool growth response to a pre-lambing drench is likely to depend on the level of post drenching reinfection. Similarly effects of lactation on wool growth in grazing ewes will be influenced by the parasite load on the sheep and their pastures. In another study live weights (16- 19%) and wool weights (22-26%) were significantly higher in ewes drenched every two weeks while grazing with ewes drenched only twice during the summer.

There is an apparent lag between the presence of parasites and their effect on wool production of up to several weeks. Much still needs to be learned about the interrelationships between wool growth, nutrition and immunity or parasitic resistance. Nutrition plays a role in immunity beyond general health such as Vitamin C, D, and E, as well as minerals and stress.

SUMMARY

Management of the sheep's environment is critical if maximum wool growth and quality of fleece is to be accomplished. Early recognition and control of disease states requires vigilance. Routine inspection and observation with planned therapy of sheep for control of external parasites is important. Dealing with internal parasitic disease is more difficult. It is helpful to have an understanding of parasite immunity and cycles of parasitic proliferation. The use of fecal egg counts may be a crucial step in judicious and effective, economical control of gastrointestinal parasites. Timing of routine worming is essential. It is far better to worm and place sheep on an uncontaminated pasture than return to a contaminated one.

References

AASGP newsletter Vol 12,#2 April-May, 1984

ibid, Vol 9 ,#4, Oct.-Dec. 1981

Baker, Norman DVM, U.C.D. Parasitology Notes, Spring 1988

Donald, A.D. McMaster Laboratory C.S.I.R.O. Health, Giebe, N. S. W. 2037 Australia, Division of Animal Health, Effects of parasites and disease on wool growth.

Castaldo, D. J. PHD, Large Animal Veterinarian, May-June, 1989

Catchpole, J. and Harris, T.J. Vet Record 124; 607-605 1989 Synergistic production of severe clinical disease.

Lipson, M., Wool Technology and Sheep Breeding, Sept.-Oct. 1978 p.27 The significance of certain fleece properties in susceptibility of sheep to fleece rot.

PHYSIOLOGICAL AND ENVIRONMENTAL EFFECT ON WOOL PRODUCTION

Martin R. Dally
Department of Animal Science
University of California - Hopland Field Station

INTRODUCTION

This paper will discuss the ways an animal's physiological state and environment affects its ability to produce wool. There are many ways that wool production is affected by the sheep's physiological state, the environment, and the interaction between the two. Because of the limited time, only those effects causing significant reduction in wool growth will be covered. No attempt will be made to discuss the effect nutrition and diseases have on wool production since the topic will be covered by other speakers.

SEASONAL VARIATIONS IN WOOL GROWTH

There is a significant difference in the rhythmic or seasonal wool growth between breeds. In New Zealand, Corriedales' winter wool growth is 73% of their peak summer growth. New Zealand Romneys' wool grows twice as fast in the summer as during the winter. Research conducted on Merino and Wiltshire sheep in Scotland showed vast differences in the seasonal effect on wool growth. The Merino fiber diameter was close to 20 microns through the year and grew approximately 7.5 mm per month, whereas the Wiltshire fiber diameter varied from 40 microns during the winter to 80 microns during the summer, varying in growth rate from three to 12 mm per month.

Another study showed that Merino wool growth was reduced by 15% in the winter compared to a 70% reduction among other breeds. The Clun Forest breed in Great Britain failed to exhibit any seasonal variation in staple growth. It is quite evident that the rhythmic wool growth pattern differs between breeds and that coarse wool breeds have the most extreme variation. New Zealand studies using Romneys have reported that the variation in wool production between seasons is largely due to the change in fiber diameter.

Seasonal variation in wool growth was first reported over 130 years ago and was thought to be due to seasonal changes in the sheep's diet. Studies where the dietary intake was held constant indicated that the seasonal wool growth rhythm was not controlled entirely by change in diet. Animals fed a constant diet still exhibited a seasonal rhythm. The highest wool growth normally takes place during the summer and the lowest during the winter. Figure 1 on the next page shows an annual wool growth cycle for New Zealand long-wooled ewes.

Wool growth changes can occur in two ways: (l) the rate at which the fiber length increases (staple growth); and (2) the change in fiber diameter. Changes in fiber diameter are measured in microns. One micron is equal to one millionth of a meter or approximately one twenty-five thousandth of an inch.

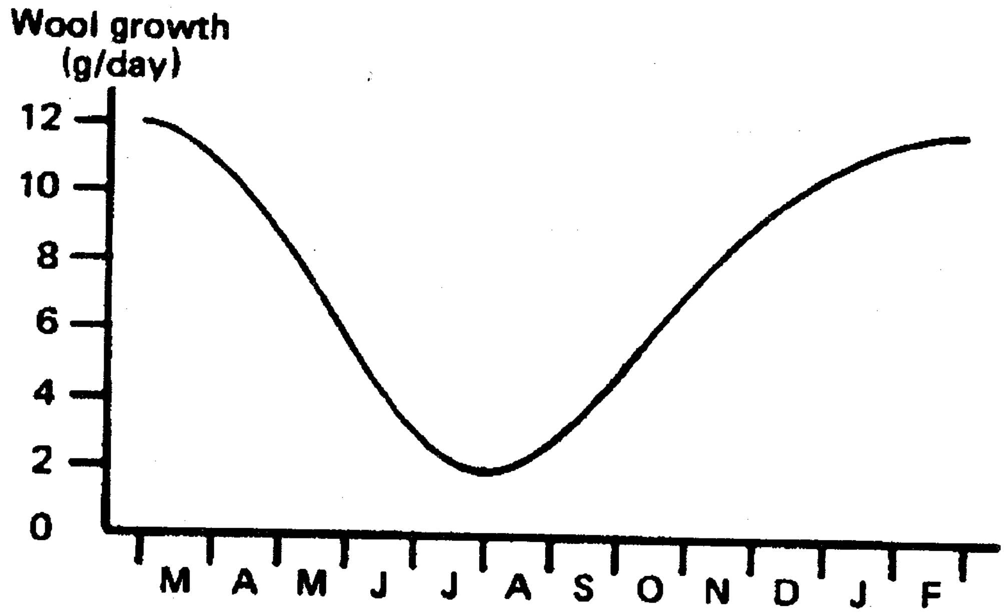


Figure 1 Seasonal wool growth pattern of New Zealand long wool ewes. Source: Aglink FPP326

Table 1 shows the monthly growth pattern for New Zealand Romney breeding ewes in staple growth rate and fiber diameter. Higher growth during the summer led researchers to believe that the higher atmospheric temperatures attributed to the increased wool production. The assumption was that high temperatures would cause dilation of the blood vessels of the skin and therefore increase the flow of nutrients to the wool follicles. The opposite effect would take place during the cold winter months causing less wool growth.

Table 1. Seasonal Wool Growth of A New Zealand Romney Breeding Ewe

Season	Month	Fiber Growth (%)	Length Growth (mm/day)	Average Diameter (microns)
Spring	Oct.	6	0.48	34.1
Spring	Nov.	9	0.61	37.3
Spring	Dec.	12	0.66	40.5
Summer	Jan.	12	0.64	41.5
Summer	Feb.	12	0.63	41.9
Summer	Mar.	11	0.59	40.0
Fall	Apr.	10	0.59	38.7
Fall	May	9	0.56	38.6
Fall	Jun.	7	0.49	35.3
Winter	Jul.	4	0.39	31.9
Winter	Aug.	3	0.41	28.5
Winter	Sept.	4	0.43	30.2

Experiments designed to study the effects of temperature on wool growth have not clearly indicated that increasing the temperature during the winter would result in greater wool growth. A Canadian study in which sheep were housed and exposed to temperatures as much as 29 F above the unhoused control animals (exposed to the normal Canadian winter weather) resulted in no significant change in wool production. New Zealand research found that raising the atmospheric temperature by 14 F modified the wool growth rhythm, but did not abolish the rhythm. Several studies have demonstrated that raising temperatures for well fed sheep during the winter had not effect on wool production. Atmospheric temperatures appear to have more of an effect when dietary intake of the sheep is limited. Australian data has demonstrated that when adequate feed is available under pasture conditions, mean temperature has little effect on wool growth. The rhythm in wool growth was 83% for the pasture grazed sheep and appeared to be related directly to seasonal changes in nutrient intake.[1]

Australian research has indicated that breed of sheep may effect their ability to respond to increased temperature. Merino ewes kept at a constant temperature, 80.6° F for 18 months, and exposed to normal variations in day length showed a complete lack of rhythmic wool growth. When the air temperature was reduced for four weeks wool production decreased. These findings suggest that Merino wool production is controlled entirely by change in atmospheric temperature when dietary needs are met. In experiments with breeds other than Merinos, where both nutrition and temperature were held constant throughout the year, the rhythmic growth pattern was still present.

Many researchers thought that the day length or photoperiod was the controlling factor for wool's rhythmic growth. Experiments designed to study the effects of photoperiod have reported mixed results. Various studies regulating the photoperiod have resulted in increased wool growth, but have not eliminated the rhythmic growth. In a controlled photoperiod trial using Corriedale ewes the rhythmic growth was still evident after two years of treatment. Another study using artificial light reported a 15% increase in wool growth. In this study the ewes received eight hours of light and 16 hours of darkness. However, the diet was not held constant and the ewes were pregnant for part of the time. These two factors may have played a major role in the trial's outcome. A study using a pattern of four hours darkness and two hours of light reported a 20% increase in wool growth during the fall to mid-winter period. It is interesting to note that the animals were on the light treatment for five months before the increase in wool growth was reported. Other trials using controlled photoperiod have failed to increase the wool production when temperatures and diet were held constant.

---

[1] The percent rhythm has been calculated from the following formula:

$$\%Rhythm = \frac{H-L}{(H+L)/2} x100$$

(H = highest wool production obtained during the summer, L = highest wool production obtained during the winter.)

In a New Zealand experiment using Romney ewes that were hooded, the rhythmic wool growth slowly declined to the point that it was virtually eliminated. The wool production of the hooded sheep was steady for two years after a five month lag period. The annual wool production of the hooded sheep was reported to be the same as unhooded animals.

In a practical sense it is not economically feasible for producers to attempt to control the photoperiod and/or temperature in order to increase wool growth. Increasing the plane of nutrition appears to be the only practical way to increase wool production. The increased wool production will not pay for the cost of increasing the dietary intake. Therefore, increases in the production traits must also take place as a result of the improved diet; for example, an increase in pound of lamb weaned per ewe exposed. Increasing the plane of nutrition may be justified if it will prevent wool from breaking. Wools with good tensile strength are considerably more valuable than broken or tender wools.

AGE AND ITS EFFECT ON WOOL PRODUCTION

Age of the sheep will affect wool production and several characteristics of the fiber. Fiber diameter increases with age. The age effect is greater in rams than in ewes. The average fiber diameter in Merino rams increases about 2 microns from 1-1/2 years to 2-1/2 years and approximately 1 micron each additional year up to 5-1/2 years of age. Therefore, it is quite possible that a ram purchased at 1-1/2 years of age with 21 micron wool (64's) would be shearing 26 micron wool (56's) at 5-1/2 years of age.

Ewes, on the other hand, only have minor changes in fiber diameter over their productive life. From 1-1/2 years to 2-1/2 years the average increase in fiber diameter is .25 microns and .5 microns for each year thereafter,up to 6-1/2 years of age. Figure 2 shows the average effect of age on fiber diameter for rams and ewes.

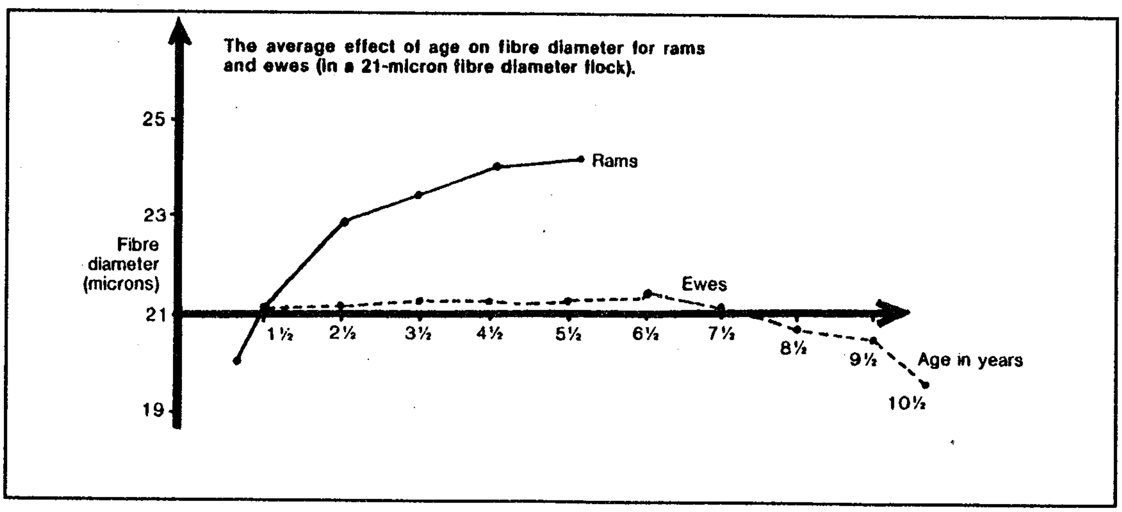


Figure 2 Average effect of age on fiber diameter for rams and ewes in a 21 micron flock. Source: Agnote 3065/85.

Staple length reaches its maximum growth at approximately 2-1/2 years and declines with increasing age. Australian data indicates that staple length decreased 5 percent between 2-1/2 and 5-1/2 years of age and the decline was 20 percent by 101/2 years of age.

Age also affects the number of crimps per inch and the amount of abnormal crimps. In Australian Merino ewes it has been reported that at age 6-1/2 there are 12.7 percent less crimps per inch than seen at 2-1/2 years of age. Older sheep have more crimp abnormalities and produce more doggy wool.

Merino rams 16-24 months of age produce 20 percent more grease wool than ewes the same age. Wethers kept for wool production in Australia produce approximately 10 percent heavier fleece than ewes. This is due primarily to the wethers' larger body size and to ewes producing lambs.

Maximum wool production among Merino, Rambouillet, Romnelet, and Corriedale ewes is reached between 3 and 4 years of age and then declines. In New Zealand, Romney ewes reach maximum fleece weight at 3 years of age, whereas Coopworth and Perendale ewes reach their maximum one year later.

There are two known reasons for the decline in wool production with age. The first is that fiber weight per follicle declines. Although fiber diameter increases with age, there is a relatively greater reduction in fiber length. The second reasons for decline in wool production is a decrease in the number of follicles producing fibers. An Australian study concluded that 20-30% of the decline in wool production was a result of a decrease in the number of follicles producing fibers, therefore, 70-80% of the loss in wool production could be accounted to a decrease in fiber volume.

EFFECTS OF TEMPERATURE

Weather conditions may cause increase or decrease in wool growth; directly, by affecting metabolism of the wool follicle, or indirectly, by affecting feed intake. Several researchers have reported depressed wool growth when sheep are exposed to heat stress. A decrease in feed intake was stated as being the reason for the depressed growth. A study using pregnant Merino ewes found that wool production was decreased when the ewes were exposed to 108 F for 8 hours and 90 F for 16 hours during the last 100 days of gestation. The food intake for the ewes was depressed by 40%. New born lambs from the heat stressed ewes had 50% less follicles than lambs from non-heat stressed ewes. Another study where ewes were heat stressed during the last month of pregnancy reported that their lambs had a decrease in number of mature secondary follicles.

The evidence shows that heat stress will affect wool production primarily due to a decrease in feed intake. The effect of heat stress on pregnant ewes can not only effect their wool production, but their offspring's as well. If possible producers should try to avoid having ewes in late gestation during periods of extreme heat. Providing shade and clean water can reduce the effect of heat stress.

Extremely cold temperatures have been reported to cause a decrease in wool growth. However, decreases have not been reported among full-fleeced sheep being fed an adequate diet. The problem occurs when sheep are freshly shorn and undernourished. An Australian study indicated that newly shorn sheep in poor body condition, exposed to cold wet weather, had a reduction in feed intake, thereby resulting in a decline in wool production. The animal feed intake was about half of their pre-shearing intake. Sheep that were in good condition had no reduction in food intake after shearing.

Mild cold exposure, post shearing, can result in an increase in wool growth if adequate feed is available. Removing the fleece increases the metabolism of the animal which stimulates increased feed consumption. Australian researchers reported a 42-62% increase in digestible organic matter consumption of grazing animals and 20-51% increase for yard fed animals after shearing. Another Australian study found that consumption only increased 16.5% post shearing. The mean minimum temperature was 65 F, whereas in the first study the minimum mean temperature was 52 F. Increased feed intake could be seen for up to 30 days post shearing.

If sheep are to be shorn during periods when wet cold weather may occur, it is recommended that adequate feed be provided to avoid depressed wool growth and death loss due to hypothermia. Sheep in poor condition should not be shorn until weather conditions are favorable.

EFFECTS OF PREGNANCY

The amount of reduced wool growth during pregnancy depends on the number of fetus and the plane of nutrition. Generally 3-10% decreases in annual wool production are seen due to pregnancy. The effects of pregnancy are greater when the plane of nutrition is lower and the effects are seen earlier, In a study comparing wool growth from Corriedale ewes, during the last 80 days of gestation, pregnant ewes produced 30% less wool than non-pregnant ewes. Similar results have been reported using Suffolk and Romney ewes. A reduction of 30% during the last 60 days of gestation has been reported among Merino ewes. In another study using Merino ewes a 40% reduction took place during the last 35 days of pregnancy.

A United States study using Targhee ewes reported a 5.4 and 7.9% reduction in clean wool production for ewes carrying one or two fetuses when compared to non-pregnant ewes. An Australian study reported that pregnancy lowered the total numbers of fiber, but lactation caused no further reduction. The opposite results were reported in a Canadian study and showed that ewes lactating for twins had a greater fiber reduction during lactation. Comparing ewes carrying singles with twins in the Canadian data shows that both average fiber diameter and staple length were affected by the number of fetuses. During late pregnancy, ewes with twin fetuses produced fiber that was 1.3 micron finer and 1.6 mm shorter than ewes carrying singles .

EFFECTS OF LACTATION

An experiment at the Pastoral Research Laboratory, Armidale, N.S.W., Australia, on 231 Corriedale ewes was conducted to determine the effects of a shorter lactation period on wool production. Two planes of nutrition were used. One represented the normal level required by lactating ewes and the other being above the normal requirement. Some lambs were weaned at 42 days of age and 84 days of age. The remainder of the lambs on the high plane of nutrition were weaned at a mean age of 145 days and the remainder of lambs on the high and low plane of nutrition were weaned at a mean age of 203 days, respectively.

Dye-bands were applied to each ewe at lambing and at 6, 12, and 18 weeks post-partum. Dye-bands were also applied to non-lactating ewes over corresponding periods. At 24 weeks post- partum, a mid-side sample was scoured to determine clean wool yield and the dye-band staples measured to determine rates of wool growth during consecutive periods after lambing.

Comparisons with the non-lactating ewes showed that lactation periods of 6, 12 and 18 weeks reduced fleece weight by 5.0, 8.6 and 9.7% respectively. This indicated that the effect on wool production diminishes as lactation advances. Over the period from 12 to 18 weeks wool growth was reduced by an average of 31 grams of clean wool per day. The reductions in the preceding six-week periods were more than twice as great. These results are similar to another Australian study using Merino ewes.

Non-lactating ewes were compared with ewes that had a 12 week lactation period. Those ewes on the high plane were found to have produced 7.1% less wool while the ewes on the low plane produced 10.7% less wool. The comparison between ewes having their lambs weaned at six weeks and those having lambs weaned at twelve weeks showed that the ewes on the high plane of nutrition had no further decline in wool production during the additional six weeks of lactation. Ewes on the low plane of nutrition showed a further reduction in wool growth. Ewes that had lambs weaned at six weeks under both levels of nutrition produced more wool than the ewes having lambs weaned at twelve weeks. The above results are similar to those reported when Merino ewes were confined in individual pens and hand-fed.

An Australian experiment was one of the first to clearly separate the effects of pregnancy and lactation. Merino ewes giving birth to single lambs were divided into two groups. Half the ewes had their lambs removed within a few hours of birth, therefore, lactation was never established. The remaining ewes nursed their lambs for 98 days. Both groups were allowed to graze pastures stocked at rates well within the pastures' carrying capacity. Seven days after lambing, tattooed patches were sheared. The patches were sheared again twice during the 98-day lactation and 35 days post weaning. Lactating ewes on the average grow 15.9% less wool than non-lactating ewes. The difference ranged from 14 to 18%. These results are comparable to a similar study using Scottish Blackface ewes where lactation reduced wool growth by about 12%. Another experiment was designed to study the effects that limiting feed intake would have on wool production during lactation. This study showed that wool growth would be reduced as much as 50% during the lactation phase.

Depressed wool growth cannot be eliminated during lactation. Its effect, however, can be lessened somewhat by increasing the plane of nutrition and decreasing the length of the lactation. This is especially true for ewes nursing twin lambs.

EFFECT OF COMBINATION OF PREGNANCY AND LACTATION

Research with New Zealand Romney ewes found that, on the average, ewes raising a single lamb sheared one pound less than barren ewes and approximately half pound more than ewes raising twins. Border Leicester x Merino ewes raising twins produced .68 pounds less wool than ewes raising singles and 1.33 pounds less than barren ewes. Australian Merino ewes raising lambs had an annual wool production of 10-14% less than barren ewes. A Texas study indicated barren Rambouillet ewes produced 5% and 9% more wool than ewes raising single and multiple lambs respectively. Corriedale and Polworth ewes in Australia were reported to have 11 and 10% decrease in wool production due to the effects of pregnancy and lactation.

Australian data also indicates that 33% of the reduced wool production was due to a decrease in fiber numbers. Decreased fiber volume accounted for 66% of the decline. Both reduction in fiber diameter and shorter staple length accounted for the decrease in volume. Decreased fiber diameter was more pronounced in ewes nursing twins. Twin nursing ewes had a 12% decline in fiber diameter compared to 6% for single nursing ewes.

It is quite clear that pregnancy and lactation causes a reduction in wool production. The effects of carrying and lactating twins may be reduced by providing a higher plane of nutrition. One could not economically justify increasing the plane of nutrition solely on improved wool production. However, increased milk production would likely take place resulting in higher lamb grains and better survival.

References

Bigham, M.L. 1975. Guidelines for Wool Production in New Zealand. Sheep Farming Annual 1975. Massey University, New Zealand.

Black, J.L. and P.R. Reis. 1979. Physiological and Environmental Limitations to Wool Growth. University of New England Publishing Unit, Annidale, New South Wales, Australia.

New Zealand Ministry of Agriculture and Fisheries. 1987. Sheep Wool Production - Nutrition and Seasonal Effects on Long-wooled Ewes. Aglink FPP 326. Wellington, N.Z.

Ryder, M.L. and S.K. Stephenson. 1968. Wool Growth. Academic Press. New York.

Victoria Department of Agriculture. 1985. Fleece Testing of Rams. Agnote 3065/85. Melbourne, Australia.

WOOL GRADING

Stephanie Larson
Livestock and Range Management Advisor in
Sonoma and Marin Counties

Grading is defined as classifying fleeces according to fineness (fiber diameter) and length of staple. There are three systems used to grade wool fineness; blood, spinning count and micron diameter. The relationship between the three systems is presented in Table 1.

Table 1. Wool Grading Systems and Variability Standards

		Standard Specifications		
Type of Wool	**Old Blood Grade**	**Numerical Count Grade**	**Limits for Average Fiber Diameter (microns)**	**Variability Limit for Standard Deviation Maximum (microns)**
Fine	Fine	Finer than 80's	Under 17.70	3.59
Fine	Fine	80's	17.70-19.14	4.09
Fine	Fine	70's	19.15-20.59	4.59
Fine	Fine	64's	20.60-22.04	5.19
Medium	½ Blood	62's	22.05-23.49	5.89
Medium	½ Blood	60's	23.50-24.94	6.49
Medium	⅜ Blood	58's	24.95-26.39	7.09
Medium	⅜ Blood	56's	26.40-27.84	7.59
Medium	¼ Blood	54's	27.85-29.29	8.19
Medium	¼ Blood	50's	29.30-30.99	8.69
Coarse	Low ¼	48's	31.00-32.69	9.09
Coarse	Low ¼	46's	32.70-34.39	9.59
Coarse	Common	44's	34.40-36.19	10.09
Very Coarse	Braid	40's	36.20-38.09	10.69
Very Coarse	Braid	36's	38.10-40.20	11.19
Very Coarse	Braid	Coarser than 36's	Over 40.20	---

Source: National Wool Grower, February 1988.

Blood System

The blood or American system as it is sometimes referred to is the oldest system originating with the early American colonies. The system was originally based on the fraction of Spanish Merino blood a sheep possessed. Merino wool is classified as fine. Wool types grown on sheep with fractional quantities of Merino breeding are called 1/2, 3/8, 1/4, low 1/4 and common blood. Therefore 1/2 blood wool would come from an animal having half Merino breeding. Over time the association with the breeding of the sheep was dropped and wool classers came to associate a certain range of fiber diameter with a specific grade. The blood system is the least accurate grading system and is obsolete by today's standards.

Spinning Count

The Bradford count system or British system is a more extensive method of grading wool. The term spinning count refers to the number of "hanks" of very fine yarn that can be spun from one pound of wool top. Top is a continuous untwisted band of wool fibers from which the shorter fibers or noils have been removed by combing. A hank of yarn is 560 yards in length. The count system divides wools into 16 grades with the counts ranging from finer than 80's to 36's. Wools with the higher counts are finer and can be spun into longer, finer yarn. For example, a pound of top graded 64's would produce 35,840 yards (64X560) of yarn or 64 hanks, while wool graded 44's would only produce 24,640 yards or 44 hanks.

Micron System

The Micron System, the most technical and accurate system of grading, was largely developed at the Denver Wool Laboratory, USDA. The system separates wool into 16 grades according to the average fiber diameter as measured by a micrometer. Wools too variable to fit in the limits of a grade are dropped down a grade. The variability limits are presented in Table 1.

The difference in the average fiber diameter between the finest and coarsest of the 16 grades is extremely small, as a single micron is one millionth of a meter or 1/25,400 of an inch. For example, an 80's wool averages about 18 microns which is less than half a 36's wool that averages 39 microns.

Fiber Diameter Measurements - Microprojection

Fiber diameter can be objectively determined by several methods. The microprojection method requires a small sample of clean wool. Shot segments of fiber less than 0.5 mm in length are placed on a microscope slide mixed in oil and covered with a glass slip. The fiber images are magnified 500 X and projected on a screen so that the diameter of individual fibers can be measured. A standard wedge card is used to measure the fibers. The number of fibers measured will depend on the accuracy required. Normally, between 200 and 800 fibers are measured per sample. Coarser wools usually require a higher number of fibers to be measured due to the higher variability in fiber diameter. Microprojection is a expensive, tedious and time-consuming task. A skilled technician can measure 200 fibers in about 20 minutes. The advantage of the microprojection method is that the average fiber diameter as well as the variability of the sample can be calculated. The variability or standard deviation is important when fiber diameter data is to be used in selecting a stud ram.

Fiber Diameter Measurements - Air Flow

The air flow method for determining fiber diameter takes less than a minute to measure a wool sample and is considerably less expensive than the microprojection method. This method only gives the average fiber diameter and therefore is not used when standard deviations are required. Airflow testing requires a 2.5 g sample of scoured and carded wool that has been stored in a conditioning room at a constant relative humidity of 65 percent and a temperature of 68 F. The sample must be free from vegetable matter and evenly blended. Once the sample is properly prepared it is loaded into the airflow instrument's chamber and compressed to a constant volume. Air is then sucked through the sample with the resistance to the air passing through the wool being measured. This resistance is proportional to the mean fiber diameter. The airflow method is a good test for measuring wools that are relatively uniform in diameter. Samples with large standard deviations usually are given higher mean fiber diameter reading with the airflow method than with microprojection.

Fiber Diameter Measurements - Sonic Fiber Test

The sonic fiber fineness test method is similar to the airflow except it involves low frequency sound waves instead of air. Tests conducted at the University of Wyoming comparing the airflow and sonic methods indicated that the sonic test tended to measure fibers finer than the airflow.

Fiber Diameter Measurements - Laser Fiber Fineness Distribution Analyzer

The most sophisticated instrument used for measuring fiber diameter is the Laser Fiber Fineness Distribution Analyzer. It was developed in Australia during the 1970's and is now commercially available as the Peyer Texlab FDA200 System for approximately $47,500.00. The FDA 200 uses it's laser optic eye to measure 2000 fibers, calculating a mean, standard deviation and coefficient of variation. A histogram is then printed out, the hole process takes approximately three minutes. The FDA200 can accurately measure fibers between 18 and 35 microns. In tests comparing the FDA200's average fiber diameter, results were only slightly and consistently higher than those obtained using the microprojection method. Standard deviations were also higher for the FDA200.

Staple Length

Grading by definition also involves classing wools according to staple length. Staple length is the length of wool obtained by measuring the natural staple without stretching out or disturbing the crimp of the fibers. Wools that are tippy with a pyramid shaped tip, should be measured from the base of the staple to a point midway between the base of the pyramid-tip formation and the end of the tip. There are three staple length classifications; staple, french combing and clothing. Table 2 gives the staple length required by grade. The coarser the wool the longer it must be to meet minimum length requirements for each classification. For example 64/70's wool only has to be 2 3/4 inches long to be classified staple, however, a 58's must be at least 3 1/4 inches long.

Table 2. Staple Length Requirements by Grade

		Length Class	
Grade	Staple	French Combing	Clothing
64/70s	2 ¾" & longer	1 ¼" to 2 ¾"	Less than 1 ¼"
60/62s	3" & longer	1 ½" to 3"	Less than 1 ½"
56/58s	3 ¼" & longer	2 ¼" to 3 ¼"	Less than 2 ¼"
50/54s	3 ½" & longer	---	Less than 3 ½"
46/48s	4" & longer	---	Less than 4"
36/40/44s	5" & longer	---	Less than 5"

Source: SID Sheep Production Handbook, 1988.

References

ASTM Standards of Textile Material. 1957. American Society for Testing Materials, Philadelphia, PA.

Jones, Travis. 1985. Wool Preparation and Marketing. National Wool Growers Association. Denver, Co.

Ralston, L. 1988. Why the Wide Spread in Wool Prices? Nation. Wool Growers. February 1988. Denver, Co.

Ryder, M.L. and S.K. Stephenson. 1968. Wool Growth. Academic Press. New York, N.Y.

SID, 1988. Sheep producers Handbook. Sheep Industry Development Program, Inc. Engelwood, CO.

ECONOMICS OF WOOL PRODUCTION

Gary D. Snowder
USDA-ARS, U.S. Sheep Experiment Station
Dubois, ID

INTRODUCTION

Sheep are considered dual purpose in the U.S., producing red meat and wool fiber. The impact of wool on the total income is often discounted by producers. Wool revenue has been estimated to contribute 25 to 30 percent of the total income on a per ewe basis. In 1991 the value of wool was a much more significant factor than in previous years due to depressed lamb prices. Some degree of control over wool prices is available to producers. Comprehension of factors influencing wool prices will help producers make sound management and marketing decisions.

Wool prices in the U.S. are greatly influenced by fluctuating international markets. The U.S. wool sales volume is relatively low compared to the volume of such countries as Australia and New Zealand; thus, the U.S. wool market has little, if any, effect on domestic and international wool prices. However, the prices a U.S. producer receives can be influenced upward or downward by several factors under his control. This paper will discuss what factors a producer can control, and how they impact the value of his wool clip.

PREHARVEST FACTORS AFFECTING FUTURE FLEECE VALUE

The value of a wool clip is influenced from the moment it continues to grow after an animal is shorn until the next shearing. This period will have the greatest effect upon the quality of wool fibers harvested. The quantity of wool, fleece weight, is usually more under the influence of an animal's genetic potential, because environmental and nutritional requirements for wool growth are generally adequate. Some environmental factors which adversely affect fiber growth and quality include poor nutrition, temperature extremes, disease and poor management. The economic impact of these factors on wool value will be discussed under marketing of a wool clip.

Quality of a fleece is determined by evaluating its uniformity for fiber diameter, clean wool yield, staple length and absence of contaminants. As will be discussed later, price variation is correlated to quality characteristics. Premiums are paid by wool processors and manufacturers of yarn and fabric for high quality wool clips. Undesirable characteristics in a wool clip, as they relate to the manufacturing of wool yarn or fabric, are discounted.

Ideally, fiber diameter is uniform the length of the fiber and over the entire fleece of the animal. Disease and nutritional stress can decrease the fiber diameter at a specific position on the fiber. If the diameter has been sufficiently depressed the fiber breaks during processing. The position of a wool break is critical to fleece value. Breaks at the ends of a fiber are less detrimental to the manufacturing process than are breaks that occur in the middle of the fiber. Because breaks often occur during late pregnancy and early lactation it is recommended that ewes be fed to meet their nutritional needs during this period. Shearing prior to or after lambing will position a break at the fiber end or tip. Fleeces from sick sheep should not be mixed with the flock wool clip.

High yielding wool reduces the manufacturers' costs of scouring and carding the wool into top, and the end quality of yarn or fabric. Low yield fleeces require additional scouring and processing to remove contaminants. If all of the contaminants are not be removed during manufacturing the end product is flawed. In most wool marketing organizations, price is influenced by estimated clean wool yield.

Two major categories of contamination have been identified: natural and foreign. Naturally occurring include urine, dung and yolk stains. The origin of foreign contaminants may be animal, plant, mineral or manmade. Natural contamination cannot generally be controlled by man. Crutching of feedlot lambs and ewes prior to lambing has been proven to reduce the amount of tags at shearing.

Foreign contaminates can be controlled to some degree. Blown dust and dirt can be controlled around feedlots and holding pens by planting windbreaks. Plant contaminants such as seeds, burrs, straw and chaff can be reduced by the following approaches:

remove the contaminant plants from grazing areas
graze the area before seed formation
avoid bedding sheep on straw prior to shearing
eliminate overhead hay feeders
skirt out contaminated wools

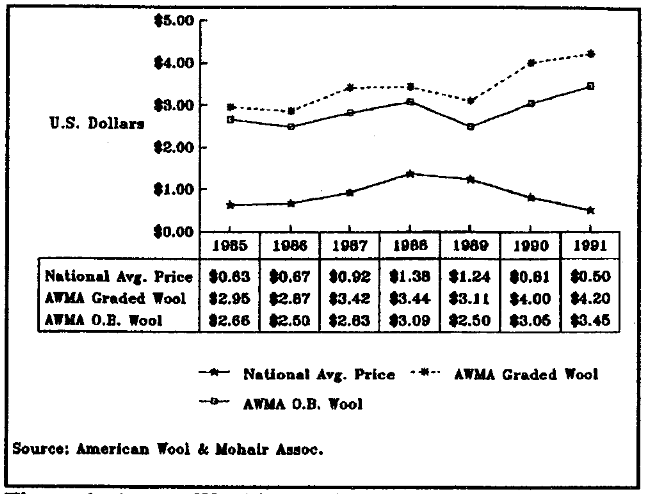
Manmade contaminants are often the most harmful contaminants to the wool manufacturing process. Manmade contaminants include polypropylene baling twine and unscourable paint brands. Wool yarn or fabric with small non-wool fibers or paint-stained fibers is defective. Polypropylene baling twine is not recommended on sheep operations. Not using any branding fluid to identify sheep is preferred, but scourable paints can be used for branding conservatively. Nose brands, ear marks or colored ear tags are an option to paint branding.

A woolgrower should always be conscious of ways to improve the quality of the wool clip Improving upon the quality of their product will result in economic compensation. Wool marketing is based upon quality; not like lamb marketing which has been driven by weight in the past.

HARVESTING, PREPARATION AND MARKETING COSTS

Several costs in the harvesting, preparation and marketing of wool may be considered fixed.

Fixed costs are listed in Table 1. It is a producer's responsibility to assure that his money is wisely invested in these expenses. For example, the hiring of a novice shearing crew cuts into profits when buyers discount wool for second cuts, presence of skin on wool, mangled fleeces, and from lost production of sheep from rough or extended handling and deep skin lacerations. Selection of a creditable warehouse and broker will also be beneficial. In 1991, wool prices for 20 micron (70s) wool sold by exceptional brokers was 12 to 32 percent higher than the national average for similar wool. In 1991, wool marketed by the U.S. Wool Marketing Association (USWMA), established by the American Sheep Industry Association and which markets skirted and graded wool, sold for 10 to 25 percent more than the national average price for clean wool within wool grades (58s to 70s) (ASI, 1992).



	1985	1986	1987	1988	1989	1990	1991
National Avg. Price	$0.63	$0.67	$0.92	$1.38	$1.24	$0.81	$0.50
AWMA Graded Wool	$2.95	$2.87	$3.42	$3.44	$3.11	$4.00	$4.20
AWMA O.B. Wool	$2.66	$2.50	$2.83	$3.09	$2.50	$3.05	$3.45

Figure 1 Annual Wool Prices for O.B. and Graded Wool.

The expenses listed in Table 1 are general expenses, and costs vary by region. Shearing costs in the southwest for 1991 ranged from $1.60 to $2.50, but in the northeast shearing ranged from $1.80 to $3.00 per head, based on flock size. Although some of these costs such as crutching and classing may appear optional, they are required of some wool marketing organizations. Crutching prior to lambing or entering a feedlot reduces the proportion of tags and dung in a fleece, and there are health benefits to be reaped from crutching at these times.

Table 1. General Harvesting, Marketing and Distribution Costs for American Wool -Shearing Shed to Mill

Cost to	Activity
Woolgrower	Crutching
	Shearing
	Classing (skirting, grading)
	Packing/bagging
	Freight
	Warehousing
	Broker's Commission
	Core test Certificate, Pre-sale
Mill	Core test Certificate, Post-sale
	Buyer's Commission/Costs
	Shipment Preparation
	Freight
	Insurance

Classing of fleeces during shearing is becoming standard in the U.S. The real incentive to prepare and class wools is to increase wool income. The aesthetic value of marketing a higher quality product is probably not as compelling as the desire to make more money. Classing requires trained individuals to skirt and sort wool accurately. Large wool marketing organizations generally provide their own wool classers to control quality and uniformity of wool offerings. Fees for skirting and classing range from 2.5 to 6 cents/lb, or on a per day basis of $300 to $350. This often includes packaging wool by an Australian type square baler, making wool more acceptable to international markets, reducing freight costs due to its compact size and minimizes contamination.

The economic advantage to wool classing is depicted in Figure 1. Prices reported for graded and non-graded (original bag, O.B.) are based upon grease wool value plus incentive payment (assumed 1991 incentive payment of 250 percent). The American Wool and Mohair Association (AWMA) (Campbell, 1992), a Texas wool marketing group, has shown that from 1985 to 1991 graded wool outsold non-graded wool by 11 to 31 percent, averaging 20 percent over the 7 year period. This was based on sales of over 20 million pounds of wool (13+ million pounds graded, 7 million pounds O.B.). Reports of minimal or negative economic benefits from skirting are often influenced by small lots and a lack of marketing by wool brokers for a value added product. In 1991 the difference was 75 cents per pound or $6.00 for a skirted and graded 8 lb fleece. Advantages to selling graded wool were observed when the average national wool price was low ($.50/lb) and high ($1.38/lb), selling 11 and 22 percent more than O.B. wool, respectively. There is no indication that this trend will not continue.

Table 2. Price Differentials for Fiber Diameter of Australian Wools Offered in the U.S. (January ,1988 and 1992)

Diameter (μm)	U.S. Grade	1988 Clean Wool ($/lb)	1988 Price Differential	1992 Clean Wool ($/lb)	1992 Price Differential
19	80	$7.57		$3.08	
20	70	5.93	1.64	2.83	.25
21	64/70	4.37	1.56	2.58	.25
22	64	3.59	.78	2.47	.11
23	62	3.18	.41	2.32	.15
24	60/62	2.70	.48	2.21	.11
25	58	2.45	.25	2.14	.07
26	56/58	2.35	.10	2.05	.09
27	56	2.33	.02	1.97	.08

Source: USDA-AMS

Wool is marketed by micron (μm) or U.S. Grade (spinning count). Finer fibers, manufactured into fine woolens sell at higher prices. The price differential between microns is influenced by the world demand for particular types or grades of wool. High variability of fiber diameter is not desirable and indicates low quality fine wool animals and/or substandard blending practices prior to marketing. Price differentials between microns are given in Table 2 on the previous page. In 1988 there was a strong world demand for fine wool as can be seen by the large differentials between 19 and 22 μm wools. The effect of market fluctuation on price can be seen by comparing 1988 and 1992 wool prices; the value of 19 μm wool dropped 59 percent. The 1992 price differential between 19 and 20 μm wool dropped 85 percent, when compared with 1988. Decreasing fiber diameter at the producer level by selection, breeding and crossbreeding should be considered, especially in flocks with an average fiber diameter in the 20 to 22 μm range. The higher price differentials among finer wools is a greater economic incentive for fine wool producers than for medium grade wool producers. Variability of fiber diameter can be controlled to some extent by proper skirting and grading.

Yield grade of wools is not a significant factor affecting selling price. Most wool clips do not have a major problem with low yields. Some variation does exist in the market place and low yielding wool is discounted (Table 3). Price differentials for yield are greater for finer wools. Producers should know the yields of their clips and consider corrective management alternatives for improvement. The economics for improving yield may or may not be significant in some situations. Consider a producer with 2,000 ewes averaging 8 lb fleeces of 22 μm wool with a yield of 44 percent who improves his yield to 52 percent by replacing overhead hay feeders and realizes a gain of $2,560 in wool sales (16 cents X 16,000 lb wool); similar annual returns will be realized over the lifetime of the new bunk type feeders. When the wool incentive payment is considered this difference becomes substantial.

Table 3. Price Differentials for Yield Grade of Grease Equivalent American Wools (February, 1992)

Diameter (μm)	U.S. Grade	Yield (%)	Average Price ($)	Price Differential[a]
22	64	52	$1.40	
		48	.96	.08
		44	.88	.16
		38	.76	.28
23	62	47	.81	
		43	.74	.07
24	60	47	.70	
		43	.64	.06
25	58	52	.69	
		46	.61	.08
26	56	52	.62	
		46	.56	.06
27	54	52	.59	
		46	.52	.07

[a]Price differential based upon difference from highest yield. Source: USDA-AMS, 1992.

Staple length has a significant effect on spinning performance and yarn properties. Top makers often specify the desired staple length, usually the coefficient of variation for fiber length. Excessive variation in staple length is detrimental to the manufacturing process. Table 4 reports a summary of over 3 million pounds of wool marketed in 1991 by AWMA within wool class. Staple wool is of longer staple (2½ inches or longer), and tender/clothing (A-2) wool is shorter. A difference of 33 cents/lb (34%) was realized between staple and A-2 wool in 1991. A producer should be concerned with reducing variability of staple length, which he can minimize by selection, skirting of belly, leg, head and other short wool, and reducing second cuts at shearing.

Table 4. Summary of 1991 Classed and O.B. Wool Sales by the American Wool and Mohair Association

Wool Class	Number of Pounds	Total Value	Average Price ($/lb)
Staple	1,610,179	$2,076,829	1.29
A-Line	364,240	479,842	1.32
Tender/Clothing	222,608	213,663	.96
Skirts (Bellies)	207,037	128,418	.62
Pieces	28,733	19,723	.69
Total for Class Wool	2,432,797	2,918,475	1.20
Total for O.B. Wool	706,084	696,228	.99

Source: American Wool and Mohair Association

Warehousing and marketing costs are customarily set. However, they can be reduced, although minimally, by increasing wool bale weight and lot size (ASI, 1989). The average bale weight in the U.S. is 385 lb; 47 lb lighter than the industry recommended 432 lbs. As seen in Table 5 on the next page, by increasing bale weight to the industry standard a producer with a flock of 2,000 can realize a gain of $225 from savings in the number of wool packs, freight and warehousing. Increasing lot size will also help cut costs. There is no minimum lot size but preferred lots sizes are: 20-25 bales for fleece wool, 10-15 for pieces and bellies and 5-15 for carding wool. Marketing charges, especially core testing, are on a lot basis. Combing similar lines into a single lot will net significant savings in core testing (Table 6). Based on information from Table 6 on the next page, if 24 bales are sold as a lot instead of six 4 bale lots or three 8 bale lots, the savings are $430 or $169, respectively.

Table 5. Influence of Wool Bale Weight on Grower's Costs[a]

Expense	52 Bales Averaging 385 lb.	46 Bales Averaging 432 lb.
Wool packs @ $6.00 each	$312.00	$276.00
Transport to warehouse @ $7.07 bale	$367.64	$325.22
Warehousing @ $24.51	$1,274.52	$1,127.46
TOTAL COST	$1,954.16	$1,728.68
Difference	**$225.48 or $4.90/bale**	

[a]Based on flock of 2,000 and average costs for wool packs, transport and warehousing.
Source: American Sheep Industry Association

Table 6. Influence of Sale Lot Size on Grower's Costs[a]

Lot Size	Core Testing Costs ($/bale)	Marketing Costs ($/bale)	Total ($/bale)	Savings ($/bale)
4	21.75	30.80	52.55	----
8	10.87	30.80	41.67	10.88
16	5.51	30.80	36.31	16.24
24	3.80	30.80	34.60	17.95
48	2.09	30.80	32.89	19.66

[a] Marketing cost figured on 385 lb bale at 8 cent/lb commission.
Source: American Sheep Industry Association

WOOL INCENTIVE PROGRAM

Incentive payments by the National Wool Act of 1954 and subsequent extensions make a significant contribution to wool producers' income from wool sales. The Act recognized wool as an essential and strategic commodity which is not produced in sufficient quantities in the U.S. to meet domestic needs. Incentive payments are paid to producers for both shorn wool and unshorn lambs. The program is financed by duties collected on wool imports. The incentive level is established by the USDA. The incentive payment for shorn wool is based upon the percentage difference between the incentive level and the weighted national average wool price. When wool prices plummet like they have since 1990, the incentive payment becomes critical to profitability. Since 1954 incentive levels have been above the weighted national average price for all but 2 years (1954 and 1982). The incentive aspects of the program are for producers to sell at the highest prices in order to increase the total value of their wool, financially encouraging fine wool production.

For example, assume the following for 1990:

> Incentive payment rate of 126%
> Producer A and B each have 2000 ewes which average 8 lb fleeces
> Producer A sold a 20 μm wool clip for $1.70/lb (total 16,000 X 1.70 = $27,200)
> Producer B sold a 21 μm wool clip for $1.60/lb (total 16,000 X 1.60 = $25,600)

The difference in wool sales is $1,600. After incentive payments this difference grows to $3,616 ($61,472 - $57,856), or $1.81 per head.

MEASUREMENTS OF WOOL PROCESSING QUALITIES WHICH MAY AFFECT FUTURE WOOL PRICES

To some extent producers should be aware of wool measurements which may be of economic significance in the future. Most measurements relate to processing characteristics. The Australian Wool Testing Authority (AWTA), the world's largest wool testing laboratory, is currently offering wool buyers quantitative information on staple strength (tensile strength measured in Newtons/kilotex), position of wool breaks (percent breaks at staple tip, middle and base), and color. This information is also provided to the producer to aid in flock management. Staple length, strength and position of breaks are important factors related to the suitability of wool fibers for high-speed automatic processing. These new measurements will replace the classification of tender or sound with quantitative values.

The clean color of grease wool is influenced by such impurities as grease, dirt, suint, vegetable matter, and its inherent color. Impurities are usually removed during processing. The final color is an important characteristic for processors. Final processed color limits the range of colors it can be dyed. The more intense the color of the top, the greater the limitation for dyed colors. In Australia, 15 percent of the sale lots were discounted during the 1986/87 season (AWTA, 1990). Discounts for off-color sale lots were up to13 percent in Australia. Pieces, bellies and carding wools are usually discounted for color. Subjective measurement of wool color is not reliable and is conducted by a colorimeter to measure yellow tints in wool. (Colorimeters are used extensively in determining the color of paints and dyes.) In New Zealand, the majority of sale lots are pre-tested for color and commonly discounted for undesirable color variation.

The future of these tests for wool marketing in the U.S. is unknown. However, if such tests become standard for the international market, it is certain that U.S. wool brokers will implement equivalent testing and reporting procedures.

IMPLICATIONS FOR PRODUCERS

Producers are able to market wool based upon quality standards, unlike the current lamb marketing system. Economic incentives for improving quality by management, breeding and packaging are significant. Price differentials for diameter, yield, skirting and classing of wools are large and should be capitalized on by all producers. There is no evidence to indicate that price differentials will not continue as they have historically.

LITERATURE CITED

ASI. 1989. Code of practices for preparation of wool clips in the United States. American Sheep Industry Association. Engelwood, CO

ASI. 1992. The American Sheep Industry Association. Unpublished data.

AWTA. 1990. The clean color of wool. Australian Wool Testing Authority. Kensington, Australia.

Campbell, F. 1992. Memo: Wool Grading. American Wool and Mohair Association. Eden, TX.

USDA-AMS. 1988. Domestic Wool and Mohair Quotations. U.S. Department of Agriculture, Agricultural Marketing Service. Greeley, CO.

USDA-AMS. 1992. Domestic Wool and Mohair Quotations. U.S. Department of Agriculture, Agricultural Marketing Service. Greeley, CO.

MARKETING WOOL TO HANDSPINNERS

Jean Near
Wool Grower

INTRODUCTION

Producing wool for handspinners is to cater to one of the more lucrative although one of the most discerning wool markets. This is a specialty market that is somewhat limited but it is one that is growing. The availability of good wool seems to be the magnet that draws spinners back to a craft they once enjoyed and helps introduce new spinners to the joy of producing handmade garments. Last spring I sold all my wool at prices ranging from one dollar per pound for lambs' wool to four dollars per pound for top quality ewe fleeces.

Basic to marketing wool to spinners is the art of preparing a good product. This starts in the selection of the sheep one plans to raise, continues in the care one gives the sheep and ends in the methods one uses to market the wool.

SELECTING THE SHEEP

There are several good wool breeds. I found on my tour of New Zealand that there is often a local preference. Spinners seem to prefer what they are used to. In New Zealand, Romney sheep and wool are popular; in Australia Merino wool is favored. Here in California grower's have quite a choice from breeds that produce very fine wool to those who produce long coarse wool suitable for rugs and saddle blankets.

I started with Corriedales and have found them to be very satisfactory. They produce wool in the medium range which is suitable for clothing. Corriedales do have the advantage that they are dual purpose sheep and the sale of their good freezer lambs helps to pay the bills.

I am not a purist as far as breed is concerned. Because I started with colored sheep and my top priority is producing many shades of brown and grey, I have concentrated on color and quality of wool first, and then considered the sheep's confirmation, size and disposition. I have used two white registered Corriedale rams, one registered Columbia, and now a half Australian-Merino-half-Targhee ram. I have used several colored rams, some of which I produced from my own flock and a few that I have purchased. I searched for a purebred black Corriedale ram but was unable to find one. Therefore, Columbia, Merino, Rambouillet and Targhee blood lines have been infused into my flock. You will note however, that these breeds are all somewhat compatible with Corriedales as far as type and grades of wool are concerned.

CARE OF THE SHEEP AND WOOL

Care of the sheep and the wool go hand in hand. Every place a sheep goes or beds down during the year exposes the fleece to possible contamination. Therefore, the producer should take every possible step to avoid fleece contamination. Handspinners do not like dirty fleeces nor vegetable matter in the fleeces. This is a frustrating problem but there are some things we can do.

1. Be careful when feeding the sheep. Do not throw the hay onto their heads and backs. If necessary turn the sheep out of the feeding area. Fill the feeders and then turn them back.

2. If you must keep your sheep in the barn at night as I do to protect them from predators, make certain they have clean bedding at all times.

3. Set your shearing date at a time before the filaree stickers, burr clover or other plants head-out. This will lower the amount of vegetable matter contamination.

4. Once the fleeces are sheared don't leave them thrown in a corner gathering dust, hay, leaves and moths. Line a cardboard box with newsprint (I use apple boxes from the nearby store.) and put the individual fleece into the box making sure it is completely covered with the newsprint. Put on the lid and label with ewe's name, weight of wool and any other identifying information you think you would need to know. You can store a fleece in this way for years and it will stay in good condition.

FEEDING THE SHEEP

Handspinners are knowledgeable about wool and if there is a break in the sheep's wool, the spinner will find it. A break is a weak spot in the staple. Breaks are usually caused by the stress of an illness, lambing or a change in diet such as too little feed during lambing and lactation. It is important for every grower to work out a satisfactory feeding program and also a routine immunization plan with his or her Farm Advisor or other knowledgeable source.

BUYING HAY

Since buying hay is in general our greatest feeding expense, I'll mention the advice given to me by my Farm Advisor. He said, "Watch the manger. You may be wasting money on cheap hay." After feeding hay to sheep for fifteen years, I'm convinced that the only good buy in hay is the best hay I can get. It is wise to talk over your anticipated needs with your supplier. If possible buy as much as you can during July and August while the price is down. That same hay in the spring will cost much more. This is reasonable as the supplier must store the hay thus handling it twice and by Spring, hay is getting scarce.

MARKETING WOOL

Once the year is over and we have beautiful fleeces to sell, we are faced with perhaps the most difficult problem of all. Where do we find a market? I have tried several means of advertising: an ad in the local paper; showing my fleeces to the spinning classes at the local college; displaying my wool at a Farmers Market and flea markets; posting my business card on bulletin boards like the one in the Ackerman Creek Clinic. All of the above will sell a few fleeces but not enough. They do help to slowly build a clientele.

It was not until after I had gone to the 1984 World Congress of Natural Colored Wool Growers which meets every five years, and met that year in New Zealand that I hit on my best sales approach. I spent a month in New Zealand where there were three million people and seventy million sheep. I think what New Zealand did for me was to give me confidence. I had seen about everything there including a field station that ran one thousand colored Romneys. On that long, boring, tiring flight home I began to formulate a plan.

Once home, I contacted a shearer I knew and asked him to give me a definite date that he could come to shear the sheep. Then I asked everyone I thought might know for names of spinners who might enjoy coming to a pot luck shear-in. Basically, I was inviting spinners and friends to share my home with me for a day.

After all the invitations were out, I worried for fear it would be pouring rain on the date of shearing or maybe the shearer would forget to come. Nothing I thought of happened. But, about a month before shearing day I fell when a part of a trail on the hillside gave way while I was out getting my sheep. As a result of the fall my ankle was broken. So then I had plenty to worry about. I finally decided I must go through with my shear-in. I contacted friends to come help.

The day came only too soon. People took a look at me and my crutches and went to work. It was a great day and everyone seemed to have a wonderful time, and I learned an important fact about spinner's. They are fascinated by the spectacle of wool coming off the sheep and then captivated by the feel of the wool as they help with skirting the fleece when it is spread out on the skirting table. I can think of no better way for us to present our wool for their inspection and choice.

That first shearing day set the stage for all of those that were to follow. Each one seems better than the last and much has been added since then. In the July 1991 Sheep! Magazine there was an article about my shear-in.

I learned another important fact from that first experience and that is that the shearer is the star of the show. My first shearer, an experienced shearer who had been shearing in Mendocino County for perhaps forty years, refused to come back. He didn't enjoy the close scrutiny of the spinners. They murmured disapproval over his second cuts and an occasional cut on the skin of the sheep. If it is possible, I believe spinners disapprove of second cuts even more than breaks in the wool. They are even more upset if they find pieces of skin in the wool when they wash it.

I went to my Farm Advisor for advice in finding a new shearer. I found a shearer that did an excellent job and pleased the spinners. Ann Kizer, my present shearer, comes from her home in Idaho to do my shearing along with several other flocks in the area. I'm going to lose her but she assures me that she is training another woman to take her place.

I'd like to give you just a brief description of my shearing day 1991. It has grown so that I could not manage it without my sons, their wives, my brother and my friends and of course the spinners themselves.

In 1991, we had three center's of interest. Ann on her platform had several helper's; one to help bring the sheep to her; one to fill the syringes as the sheep received their injections after being sheared; one to sweep off the platform. Ann placed the newly shorn fleece on the skirting table and those spinners who want to, skirted the fleece. Another friend rolled, tied, tagged, weighed and boxed the fleece. The price was written on the box and the buyer's name, if the fleece had sold. The tag, by the way, was the name of the sheep. Buyers sometimes come back year after year for a certain sheep's fleece. Approximately 90% of my fleeces sold on shearing day. I sent the rest to be washed and sold the remaining wool at the Farmer's Market.

A second center of interest was a platform by the river ringed with bales of straw to sit on, where spinners and would-be spinners gathered with wheels and drop spindles to learn and to share. The leader of this group was Doug Elliott, an experienced spinner and an expert with a drop spindle.

A third center of interest was the tables along the side of the barn where processed wool, tanned hides and some garments knitted from my wool were on display. One of my sons took care of sales.

I should mention here that sometimes it is profitable to spend money to make money. I deliberated a long time before I sent the first wool off to be processed-that is scoured (as they call washing it) and then carding it into either bats or bumps, sometimes called slivers. I have found that it is worthwhile to have some processed wool on hand. Some spinners have grown tired of washing and carding the raw fleece and are happy to leave out the dirty work in the process of knitting garments.

I also send my sheep hides to be processed. The nicer they are the more readily they sell.

The shear-in seems to be a little like the barn raising of our pioneer ancestors, a little like the thrashing crews that circled the valley when I was a child and a little like all the parties I attended in New Zealand. I try to listen to all the "Why don't you" from my friends and incorporate their workable ideas into the day.

I ran across this story the other day which reminded me of some of my struggles. A little boy set out to find the Wishing Gate. He was so intent on his search that he didn't notice where he was going. He lost his way and he was tired so he sat down on an old stile to rest. The North Wind came along and offered to take him home and the boy accepted the offer. As they traveled along the North Wind asked the boy how he came to be lost. "I was looking for the Wishing Gate," he said. The Wind laughed all the way to the boy's home. When they reached the boy's doorstep the North Wind said, "Next time you go in search of something, keep your wits about you. You were sitting on the Wishing Gate when I found you." Maybe I didn't need to go all the way to New Zealand to find my Shear-In.

AN INVITATION

For those of you who would enjoy seeing my sheep operation first hand, my Ninth Annual Shear-in will be next Saturday, April 11, 1992 from about 9:00 a.m. to 3:00 p.m. Bring your lunch or a prepared dish and join our potluck around 1:00 p.m. Let me know if you plan to come.

FOR YOUR INFORMATION

PUBLICATIONS

Black Sheep Newsletter
25455 N. W. Dixie Mountain Rd., Scappose, Or. 97056

National Wool Grower Magazine
6911 South Yosemite St., Englewood, Co. 80112-1414

Raising Sheep the Modern Way, Paula Simmons
48793 Chilliwack Lake Rd., Sardis, B.C. Canada V2R2P

Sheep! Magazine
Rt 1, Helenville, Wisconsin 53137

Shepherd Magazine
5696 Johnson Rd., New Washington, Ohio 44854

The Marker (Natural Colored Wool Growers)
Steven Mendenhall (916) 743-0739
4519 Fruitland Rd., Loma Rica, Ca. 95901

WOOL PROCESSING

Arachne's Obsession (916) 758-4488
704 Radcliffe Dr., Davis, Ca. 95616

Custom Wool Processing
by Marj 707-998-3427 and Meredith 707-263-3853

Yolo Wool Products 916-666-1473
9 East Main St., (also 41501 Co RD 27),
Winters, Ca. 95694 Woodland, Ca. 95695

TANNING COMPANIES

Buck's County Fur Products 215-536-6614
P 0 Box 204, 220 1/2 N. Ambler St., Quakertown, Pa. 18951

L & M Fur and Woolen Enterprises, Inc. 215-538-1181
Erie and Belmont Ave., Quakertown, Pa 18951

Stern Tanning Co Inc. 414-467-8615
P 0 Box 55, 334 Broadway, Sheboygan Falls, Wi 53085

SHEEP COVERS

Powell Sheep Co 619 789-1758
P 0 Box 183, Ramona, Ca. 92065

FOOD FOR THOUGHT

1. It has been said that "the good shepherd observes each of his sheep at least once every day of the year."

2. "The sheep is the no. 1 conservation animal; we must educate others of this fact." Don Torell, Former President of the California Wool Growers, retired as first research person at Hopland Field Station and is still very active raising sheep full-time in the Ukiah Valley.

3. "Wonder if, in all the technical writing on animal husbandry, anyone notes the civilizing influence animal raising may have on people. Maybe its simply understood by all that for all the modern discoveries, shepherding is an ancient scientific culture and teaches people more than they intended to learn...." Garrison Keillor, in THE SHEEP BOOK.

4. "There's no such thing as a dumb animal; of course some are smarter than others." Frank Ledford, Former Lake County Sheep Rancher. (Frank grew up on a sheep ranch and raised sheep all his life.)

WOOL QUALITY IMPROVEMENT PROGRAM-AN EVOLUTION

R.E. Pope
American Sheep Industry Association

INTRODUCTION

The American Sheep Industry Association (ASI), Wool Council, Wool Quality Improvement Program (WQIP) has had a long and colorful history. Since ASI is a new organization, formed in 1989 by the merger of the National Wool Growers Association (NWGA) and the American Sheep Producers Council (ASPC), we must look back and see how the program has evolved to its present form. This will give a better perspective to the current program.

In 1982 the national program Pack it With Pride (PIWP) was initiated with the development and distribution of many educational materials which built producer awareness. The ASPC contracted with the NWGA to implement the PIWP program from 1987 to 1989. The focal audience was the producer, with the goal of making them more knowledgeable about their product, wool. With increased knowledge a better understanding would develop, enabling producers to make positive and educated changes concerning their wool clip.

The PIWP program was a success and the next step was initiated. In October 1989 the ASI WQIP was implemented, and was the first attempt to package raw wool by world standards on a national scale. In the spring of 1990 Australian wool classers were brought in and a portion of the domestic clip was skirted, classed, and packaged to international specifications.

In May 1990 the first wool sale was conducted in Denver, Colorado with every domestic wool buyer (18) and four foreign buyers present. The sale was a qualified success. The sale brought in buyers, increased competition, and offered a sizable volume of quality wool at one offering. However, Australia dropped its floor price only days before the Denver sale, thus domestic prices dropped. In 1991 Australian and domestic classers prepared wool that was sold in three separate sales.

It became apparent that a quality standard was needed, and this need resulted in the creation of the Code of Practice in 1990. The main concern was to develop standards that were simple and direct, adaptable to most sheep enterprises, and improved the wool clip without unnecessary fragmentation of individual wool clips.

After the 1991 shearing season, work began on the Certified Wool Classers Program. This program uses four day schools to instruct participants in proper techniques and guidelines set by the Wool Council. The guidelines were developed by many expert individuals in various segments of the wool industry. There is a four level system incorporated in the classer certification. Level I is beginner and can class wool with the assistance of a Level II classer. Level II receives a certified number, stencil, and can class wool without assistance in their geographic area. Level III can class wool in several geographic areas and must attend a scheduled mill visit. Level IV is certified to instruct. Each classer level must be reviewed by a classer committee and Level II certification applicants must each meet 100,000 pound classed wool requirements.

The technical background is a longer story, but will be greatly abbreviated. Core testing of grease wool for yield commenced on a significant scale in the United States in 1938 when U.S. Customs Department first started coring wool for assessment of tariff duties. The U.S. can be credited with the development of accurate objective wool measurement methods, but Australia and South Africa must receive credit with implementation to raw wool sales.

ASI's WQIP has benefitted from this foreign experience and has, with the assistance of many expert individuals here in the U.S., developed a program fashioned to suit the domestic clip. Skirting and classing of wool is done to enhance the overall quality of the wool clip; quality as viewed from the processors standpoint, our customer.

COMBING TRIALS

In 1989 ASI worked with a wool processor in combing selected U.S. wools. This first ever endeavor included a range of grades and warehouse sorted wools. The wools were extensively handled by removal of bellies, stains, and short wool in the fleeces.

These combing trials are useful as a reference and provide general wool information that can be used to help U.S. producers understand reasons for proper packaging. No statistical analysis was attempted on the data generated; however, general information can be obtained (Table 1).

Table 1. 1989 Combing Trial Results

Characteristic	First Trial	Second Trial
Fiber Diameter	Acceptable grease to top relation	Wide Variation between grease and top evaluation. Inter-Lab variation large on grease samples
Vegetable Matter	Type of VM (straw) from one lot posed problems in both trials	
Romaine	Acceptable levels in both trials	One lot of coarser wool not acceptable due to high VM and short fibers
Length	Acceptable; Top lengths related well to grease measures	Acceptable except for 28μ lot
Colored Fibers	Finer grades acceptable in both trials; Coarser grades unacceptable in both trials. Inconsistent results	
Conversion Yield (processing)	Acceptable in both trials	

In the second trial the micron differences between two labs on grease samples and one lab on grease vs. top samples could have resulted from sampling error, method of diameter determination or interlab variation. However, there were no discrepancies in the same samples and yield results either between labs or between grease and processing top. In the areas of length, noils, and colored fiber content, processors indicated some problems, but felt these could be corrected. Corrections by proper shearing, skirting, and packaging or by genetic selection.

In 1990 combing trials were conducted on wool skirted and classed at shearing. This involved three separate processors and separate wool lots. Again, no statistical analysis was done on data collected. Results are generally personal communication with the respective processors relative to their observations regarding the wool they processed.

Fiber diameter repeatability between grease and top was very acceptable in two of the combing trials. The other trial gave a variation of one micron between grease and top measures, with the top being coarser. This probably is associated again with errors in sampling, method of fiber diameter determination, or interlab variation.

Variations in length within lots was a problem in one trial. This could be traced back to one lot of original bag wool with bellies not removed. In this particular case the processing equipment, comb setting, and scouring method could have also contributed by excess breakage of wool fibers.

Romaine is a measure of combing or conversion yield. It is noil/(top+noil)x100. Romaine proved to be acceptable in all trials indicating proper skirting technique at shearing. It also indicates that shearing is the time to correct these problems as they relate to the problem of length variation in the lot with bellies not removed.

Colored fibers were an issue in one combing trial. When considered more closely it was determined that this was genetic in nature. Results of colored fibers were inconsistent and indicate that progress can be made by skirting at shearing, since these wools were skirted at the warehouse.

The problem of most concern to the processors was the presence of polypropylene in the clip. Also, the straw contamination proved to be a more serious problem than other sources of vegetable matter, due to the fact that the straw tended to become fragmented and act as a fiber during processing. Kemp fibers were another genetic source that may or may not be corrected by skirting.

To summarize, most U.S. wools processed well and were comparable to Australian wools of similar grade. The colored fiber and kemp issues seem to be issues that may be addressed through genetic selection. Since these wools had been warehouse skirted, if skirted properly at shearing there is the potential for improved results regarding colored fiber content and kemp. Wool preparation did seem to improve most wool characteristics, but type of vegetable matter and the polypropylene problems need to be concentrated on and eliminated prior to shearing. These combing trials indicate that U.S. wools can reach international standards in processing, but care in preparation must be taken to attain these goals.

ECONOMICS

In 1989 the United States Wool Marketing Association (USWMA) was formed and has worked very closely with ASI Wool Council. As a non-profit organization, it is not the function of ASI to market wool. Conducting sales on objective measure and by sample has enhanced the WQIP and credit must be give to USWMA. Without economic considerations being addressed, any program would meet greater resistance in acceptance. As stated, skirting and classing is done to improve the overall quality of the clip, but if producers are not compensated for their efforts the program is useless.

There was a total of 1.7 million pounds of wool involved in the 1990 WQIP (Figure 1). In the A line there was a total of 769,437 pounds offered in the first USWMA sale in Denver. The fiber diameter (micron) and corresponding pounds are represented in Table 2. Percent of wools sold was high (91-100%) for all micron ranges except the very coarse (< 24 micron). This might be expected due to limited volume in this range and because there tends to be less processor demand for such wools.

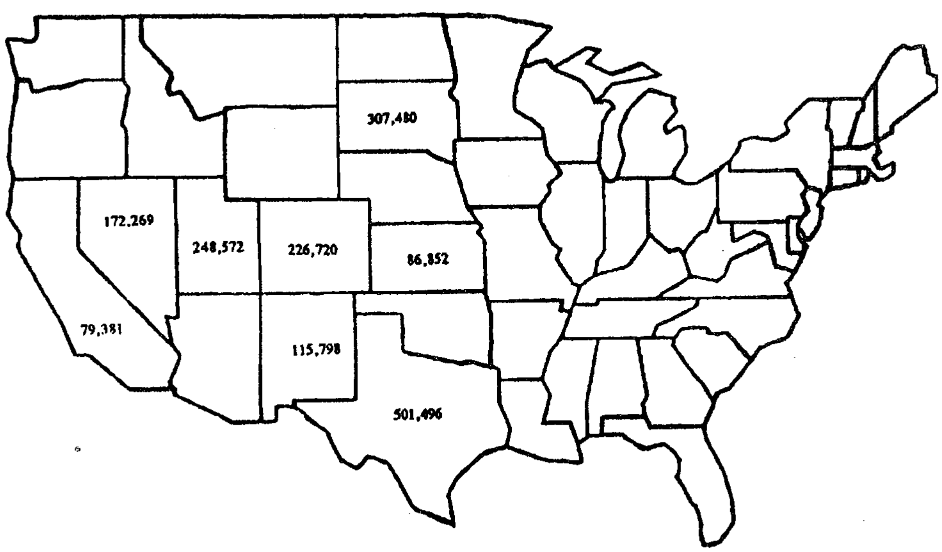


Figure 1 Number of pounds of wool contributed by state

Table 2. Pounds Offered and Sold at USWMA Sale 1990

A Line	< 19 Micron	19-20 Micron	20-21 Micron	21-22 Micron	22-23 Micron	23-24 Micron	> 24 Micron	TOTAL
Offered	37,503	87,868	146,225	212,181	130,599	104,680	50,381	769,437
Sold	37,503	87,868	145,225	203,708	127,623	95,673	24,176	720,776
% Sold	100.0	100.0	100.0	96.0	97.7	91.4	48.0	93.9

The weighted grease prices for the various lines are shown in Table 3. The A line - bulk of the individual producers clip - brought the highest price, as would be expected. The A-1, coarser end, and the A-2, short/tender, were sorted out of the main line. However, it must be noted that these other lines have a value and due to separation the producer receives more and the buyer can afford to pay more for specific lines. Weighted average grease and clean prices indicate strong demand for wool 20 micron and less (Table 4). Wools over 24 micron received lower prices.

Table 3. Weighted Average Grease Prices 1990

	PRICE (Cents per Pound)
A-LINE	150.71
A-1 LINE	108.06
A-2 LINE	111.08
A-3 LINE	91.72
A-4 & 5 LINES	83.66
BELLIES	61.24
PIECES	79.16
STAIN	34.92
LOCKS	33.72

Table 4. Weighted Average Grease Prices and Indicated Weighted Average Clean Values of Wool Sold at USWMA Sale 1990

A LINE	< 19 Micron	19-20 Micron	20-21 Micron	21-22 Micron	22-23 Micron	23-24 Micron	> 24 Micron	TOTAL
Grease	220.26	216.07	167.32	148.68	124.94	94.56	54.06	150.71
Clean	428.58	402.95	319.60	281.68	234.21	170.61	100.72	247.31

Weighted Clean Value Calculated Based on CWFP Yield--Weighted Grease and Clean Values FOB Warehouse

In 1991 three sales were conducted with similar volumes of wool in the WQIP as 1990. However, the total was split among three sales and could have affected the overall prices paid due to lower volumes being offered at any one time (Table 5). Due to the three sales, records of any detail were more difficult to access and therefore, results are more difficult to assess.

Table 5. USWMA Sale Summary 1991

	1st Sale	2nd Sale	3rd Sale	Total Pounds
Total	403,341	489,753	539,869	1,421,963
Reoffers		55,400*	45,822*	101,222*

Domestic wool prices in April and May 1991 are represented in Figure 2 for the various grades and marketing schemes. The range for graded wools dipped to those of original bag (OB) wools of the same grade. However, it is evident that the buyers have greater latitude to pay more for classed wools even though both may have objective measures available at sale time. It says that buyers are more confident that there will be fewer problems in processing classed wools as variation extremes in fiber diameter, vegetable matter, length, and colored fibers are eliminated.

The potential for large volumes of skirted and classed wools sold at auction would increase the competitiveness among buyers to remove this wide fluctuation and increase prices paid at any given time.

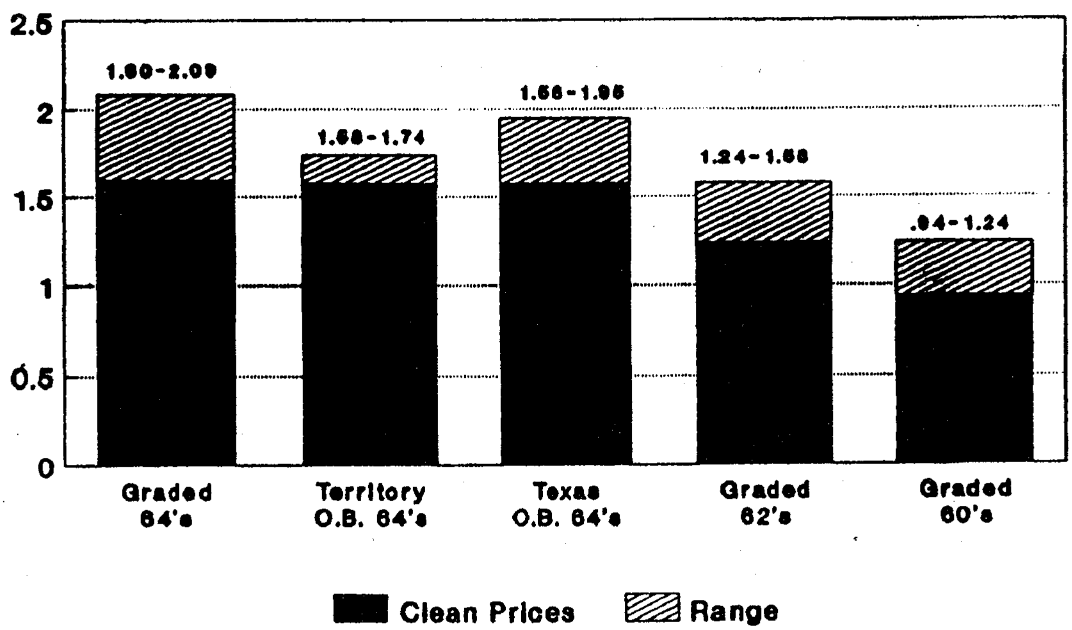


Figure 2 Domestic wool prices April - May 1991

The bulk of wools sold in 1991 showed a higher percent in the 64's to 70's range than the 58's and lower (Figure 3). This may be attributed to the poor showing of coarser wool in the 1990 sale.

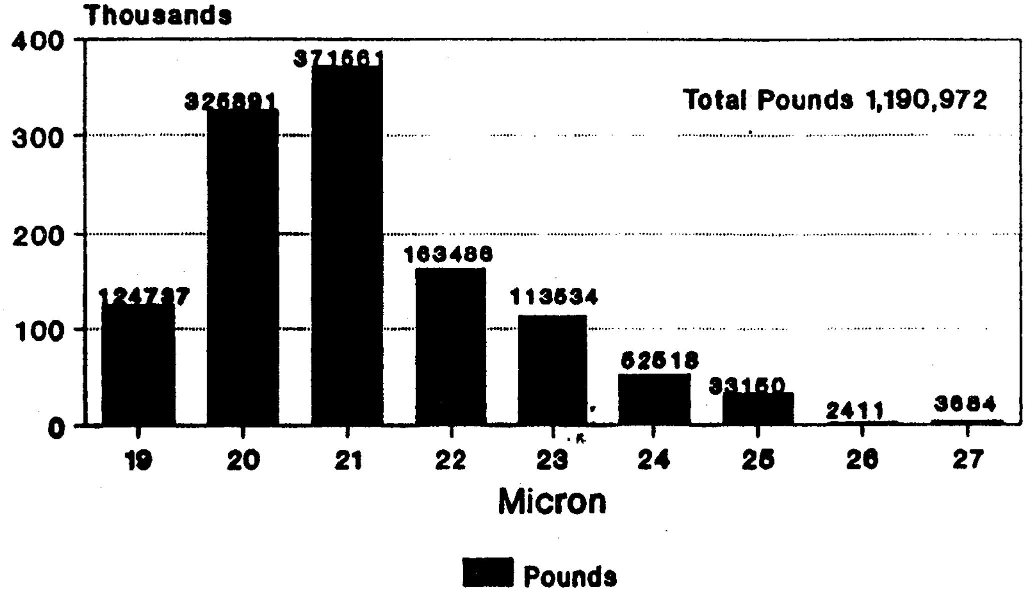
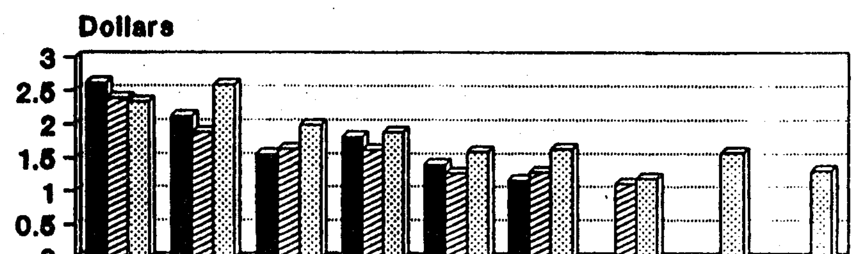


Figure 3 Pounds of wool - per micron

Figure 4 relates somewhat the narrowing of the price spread for similar wool grades over a period of two months. There are some factors that caused a wide variation in prices received for 20-24 micron wools in the third sale relative to the first two sales. It was generally thought by those involved that the second sale prices were reduced related to specific market considerations not associated with the first and third sales.



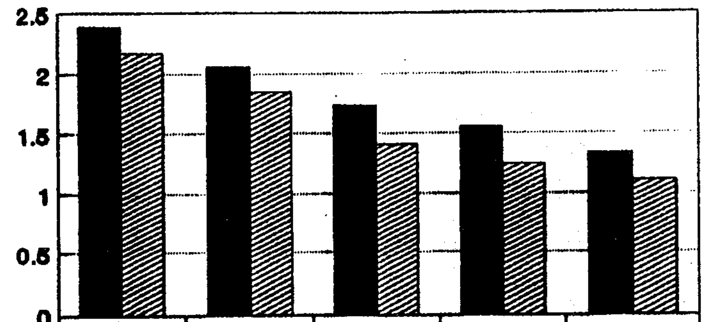
	19	20	21	22	23	24	25	26	27
1st Sale|Apr 16	2.63	2.13	1.56	1.83	1.42	1.18			
2nd Sale|Apr 30	2.4	1.89	1.64	1.63	1.28	1.3	1.13		
3rd Sale|May 21	2.34	2.6	2	1.9	1.6	1.64	1.2	1.59	1.32

Micron

1st Sale|Apr 16 2nd Sale|Apr 30
3rd Sale|May 21

Figure 4 USWMA sales - average prices

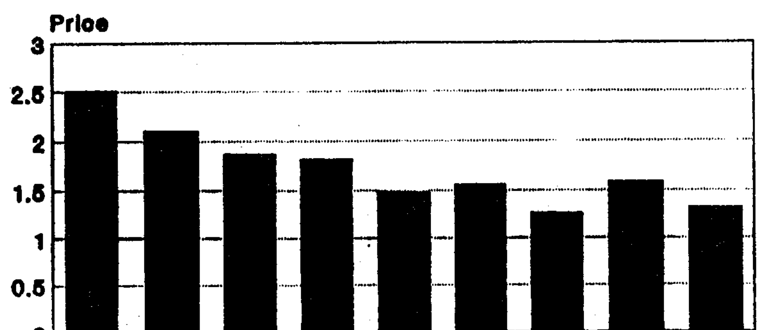
In Figure 5 the USWMA prices are averages of actual prices received for these grades. The prices for bellies, pieces, locks and stained wools are added back in, but are averages for all grades involved. In all grade categories, skirted and classed wools brought more than the national average.



	70's	64's	62's	60's	58's
U.S.WMA	2.39	2.06	1.74	1.56	1.34
National Average	2.17	1.85	1.41	1.25	1.11

Figure 5 USWMA prices - spinning count

Clean prices received by micron category indicated that there was adequate demand and competition for the coarser range wools (23-27 micron) even though the volume of these wool grades were lower than other grades (Figure 6).



	19	20	21	22	23	24	25	26	27
Clean Price	2.51	2.11	1.88	1.82	1.48	1.56	1.27	1.59	1.32

Figure 6 USWMA average prices - micron category

The percentages skirted off the fleece are represented in Figure 7. It is noted that keeping pieces and bellies separated proved advantageous as pieces and bellies brought a higher percent price in relation to main line wool than locks (Figure 8). The percentages skirted off are consistent with a joint study involving Montana State University and the University of Wyoming (Kott, 1991). This study compared O.B., bellies removed, and skirted wools. McFadden (1958) compared unskirted vs. skirted and estimated that a 7 percent premium was needed to justify skirting when offsorts were discounted no more than 11.3 percent with 20.4 percent of the fleece removed in skirting. Early (1984) reported that wool producers who skirted similar types of New Mexico wool in the same locality received approximately \$.22/Kg (\$.10/lb) more than producers who did not skirt their wool.

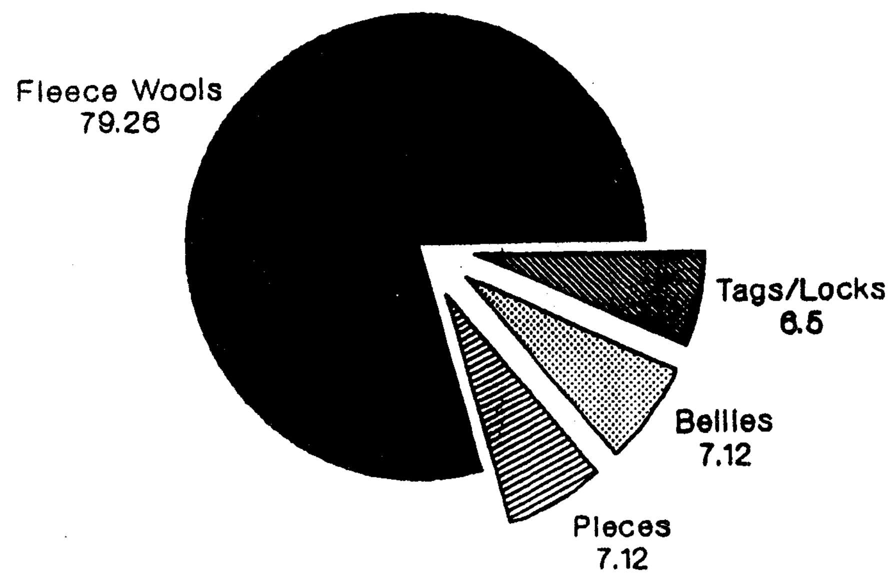
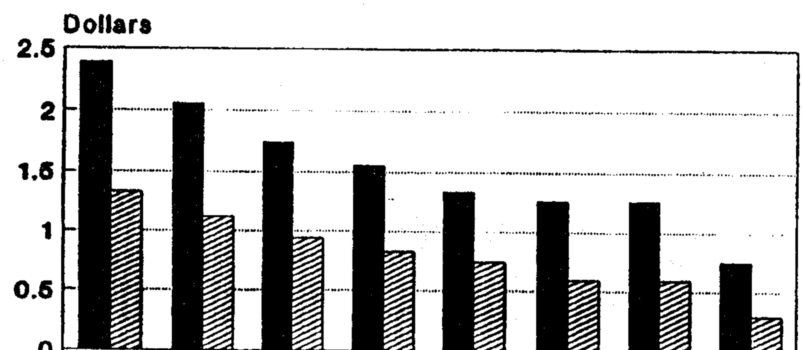


Figure 7 Skirting percentages - National program



	70's	64's	62's	60's	58's	pieces	bellies	locks
Clean Price	2.39	2.06	1.74	1.56	1.34	1.26	1.26	0.75
Grease Price	1.33	1.12	0.94	0.83	0.74	0.59	0.59	0.3

Clean Price · Grease Price

Figure 8 USWMA prices - spinning count

Kott (1991) constructed a model to compute the premium needed for A line wool relative to percentages of offsorts (Figure 9). The additional labor required at $.32/ sheep equates to $.04/lb assuming a 8 pound fleece. This is similar to values determined by Texas (Cook personal communication) and New Mexico (Parker personal communication) USWMA warehouses at $.03 and $.05 /lb., respectively. These rates were computed on 188,835 and 80,853 pounds of wool, respectively.

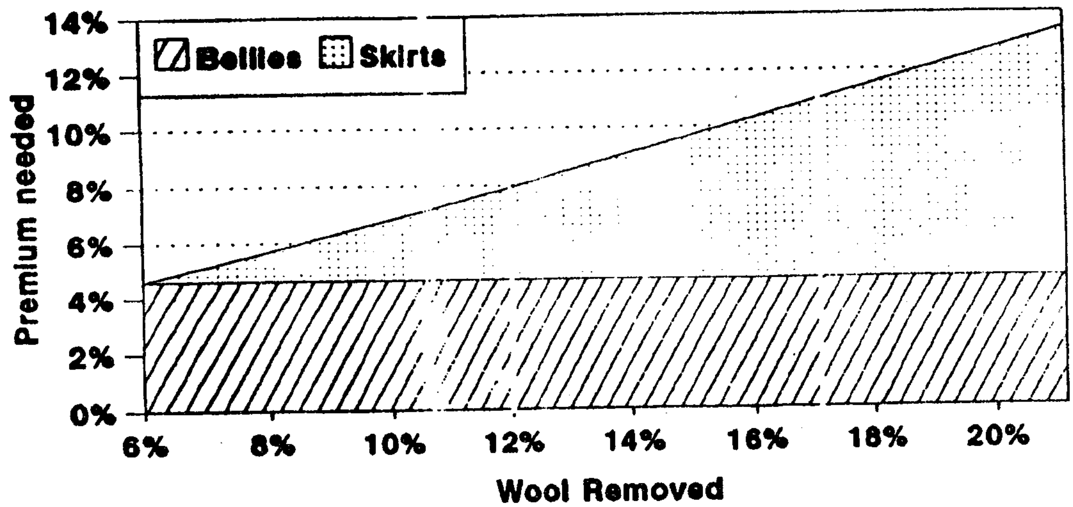


Figure 9 Premium needed to justify skirting

The New Mexico warehouse gathered data on total pounds skirted, bellies out untied (BOU), and original bag (Figure 10). The skirted wools averaged just under 22.5 micron, while BOU and OB wools averaged under 22.0 micron (Figure 11). Comparing prices of skirted with BOU and OB wools shows an average premium of $.05 and $.03 /lb clean, respectively (Figure 12). These premiums paid for the lower grade skirted wool would offset the extra cost for skirting even when compared higher grade wool in this case, assuming $.05/ lb skirting cost.

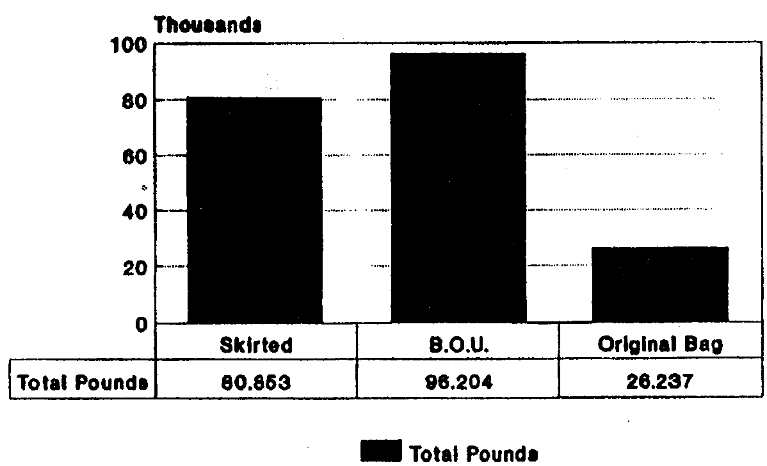


Figure 10 Artesia results - skirted BOU-OB

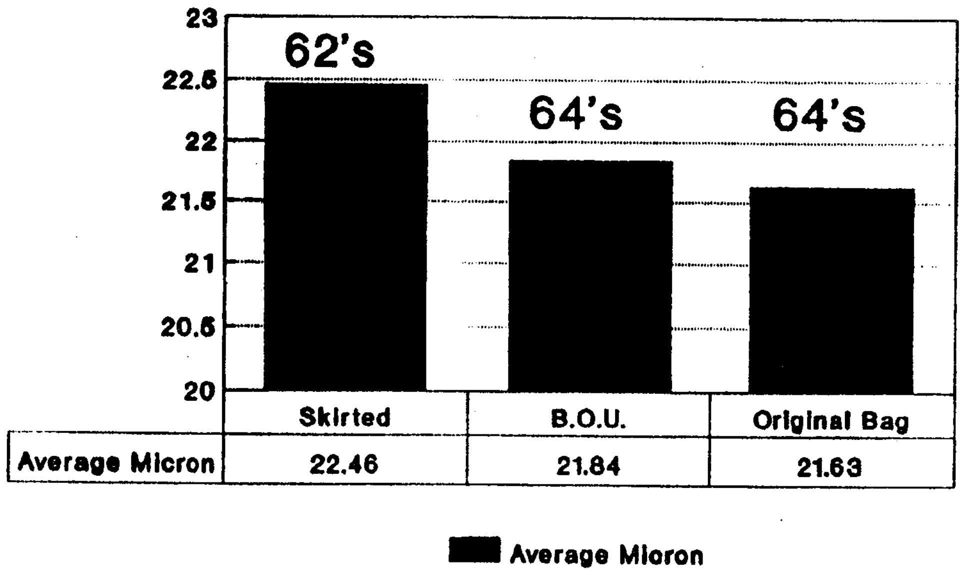


Figure 11 Artesia results - skirted BOU-OB

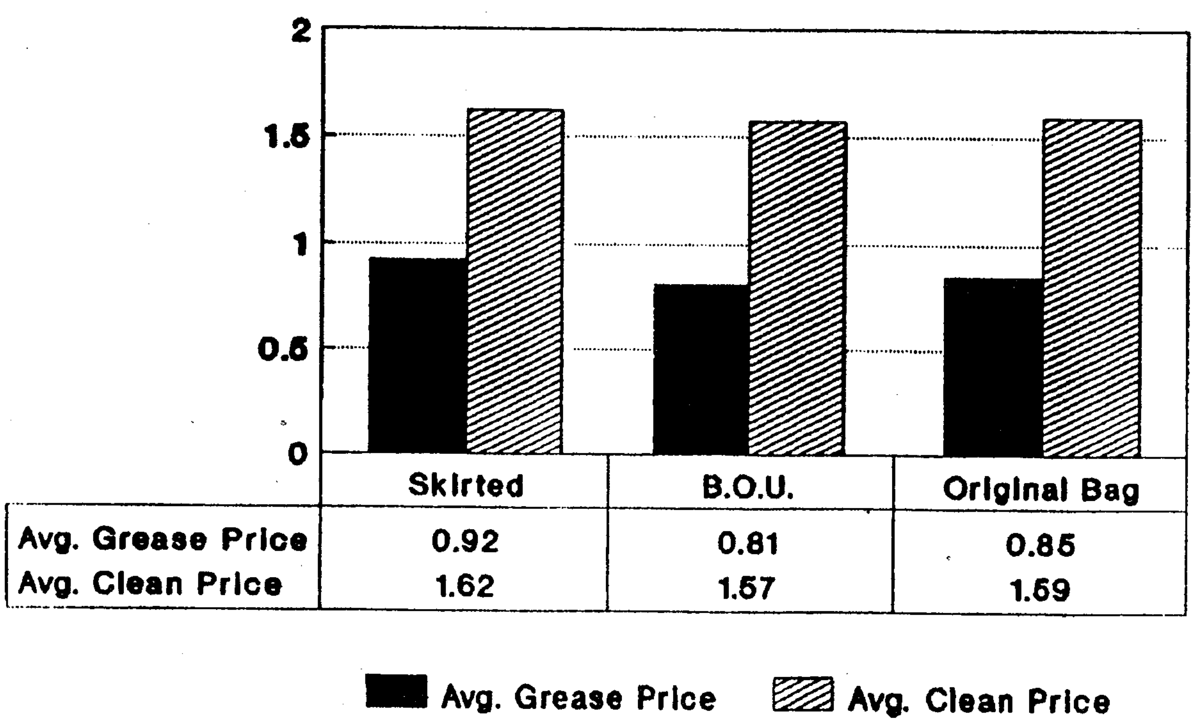


Figure 12 Artesia results - skirted BOU-OB

A warehouse association in Texas compared prices, including incentive payment, of prepared (classed) wool with ungraded wool over a seven year period (Campbell personal communication). The prepared wool consistently brought a higher price over ungraded wool. The differences ranged from a low of $.29 to a high of $.99 per pound grease. A price summary of 1991 classed and O.B. wools showed a $.21 grease price advantage and a $.54 incentive price advantage for a total $.75 bonus for classed wools.

To summarize the economic considerations there are certainly some very positive results to review. The potential for increased volumes of quality wools will increase buyer participation thus increasing competition and ultimately increase prices for raw wools that are properly prepared.

IMPLICATIONS

This discussion has only dealt with the WQIP as it pertains to raw wool preparation. There are many more facets of the WQIP. As mentioned, many individuals and groups have been working many years to propel ASI's WQIP to its current position. This classer program has not fully matured. However, progress has been indicated and acceptance gained. There are some basic implications and conclusions that can be stated.

Skirting and classing wools does improve the overall quality of the fleece and clip. The classer schools should maintain a quality standard for skirting and classing. As classers gain experience with producers, warehouses, and mills this quality will reach higher standards. Coupled with more sales and volumes in the sales, the ability to improve sale by objective measure and by sample will make U.S. wools more competitive.

The increased use and the ability to track individual lots through processing will give the industry valuable information on particular wool types, which then can be analyzed giving back results that can be implemented in further change and improvement. This may reflect management or genetic changes to individual producers.

There is a need in this program. One consideration is an objective, rational, and patient view by individuals who are not convinced this is the right track. The other is more research, such as has been presented, including combing trials and value added methods.

REFERENCES

Kott, R. W., R. H. Stobart, C. M. Hoagland, C. L. Johnson, B. A. Cameron, and V. M. Thomas. 1991. Effects of Skirting on Processing Characteristics of Targhee Wool. Montana Agric. Exp. Sta., J. Series Number J-2662.

Early, J. O. 1984. Cost and returns of an alternative wool preparation method. New Mexico Coop. Ext. Ser., Guide B-407.

McFadden, W. D. 1958. The economic effects of skirting fine wool fleeces. New Mexico Agric. Exp. Sta. Bull. 422.

Personal Communication: Campbell, Fred. Paint Rock, TX; Cook, J D. Mertzon, TX; Parker, Wendell. Artesia, NM.

LAPAROSCOPIC ARTIFICIAL INSEMINATION A MEANS TO IMPROVE GENETICS

Martin R. Dally
Animal Science Department
University of California - Hopland Field Station

For many years artificial insemination of sheep was thought to be impractical, mainly due to the difficulty of detecting estrus and controlling the ewe's estrus cycle. The inability to freeze ram semen was another factor which limited a wider use of AI. However, today with the use of progestogen and PMSG the synchronization of the ewe's estrus cycle is possible. In addition, ram semen can now readily be frozen which opens the door for interstate as well as international movement of semen. Even with these technological breakthroughs the conception rate of artifically inseminated ewes was relatively low and therefore was not practical for the commercial producer. The main reason for the low conception rate is that semen can only be placed at the opening of the cervix or slightly inside the cervix. The anatomical structure of the ewe's cervix makes the penetration of the cervix nearly impossible. Cervical AI conception rates using fresh or frozen semen are approximately 55 and 25 percent, respectively. If semen could be deposited in the uterus as is the case with cattle, the conception rate would improve to the point where AI of sheep would be practical on a commercial basis.

In 1982 Australian researchers developed a laparoscopic insemination procedure which revolutionized the sheep AI technique. Conception rates using frozen semen range from 50-80 percent when a skilled technician uses the laparoscopic insemination technique to place the semen directly into the ewe's uterus. Laparoscopic AI conducted at the University of California's Hopland Field Station, using frozen semen has routinely resulted in a 70+ percent conception rate. Individual rams have consistently produced 85 percent conception rates. Conception rates can vary greatly depending on semen quality breed of sheep, management, time of year and the technician. An additional advantage of laparoscopic insemination, also referred to as intrauterine insemination, is that lower numbers of sperm are required per insemination.

The number of spermatazoa needed for laparscopic insemination is at least one third of that required for cervical insemination using frozen/thawed semen. A suitable ejaculation is diluted and processed into fifty to ninety 1/4 cc French straws for laparoscopic insemination. One straw is required per ewe inseminated and contain between 40-60 million spermatoza post thawing. If frozen pellets are used approximately 22 pellets can be made per ejaculation with each containing enough semen to laparoscopicly inseminate three ewes. Straws and pellets are stored in liquid nitrogen at minus 196 C (-385 F). Prior to insemination the straws are thawed in a waterbath at 37-38 C(98.6-100.4 F) for 2-3 minutes. Fresh ram semen can be used but insemination should take place with in 10 hours of collection.

The laparoscopic insemination procedure is a minor surgical method by which semen is placed in the uterus horns. Prior to surgery the ewe's estrus cycle should be synchronized by the use of hormone therapy. This normally involves inserting a pessary impregnated with progestogens into the ewe's vagina and leaving it there for 12 to 14 days. During that period the progestogen is slowly absorbed through the vaginal wall into the ewe's blood stream. The increased level of progesterone inhibits follicle development and prevents the ewe from coming into estrus. Once the pessary is removed (12 to 14 days after inserting) the progesterone level drops off and follicles develop. At the time the pessary is removed PMSG is given to tighten up the degree of synchronization. However, if a high level of PMSG is given the ovulation rate will be to high resulting in excessive number of multiple births. Normally, 400 international units of PMSG are given. If insemination is to take place at the peak of the natural breeding season and the ewes are in excellent condition the level of PMSG may be reduced to 300 international units. Insemination should take place 56-66 hours after pessary withdrawal.

Twenty-four hours before surgery both feed and water should be withheld from the ewes. This reduces the contents of the rumen and bladder. A full rumen and/or bladder may hinder locating the uterus and increase the chance of puncturing the rumen or bladder during surgery. Five to ten minutes before surgery the ewes are given an intramuscular injection of a mild tranquilizer. Once the ewe becomes tranquilized she is placed in a laparoscopy cradle. The posterior abdominal region in the area of the pubis is surgically prepared by removing the wool and disinfecting the skin. Approximately 5 inches anterior of the udder and 2 inches on both sides of the mid-line the ewe is given an injection of a local anesthetic. The cradle is then placed in it's surgical position.

The ewe is now laying on her back at an approximate 40 degree angle with her head in the downward position. Two small incisions approximately one half inch in length are made in the skin at the site where the local anesthetic was injected to facilitate puncturing the abdominal wall with a trocar. The muscles of the abdominal wall are not cut, the muscle fibers are separated and once the cannula is removed at the completion of the laparoscopy, the fibers return to their normal position in relation to each other. Once the abdominal wall is punctured the trocars are removed from the cannulas and an endoscope and a manipulating probe are placed through the cannulas into the abdominal cavity.

An endoscope is a special telescope with a fiberoptic light, which permits the technician to view the ewe's reproductive tract. A small amount of carbon dioxide is then placed into the abdominal cavity, which helps isolate the uterus from other organs. The carbon dioxide also has a mild anesthetic effect on the ewe. The probe is then used to bring the uterus into the proper position from insemination. In some cases it is not necessary to use the probe since the uterus may already be in the proper position. The less the reproductive tract is manipulated the better the conception rate. Once the uterus is in the correct position the probe is removed and replaced by the inseminating gun containing the semen.

The technician then punctures the uterine horn half way between the uterine bifurcation and the utero-tubal junction as seen in Figure 1. The semen is injected directly into the lumen of the uterus. The inseminating needle which enters the uterus wall is extremely fine having an outside diameter of 0.04 mm. The same procedure is then repeated on the other uterine horn. The insemination procedure takes only 2 to 5 minutes.

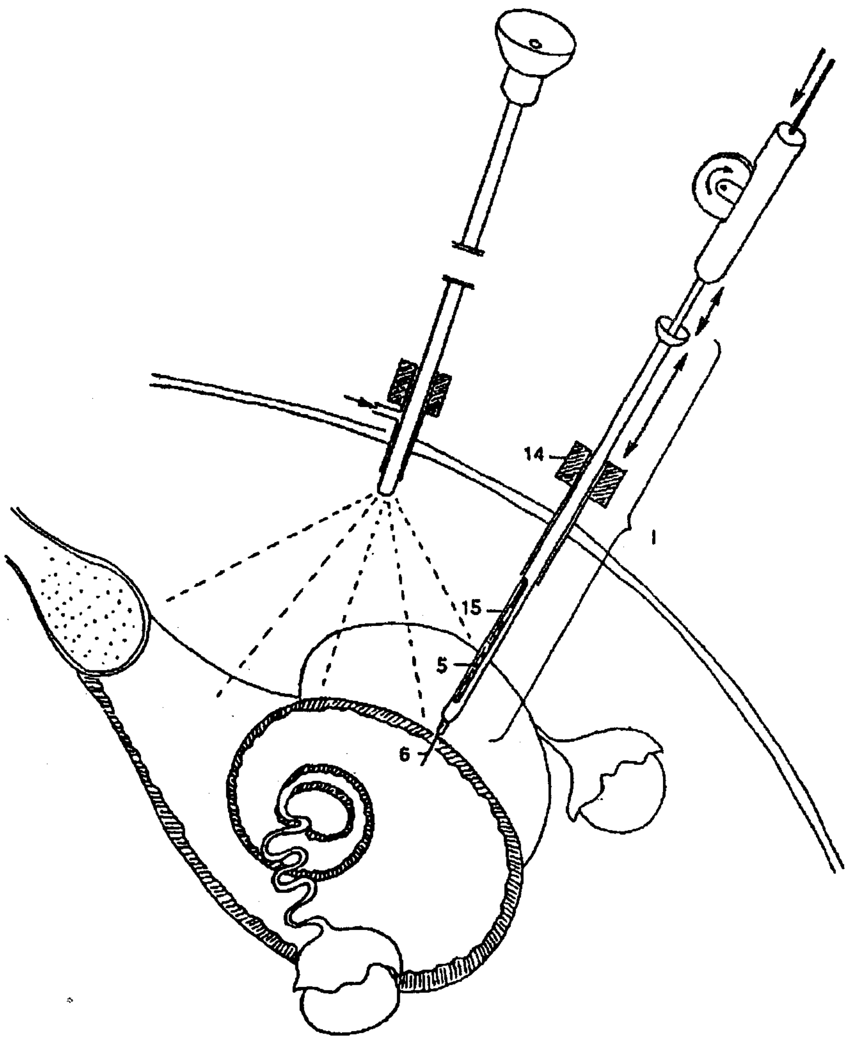


Figure 1 Laparoscopic AI. Instruments inserted in the female, with the palpator. Source: FAO 83, 1991

Once both horns have been inseminated the cannulas are removed and a topical antibacterial spray is applied on the two small incisions. In some cases bleeding may occur which is due to the perforation of surface blood vessels. If excess bleeding takes place, michel wound clips can be used to close the wound. My experience is that very little suturing is required. The ewe is removed from the cradle and then allowed to walk, under her own power, to a holding pen. Ewes normally start eating within minutes of being place in the holding pen. The incidence of infection as a result of the surgery is extremely low.

The genetic gains that AI can offer sheep producers is almost unlimited. Semen from superior domestic and international rams is now available. Straws can be purchased for as little as $7.50 to as much as $75.00 depending on the breed and quality of ram. Semen from Australian Merino rams that produce in excess of 35 pounds of grease wool are available for $30-40.00 per straw. The cost of insemination will vary depending on the number of ewes inseminated and transportation costs. When small numbers of ewes are inseminated there is normally a set-up charge plus a per head fee. Cost for AI-ing small groups of less than 10 head run between $20-25.00 per animal. Larger groups of 100 or more costs about $12.50 however, this cost is negotiable. The price of the hormone therapy will vary greatly depending on the amount of PMSG given and number of ewes treated. The cost may be as low as $7.00 perhead.

Implication For the Sheep Producer

AI is the gateway toward the use of top sires, both domestic and international. It offers progressive producers the opportunity to make previously unthought of genetic gains in a very short period of time. Rapid genetic gains can be made in wool quality and quantity, due to their high to moderately high heritability estimates. This is especially true when Merino semen is used because of the superior fleece characteristics. In selecting a sire one should consider the progeny's ability to adapt to the environment. The possibility of negative affects on economically important traits are particularly important when exotic breeds are being considered.

References

Chemineau, P., Y. Cagnie, Y. Guerin, P. Orgeur and J. C. Vallet. 1991. Training Manual on Artificial Insemination in Sheep and Goats. FAO Animal Production and Health Paper 83. Rome.

Evans, G. and W. M. C. Maxwell. 1987. Salamon's ArtificialInsemination of Sheep and Goats. Butterworths. Sydney.

ELECTRIC FENCES FOR PREDATOR CONTROL

David W. Pratt
Livestock/Range Management Advisor
Solano and Yolo Counties

INTRODUCTION

The effectiveness of a fence depends on the degree to which it restricts animal movement into, or out of, the fenced area. Fences restrict movement by creating physical and/or psychological barriers to animals. Since the introduction of barbed wire most American ranchers have built fences to create physical barriers. For the most part, they have adequately contained livestock, but have not effectively kept predators out.

The potential of a painful shock from touching an electric fence creates a psychological barrier to animal movement. Once shocked animals are reluctant to challenge the fence because of their fear of pain. This psychological barrier can be an effective barrier to predators. Under situations of high predator pressure, both physical and psychological barriers may be necessary for livestock protection.

There are three basic types of electric fences: 1. Temporary, portable electric fences; 2. Retrofitted electric fences; and 3. High-tensile electric fences. There are dozens of variations of each of these basic fence types. The fence type, the kind of materials, fence height, number of wires, wire spacing, and post spacing needed for an effective predator fence depends on the species of predator, the type of stock protected, terrain, soil moisture, remoteness of the site, soundness of existing fences, and costs. It also depends on the degree of predation pressure. As one fence supplier remarked to me not long ago, "you must fence the desire." (Coyle 1989) In other words, if none of your neighbors have predator fences, it won't take an elaborate electric fence to stop predation on your ranch. However, if all of your neighbors have five foot tall, 9 wire, high-tensile electric fences, predators will probably begin to find ways through your fence. Simply building an electric fence will not protect livestock from predators. In addition to careful planning and proper construction, effective electric fences also require monitoring and maintenance. Managers must be committed to making the fence work.

This paper describes basic design considerations for building effective predator fences.

TEMPORARY PORTABLE ELECTRIC FENCES

Temporary portable electric fences usually consist of one to five light flexible wires fastened to plastic or fiberglass posts and charged by an energizer. Some times of steel or aluminum wire can be used for temporary electric fencing, but polytape or polywire type products are more commonly used for this purpose. These products consist of tiny stainless steel or aluminum wires interwoven with plastic or fiberglass threads. The wire, is dispensed and rewound on reels. As much as a mile of temporary fence can be constructed in an hour.

The primary intended use of these products is to divide pastures for better grazing management. One hot wire can control cattle in irrigated pastures. Where soil moisture is lacking more wires are needed. Three to five wires are needed to control sheep.

Temporary, portable electric fences constructed from polywire are psychological barriers. Livestock must be exposed to the wire in a controlled setting to learn that touching the fence will cause pain. Once stock are trained, these fences can be very reliable. It is much more difficult to train predators to these fences and therefore, one would not expect these psychological barriers to provide much protection against predators. But some producers have found that temporary electric fences with four to five wires can keep dogs and coyotes from attacking sheep. However, if the predation pressure were increased (if everyone else had sheep confined in hi-tensile electric fences) coyotes and dogs would probably go through, or over, temporary fences.

Polywire, under continuous use should last three to five years, depending on the number of times it is rolled and rerolled, the brand, and environmental conditions. Posts, clips and reels should last five to ten years. The energizer should last indefinitely. Costs usually range from $0.10 to $0.29 per foot (Pratt 1988).

RETROFITTING EXISTING FENCES WITH ELECTRIC WIRES

Retrofitting an existing barbed or woven wire fence with smooth light gauge wires mounted on offset insulators can reduce dog and coyote predation problems. Fifteen to seventeen gauge steel wire is most commonly mounted on high density plastic insulators which are fastened to the wood and metal posts of the existing fence. These insulators hold the "hot" wire one to five inches away from the rest of the fence (depending on the length of the insulator). The soil and the original fence wires are used to ground the system. Avoid using post-mounting offset brackets longer than six inches.

The mounting brackets on "t" post insulators attach only to the wire side of the post. Ideally insulators should be installed so that the offset wires are on the outside of the fence (predator side). Since fence wires are usually installed on the stock side of the fence, the posts often face the wrong direction so that the offset wires must run on the inside of the fence. While less desirable, installing the hot wires on the inside of the fence can also be effective.

Offset brackets that mount on the existing fence wire permit installation of hot wires on the predator side of the fence regardless of how posts have been installed. In addition, they generally require less maintenance.

Traditional sheep fences consist of woven field wire with one or two strands of barbed wire. Wires are mounted on metal "t" posts spaced ten to twelve feet apart. Material costs for this type of fence are about $0.71 per foot (Pratt 88). To retrofit this type of fence an offset bracket should be attached at the bottom of the fence so that the bottom wire is two to four inches from the soil surface. The top bracket should be installed an inch higher than the top wire of the original fence so that the top hot wire is at least 46 inches from the soil surface. Retrofitted fences with two hot wires have been effective (Kingsbury 1987), however, most ranchers install a third hot wire on offset brackets between the top of the woven wire and the bottom barbed wire. Material costs for the retrofitting described above would be approximately $580 or about $0.11 per foot.

Some ranchers who have installed this style of fencing remark that debris or vegetation growing on the fence can drain power or short the fence out. These problems can be overcome with the proper type of energizer, proper grounding, and/or improved monitoring and fence maintenance.

Aluminum wire, which is lighter and much more conductive than the steel wire traditionally used, is now available. While slightly more expensive, aluminum will not rust, and should reduce long term maintenance costs.

A RETROFIT PREDATOR FENCE IN SOLANO COUNTY

Three electric wires were added to the existing barbed and woven wire fence on a large commercial sheep ranch in Solano County California. Sheep losses due to coyote predation on this ranch had increased every year. In the 1984-85 season 200 lambs and 50 ewes were killed by coyotes resulting in losses estimated at over $15,000.

In 1985 a predator fence consisting of three "hot" wires mounted on offset insulators on wooden fence posts and metal "t" posts" of the existing barbed and woven wire fence.

Fence construction began with clearing vegetation and debris from the eight miles of fence surrounding the pasture. This was followed with a herbicide application to keep the fence line free of weeds.

The existing fence (woven wire with two strands of barbed wire at the top on metal "t" posts) was patched as needed. About 1/4 mile of new woven wire fence was built where the old fence was beyond repair.

Three hot wires were installed on five inch plastic offset insulators mounted on existing posts. The bottom wire was six inches off the ground. The second wire was at a height of 18 inches and the third wire was placed along the top of the old fence.

After the fence was built losses were reduced but continued to occur primarily due to incidence of human trespass and damage to the fence. Once a daily maintenance schedule was adopted losses to predators ceased. Maintenance consisted of checking to make sure each section of fence was hot and to remedy any problems in uncharged sections on the spot and required about two hours a day while sheep were in the pasture.

The fence dramatically reduced predation losses to coyotes. The estimated value of the lambs and ewes saved was over $12,000. The fence paid for itself in the first year (Table 1). Conservative estimates of the value of lambs lost show that by the end of the second year the fence had saved nearly $14,000.

Table 1. Cost/Benefit of Solano County Retrofit Predator Fence

	Item	Cost ($)	Item	Benefit ($)
YEAR 1	Materials	2,676		
	Labor	6,300	Lambs Saved	10,460
	Maintenance	2,996	Ewes Saved	1,750
	Total 1st Year Cost	**$11,972.00**	**Total 1st Year Benefit**	**$12,210.00**
YEAR 2			Lambs Saved	13,300
	Maintenance	1,600	Ewes Saved	1,750
	Total 2nd Year Cost	**$1,600.00**	**Total 2nd Year Benefit**	**$15,050.00**
1st Year Benefits - Costs = $518				
2nd Year Benefits - Costs = $13,450				
Total Savings From Fence After Two Years = $13,968				

HIGH-TENSILE ELECTRIC FENCES

Properly planned, constructed, and maintained high-tensile electric fences can provide protection from predation by dogs, coyotes, mountain lions, and bears. These fences are constructed using smooth 12-1/2 gauge wires strung at 250 to 350 pounds of tension per wire. High-tensile predator fences usually have seven to eleven wires. Posts are usually set further apart than posts for conventional fences (up to 120 feet). Wire spacing is maintained by using stays or droppers between posts. Droppers may be fiberglass rods or standard metal "t" posts with insulators. They are usually spaced at 12 to 15 foot intervals. Due to the number of wires and the high tension on each wire, corner and end posts must have special bracing to keep them from pulling out of the ground (Pratt, 1989).

Most problems with hi-tensile electric fences can be traced to inadequate grounding, energizers with too little capacity, or lack of regular fence monitoring and maintenance.

Building a new high-tensile predator fence is more expensive than retrofitting an existing fence with hot wires. It is often roughly equal to the cost of building a traditional barbed/woven wire fence (Pratt 1988) and is much less than the cost of building a new barbed/woven wire fence with offset electrical wires. Material costs usually range from $0.50 per foot to $0.80 per foot, depending on terrain.

A HIGH-TENSILE PREDATOR FENCE IN NAPA COUNTY

A small scale sheep producer in Napa County built a nine wire high-tensile predator fence to protect her flock against predation from dogs and coyotes.

The wires from bottom to top were spaced 4, 5, 6, 6, 6, 8, 10, and 12 inches apart with the bottom wire 4 inches off the ground and the top wire 60 inches off the ground. Five wires were hot (wire numbers 1, 3, 5, 7, and 9). All other wires were connected to the ground rod.

Four inch diameter, pressure treated lodgepole pine posts were spaced at 60 feet apart except where changes in terrain or turns in the fence line made it necessary to set additional posts. Kiwi strainers and breast blocks (Pratt 1989) were used to brace corners and ends. Five inch diameter, pressure treated lodgepole posts were used to build breast blocks and strainer assemblies. The owners wanted the fence to parallel the ranch road which curved in several places. This required installation of several kiwi strainers and breast blocks and drove the total cost of the fence up. Material costs were 1941.17 ($0.73/foot).

The owners have checked the fence daily to make sure power is on. Thus far, there has been no other maintenance required. Since its construction (May, 1989) there have been no predation losses.

SUMMARY

1. There are three basic types of electric fences:
   1. Temporary, portable electric fences;
   2. Electric wires mounted on offset brackets attached to existing fences; and
   3. High-tensile electric fences.

2. The fence type, the type of materials, fence height, number of wires, wire spacing, and post spacing needed for an effective predator fence depends on the species of predator, the type of stock protected, terrain, soils, remoteness of the site, soundness of existing fences, and costs. It also depends on the degree of predation pressure.

3. Grazing management is the primary use of temporary portable electric fences (made from polywire or polytape). Their value of predator control is limited.

4. Retrofitted electric fences can provide inexpensive, effective protection for sheep against dogs and coyotes.

5. Properly planned, constructed, and maintained hi-tensile electric fences can provide protection from predation by dogs, coyotes, mountain lions, and bears.

6. For effective predator control, all electric fences require careful planning, proper construction, and regular monitoring and maintenance. Managers must be committed to making the fence work.

LITERATURE CITED

COYLE, A. 1989. Personal Communication 12/1989 (Coyle owns and operates HTF Posts & Poles, 851 Richards Blvd., Sacramento 95814).

KINGSBURY, R. 1987. Personal Communication 11/1987 (Kingsbury is a ranch management consultant Box 1988, Woodinville, Washington 98072)

PRATT, D. 1988 Stock Talk, vol. 4, no. 6. (Solano County U.C. Cooperative Extension Newsletter) Hi-tensile fencing costs. p 1-3.

PRATT, D. 1989. Stock Talk, vol. 5, no. 1. (Solano County U.C. Cooperative Extension Newsletter) Strainer assemblies for hi-tensile fences, p 8-12.

THE HOPLAND LONG TERM SELECTION PROJECT[2]

Eric Bradford, Martin Dally and Hakan Sakul
Department of Animal Science
University of California, Davis

The primary source of income from sheep flocks in the U.S. is the sale of lambs for meat. Weight of lamb sold per ewe is determined by number of lambs weaned and their weaning weights. Selection for multiple births and for weaning weight are frequently recommended as means of achieving genetic improvement in performance of sheep. There have been only a few long term selection experiments in sheep to evaluate the effectiveness of selection for these traits. A further consideration is the environment in which the selection experiment is carried out. The question of optimum environment has been investigated in several experiments, mostly in laboratory animals. However, a controlled laboratory environment does not adequately represent a typical livestock environment. For these reasons, selection of sheep in two environments, consisting of feedlot (Davis) and range (Hopland) environments, was undertaken to determine: 1) the direct and correlated effects of selection for weaning (120-day) weight, and 2) the extent to which the improvement through selection under feedlot conditions was expressed under range conditions.

DESCRIPTION OF THE EXPERIMENT

The foundation stock was a crossbred "whiteface" population including Rambouillet, Merino, Corriedale and Targhee breeding. The sheep averaged 70 to 75% finewool ancestry and closely resembled Targhees in performance and appearance. The design of the selection experiment is shown in Table 1.

Table 1. Design of the Selection Experiment

	Location							
	Davis				Hopland			
Selection Criterion	Line	No. rams/ Yr.	No. ewes/ Yr.	Years	Line	No. rams/Yr.	No. ewes/ Yr.	Years
120-d weight	DW[1]	5	80	'61-'77	HW	5	70-100	'61-'92
120-d weight					DH[1]	5	60-100	'61-'92
Multiple births	DT	5	80	'64-'71	HT[2]	5-8	80-120	'63-'92
Unselected	DC	5	40	'64-'77	HC-1 HC-2	5 5	40-70 40	'61-'92 '61-'77

1 Selected DW rams used as lambs in line DW at Davis and as yearlings in line DH at Hopland, 1961-1978. DH rams selected at Hopland beginning 1979 (sires of 1980 lamb crop).
2 DT line transferred to Hopland in 1971 and combined with HT

[2]The contributions of Don Torell, Laurel Lasslo and Roberto Neira to this work are gratefully acknowledged.

Some details are as follows. In 1959, ewes were randomly allocated to weight-selected and control lines in Davis (DW and DC) and Hopland (HW, and HC1 and HC2), respectively, and selection started in 1961. In 1963, the older ewes from all lines, and some additional Hopland flock ewes of similar breeding, were ranked on mean lifetime number of lambs born and used as the foundation for a multiple birth selected line (HT). Selection of rams in the T line was based on dam's lifetime number of lambs born. In addition to selected and control lines in each location, a third line (DH) has been maintained at Hopland throughout the experiment. The DH line ewes were allocated from the same pool as the other lines and have been selected on the same basis as in the HW line. The DH rams have been the selected DW rams, which were used in Davis and held over for use in the DH line as yearlings. Thus, DH is analogous to a range flock consistently buying rams raised and selected under conditions comparable to that in which many purebred flocks are kept. The HW line, in contrast, represents a range flock raising and selecting its own rams under range conditions. The C lines represent flocks in which no selection is practiced.

RESULTS

1. 120-d weight: There was a large year-to-year variation in both lactations. Results showed that selection in both environments increased weaning weight compared to the unselected controls. However, it was clear that the improvement achieved in feedlot conditions (Davis) was much more than under range conditions (Hopland). The improvement made at Davis was expressed at Hopland, to a lesser extent, but the line was still slightly heavier than the HW line. There has been a negative environmental trend at Hopland. The overall direct response to selection for the first twenty years, calculated as the average divergence per year between the selected and control lines in each location, multiplied by the number of years of selection, resulted in increases in 120-d weight of 15.8, 7.4 and 10.4 lbs for the DW, HW and DH lines, respectively. Genetic potential for early growth rate appears to be expressed more fully under better feed conditions.

2. Correlated response in reproduction: Selection for 120-d weight caused a correlated increase in birth weight for both singles and twins, with a relatively greater increase in the drylot environment. Correlated response was also observed in mature ewe weight, greater in line DW and DH than HW. The difference in mature weight between the two selected lines in Hopland and the Hopland control was about 20 lbs. Because increased feed intake is associated with greater mature weight, this increase in mature weight would offset a significant part of the advantage of the heavier lambs. Especially, in situations where the feed supply is limited; fewer selected animals can be grazed than control animals in a fixed acreage. The traits that changed most as a result of selection for 120-d weight, were fertility and lamb survival. Fertility declined in both lines DW and DH, as compared to their respective controls. Lamb survival was lower in selected lines, and showed little change in the control lines. Decreases in lamb survival were 10.2, 5.5 and 10.8% in lines DW, HW and DH as compared to respective control lines.

3. Multiple births: Litter size was similar among mature ewes from lines T and HW and above the control lines, while a decline was seen for line DH. The main finding from selection for multiple births was that selection resulted in little further response after a significant increase of .16 lambs from initial screening of 80 ewes from 400-500 base ewes. Besides an average of 16% more lambs, the HT line showed no significant difference in fertility and lamb mortality, 1 lb more lamb at birth and 6 lb. more at weaning per ewe lambing, compared to the control line. It is puzzling that multiple birth rate did not respond to selection after the initial screening. A similar result occurred in the Wallace high fertility line of Romneys in New Zealand, where no further change was observed in twinning rate after 10-15% increase due to initial screening. However, after about 20 years the lines diverged and resulted in a difference of 62% in twinning between High and Low selected lines. Comparison with an unselected control revealed that more than three-fourths of the difference represented improvement in the High line. The date from later years in our experiment are being analyzed to investigate whether further selection resulted in a similar situation.

SUMMARY

A selection experiment was designed in grade Targhee sheep to investigate the direct and correlated effects of selection for 120-d weight, and to determine the extent to which improvement through selection under feedlot conditions was expressed under range conditions. Ewes were randomly allocated to weight-selected (DW) and control (DC) lines at Davis and at Hopland (HW, and HC1 and HC2). A separate selection line (DH) was also maintained at Hopland. Selection started in 1961. In 1963, a multiple birth selected line (HT) was formed at Hopland using the older ewes from all lines and additional Hopland flock ewes. Selection continued to date in both weight-selected and multiple birth-selected lines. Response to selection for 120-d weight fluctuated among years. Improvement achieved in the feedlot conditions (Davis) was much more than under range conditions (Hopland). Direct cumulative responses to selection for the first 20 years were 15.8, 7.4 and 10.4 lbs for the DW, HW and DH lines, respectively. It was concluded that genetic potential for early growth rate appears to be expressed more fully under better feed conditions. Also, selection for 120-d weight caused a correlated increase in birth weight and mature weight. While litter size did not change, fertility and lamb survival declined in selection lines. Selection for multiple births resulted in only a little response following an increase of .16 lambs per ewe lambing from the initial screening.

References

Bradford, G.E., J.F. Quirke and T.R. Famula. 1986. Fertility, embryo survival and litter size in lines of Targhee sheep selected for weaning weight or litter size. J. Anim. Sci. 62:895-904.

Lasslo, L.L., G.E. Bradford, D.T. Torell and B.W. Kennedy. 1985. Selection for weaning weight in Targhee sheep in two environments. I. Direct response. J. Anim. Sci. 61:376-386.

Lasslo, L.L., G.E. Bradford, D.T. Torell and B.W. Kennedy. 1985. Selection for weaning weight in Targhee sheep in two environments. II. Correlated effects. J. Anim. Sci. 61:387-397.

Neira, R. 1989. Selection for Multiple Births in Targhee Sheep. Ph.D. Thesis, University of California, Davis.

QUALITY WOOL CLIP ESSENTIAL TO SURVIVAL OF WOOL INDUSTRY

Martin R. Dally
Department of Animal Science
University of California - Hopland Field Station

The Ford Motor Company has the motto *"Quality is Job One,"* while other companies say *"The Quality Goes in Before the Name Goes On"*. Major companies throughout the world know that their success often depends on their ability to produce a quality product. The survival of the American wool industry may very well depend on its ability to deliver a high quality wool clip. The time has come for our industry to ***"Pack Our Wool With Pride"***.

Wool is an international commodity and American wools must compete in the international market. Countries such as South Africa, Australia, and New Zealand have strict quality control programs. Australia has about 35,000 registered wool classers or quality control officers to assure that their wool is of the highest quality. Approximately 99% of Australian wools are objectively measured prior to sale. Due to high standards, Australian grease wools have averaged 28 cents a pound more than the same grades of American wools between 1971 and 1980. The reason for the higher price is that Australian wools have 7 to 8% less noilage and cost 5% less to clean than domestic wools. Australian fine wools yield 60-70% fiber while similar domestic wools yield only 40-50%. The colored fiber counts are much lower in Australian wool which adds to their value.

The American sheep producer his the ability to produce and market a quality product. Those producers that are willing to adhere to the standards presented in the ASI booklet, *"Code of Practice for Preparation of Wool Clips in the United States"*, should be economically rewarded for their efforts. In times of depressed wool prices, as we have seen in the past two seasons, the difference between being offered a price and not being able to sell our wool may very well depend on how well the clip was prepared for market.

The first step in marketing a quality wool clip is to allow the sheep to produce the highest quality fleece as possible, within economic limits. Providing adequate nutrition plays a key role in assuring proper wool growth. Establishing a breed improvement program by culling animals with inferior fleeces and selecting superior fleeced replacement animals will allow wool quality as well as quantity to improve. Wool characteristics are moderate to highly heritable; therefore, genetic progress can be made relatively fast.

One of the largest problems with the American wool clip is the amount of contamination. There are three sources of wool contamination-natural, acquired, and applied. Natural contaminations are wax, suint and color fibers. The amount of wax and suint can be decreased by selection; however, the amount they can be reduced by is very limited.

Color fibers are the most serious form of natural contaminates. Many major wool mills in the U.S. and overseas require less than 5 colored fibers per ounce of top when making white or pastel fabrics. Presently, the best prepared clips in the U.S. seldom have less than 10-15 colored fibers per ounce and most clips have 130 per ounce. Top with high colored fiber counts are limited to products dyed medium or dark shades. Clips with low colored fiber counts sell for approximately 10% higher than clips with high counts.

Burlington Industries can only on rare exceptions use domestic wool in their white or pastel shades of fabrics due to the color fiber contamination. These fabrics are normally made from South African and Australian wools and have 0-4 colored fibers per ounce.

Lowering the amount of colored fibers in the American clip would be a major step in improving its quality. Natural colored fibers can be controlled through shearing floor management and culling. Listed below are several suggestions that can help control the amount of natural color fiber contamination.

(1) Asking shearers to call out spots of colored fibers and removing them. This will substantially lower the amount of color fiber contamination.

(2) Removing the belly wool at shearing will help in lowering the amount of colored fiber contamination.

(3) Any animals having colored wool should be culled. A close inspection of all replacement animals for color fibers after shearing will assist in eliminating the problem.

Acquired contaminates are vegetable matter (VM), polypropylene, color fibers and stained wool. All acquired contaminates can be eliminated or significantly decreased by improved management. Often times it is the small changes in management that make a vast difference in the amount of acquired contamination.

Vegetable matter contamination is a serious problem in some wool clips and results in considerable economical losses. Clips containing high levels of VM contamination are severely discounted. Wool having excessive VM must be carbonized before carding. Carbonizing is a process whereby wool is immersed in a dilute sulfuric acid solution. The acid reduces the VM to a carbon compound which is then removed mechanically during carding and combing. Carbonizing decreases the fiber strength and staple length as well as making the wool feel harsher. Carbonizing wool is expensive and lowers the economic value of the wool.

It is important that producers take every possible measure to decrease the amount of VM contamination. There are several management practices that can be initiated to help lower the amount of VM contamination.

(l) Avoid throwing hay on the back of the sheep and pouring grain on the heads and necks during feeding.

(2) Shearing before seeds head out can significantly lower the amount of VM in the wool. Changing the shearing date at the Hopland Field Station from June to mid-April has been very beneficial in lowering VM in our wool.

(3) Restrict sheep from grazing areas that contain plants known to cause contamination, especially when fleeces are long. These areas can be successfully grazed just after shearing when the freshly shorn fleece are not likely to become contaminated with VM.

(4) In extreme cases the use of herbicides may have to be used to control weeds causing VM contamination.

(5) Corrals should be cleared of vegetation before being used. Often corral areas are not grazed and excess vegetation is present which readily contaminates sheep being worked.

(6) Skirting fleeces prior to packing has resulted in lowering the amount of VM and increased the value of the skirted wool. In a western South Dakota skirting trial, skirted fleeces contained 0.8% VM where unskirted fleece had 1.9% VM.

(7) Avoid bedding sheep on hay or straw prior to shearing.

POLYPROPYLENE CONTAMINATION

Polypropylene contamination is a serious problem which has been estimated to cost the United States sheep industry 10 million dollars annually. Small pieces of polypropylene that become entangled in the fleece can't be removed mechanically or chemically. They must be removed by hand which is extremely expensive. Many domestic mills will not accept polypropylene contaminated wools.

Hay bale twine is the primary source of contamination; however, food wrappers, garbage bags, and tarps used as ground cover during shearing have been reported as other sources of contamination. If possible, only bales tied with wire should be used. When polypropylene tied bales are used, every possible precaution should be taken to dispose of the twine. When a hay baler ties a bale off, two pieces of polypropylene approximately one-inch in length are cut off. These small pieces will fall to the ground or remain with the bale. It is these small pieces that cause a majority of the contamination, especially on the bellies of the sheep. Contamination can be avoided by removing the belly wool at shearing time and packing it separately.

COLORED FIBER CONTAMINATION

Fibers from other animals such as dogs, goats, cats, cattle, and horses, as well as blackface and colored sheep, can cause serious colored fiber contamination. The following suggestions can help control acquired color fiber contamination.

(l) Sheep dogs should not be permitted in the shearing barn.

(2) Steps should be taken to avoid direct contact between sheep and other animals.

(3) Avoid using working areas used by other animals.

(4) Avoid running blackface or colored sheep with white sheep. An Australian study indicated that running two black sheep per 100 white sheep would increase the black fiber count in the white sliver card from 1 to 34 dark fibers per 100 grams.

(5) Shear blackface and colored sheep last. Clean shearing boards thoroughly after shearing colored sheep.

(6) Never sack or bale blackface or colored fleeces with white wool.

STAINED WOOL

Wool stained from bacterial discoloration (fleece rot), urine, and dung can cause economic losses. In Australia, approximately 70% of the colored fibers are the result of stains. Good management practices can decrease the amount of stained wool. The following suggestions will aid in decreasing the amount of stained wool.

(1) Select sheep or wool types that adapt to your environment. In high rainfall areas selecting the correct breed or strain that can withstand the moisture will aid in controlling fleece rot. For example, strong-wooled Merinos do not adapt to high rainfall areas, whereas the Saxon Merino do quite well.

(2) Avoid penning sheep in corrals for long periods of time. When sheep are herded into a corral their wool can become soiled with manure and urine.

(3) Avoid working sheep in muddy corrals.

(4) If ewes are barn-lambed, provide clean bedding at all times.

(5) Tag sheep before shearing. By tagging before shearing, the majority of the stained wool from the rump region is removed.

(6) Never shear wet sheep or pack wet wool. Wool that is packed damp will support bacteria growth which in turn will cause staining.

(7) Remove belly wool and skirt fleeces. Belly wools can be heavily stained with urine and dung. By removing the bellies the stained wool is removed.

(8) During skirting remove locks and other stained wool.

(9) Keep shearing floor clean. Sweeping the shearing floor between sheep will prevent manure, locks, and damp tags from causing stains on the freshly shorn fleeces.

APPLIED CONTAMINATES

Paint brands are the major applied contaminates. Marking chalk, copper sulfate stains (from foot baths), and phenothiazine stains (when used to control internal parasites), can cause unscourable stains. Paint branding should be avoided when possible. Alternate forms of identification such as colored ear tags, nose brands, and ear marking should be used. When paint brands must be applied only use approved scourable paints. A study conducted for ASPC indicated that blue branding paint was the most durable and scourable of the colors being offered, followed by black. The least scourable color was red and should be avoided. When branding do not use an excessive amount of branding fluid. Scourable paints can cause permanent stains when an excessive amount is applied. Using a medium sized brand and branding on the back above the hip is recommended. Brands placed on the back can be clipped off in a chute prior to shearing. If the brands are removed in this manner, the clip can be sold as *"paint free"*. Marking chalk should be used sparingly and never used just prior to shearing. Marking on the head is the preferred location since these marks can be easily removed at skirting. The use of phenothiazine for the control of internal parasites should be avoided since urine and feces from drenched animals will stain wool a bright red color. There are many approved anthelmintics on the market that don't cause staining. Also replacing copper sulfate with zinc sulfate in foot baths will prevent stainning the wool.

REFERENCES

American Sheep Industry Association. 1991. Code of Practice for Preparation of Wool Clips in the United States. American Sheep Industry Association, Englewood, CO.

American Sheep Producers Council, Inc. 1982. National Wool and Pelt Workshop, November 15-18, 1982. Denver, CO 162 pp.

Department of Agriculture. Victoria. 1985. Dark Fibre Contamination in the Wool Clip. Agnote No. 3110/85. Victoria, Australia.

Sachse, James M. 1985. Shearing Facilities and Wool Preparation at Shearing. New Mexico State University. Extension Service Circular 518.

SID, 1988. Sheep Producers Handbook, Sheep Industry Development Program, Inc. Engelwood, CO.

EVALUATING WOOL ON THE LIVE ANIMAL

Paul E. Briggs
Manager, Glenn County Fair

Evaluating the wool or fleece on the live animal is very difficult for many people. Most of us are used to looking at shorn fleeces with the flesh 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:

1. When purchasing replacement animals away from your ranch.
2. When evaluating fleeces in your own breeding program.
3. 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 most 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 difference in physiological state of the animals and its effect on wool production. Barren ewes will have better fleeces than ewes that have raised a lamb(s).

Now, to start analyzing the fleeces. Where do we start?

First let's pick out the areas on the animal's body to look at for evaluating the fleece. Looking at the animal from the side, draw an imaginary horizontal line halfway between the top line and underline of the animal (see Figure 1, Drawing A). This should put your line at approximately the middle of the side.

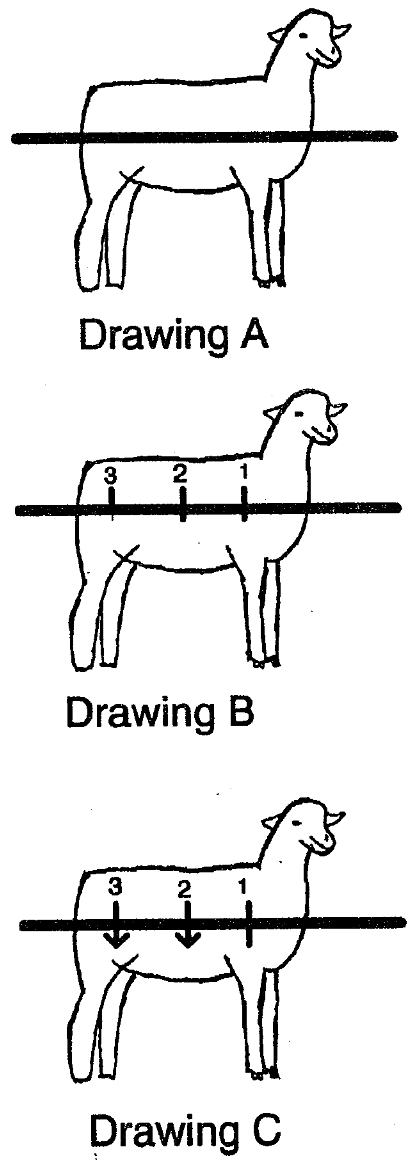


Figure 1 Fleéce evaluation points on the live animal

Figure 1, Drawing B shows three locations in which the fleece should be examined on the imaginary line. These three points are where you want to look at the fleece:

Point 1 is on the shoulder.

Point 2 is in the middle of the side just past the last rib.

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. We are looking at and estimating the following criteria: 1) Fiber diameter or grade, 2) Uniformity of fiber diameter, 3) Staple length, 4) Character, 5) Yield and 6) Density. Each of these criteria are explained below.

Fiber Diameter or Grade

You are going to 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. Refer to Table 1 in the paper *Sheep Breeds and Their Wool* located elsewhere in this proceedings.

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. On the other hand 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 determing the value of wool. Each grade of wool has a minimum length to be classified as staple, French combing or clothing wool. The standard grades and classification length requirements are found in Table 2 in the paper entitled *Wool Grading* found earlier in this proceedings

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 wool fiber, is an important characteristic. Well crimped wools usually pass 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 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 the 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:

1) 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.
2) The density can be evaluated by grabbing a hand full of wool and squeezing it. By doing this at point 1, 2 and 3 as seen in Drawing B in Figure 1 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. Each is described below.

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 on Drawing C in Figure 1 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 which lacks strength, elasticity, and crimp. The fiber is medullated and considerably coarser than other fibers in the shame 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 (Drawing C, point 3). Kemp is acceptable on carpet wool breeds such as Scotch black faces and Drysdales. If kemp is found on a fine wool sheep the animal should be culled.

AUSTRALIAN MERINOS AND THEIR WOOL

Martin R. Dally
Department of Animal Science
University of California - Hopland Field Station

Why is the Australian Merino one of the most sought after breeds of sheep in the world today? They are not known for their carcass characteristics nor growth rate. Their prolificacy is considerably below that of the breeds presently being used in the United States, with exception to the Booroola strain. The answer is quite simple, "Wool Production". One Merino is able to produce nearly 5,500 miles of wool fiber per year. Merino rams have been known to produce 48 pound fleeces compared to 16 to 23 pounds for U.S. wool breeds.

Australia presently has 155 million sheep and approximately 70, 000 sheep producers. A typical Australian sheep operation runs 4,000 head. Between 75 and 85 percent of Australia's sheep are Merinos with the remainder being primarily Polwarth (3/4 Merinos) Corriedale and Border Leicester. New South Wales (NSW) has the largest number of sheep 57.2 million head which is approximately 6 times the U.S. population.

Most Americans think of Merinos being a fine or super fine wool producing sheep. However, this is simply not true. Merinos can produce wool as fine as 16.0 μm (100's) to as coarse as 30 μm (54's). Only 5.5 percent of the Australian wool clip is classified as fine or super fine. Medium wools make up approximately 49 percent of the annual clip and the remainder is classified as strong wool.

The Australians divide the Merinos into three general classes determined by the fineness of fiber produced. The classes are; fine (19.5 μm and finer) medium (21 to 22 μm) and strong (23 μm and coarser). These classes can be broken down into strains of Merinos.

Spanish Merinos were the first Merino strains to be imported into Australia in 1797. They are classified as fine wool sheep with an average frame size. Typical yearling ewes weigh approximately 110 pounds and shear a highly crimped, bright wool in the 20 to 21 μm range. However, some Spanish Merino lines are considerably coarser. Spanish Merino flock ewes shear between 10 and 12.5 pounds of grease wool while special stud ewes will shear 18 pounds. Their staple length will range between 4 and 5 inches. The Macquarie Valley of NSW is the major Spanish Merino production area in Australia.

Saxon Merinos were imported into Australia during the 1820's. They produce fine and super fine wool and are somewhat smaller in frame than Spanish Merino's. Their wool is very bright and has a high number of crimps per inch. They are renowed for producing the finest wool in the world, with fiber diameters between 15.7 and 20.0 μm. Flock ewes shear approximately 7 pounds while special stud ewes will shear around 10 pounds. The Saxon Merino staple length is normally 3 inches. Saxon's fleeces have been known to yield in excess of 70 percent. Saxons are mainly raised in the high rainfall regions of Tasmania, Victoria and NSW. A big advantage of this strain is their resistance to fleece rot. They have been successfully raised in 50 inch rainfall zones in both Australia and New Zealand.

The Peppin Merino is the most numerous of the Merino strains. It was developed by the Peppin family in the Riverina district of NSW. The strain is a result of crossing the original Merinos and Rambouillets. The progeny were then interbred to form the Peppin strain. Peppins are a large to average frame sheep. Yearling ewes weigh approximately 121 pounds in the poorer environments and 154 pounds in the best environments. They produce a bright wool in the 21 to 24 μm range with a 5 inch staple length. The strain is renowed for its high secondary to primary follicle ratio and having a very dense fleece. Peppin flock ewes will shear between 13 and 14 pounds where special stud ewes can shear in excess of 20 pounds. They are the primary strain found in the NSW semi-arid regions with annual rainfall between 12 and 18 inches.

As the Australian sheep industry developed into the hot dry interior plains it was soon realized that the smaller framed fine wool sheep could not adapt to the harsh environment. The small framed animals could not travel the distance required to survive in the arid interior. Australia needed a strain that could thrive in the 6 to 12 inch rainfall zone. Through selection, the South Australian Strong Wool strain was developed along with the Extra-Strong Wool strain. The Strong Wool strain is a large framed animal. Yearling ewes raised in the better environments will weigh upward to 165 pounds. This strain is a smooth bodied animal when compared to the other Merino strains. Their wool is long and bulky with a creamy color. The Strong wooled Merinos have a very bold crimp and produce 21 to 26 μm wool. Flock ewes produce 14 to 15 pound fleeces and special stud ewes can produce fleeces in excess of 20 pounds. Stud rams have been known to produce 48 pound fleeces that yield 75 percent. The Extra-Strong strain is very similar except it has 24 to 30 μm wool which is dry and discolored. Strong and Extra-Strong wooled Merinos are susceptible to fleece rot and therefore do not adapt to high rainfall areas.

References

Black, J.L. and P.J. Reis. 1978. Physiological and Environmental Limitation to Wool Growth. The University of New England Publishing Unit, Armidale, New South Wales, Australia.

Ryder, M.L. and S.K. Stephenson. 1968. Wool Growth. Academic Press. New York.

Turner, H.N. and S.S.Y. Young. 1969. Quantitative Genetics in Sheep Breeding. Cornell University Press, Ithaca, New York.

National Geographic May 1988 Wool-Fabrics of History.

Wool Australia The Official Record 1990-91. Rural Press Limited. North Richmond, NSW.

HOPLAND FIELD STATION

Division of Agriculture and Natural Resources
University of California

The Hopland Field Station is the University of California's north coast agricultural research station. Located within Mendocino County's Russian River watershed, it provides a unique opportunity for the study of California's natural and agricultural resources.

Users of the station include faculty and staff of the University of California Division of Agriculture and Natural Resources, who can utilize land, facilities, and labor in pursuit of their specific research objectives. Researchers from other colleges and universities also may use the station for special projects. Graduate students as well as undergraduates find excellent opportunities to pursue field research in an ideal environment. Many visitors from California and throughout the world learn about the station's research while attending field demonstrations and seminars, or while visiting with individual station staff members.

The station is 100 miles north of San Francisco, 40 miles inland from the Pacific Ocean, and is 5 miles east of the town of Hopland and Highway 101. Restaurants, gas stations, grocery stores, and other basic services are available in the town of Hopland. Motels and other Lodging facilities are available in Ukiah, the Mendocino County seat, 18 miles north of the station.

RESOURCES OF THE HOPLAND FIELD STATION

Natural Resources

Purchases of land by the University, begun in 1951, have brought the total area to 5,358 acres ranging in elevation from 500 to 3,000 feet. The station has sites representing California's major north coast vegetation types, exposures, and elevations. Of the total area, 468 acres have been livestock-free since about 1957. The station's extensive resources can be reached by approximately 30 miles of all-weather roads.

Agricultural Resources

The station's grazing Land is divided into 32 fenced pastures ranging in size from 14 to 650 acres. Of these, 12 areas, totaling 250 acres, are surrounded by dear-proof fences. A 20-acre parcel on the valley floor of the Russian River drainage is irrigated.

Physical Facilities

Facilities and accommodations include a dormitory with cooking and sleeping areas for researchers and students; an office building with library, meeting room, and microcomputers and a laboratory equipped for chemical and biological analyses of plant, soil, water, and animal materials. A greenhouse of 950 square feet and a lysimeter facility with 72 tanks support range management and agronomy research. Livestock facilities include two sheep barns with working corals, as well as feed storage barns. Vehicle and equipment maintenance facilities and storage buildings support the station's ongoing operation and provide flexibility for designing and maintaining research.

Climate

The geographic location of Hopland Field Station is latitude 39°00' N and 123°4' W. The climate is Mediterranean, characterized by hot, dry summers (June through September) and mild, rainy winters. Rainfall normally occurs between October and May, with 75 percent of the precipitation received from November through February. Annual precipitation averages 37 inches at the 800-foot elevation and 45 inches at 3,000 feet. Snow is infrequent, generally not lasting more than a few days. Mean average temperature in July through September is 70 F, and the mean maximum is 92 F. July is generally the hottest month with daily maximums occasionally reaching 110 F. Nights are usually cool. Temperatures drop to a mean of 44 F to 47 F from December through February. The frost-free growing season averages 250 days, with the first frost sufficient to cause soil heaving usually occurring in mid-November. Rainfall influences herbaceous forage growth more than temperature does, limiting the growing season to about 180 days (November through April).

Soils

Geologically, the area is part of the Franciscan formation, which is mostly sedimentary material and quite variable. Seventeen soil series were recognized in a detailed survey of the station.

Vegetation and Wildlife

Four principal vegetation types (grass, woodland-grass, dense woodland, and chaparral) include more than 600 species and cover 95 percent of the station's acreage. The station maintains an herbarium collection and a small study collection of vertebrate species found within its boundaries. Additional information, including plant and animal lists, is available upon request.

Livestock Management

The station maintains a sheep flock of 900 to 1,500 ewes. Animals in excess of research needs, including lambs, are sold at auction, usually in May and June. Wool produced is sold through a marketing association.

RESEARCH EMPHASIS

The following areas currently receive principal research emphasis at the Hopland Field Station:

Vegetative Resources and Soils: Range plant and animal nutrition (including trace mineral studies), range fertilization, evaluation of subclover cultivars, oak regeneration and management, biological and economic responses and interactions of plants and animals to grazing systems, influence of integrated use of irrigated pasture, testing herbaceous plants for emergency re-vegetation.

Animal Science: Selection for growth and prolificacy of sheep, production of improved rams, behavior patters of ewes to alien lambs, comparison of sheep breeds for lamb and wool production, forage intake, physiological parameters and nutritive content studies of sheep and of improved pastures.

Wildlife: Productivity and yield of deer populations, behavior of coyotes and predator damage control in relation to sheep production, population dynamics and dispersal of rodents, management of non-game and upland game species.

Entomology and Public Health: Biology and pest management of arthropods of public health and veterinary importance, studies of tick-borne diseases of importance to livestock and humans.

Long-term data bases on the climate, hydrology, plant composition, livestock, wildlife, and insects serve as a reservoir of knowledge supporting current and future research thrusts. New research projects are encouraged and welcomed by station personnel.